

**DYNAMIC EQUITY THEORY:
MODELING PAY FOR PERFORMANCE'S
CROSS-LEVEL EFFECT**

PHANG RIYANG

Nanyang Business School

Thesis submitted to the Nanyang Technological University
in partial fulfilment of the requirement for the degree of
Doctor of Philosophy

2015

ACKNOWLEDGEMENTS

I would like to express great thanks to my examiners who willingly take up the challenge of grading a long thesis. Great thanks also go to my committee members who kindly devoted time and shared advice to help improve my work. Their comments pushed me and made this thesis so much more improved. Thank you, Prof. Hong! Thank you, Prof. Riyanto!

Deep thanks go to two good men, my advisors.

Prof. Georgios Christopoulos believed in me, gave me courage when I struggled with ill health, and never allowed me to stray from my journey. Prof. Chiu Chi Yue gave me the sense of sight to the world of research, showing me its taxa and genera. Without them, I would not have made it this far. Thank you, Prof. Chiu! Thank you, Prof. Christopoulos!

Special thanks go to Prof. Quazi who started me on this journey, and to SMO division who supported me and ensured I have a well-balanced training. They nurtured the researcher in me. Thank you, Prof. Ang! Thank you, Prof. Quazi!

Special thanks also go to Prof. Chernyshenko and Prof. Yu who read through my thesis in short notice and help assess the fitness of my work in the great discourse of management and HR. Thank you Prof. Yu! Thank you Prof. Chernyshenko!

Lastly deep in my heart, I dedicate this thesis and thank my parents for their patience and support all these years. It has been a difficult seven and a half years for you. Thank you Dad, thank you Mum!

TABLE OF CONTENTS

LIST OF TABLES	i
LIST OF FIGURES.....	ii
LIST OF ABBREVIATIONS	iv
RELATED WORK	vi
ABSTRACT.....	viii
Chapter	
1. INTRODUCTION.....	1
2. EQUITY THEORY	6
Equity Theory and its Developments	6
Equity Theory Application in the Workplace.....	20
3. PAY FOR PERFORMANCE.....	24
Research and Applications	24
Pay for Performance Paradox	27
4. RESEARCH QUESTIONS	41
Sufficient Condition for Pay for Performance.....	41
Equity Theory through Time and Social Space.....	42
Incorporating Cognitive and Social Aspects	43
5. INTRODUCTION TO AGENT-BASED MODELING	44
Agent-based Modelling	44
Some Known Uses of ABM	56
Cellular Automata.....	75
6. COMPUTATIONAL EXPERIMENT 1 (BASE MODEL)	83
Model Design.....	83
Model Verification.....	89
Data Collection	92
Results.....	94
Discussion.....	100
7. COMPUTATIONAL EXPERIMENT 2 (MEMORY).....	104
Memory.....	104
Code Modifications	108
Data Collection	110
Results.....	110
Discussion.....	121

8. COMPUTATIONAL EXPERIMENT 3 (COGNITIVE BIAS).....	124
Cognitive Bias	124
Code Modifications	126
Data Collection	129
Results.....	130
Experiment 3A.....	137
Discussion.....	147
9. COMPUTATIONAL EXPERIMENT 4 (SOCIAL COMPARISON)	150
Social Comparison.....	150
Number of Comparison Others.....	157
Code Modifications	160
Data Collection	162
Results.....	162
Discussion.....	165
10. GENERAL DISCUSSION.....	167
Implications for Theory	175
Implications for Practice.....	182
Limitations of Study	184
Empirical Links and Future Directions.....	190
Conclusion	201
REFERENCES.....	203

LIST OF TABLES

- Table 2.1. Issues of Equity Theory
- Table 5.1. General Characteristics of ABM
- Table 6.1. Parameters Setup for Experiment 1
- Table 7.1. Parameters Setup for Experiment 2
- Table 7.2. Aggregate output at $t=1,000$ for different levels of reward schemes and memory capacities
- Table 7.3. Frequency of Time Periods Required to Reach Equilibrium at Zero (Experiment 2)
- Table 8.1. Parameters Setup for Experiment 3
- Table 8.2. Aggregate output at $t=2,000$ for different reward schemes and levels of recency effect
- Table 8.3. Frequency of Time Periods Required to Reach Equilibrium at Zero (Experiment 3)
- Table 8.4. Parameters Setup for Experiment 3a
- Table 8.5. Aggregate output at $t=2,000$ for different reward schemes and levels of primacy effect
- Table 9.1. Parameters Setup for Experiment 4
- Table 9.2. Time to Stability for Different Reward Schemes and Number of Comparison Others
- Table 10.1. Summary of Findings

LIST OF FIGURES

- Figure 6.1. Agent processes for Base Model
- Figure 6.2. Graphical User Interface of Model Implemented on Netlogo 5.1.0
- Figure 6.3. Typical Equity States and Motivation Condition at $t = 1$
- Figure 6.4. Average Aggregate Output of Different Reward Schemes across Time
- Figure 6.5. S.D. of Aggregate Output of Different Reward Schemes across Time
- Figure 6.6. Evolution of effort levels across time under different reward schemes
- Figure 7.1. Agent processes to account for storage, recollection, and evaluation of discrepancy information.
- Figure 7.2. Aggregate Output of Different Reward Schemes and Memory Capacities across Time
- Figure 7.3. Aggregate Output of Different Reward Schemes and Memory Capacities at $t=1000$
- Figure 7.4. Evolution of effort levels across time under PFT 5-Turns
- Figure 7.5. Aggregate Output of Two Separate Runs for Parameter Combination of Pay for Time and Memory Capacity of 3-Turns
- Figure 7.6. Aggregate Output of Two Separate Runs for Parameter Combination of Pay for Time and Memory Capacity of 3-Turns
- Figure 7.7. Proportion of Equity Types and Aggregate output in a typical run for parameter combination of PFT and Memory Capacity of 3-Turns
- Figure 7.8. Proportion of Equity Types and Aggregate output in a typical run for parameter combination of PFT and Memory Capacity of 5-Turns
- Figure 8.1. Relative Weights Showing Recency Effect when $t \leq k$ and $t < k$
- Figure 8.2. Agent processes to account for recency effect.
- Figure 8.3. Aggregate Output of Different Reward Schemes and Recency Effect across Time
- Figure 8.4. Aggregate Output of Different Reward Schemes and Recency Effect at $t=2000$

Figure 8.5. Aggregate Output of Two Separate Runs for Parameter Combination of Pay for Time and Recency Effect of $\lambda=0.25$

Figure 8.6. Aggregate output of typical runs of PFT with various values of λ .

Figure 8.7. Relative Weights Showing Primacy Effect when $t \geq k$ and $t < k$.

Figure 8.8. Aggregate Output of Different Reward Schemes and Primacy Effect across Time.

Figure 8.9. Aggregate Output of Different Reward Schemes and Primacy Effect at $t=2000$.

Figure 9.1. Von Neumann versus Moore neighborhood

Figure 9.2. Aggregate Output of Different Reward Schemes and Number of Comparison Others across Time

Figure 9.3. Time to Stability for Different Reward Schemes and Number of Comparison Others

Figure 10.1. Sample Pay Slip for Experimental Condition of Memory 3 Turns in a Multi-Outlet Restaurant Chain

LIST OF ABBREVIATIONS

ABM	Agent-based Model
ACE	Agent-based Computational Economics
ACT-R	Adaptive Control of Thought – Rational, cognitive architecture developed by John Anderson and collaborators
B2B	Business to Business
BDI	Belief-Desire-Intention, cognitive architecture developed by Anand Rao and Michael Georgeff and collaborators
BOID	Belief-Obligation-Desire-Intention, cognitive architecture developed by Jan Broersen, Mehdi Dastani, Joris Hulstijn, Leendert van der Torre and collaborators
BOLD	Blood Oxygen Level Dependent
CA	Cellular Automata
CLARION	Connectionist Learning with Adaptive Rule Induction On-line, cognitive architecture developed by Ron Sun and collaborators.
DES	Discrete Event Simulation
EPIC	Executive-Process/Interactive Control, cognitive architecture developed by David Meyer and David Kieras
ESOP	Employee Stock Ownership Plan
FIFO	First In First Out
FHT	Fairness Heuristics Theory
GDP	Gross Domestic Product
HR	Domain of Human Resource
I/O	Domain of Industrial-Organizational Psychology
IPD	Iterated Prisoners Dilemma
KISS	Keep It Simple, Stupid

KSAO	Knowledge, Skills, Abilities, and Others
MBO	Management by Objectives
OB	Domain of Organizational Behavior
OBHR	Domain of Organizational Behavior and Human Resource
PFP	Pay for Performance, mostly referring to pay for individual performance
PFT	Pay for Time, fixed salary amount regardless of performance
SCO	Social Comparison Orientation
SIM-NORM	ABM program developed by Cristiano Castelfranchi and collaborators to study normative reputation and compliance costs
SITSIM	ABM programmed by Andrzej Nowak and Bibb Latane to model Social Impact Theory
SOAR	Cognitive architecture developed by John Laird and Allen Newell
TMT	Top Management Team

RELATED WORKS

Parts of this dissertation have been presented at the following outlets.

Phang, R., & Christopoulos, G. (2015). Motivational Dynamics in the Search for Fairness. Paper presented at Asia-Pacific Econophysics Conference 2015, Singapore.

Phang, R., & Christopoulos, G. (2015). Rethinking Equity Theory: Fairness Restoration and its Dynamic Outcomes. Accepted for paper presentation at CCS'15 Conference on Complex Systems, Tempe, Arizona, U.S.A.

Phang, R., & Christopoulos, G. (2015). Agent-based Modelling for OBHR Research. Invited presentation at Complexity Institute, NTU, Singapore. (26 Nov)

Parts of this dissertation are in preparation for submission to the following outlets

Human Resource Management Journal (Call for Paper)

Title: Agent-based Modelling for HRM Research

Academy of Management Review (Regular Submission)

Title: Dynamic Equity Theory

SPECIAL CREDITS

The works above and this thesis benefitted greatly from valuable discussion with members of Prof. Chew Lock Yue and Prof. Cheong Siew Ann's lab from the Complexity Institute. Gratitude also goes to Prof. Chen Shu Heng and Prof. Robert Axtell for clarifying key agent-based modeling concepts with me. Any mistakes or errors here are however solely my own.

ABSTRACT

Productivity is a concern for firms facing manpower crunch in recent years. Of management tools, pay for performance (PFP) is one widely studied but remained controversial. Among motivation theories, Adams's (1965) equity theory is one well used in total rewards research, but difficult to predict PFP's effect on collective performance. To address these twin concerns, organizations were construed as complex systems and agent-based modelling (ABM) was employed. PFP's cross-level incentive effect, along with several other effects, was found to emerge from localized equity-based comparisons and effort adjustments.

This research built an ideal-type ABM model from Adams's (1965) formulaic expression. Results of experiment 1 showed emergence of PFP's cross-level incentive effect, and PFP to outperform pay for time (PFT) in generating higher collective performance (aggregate output). For this to manifest, substantial time periods must have lapsed, suggesting critical research design issues even for longitudinal studies. These stabilized and time-based patterns of collective performance were consistent across random initializations and robustness checks. To uncover possible individual-level explanations for PFP's contradictory findings, basic cognitive and social psychological differences were considered, modifications to the base model made, and three more computational experiments performed.

Experiment 2 showed memory capacity to negatively affect PFP's positive effect on collective performance, such that aggregate output declines as agents recall information further into their past. Experiment 3 showed recency effect to support and extend the results of the base and previous experiment, with higher collective performance attained when agents give greater weights to information from recent than distant events. And Experiment 4 showed agents who compared with more others, rather than less others, led to PFP generating levels of collective performance higher than that achieved in experiment one's base model. To better

understand PFP as a reward scheme, PFT was simulated alongside PFP in all above experiments as a contrast. Amongst several additional insights gained, PFT was found capable of reversing its negative cross-level incentive effect to generate higher levels of collective performance under specific conditions. These combinatorial interactions indicate unexplored avenues for future studies on PFP and firm performance.

By investigating an enduring controversy, this set of studies reconstructed a classic motivation theory to offer a new ABM model of comparison-adjustment-production to the research community. The paradigm employed enabled the observation of cross-level dynamics in-vitro, yielding implications for PFP and equity theory research. Most significantly, the findings here (1) illustrated the emergence of PFP's cross-level incentive effect from mutual fairness restoration, (2) provided plausible explanations for controversies surrounding PFP, and (3) expanded the predictive and explanatory utility of equity theory.

Chapter 1

INTRODUCTION

Stop Tying Pay to Performance.

The evidence is overwhelming: It doesn't work.

(Frey & Osterloh, 2012, Harvard Business Review, p. 1403)

Pay for performance (PFP) is a tool firms use to manage workforce productivity. Less affected by market forces than pay levels, it is a central component of total rewards with more flexibility in its design and implementation (Gerhart & Milkovich, 1990). Yet as the preceding quote shows, not everyone agrees to its efficacy. The debate that began 40 years ago continues to this day with few signs of resolution (Gerhart & Fang, 2015, Meyer, 1975, Notz, 1975; see also Risher, 2013).

PFP has often been reasoned to work via expectancy theory, goal-setting theory, tournament theory, and agency theory (e.g., Bonner & Sprinkle, 2002; Garbers & Konradt, 2014; Gerhart, Rynes, & Fulmer, 2009) but objected from the perspectives of crowding-out, self-determination theory, or simply the measurement and administrative difficulties involved (e.g., Beer & Cannon, 2004; Deci, Ryan, & Koestner, 1999; Festre & Garrouste, 2014; Meyer & Gupta, 1995; Risher, 2014). Advocates and opponents were both right in their arguments, each with different sets of meta-analyses to back their findings. So as generators of knowledge, what can researchers advise firms and policy makers? This dissertation takes a new look at Equity Theory (Adams, 1963a,b, 1965), a classic theory in work motivation (Miner, 2006) and total rewards (Milkovich, Newman, Gerhart, 2013) to bridge differences from both sides. Doing so, the theory is considerably expanded to derive critical implications for organizational and HR theorizing.

Equity theory is frequently cited for studies of pay equity and variations (e.g., Brown, Sturman, & Simmering, 2003; Gupta, Conroy, Delery, 2012) and the basis behind reward practitioners' everyday concerns: external competitiveness and internal equity. It is one of the few work motivational theories with social comparison as an underlying process and scenario of analysis as dyadic or co-acting. Unlike theories that could explain and predict PFP's directional drive of effort (Jenkins, Mitra, Gupta, & Shaw, 1998), such as those explicating the hedonic rationale for more rewards, equity theory has more often been invoked to explain the need/acceptance of PFP plans (e.g., Chang & Hahn, 2006; Larwood, Levine, Shaw, & Hurwitz, 1979), the moderating conditions to PFP plans (e.g., Barnes, Hollenbeck, Jundt, DeRue, & Harmon, 2011; Vecchio, 1981), or the reasons PFP plans may or may not work as planned (e.g., Larkin, Pierce, & Gino, 2012).

The inability of Adams's (1965) equity theory to predict PFP's motivational effect on any focal individual lies in the theory's requirement of a comparison other(s). The sheer linking of rewards to the achievement of performance goals does not motivate an individual any more or less without someone to compare with. If the comparison other is paid the same rate, there will hypothetically be little or no motivational effect. Recognizing this limitation to individual-level motivation, Weick and Nessel (1968) extended Adam's theory to incorporate intrapersonal comparison. Despite that and refinements by others (e.g., Crosby, 1976; Folger, 1986), Adams's core theory remains intact and widely propagated in popular and academic discourse (Miner, 2006 & 1984).

Adams's (1965) theorizing was specific on the outcome and input of self and others, proposing that such information will guide a formulaic adjustment of effort towards equity. But what if the comparison other adjust effort simultaneously? What if many comparison others compare amongst themselves simultaneously? Over-adjustment, equity attainment after adjustment, or deterministic chaos? What will be the collective outcome? The theory's

application (not the formula) appears to break down when simultaneity is considered, is silent when three or more parties are involved over time, and is seemingly muted in the context where comparison groups of two focal individuals overlap partially. While across-time aspect of equity theory enjoyed some discourse in Huesmann and Levinger (1976), Gould (1979), and more memorably in Cosier and Dalton (1983), the simultaneous adjustments of partially connected individuals, a common aspect of everyday life, has not been sufficiently theorized or investigated.

For this research, I abduct controversies surrounding PFP and constraints of equity theory to ask, if equity theory could explain PFP's effect on the firm, but we are just looking at the wrong time scale and level? For organizations, collective performance is more important than any individual's. If equity theory does indeed mediate and drive PFP's effect upwards or downwards, the most likely avenue to discover it would be at the collective level due to its dyadic formulation.

To make this discovery possible, this study deviates from the dominant hypothetico-deductive paradigm to utilize formal theory method (Adner, Polos, Ryall, & Sorenson, 2009). The chosen method is that of agent-based modelling (ABM) and the simple-theory (Davis, Eisenhardt, & Bingham, 2007) is Adams's (1965) equity theory. This generative paradigm (Epstein, 2006a, b) lies within a positivist approach deducing computable first-order logics to test implications of theory across time and space. Hence it is characterized by high levels of internal validity and theoretical precision (Davis et al., 2007; Burton & Obel, 2011; Adner, et al., 2009; Labro, 2015) albeit lower external validity. It is a method that allows longitudinal monitoring of macro-level patterns from micro-level interactions. Characteristically, it is useful for uncovering empirical paradoxes and a priori hypotheses are advisedly refrained (Adner et al., 2009; Davis et al., 2007; Harrison, Lin, Carroll, & Carley, 2007, p. 1233, see also chapter 5).

The following sections begin with a review of equity theory research as applied to work motivation, followed by an overview of the debate surrounding PFP. From these sources, I identify gaps (Alvesson & Sandberg, 2011) in equity theory and PFP discourse for further exploration. The gaps culminate in a set of questions anchored by a search for sufficient conditions (Adner et al., 2009, p. 206) for PFP's cross-level effect to manifest. As agent-based modelling is not yet mainstream in management, OB, or HR, I review the essence of the method, followed by a brief survey of its use in psychological and business sciences to make a case. The section on model development details the formulas used at each part of the simulation, stating the assumptions and steps to collect data. To understand if PFP could generate cross-level incentive effect, I design a base experiment monitoring changes in aggregate output over time. Pay for time (PFT), construed as fixed-interval salary irrespective of output, is added to probe if the effects of PFP are indeed due to reward scheme differences.

Three further simulation studies were conducted to explore the human dimensions of memory, cognitive bias, and preference for comparing with more or less others. The experiments explored boundary conditions to PFP's incentive effect and help predict the conditions where PFT may show higher collective performance. Specific discussion follows each experiment with a general discussion at the end summarizing all findings, stating implications to theory and practice, and discussing limitations, future steps, and ways to enhance external validity.

In sum, the study of PFP and equity theory may be timely. The call for methodological diversity in management, especially simulation (March, 2001; Davis, Eisenhardt, & Bingham, 2007), and the explicit consideration of time and levels in HR theorizing (Gupta & Shaw, 2014; Wright & Boswell, 2002; Dipboye, 2007) are answered through the use of agent-based modelling. The call to look beyond cause-and-effect to consider conditions of emergence (Hackman, 2012) is closely adhered to, and the neglected status of compensation research

(Gupta & Shaw, 2014; Cascio & Aguinis, 2008) addressed with a set of studies investigating reward schemes and their application over time. Given the fit of paradox-theory-and-method (Van Maanen, Sorensen, & Mitchell, 2007) and the large research-practice gaps on the topics of compensation and motivation for HRM (Deadrick & Gibson, 2007), the insights uncovered here may foster positive conversations between this divide.

Chapter 2

EQUITY THEORY

Fairness, justice, and equity are cornerstones to understanding social structures and its constituent dynamics. In modern discussions, equity theory is deemed the “starting point ... in the social psychology of justice” (Deutsch, 1985, p. 5), and a “paradigmatic theory” in the management sciences on par with agency theory and behavioral theory (Whetten, Felin, & King 2009, p. 540). So fundamental and pervasive is fairness and equity that recent researchers have uncovered neural correlates of human responses to inequity for self and others (Christopoulos & King-Casas, 2015; Cappelen, Eichele, Hugdahl, Specht, Sorensen, & Tungodden, 2014; and Tricomi, Rangel, Camerer, O’Doherty, 2010).

Often attributed to the work of Adams (1965), this theory could be considered as the accumulation of Homans’s (1961) thoughts on distributive injustice, Festinger’s (1957) theory of cognitive dissonance, and Spector’s (1956) investigation into relative deprivation. Like Adams’s own theorizing which changed over time (cf. Adams 1963a, 1963b, 1965, & 1968; Adams & Rosenbaum, 1962; Adams & Jacobsen, 1964; and Adams & Freedman, 1976), many researchers have sought to improve this intellectual tradition (e.g., Walster, Berscheid, & Walster, 1973 & 1978; Weick, 1966; Anderson, 1976; Deutsch, 1975; Lerner, 1974; Homans 1974). However, despite such variations and alternatives, as those by Walster, Walster, and Berscheid (1978), it is Adam’s (1965) equity theory that influenced management discourse most. It is this original theory that forms the basis of this research.

Equity Theory and its Developments

Adams Equity Theory

Holding inequity in similar manner to Homans’s distributive injustice, Adams (1965) considered that

“inequity exists for Person whenever he perceives that the ratio of his outcomes to inputs and the ratio of Other's outcomes to Other's inputs are unequal, either (a) when he and Other are in a direct exchange or (b) when both are in an exchange relationship with a third party and Person compares himself to Other.” (p. 280).

Therefore in either condition (a) or condition (b), inequity exists when

$$\frac{O_p}{I_p} < \frac{O_a}{I_a} \quad \text{or} \quad \frac{O_p}{I_p} > \frac{O_a}{I_a}$$

where O refers to outcome and I refers to input, and p and a denotes Person and Other, respectively (notation taken from Adams, 1965, p. 281). The inequality expression on the left refers to overreward (or positive inequity) for the Person and the inequality expression on the right refers to underreward (or negative inequity) for the Person.

In Adams's (1965) work, he makes a few assumptions central to his theory. First, it is perceived inputs and outcomes rather than any actual manifestation that matters. Second, parties to the exchange must consider the outcomes and/or the specific input they invested as relevant to them. Third, the outcomes and inputs can be single item or multiple items weighted in terms of importance and aggregated to form an overall perception. Fourth, *inputs* is a general term that can include experience, age, skills, network, hours worked, and effort, while *outcomes* can be pay, benefits, welfare, compliments, perquisites, and developmental opportunities. Fifth, following Jaques (1961) and Patchen (1961), humans are capable of relatively precise judgment and response rather than just an ordinal and directional one. Sixth, the magnitude of experienced inequity will be monotonically related to perceived size of discrepancy. Seventh, there exists threshold levels for an individual to experience the inequity; where, following Homans (1961), a higher threshold when inequity exist in an advantageous manner for oneself.

Adams (1965) theorized effects of inequity as synonymous with cognitive dissonance (Festinger, 1957) and considered the tension from inequity to be so much so that an individual is motivated to eliminate or reduce it. This resultant motivation is proportional to the felt tension where tension will be resolved when equity ratio of Person and Other are equal:

$$\frac{O_p}{I_p} = \frac{O_a}{I_a}$$

Adams cited, then existing, evidence to show that to achieve equity, Person will singly or in combination (1) alter his/her inputs; (2) alter his/her outcomes, “rarely”; (3) distort inputs and outcome cognitively; (4) leave the field/situation; (5) cognitively or behaviorally act on Other; and/or (6) change the comparison other. Hence, combining the formula and propositions the theory is distilled as containing four components, namely, inputs, outcomes, referent others, and modes of inequity reduction.

Issues and Corresponding Developments

As with any theory too specific or parsimonious, critiques are aplenty. For a start, Weick (1966), amongst other criticisms, noted Adams changed his original view of inequity from just an “obverse” (p. 416) co-acting situation applicable between co-workers in a salary-receiving context, to one where inequity can also arise out of direct exchange relationships. In another observation, Adams, himself, in 1965 downplayed equity theory’s temporal aspect including his earlier comment that “dissonant relation... is historically and culturally determined” (Adams, 1963a, p. 425). This have likely led to subsequent studies tending to only investigate a “short term effect of inequity on performance” (Goodman & Friedman, 1971, p. 285) rather than its long term impact.

Beyond these two little known issues, there are several other aspects of equity theory the research community has frequently picked up (summarized in Table 2.1). Some pertain

more to the implicit assumptions underlying the theory, some on the formula proposed by Adams (1965), while some on the approach taken on by later researchers.

Table 2.1

Issues of Equity Theory	Examples of Critiques & Attempts to Address
Over emphasis that Equity is the main principle underlying distributive justice	Sampson (1975); Deutsch (1975); Rawls (1971), Leventhal (1976)
Ignores the interactional and interdependent nature between comparison others, and parties of the exchange relationships	Camerer & MacCrimmon (1983); Deutsch (1985)
Negative Inputs/Outcomes controversy	Harris (1983); Samuel (1978); Romer (1977), Alessio (1980)
Multiple Inputs and Outcomes	Anderson & Farkas (1975); Anderson (1976); Greenberg & Ornstein (1983)
Most group experiments considered resultant group-level effects as simple additive function of individual inputs.	Camerer & MacCrimmon (1983); Deutsch (1985)
Most research focuses on two-person dyadic exchange or co-acting situations	Cook & Hegtvedt (1983)
Most experiments, especially those exploring the functional relationship between outcome-input discrepancies tended to adopt the paradigm of indicating reward based on input, rather than input as a function of outcome.	Camerer & MacCrimmon (1983)
Unclear on the specifics of how choice of referent person is made	Pritchard (1969); Weick (1966)
Ignores effects of Finite versus Infinite Allocation Pool	Lane & Messe (1972)
Most studies and mathematical representations tended to be static	Vecchio (1982 & 1984), Cosier & Dalton (1983), Lawler et al. (1968)
Limited specification of when different equity restoration modes will operate	Greenberg, (1990); Cook & Parcel (1977)
Limited specification on the influence of Culture	Greenberg (2001); Kilbourne & O'Leary-Kelly (1994); Bolino & Turnley (2008)
Effects of Individual Differences	Weick & Nettet (1968); Vecchio (1981)
Trade-offs when moving between equity and equality	Camerer & MacCrimmon (1983); Deutsch (1985)

The contention of equity theory over-emphasizing the rule of proportionality in distributive justice (Lerner, Miller, & Holmes, 1976; Mikula & Schwinger, 1978; Sampson, 1969), serves only to remind researchers and policy-makers the presence of alternatives to the equity rule, such as equality/egalitarian and needs-based rule. Much research has since been done on these alternatives to show that the choice of equity rule versus alternatives is contingent on various dimensions of the individual, outcomes, production tasks, situation, relationships, and cultural backgrounds (e.g., Chiu, 1990a, b; Leung & Bond, 1984; Morris, Leung, Ames, & Lickel, 1999; Shapiro, 1975; Tornblom, 1992; Rohrbaugh, McClelland, & Quinn, 1980; Fisek & Hysom, 2008; Fu et al., 2007; Meindl, 1989; Chen, 1995; Chen, Meindl, & Hui, 1998; Wagner, 1995; Morand & Merriman, 2012; Walster & Walster, 1975; Schwinger, 1980, Kahn, 1972; Campbell, 1978) advancing our understanding of justice and its rules.

Camerer and MacCrimmon's (1983) and Deutsch's (1985) concern of work situations where actors are interactional and interdependent are twofold. First, critics proposed that workers could withhold responding or strategize their response beyond immediate increase or reduction of efforts so as to maintain relationships or obtain gains from non-task relevant aspects of the relationships. Second, because there are many interactions and interdependencies in modern day work, the dynamic multi-level group effect of response to equity theory was not well investigated by most experiments then (Camerer & MacCrimmon, 1983). However, Jasso (1983) provided an exception to show, via numerical analysis, how group-level phenomena such as cohesiveness and tension between two subgroups can emerge by manipulating values to the formula of proportionality-based distributive justice, while Messe, Vallacher, and Phillips (1975) showed how equity theory's predictions help in explaining coalition formation.

On the formulaic front it is clear that Adams's (1965) theory did not clearly define situations where inputs and/or outputs were negative. This gave rise to a "controversy" (in the words of Samuel, 1978; see also Romer, 1977). Additionally, the theory stated

outcomes/rewards and inputs used in the outcome-input ratio can be a weighted sum of multiple different items of relevance. It was, however, incomplete in showing why alternative evaluation methods may not hold. This gave rise to a new theory, Information Integration Theory (Anderson, 1976). And on the closely-linked non-divisibility of outcome, the little research has been done mostly performed by economists (commented in Camerer & MacCrimmon, 1983).

While the influence of individual differences and cultural factors was implied by Adams (1965), his silence on the manner of influence opened the theory to criticism on this front (e.g. Vecchio, 1981; Huseman, Hatfield, Miles, 1987; Carrell & Dittrich, 1978; Tornow, 1971; Pritchard, 1969; Deutsch, 1975; Weick, Bougon, & Maruyama, 1976). These criticisms, on hindsight, have enabled much research to accumulate on this avenue. For instance, on the individual differences front, Hofmans (2012) showed individuals differ in the “cognitive algebra” (Anderson, 1991) used to form equity judgments and that this difference is distinct from equity sensitivity; Vecchio (1981) showed moral development as a positive moderator for effects of the equity norm; and Huseman, Hatfield, and Miles (1985) showed individual differences in perception and responses to differential outcome-input ratios, from which they (Huseman, Hatfield, & Miles 1987; Miles, Hatfield, & Huseman, 1989) subsequently theorized and proposed a new construct. On the cultural front, Feldman (1968) found American subjects more likely to take the behavioral approach to restoring inequity than French or Greek participants; Chiu (1991a, 1991b) through an emic approach found confrontational-based responses to injustice to be least favored by Hong Kong Chinese; Weick, Bougon, and Maruyama (1976) found Dutch compared to Americans not only gave greater consideration to background and residual stimuli, but were also more able to uncouple outcome from input; and Chiu (1988, 1989) found Hong Kong subjects to exhibit asymmetrical input integration effect, where positive personality factors (also known as background stimuli in Weick, Boudon, &

Maruyama's (1976) terms) play a bigger role when recipients of outcome possess lower performance.

The above paved way for a large collective research effort at the cross-roads of equity theory, reward allocation, and cross-cultural research. It focuses not on the details of Adams's formula, but on understanding the extent and reasons subjects from different nationalities and ethnic backgrounds apply different distribution rules (see Powell, 2005; Fischer & Smith, 2003). Perhaps under influence of intersubjective norms (Chiu, Gelfand, Yamagishi, Shteynberg, and Wan, 2010), European subjects in Gergen, Morse, and Gergen (1980) and Törnblom, Jonsson, and Foa's (1985) studies were found to prefer equality distribution norms compared to the equity norm found for Americans. In other studies, Berman, Murphy-Berman and Singh (1985) noted that while Indians and Americans both applied the needs-based rule in preventing negative rewards, Indians more than Americans applied the needs-based rule when offering the positive rewards; and Fu et al. (2007) showed how biculturals when primed with Chinese culture symbols favored the equality norm more so than when primed with American cultural symbols.

To that end, such reward allocation studies can be seen as the fruitful integration of the social psychological and management domains. Leung and Bond (1984), most commonly cited (e.g. in Fu et al., 2007; Kim, Edwards, & Shapiro, 2014) for finding Chinese to favor the equality norm versus equity norm for the Americans, inspired a community of researchers (e.g., Bond, Leung, & Wan, 1982; Leung & Park, 1986; Zhang & Yang, 1998). More specifically, they (Leung & Bond, 1984) showed that while equity rule is pervasive, Chinese more than Americans apply the equity rule to out-group members. Still other studies such as Kim, Park, and Suzuki (1990) found support for the omni-presence of the equity norm and its content dependence, but noted mild variations that subjects from less masculine and individualistic culture favor the equity norm less; Chen (1995), having had participants role-

play a manufacturing firm's president, found Chinese subjects to favor the equitable distribution of both material and socioemotional reward while Americans to only favor the equity rule for material rewards; Chen, Meindl, and Hui (1998) found "situational" strength to reduce the influence of national culture, such that American and Hong Kong Chinese both apply equality rule for interdependent tasks and equity rule for independent tasks; and Chen, Meindl, and Hunt (1997) focusing on within-culture variations found that Chinese employees high on vertical collectivism were in favor of reform to the egalitarian socialist payment system in the country. More fundamentally explained, such observed correlation between culture and equity-equality distinction may be elegantly explained by the extension of a self-serving bias versus other-serving bias between subjects of different cultural background (Leung, Kim, Zhang, Tam, Chiu, 2012).

With so much interests and boundary conditions of justice concepts made apparent (Table 2.1 and preceding paragraphs), it is foreseeable that modifications (e.g., Weick & Nessel, 1968) and new models of equity theory (e.g., Huseman, Hatfield, & Miles, 1987) have surfaced through the years.

Theoretical Advancements

Theorists whose aim focuses on providing modifications and extensions have helped extend the precision and applicability of Adams's (1965) equity theory (e.g., Harris, 1983; Anderson, 1976; Lane & Messe, 1972; Leventhal & Michaels, 1969). For instance, Weick and Nessel (1968), subsequently supported in Pritchard's (1969) review, proposed that individuals possess an internal reference guide independent of others, and therefore individuals may differ in the extent they emphasize/prefer own equity, comparison equity, and own-comparison equity, an array of three equity ratio types; and Mellers (1982 & 1983) proposed that in the co-

acting application of equity theory, it is the relative merit ranking between co-actors that matters more in terms of evaluating just reward allocation.

On *individual differences*, Huseman, Hatfield, and Miles (1985, 1987, & 1994) offered Equity Sensitivity Theory to explain the large variation of responses to inequity as measured through Adams's (1965) formula. In their theory, there exist three classes of individuals on the unidimensional construct of equity sensitivity. Measured via the Equity Sensitivity Instrument (Huseman et al., 1985), these three classes of individuals are the equity sensitives, the entitled, and the benevolents. The equity sensitives conform to Adams's prediction best as they feel distress when they are both under- or over-rewarded. Entitleds prefer their outcome-input ratio to be greater than that of comparison others, while benevolents prefer their outcome-input ratio to be less than that of comparison others. Due to the wide reception among management scholars, this theory underwent much criticism (e.g., Greenberg, 1990) and development. One of which is to reconceptualize "preference" as "tolerance for" a particular range of outcome-input ratio (King, Miles, & Day, 1993), while the other is the development of a psychometrically sound three dimensional measurement, Equity Preference Questionnaire (Sauley & Bedeian, 2000).

On the *time dimension*, Gould (1979) integrated Adams's Equity Theory with Etzioni's (1961) Theory of Compliance and the time-value of money. In his theory, the Equity-Exchange Model, the organization offers inducements for an employee's involvement. Depending on the discrepancy from equity and the inducement offered, an employee may be motivated to adjust either his/her moral, calculative, or alienative involvement. Though the extension is intuitive and relatively straightforward, its contribution may lie in showing more contingent classes of responses to inequity, as well as schematically limiting the boundaries where the Adam's theory may function.

A possibly better integration of time and Equity Theory is, however, found in Cosier & Dalton's (1983) reformulation. Not only did Cosier and Dalton show formally how Adam's prediction may hold between time periods, but they theorized how it affects motivational levels and incorporated the effects of cognitive biases. The fact that their theory provides clarity, precision, and treats time "as discrete in (their) model" (p. 313), their theory and formula will be depicted in greater detail. From Adams's (1965) formula above, using their own convention, Cosier and Dalton theorized that tension from inequity is represented by

$$T_t = \beta \left| \left(\frac{O_p}{I_p} \right)_t - \left(\frac{O_o}{I_o} \right)_t \right|$$

- T : the amount of tension experienced by Person
 β : proportionality parameter representing the degree to which inequity causes tension in Person for the time period in question; $\beta > 0$
 t : time period, discrete

Where subscripts p and o refer to focal Person and Others, and O and I refer to outcome and input, respectively. And the motivational strength to reduce the tension in the current time period, M_t , is a cumulative function of inequities from previous time periods, modified by a weight (λ) to account for the diminishing effect of inequities from distant past.

$$M_t = \alpha (\lambda^0 T_t + \lambda^1 T_{t-1} + \lambda^2 T_{t-2} + \dots + \lambda^n T_{t-n})$$

- M : motivational strength aroused in Person to reduce the tension
 α : proportionality parameter representing the degree to which sum of all past tensions motivates Person for the time period in question; $\alpha > 0$
 λ : weighting (discount) factor
 t : time period, discrete

Using an analogy, Cosier and Dalton (1983) argued that this reformulation overcomes previous conceptualizations that erroneously assumes away effects of inequities from the past, including those beneath the threshold, which does seem to not affect inequity feelings in the present or future. Though Cosier and Dalton did not elaborate on the values for the constants

(“proportionality parameter”) or the weighting factor. Their article suggests that (1) the “proportionality parameter” can vary between people, and (2) in the sequence from which inequity affects behavior, there exists at least two cognitive stages, perception to tension, and tension to motivation.

Theoretical Alternatives

Work focusing on providing alternatives include Berger, Fisek, Norman, and Wagner’s (1985) Reward Expectations Theory, Crosby’s (1976, 1984) theory of Egoistic Relative Deprivation, Folger’s (1986) Referent Cognitions Theory, Lind’s (1995 & 2001) Fairness Heuristics Theory, Walster, Berscheid, and Walster’s (1973 & 1978) version of Equity Theory, Thibaut and Kelley’s (1959,1978) Interdependence Theory, and Huesmann & Levinger’s (1976) Incremental Exchange Theory. The first two theories draw from sociological-oriented origins, the third and fourth influenced organizational behavior research, the fifth and sixth formed the basis of several modern social psychological theories, and the seventh came from an artificial intelligence modelling attempt.

The intricate propositions of Reward Expectations Theory (Berger et al., 1985), posits that an individual possesses several characteristics (called referential structures) of which not all are important to a task or comparison scenario. Only those referential structures that are “salient in a particular situation and (that) the actors know of and accept” (Berger et al., 1985) are critical in determining the expected reward levels. Most applications of this theory lies in determining expected levels of pay (e.g., Melamed, 2012). In the theory of Egoistic Relative Deprivation, Crosby’s (1976, 1982) and colleagues (Cook, Crosby, & Hennigan, 1977, Bernstein & Crosby, 1980; Crosby & Gonzalez-Intal, 1984) posit that egoistical deprivation (compared to fraternal deprivation) is experienced when five preconditions are fully met, and,

more importantly, that deprivation varies as a positive function of past expectations and as a negative function of future expectations.

Extending from relative deprivation theory and popular interest in procedural justice (Thibaut & Walker, 1975; Folger, 1977), Folger's (1986) Referent Cognitions Theory placed procedures (rather than outcome) center in fairness judgment, and posited that perceived unfairness will occur when an individual believes a more favorable outcome would have resulted from an alternative procedure. Seeing limitations in his theory, Folger and Cropanzano (1998) proposed that prior to making a fairness judgment, three judgments must be made, namely (a) would the same outcome occur in another situation/procedure, (b) could referent other acted differently, and (c) how should a referent other acted in the referent situation. Around the same time, van den Bos and colleagues (van den Bos, Lind, Vermunt, & Wilke, 1997; van den Bos, Vermunt & Wilke, 1997; van den Bos, Lind, & Wilke, 2001) posits in Fairness Heuristics Theory that in situations of uncertainty and insufficient information, people heuristically use information from a variety of sources to derive a general impression of how fairly they are being treated. While initial judgments are considered malleable within the theory, resistance to judgment revision result from primacy effect seen in fairness judgment.

In even earlier works with an explicit aim to provide a "general theory that social psychologists so badly need" (Walster, Berscheid & Walster, 1978, p. 2), Walster, Berscheid and Walster (1973 & 1978) proposed a direct alternative Equity Theory that posits (1) individuals will try to maximize outcomes, (2) groups will evolve systems to apportion rewards and costs such that the system will bring maximum reward to the group, and that the group will induce members to accept such system, (3) individuals in inequitable situation will feel distress, monotonically, (4) individuals in inequitable relationship will attempt to reduce the felt distress by restoring equity. Whiles similar to Adams's (1965) formula with a ratio

defining equity, a difference formula for outcomes is used in the numerator to avoid some occurrences of negative inputs.

Despite Walster et al's (1978) endeavors, it was Thibaut & Kelley's (1959 & 1978) Interdependence Theory that appeared to have influenced theorizing on numerous domains, from interpersonal relationships, to inter-departmental conflict and cooperation (Victor & Blackburn, 1987). In essence, Interdependence Theory predicts relationship satisfaction in terms of relational rewards and costs, wherein the residual difference between the rewards from costs is the relational outcome. Current outcome levels are compared with expectations ("comparison level"), developed from personal experiences or vicariously from when a negative (or positive) discrepancy occurs, and relationship satisfaction (or dissatisfaction) experienced. When expectations fall below an alternative comparison levels, relationship dependence is predicted to decline. The 'exchange' aspect of Interdependence Theory was elaborated more thoroughly in Kelly and Thibaut (1978) where an individual's outcomes (hence the rewards and costs, and subsequently expectations) are representatively dependent on the matrix shared between two parties. Partners in relationship are proposed to be able to strategize and work together (or individually) to transform an initial "given matrix" into an "effective matrix" from which the final behavior-outcome contingencies are based.

Remarking Thibaut and Kelley's (1959) exchange matrices as "predominantly static" (Huesmann & Levinger, 1976, p. 193), Huesmann and Levinger created Incremental Exchange Theory to formally state how relationships and actors behavior evolve over time. Huesmann and Levinger posited that parties to a relationship stays if the "expected payoff from a competing relationship minus the cost of terminating the current one (do not) exceed the expected payoff from the current relationship by an amount sufficient to overcome the effect of past" experiences (p. 201) Clearly there are costs and rewards prescribed in a payoff matrix for decisions taken by an actor. A major assumption in this theory is that greater weight and

magnitudes in both parties' payoffs increase as they progress from one level (or "state" in their terms) to another. Notably, state reflects maturity of relationship not chronological time.

Operationalizing their theory in RELATE, an artificial intelligent environment with two agents running "tree searching optimizing procedure" (p. 201), each actor (or agent) has a finite set of actions and guesses its co-actor's set of actions and probability of executing each action. For each actor-co-actor action pairing, there exists a pre-determined payoff for each actor pre-stated in one's own pay-off matrix. Based on the response probability of co-actor's action and corresponding payoff, the focal actor estimates the expected values for each action choice he/she has and chooses the best option. Given a pre-determined transition matrix and actions taken by the actor and co-actor, the relationship will develop into a more or less mature state. Illustrating RELATE with dyadic altruism, self-disclosure, and romantic involvement, Huesmann and Levinger (1976) showed how relationships move between stages of maturity and the corresponding types of payoffs leading relationships to alternate between two adjacent maturity stages. Likely owing to the model's "large number of parameters, which render it complex ... and difficult to disconfirm" (Huesmann & Levinger, 1976, p. 228 – 229), the theory has had limited reception and been mostly applied to the study of dyadic interpersonal relationships such as romantic and familial relationships (e.g., Levinger & Huesmann, 1980).

This cursory review shows that Adams's (1965) Equity Theory was influenced by and symbiotically influenced decades of socio-psychological and management thinking. Despite critiques, advancements, and alternatives to equity theory, the basis of its formula has been well applied in many areas as diverse as retail, service recovery and customer relations (Ashworth & McShane, 2012; Gelbrich, 2011; Huppert, Arenson, & Evans, 1978; Oliver & Swan, 1989; Lapidus & Pinkerton, 1995; Leventhal, Younts, & Lund, 1972), sex, mating and intimate relationship (Walster/Hatfield, Walster, & Traupman, 1978; Lujansky & Mikula, 1983; Floyd & Wasner, 1994; Buunk & Van Yperen, 1991; Michaels, Edwards, & Acock,

1984; Brock & Lawrence, 2009), friendships (Roberto & Scott, 1986), communications (Wilkins & Timm, 1978), crime and law (Rablen, 2010; Fedler & Pryor, 1984; Wagstaff & Preece, 1997), and marital and familial relationships (Grote, Clark, & Moore, 2004; Vogl-Bauer, Kalbfleisch, & Beatty, 1999; Schafer & Keith, 1980; Schumm & Kirn, 1982).

For this thesis, it is Equity Theory's original formula and founding application in wages and production output (Adams, 1963a,b; and Adams, 1965, Adams & Rosenbaum, 1962; Adam & Jacobsen, 1964; Andrews, 1967; Friedman & Goodman, 1967; Goodman & Friedman, 1968; Lawler at al., 1968; Lawler & O'Gara, 1967) that will be the focus.

Equity Theory Application in the Workplace

In the study of work motivation, no “master” theory exists, except that which may best be used by a manager for a phenomenon in time (Steers & Porter, 1991, p. 557). Where the concern is to attract, retain, and motivate employees (Lawler, 1990), Equity Theory has provided guidance for much of modern day management know-hows and best practices (Fall & Roussel, 2014; Miner, 2006 & 1984; Colquitt & Zapata-Phelan, 2007; Ambrose & Kulick, 1999). From pay design, to bonus allocation, to the emancipation of female workforce, Equity Theory and its assumptions had and continues to play a key role. Compensation, recently Total Rewards, practitioners know well the dual challenges of external competitiveness and internal equity as perennial concerns in designing pay throughout the organization (Milkovich, Newman, & Gerhart, 2013; Martocchio, 2012; Wallace & Fay 1983; Dulebohn & Werling, 2007). Paying too much or too little affects not just the direction, amplitude, and persistence of behavior of an employee (Campbell & Pritchard, 1976) but also those of his/her colleagues.

Equity Theory in the form proposed by Adams (1965) has been extensively studied in work-like laboratory-based or vignette-based context, or in the field, especially where the

outcomes are pay-related. From Adams and Rosenbaum's (1962) study of qualified versus underqualified subjects; Middlemist and Peterson's (1976) two-time periods between-subject study of 40 subjects in two-by-two factorial of high-low qualifications and fast-slow working confederates; Evans and Molinari's (1970) field experiment of street interviewers showing predictions of equity theory to be contingent on job security perceptions; to Greenberg and Ornstein's (1983) showing prestigious job title may compensate for underpayment when higher job title is earned (than unearned), much is said about Equity Theory's application at work. Additionally, Greenberg (1988) found that 198 employees of an underwriting department assigned to either higher, lower, or equal status, changed levels of performance corresponding to equity theory's prediction; Lawler, Koplun, Young, and Fadem (1968) investigated how overpaid responded across three sessions showing that (1) overpaid compensate their overpayment with quality at the start, and (2) the overpaid show significant increase in productivity level between first and second period, but show only modest increase in production levels thereafter; and Van Yperen, Hagedoorn, and Geurts (1996) study of Dutch blue-collar workers showed those deprived to exhibit higher turnover and absenteeism intentions than the advantaged. Yet two studies showed support of equity theory but emphasized a potential *asymmetrical* response. Cohn, Fehr, Hermann, and Schneider (2014) showed that when one worker sees its co-worker getting more than him/her, he/she will reduce its effort more than the amount he/she reduced when both workers suffer a pay reduction of the same magnitude, though receiving a relative higher pay did not correspond to an increase in effort. Further supporting the strength of the negative inequity (underreward), Fliessbach and collaborators (2007) showed regions of the brain centered around ventral striatum exhibiting higher than average blood oxygen level dependent (BOLD) response in conditions of equity and positive inequity, but lower than average BOLD response in condition of negative inequity.

On aspects of choice of “other” in Adams’s formula, Goodman’s (1974) study of 217 managers showed an information dependence effect on choice of referents when one evaluates the outcome-input ratio of self, others, or system; Scholl, Cooper, and McKenna (1987) found that comparisons using others outside the company in similar jobs and comparisons of one’s own pay in the past were significant predictors of turnover intentions; Summers and DeNisi (1990) and Summers and Hendrix (1991) found that referent groups can be self or others of similar KSAOs, hence the system, internal or external to the organization, contributes to overall perception; Tyagi (1990) found monetary and task inequity to affect satisfaction and work motivation most in a sample of insurance salesperson; and Wade, O’Reilly, and Pollock’s (2006) five year lag-time study found that despite apparent non-comparability, CEO’s over-payment affects lower-level employees’ own equity perception.

Still others such as Dittrich and Carrell’s (1979) longitudinal study of 158 clerical employees in twenty departments showed equity perceptions to be stronger predictors of absence and turnover than job satisfaction; Berg’s (1991) study of television employees showed global perceptions of equity positively predicts intention to stay; Vecchio, Griffeth, and Hom (1986) and Griffeth and Gaertner (2001) using possibly the same sample of hospital employees, showed work-pace inequity and pay-rule inequity (composite within Adam’s formula) to marginally relate with turnover and turnover intentions; Van Dierendonck, Schaufeli, and Buunk (1998) showed through a field experiment of 352 mental health professionals that inability to reduce inequity, and hence the corresponding distress, led to higher prevalence of burnout and absenteeism; Oldham, Kulik, Ambrose, Stepina, and Brand (1986) also using a longitudinal design found those feeling under-rewarded in terms of higher job complexity to exhibit lower performance, higher absenteeism and greater turnover, giving empirical support to two of Adams’s (1965) modes of inequity resolution.

To keep focus, equity theory's extension onto organizational justice, pay equity, labor inequality, and other models of motivation is left out. Therein lies even larger bodies of work leveraging the equity norm synonymous with Adams's base assumptions. In distributive justice for instance, numerous reviews including those on organizational justice, have been conducted (e.g., Crawshaw, Cropanzano, Bell, Nadisic, 2013; Shao, Rupp, Skarlicki, & Jones, 2013; Gilliland, 2008; Taylor, 2001; Cohen-Charash & Spector, 2001; Colquitt, Conlon, Wesson, Porter, & Ng, 2001; Cook & Hegtvedt, 1983; Greenberg, 2010; Li & Cropanzano, 2009), and amidst numerous moderators, distributive justice is shown to affect pay and job satisfaction (e.g., Fields, Pang, & Chiu, 2000; Sweeney, 1990; McFarlin & Sweeney, 1992; Sweeney & Mcfarlin, 1993), turnover (e.g., Aquino, Griffeth, Allen, & Hom, 1997; Haar & Spell, 2009; Kim & Leung, 2007), reputation (e.g., Ripp, Shao, Thornton, Skarlicki, 2013), organizational commitment (e.g., Chang, 2002; Dubinsky & Levy, 1989; Schwarzwald, Koslowsky, & Shalit, 1992), organizational citizenship behavior (e.g., Moorman, 1991; Farh, Earley, & Lin, 1997; Karricker & Williams, 2007), counterproductive work behavior (e.g., Jones, 2009; Skarlicki & Folger, 1997; Goodboy, Chory, & Dunleavy, 2008), trust (e.g., Colquitt & Rodell, 2011; Jones & Martens, 2009; Pillai, William, Tan, 2001; Forret & Love, 2008; Hubbell & Chory, 2005), leader-member exchange (e.g., Roch & Shanock, 2006; Erdogan, Liden, Kraimer, 2006), engagement (e.g., Biswas, Varma, & Rasmuswami, 2013; Ghosh, Rai & Sinha, 2014), and health outcomes (e.g., Robbins, Ford, & Tetrick, 2012; Spell & Arnold, 2007; Tepper, 2001; Taris, Kalimo, & Schaufeli, 2002).

From direct applications of equity theory in the workplace, and derivations into new aspects of organizational justice, there is little doubt that Adams's formalizing paved the way for much thoughts in management, HR, and especially compensation sciences (Wallace & Fay, 1983; Bartol & Martin, 1988).

Chapter 3

PAY FOR PERFORMANCE

Research and Applications

Human resource management practices in general and compensation systems in particular, have been shown to be highly related to organizational performance (Banker, Lee, Potter, & Srinivasan, 1996; Becker & Gerhart, 1996; Becker & Huselid, 1998; Shaw, Gupta, & Delery, 2002). Compensation strategy is the “deliberate utilization of the pay system as an essential integrating mechanism through which the efforts of various subunits and individuals are directed toward the achievement of an organization’s strategic objectives” (Gomez-Mejia, Berrone, & Franco-Santos, 2010, p. 22), where reward/pay systems are key management tools that contribute to a firm’s effectiveness by influencing individual and collective behavior (Lawler & Cohen, 1992). Though there are several aspects of compensation and pay systems one can investigate, this research follows Gerhart, Rynes, and Fulmer (2009) to focus research on pay for performance (PFP) because

1. PFP is a component of Total Rewards where organizations have more leverage in designing as compared to pay levels determined by market forces (Gerhart et al., 2009; Gerhart & Milkovich, 1990)
2. Motivational effects of PFP, especially in monetary forms, are often times “strong” and could be “larger than the effects of any other single type of motivational system” (Gerhart & Rynes, 2003, p. 116; Locke, Feren, McCaleb, Shaw, & Denny, 1980; Gerhart, 2001; Gerhart et al., 2009)
3. PFP have existed since antiquity (Peach & Wren, 1991; Coens & Jenkins, 2000; Driver & Miles, 1952)
4. PFP has been increasingly embraced by private and public organizations after World War II and recession of the 80’s, and will continue to form a larger component of total compensation (Aon-Hewitt, 2014; Baron, Dobbin, & Jennings, 1986; Mitchell, Lewin, & Lawler, 1990; Heneman & Werner, 2005; Lemieux, Macleod, & Parent, 2009)
5. There are numerous debates, “Myths”, “Controversies”, and “Dilemma” revolving the efficacy of PFP (Vecchio, 1982; Meyer, 1975; Kerr, 1975; Markham, 1988; Waldron,

1988; Kessler & Purcell, 1992) yet to be convincingly accepted by research communities and practitioners (see Gerhart & Fang, 2014 & 2015) despite insightful meta-analyses performed on this topic (e.g., Jenkins, Gupta, & Shaw, 1998; Gagne & Forest, 2008; Garbers & Konradt, 2014)

As with most areas in organization science (Osigweh, 1989), pay for performance and related terms in compensation research are multi-specified. The applied aspect of compensation does not help in clarification. The term PFP have often been used interchangeably with financial incentives, incentives, rewards, earnings-at-risk pay, performance-related pay, contingent pay, performance-based schemes, and other like variations. And, in some rather weird instances, been equated with variable pay and merit pay. These uses, especially the latter, while problematic also suggest fuzzy boundaries involved in scoping this research. (see Honeywell-Johnson & Dickinson, 1999; Miceli & Heneman, 2000; Garders & Konradt, 2014; Merriman, 2014; and for a variety of interchangeable usage and attempts at categorization, see Durham & Bartol, 2000, Bonner & Sprinkle, 2002; Wynter-Palmer, 2012).

Generally, PFP is pay contingent on performance of an individual, group, or organization, a “compensation arrangement in which the final salary of an employee is a function of some form of measured performance” (Hasnain, Manning, Pierskalla, 2014), or “pay that varies with some measure of individual or organizational performance” (Milkovich, Newman, & Gerhart, 2013). It is sometimes seen as a system (e.g., Deckop, Mangel, & Cirka, 1999; Kerrin & Oiver, 2002), a structure (e.g., Ernst, 2013), a scheme (e.g., Cadsby, Song, & Tapon, 2007; Lazear, 2000), a plan (e.g., Deckop et al., 1999), a program (e.g., Zingheim & Schuster, 2007; Gerhart & Fang, 2014), tools or techniques (e.g., Luthans & Stajkovic, 1999; Zingheim & Schuster, 1995), or simply a “linkage of monetary rewards to performance” (Ledford, 2004, commenting on Beer & Cannon, 2004). A simple deduction would show the definition of PFP (e.g., Ledford, 2004) to be an overly restrictive definition, as clearly, if pay equated to compensation, refers to “the sum of all incentives and rewards, pecuniary and

nonpecuniary, arising from the agency relationship” (Pepper & Gore, 2012) or “the rewards (monetary and nonmonetary) that employees receive for performing their job” (Martocchio cited by Gagne & Forest, 2008), then PFP goes beyond monetary rewards and authors ought to be careful in delineating which aspect of PFP they are researching on. Clarifying which aspects of PFP a study focuses on prevents erroneous extrapolation. Exemplars of such good clarifications include those by Jenkins, Mitra, Gupta, and Shaw (1998), Bonner and Sprinkle (2002), and Garbers and Konradt (2014) who focused on financial/monetary incentives, and Bareket-Bojmel, Hochman, and Ariely (2014) who focused solely on short-term bonus.

While the above shows great variations in PFP implementation and conceptualization, a central theme underlying them is reward or incentive given based on performance, where incentives are determined ex-ante and rewards are determined ex-post (Patten, 1977). Such PFP schemes/programs, according to Gerhart and Rynes (2003) can vary in terms of their extent of emphasis on results- vs. behavior-orientation of performance measure, emphasis on performance measures at individual or collective level, and extent of incentive intensity. A survey of when to use various manifestations of PFP programs (such as gainsharing, profit-sharing, stock options, spot awards, piece-rate, sales commission, lump sum bonus, merit pay, staff-of-the-month awards) and the strategic context to use them, including the appropriate mix, is not discussed here. To note, though, that merit pay plans have been the most widely used attempt at linking pay to performance (Durham & Bartol, 2000; Gerhart, Rynes, & Fulmer, 2009) and that PFP is widely used as a means to control operational costs (Gomez-Mejia et al., 2010, Klaas, 1999; O’Dell & McAdams, 1987), boost productivity (Lazear, 1998), aid macroeconomic efficiency (especially in the form of profit-sharing, Weitzman, 1984), and control employees (Oliver & Anderson, 1995; Gagne & Forest, 2008).

Pay for Performance Paradox

Paradox, controversies, disputes, and myths are not new to pay for performance (Meyer, 1975; Vecchio, 1982; Markham, 1988; Meyer & Gupta, 1995; Eisenberger & Cameron, 1996; Rousseau, 1997; Pfeffer, 1998; Kohn, 1993a,b; Gagne & Forest, 2008; Marsden, 2010) but appear to continue (Gerhart & Fang, 2015; Risher, 2013; Nyberg, Pieper, & Trevor, 2013; Cameron, Banko, & Pierce, 2001; Ledford, Gerhart, & Fang, 2013; Cerasoli, Nicklin, & Ford, 2014; Gerhart & Fang, 2014; Lawler, Benson, McDermott, 2012) for a while more. Pay in this sense refers mostly to the extrinsic tangible component of the Total Returns model (Milkovich, Newman, & Gerhart, 2013), where most (not all) contentions revolve around the use of extrinsic reward, mostly financial, for enhancing job and organizational performance (e.g., Gerhart & Fang, 2014).

Controversies arise not just because research and anecdotal evidences show both equivocal effects of PFP, but also because theoretical explanations revolving around PFP are aplenty. PFP has been shown to contribute to task and workplace performance (Farr, 1976; London & Oldham, 1977; Weinstein & Holzbach, 1973; Pritchard & Curts, 1973; Bartol & Locke, 2000; Fay & Thompson, 2001) and organizational performance (Lazear, 2000; Shearer, 2004). Meta-analytic studies have generally shown PFP, in its various operationalizations exerting mean positive effects on performance of sizes ranging from .65 (Condly, Clark, Stolovitch, 2003), .57 (Guzzo, Jette, & Katzell, 1985), mean $r = .32$ (Garbers & Konradt, 2014), mean $r = .30$ (Jenkins, Mitra, Gupta, Shaw, 1998), mean $r = .23$ (Weibel, Rost, & Osterloh, 2010). These are mostly moderate effect sizes.

One highly cited study by Lazear (2000) on employees of Safelite Glass Corporation showing the switch from hourly wages to piece-rate pay resulted in a 44% gain in average worker output, and other studies such as, Kruse (1993) found firms (especially small-medium sized firms) with profit-sharing schemes to exhibit higher productivity growth; Kelley and

Hounsell (2007) showed how a company implementing a form of gainsharing plan reaped benefits of increased productivity and monetary savings; Schuster, Weatherhead, and Zingheim (2006) showed how PFP improved organizational performance of United States Postal Service over a 10 year period; Banker, Lee, Potter, and Srinivasan (1996) showed a major retailer enjoying higher sales, customer satisfaction, and profit from its stores with store-level incentive plans than from stores without; Shearer (2004; see also Paarsch & Shearer, 1999) in a within-and-across subject field experiment showed piece-rate compensation plans to result in 20% productivity gain; and Jones and Kato (1995) found implementation of ESOP to relate to “4-5 percent increase in productivity” (beyond the cost ESOP) over a 3-4 years period for Japanese firms.

With focus on individual performance as an outcome, Fernie and Metcalf (1999) via eight-year performance data showed jockeys under incentive contract performing better than those on retainer fees; Greene and Podsakoff (1978) showed the removal of a merit pay system from a unionized paper plant related to dropped average performance ratings over time and compared with other non-affected plants; Kopelman and Reinharth (1982) using three year lagged data linked to performance to merit-increase data showed that the stronger the performance–reward relation, the higher the level of subsequent performance; Drago (1991) showed incentives predicted work effort and performance; and Mattson, Torbiorn, and Hellgren (2014) showed a bonus system when implemented appropriately may encourage safety behaviors in Swedish nuclear power plants. Beyond individual performance, Shaw and Gupta (2007) showed PFP to be associated with retention of good performers, and Scott, Shaw and Duffy (2008) showed merit pay to be related to organization-based self-esteem for older employees.

On null or negative effects, Beer and Cannon (2004) have famously shown how PFP implementation at Hewlett-Packard was not successful and undermined the cultural and

relational integrity between management and workers, and Pearce, Stevenson, and Perry (1985) showed PFP has no effect on organizational performance, and contributed to unfairness perceptions and negative evaluations of others at work in the latter study. Additionally, Brown and Huber (1992) showed satisfaction with pay outcome and process to decline after the implementation of an earnings-at-risk program, Pearce and Perry (1983) showed dysfunctional effect of PFP for civil servants, and Messersmith, Guthrie, Ji, and Lee (2011) showed higher turnover for underpaid especially when larger portions of their pay are at risk.

Opposition to Pay for Performance

To the extent that management domain are dominated by prominent thought leaders, fads, and fixation with executive compensation, comments by Pfeffer (1998) that “literally hundreds of studies and scores of systematic reviews of incentive studies consistently document the ineffectiveness of external rewards” (p. 214-215) have certainly influenced thinking of a sizeable community of researchers. Extended opinion pieces by Kohn (1993a,b) and numerous studies of executive compensation showing meagre correlation (near zero) of executive compensation with firm performance even with pay of large incentive intensity (see reviews and meta-analysis in Dalton, Daily, Certo, & Roengpitya, 2003, Tosi, Werner, Katz, & Gomez-Mejia, 2000) serves to further downplay the positive cross-level effect of PFP.

Key arguments of opponents include the following with the first two being the most widely cited arguments.

1. External reward reduces self-determination and intrinsic motivation
2. Money is not an important motivator at work
3. Choking under pressure
4. Upwards adjustments of goals after prior achievement, Ratchet Effect
5. Risk adverse when stakes are too high

6. Rewards harms relationship and undermines performance on interdependent tasks
7. Inhibits performance on creative work tasks
8. PFP can work too well
9. Excessive narrow focus on a task
10. Gaming the system
11. Rewards hides underlying problems and innovation.
12. Implementation is the weakest link of PFP

Compiled from Eisenberger, Rhoades, & Judy (1999), Kamenica (2012), Gerhart & Fang (2014), Bracha & Fershtman (2013), Ariely, Gneezy, Loewenstein, & Mazar (2009), Beilock et al. (2004), Kohn (1993a & 1988), Meyer (1975), Carmichael & MacLeod (2000), Parnell & Sullivan (1992), Lawler (1971 & 1987), Deci, Ryan, & Koestner, 1999 (1999), Cardenas, Stranlun, & Willis (2002); Steininger (1994), Patton (1972); McGraw (1978); Garber & Konradt (2014), Kerr (1975), Gomez-Mejia, et al., 2010

The trade-offs between intrinsic and extrinsic motivation have traction in both economics and psychology. For the former, crowding-out effect has been found in numerous studies (e.g., Frey & Oberholzer-Gee, 1997; Gneezy & Rustichini, 2000), formalized in Frey (1997) and Benabou and Tirole (2000), and applied to education and health domains (see Gneezy, Meier, & Rey-Biel, 2011). In this effect, an external intervention (of which external reward is an element) effects a change in preference for a task or a change in perception of the task, thereby moving along a continuum of intrinsic-extrinsic motivation (Frey & Jegen, 2001). For the latter, Cognitive Evaluation Theory (CET: Deci & Ryan, 1985), a sub-theory of Self-Determination Theory, has been used to explain that when one must perform “in some particular way, at some particular time, or in some particular place...to receive the reward, the reward tends to be experienced as controlling” (p. 738). The perception of being controlled is considered to undermine intrinsic motivation. This assumption and a meta-analysis (Deci, Ryan, & Koestner, 1999) of 128 experiments performed on mostly children or students, showing moderate negative effects of rewards on free-choice behaviour, has been often used to ground arguments against extrinsic motivation, hence PFP. Some changes are taking place though. Though in both crowding-out effect and CET, intrinsic motivation has often been shown not to return to pre-PFP/reward levels, facing mounting evidence from field studies and

other meta-analyses (Rummel & Feinberg, 1988; Cameron & Pierce, 1994; Cameron, Banko, & Pierce, 2001) stating the undermining effect (Cerasoli, Nicklin, & Ford, 2014) as less commonplace, Gagne and Deci (2005) began to argue that PFP could enhance intrinsic motivation “when rewards are administered in an autonomy-supportive climate” (Gagne & Deci, 2005, p. 354) via increases in perceived autonomy (Eisenberger & Aselage, 2009).

Possibly influenced by the hugely popular work of industrial psychologist Herzberg (1964) and survey results that seemed to reveal pay as not the top job criteria for satisfaction or attraction (Rynes, Gerhart, & Minette, 2004), consultants and commentators such as Kohn (1993a,b) and Pink (2009) commented that pay is not an important motivator at work, hence PFP is unimportant. Returning to economics, behavioral economist Beilock (2010) and Ariely et al. (2009) showed that in choking-under-pressure, similar to the Yerkes-Dodson law, higher incentives showed greater performance only up till a point when the incentives at stake are too high and performance drops (an inverted-U relationship). Labor economists Carmichael and Macleod (2000) extending work of Freixas, Guesnerie, and Tirole (1985), identified the ratchet effect as the tendency for performance standard to increase after good performance or achievement has been made. As workers became aware, vicariously or personally, of policy implications, they will see this as a game where good performance may only make future performance harder to achieve. Considering that employees are less mobile and able to diversify their investment of time and effort, they are more likely to be risk-averse than investors of the firms. Hence, companies would need to offer a compensating premium for employees to accept PFP (Weitzman & Kruse, 1990; Kuhn & Yockey, 2003; Larkin, Pierce & Gino, 2012). Even if accepted, the tension of different risk preference of employee and stockholders (especially when incentive intensity is high) would exert a downward effect on PFP.

Two other convincing arguments are made on PFP's effect on team and interdependent tasks, and performance on creative work. Pay dispersion, a thriving area of research, has often been discussed alongside and as a result of PFP (see Shaw, 2014; Trevor, Reilly, & Gerhart, 2012), and argued that resultant and/or potential pay differentials between team members of colleagues may curtail cooperation between peers (Lawler and Cohen 1992; Gross, 1995; Rosenbaum et al. 1980; Hansen, 1997; Mohrman, Mohrman, & Lawler, 1992; Cardenas, Stranlund, & Willis, 2002; Bloom, 1999, Pfeffer & Langton, 1993; Heneman & von Hippel, 1995; Mitchell & Silver, 1990; Shaw, Gupta, & Delery, 2002) and information exchange (Taylor 2006), invoking Deutsch's (1949) social interdependence theory that distinctiveness in rewards undermines collaboration.

With lateral pay dispersion as focus, and at times invoking Equity Theory (e.g., Barnes, Hollenbeck, Jundt, DeRue, & Harmon, 2011), studies such as that by Shaw et al. (2002) showed the safety performance of workers in highly interdependent team settings to be lower when pay dispersion was high; a study by Markham (1988) showed that the PFP relationship to be significant at the team-level but not at the individual level as managers' distribute rewards equally to maintain team cohesion; and study by Deckop, Mangel, and Cirka (1999) showed that stronger PFP relationship relates to lower OCB for employees whose values are low in alignment with the firm. To note the above relates to PFP based on individual incentives even in teams. Despite concerns on social loafing (see Karau & Williams, 1993), when PFP was based on team-level performance, team performance (comparing to teams without team-level based PFP) were generally positive and small to moderate in size (see meta-analyses: Condly, Clark, Stolovitch, 2003, and Garbers & Konradt, 2014).

On creativity, Hunter, Cushenberry, & Friederich (2012), Pfeffer (1998), Kohn (1993), Amabile (1983 & 1996) and McGraw and McCullers (1979) arguing from different aspects that while PFP may encourage performance on repetitive tasks, it inhibits exploration of

untested approaches. Using arguments from CET, they posited that creativity requires intrinsic motivation, enjoyment, and a climate of psychological safety (Edmondson, 1999), and extrinsic motivation being a control mechanism is “detrimental” (p. 15) to creativity in that it fixates one on gaining/losing of the reward to the expense of exploration of alternatives to task performance (Amabile, 1996). In an indicative exploration (as results were not based on actual differences in payment schemes) of equity’s effect in PFP for creativity tasks, Goncalo & Kim (2010) showed primed equitable distribution of rewards led to greater production of ideas only for subjects with high independent self-construals.

That it works, but too well, can be a problem (Baker, Jensen, & Murphy, 1988) as well. This, often being the case for result-oriented measures (Gerhart & Fang, 2014), could also manifest in behavior-oriented PFP programs. “The drive to achieve objectives ... may be so relentless as to cause other important objectives to be ignored” (Gerhart & Fang, 2014, p. 46) sums the numerous examples given in Kerr (1975). The effects of it would be most obvious when a holistic performance (such as patient recovery) is required, but single measures (number of patients seen) are used, leading to dysfunctional behavior (such as hastiness in diagnosing and referral of patients). When emphasis on a small set of measures is large enough, questionable behavior (owing to informational asymmetry, and hence moral hazard context) may occur. Such gaming behaviors (see Jensen, 2003) are well-known in accounting studies on timing of performance within and across financial years (Courty & Marschke, 2004), and colloquial with terms such as Sandbagging, referring to lowering of goals to make them easier to achieve. It seems then that the calculus of PFP trumps the automaticity of moral and professional ethics.

Contradictions and Contingencies

It will be apparent that numerous factors undermining efficacy of PFP can be mitigated through better design and implementation of PFP, giving consideration to the context of organization's strategy, structure, operations, and stakeholders of PFP. A strong point in case would be the numerous meta-analyses showing large variances of main effects reflecting moderators and boundary conditions for PFP. For instance, Guzzo, Jette, and Katzell (1985) showed programs that "tie monetary rewards to individual, group, or organization-wide performance" to have mean effect size of $d = .57$ but insignificant at 95% level; incentives to have large positive effects (.96) in manufacturing firms but small (.37) in service firms (Stajkovic & Luthans, 1997); PFP to have positive effects for non-interesting tasks (mean $r = .42$) and negative effects for interesting tasks (mean $r = -.13$) (Weibel, Rost, & Osterloh, 2010), and in terms of creative performance, when rewards tied to creativity led to significant increase in creative performance ($g = .62$) than when reward were tied to overall performance ($g = -.04$) or completion of task ($g = -.01$) (Byron & Khazanchi, 2012). Distinguishing quantity from quality performance tasks, Cerasoli, Nicklin, & Ford (2014) showed extrinsic incentive to have an effect on only quantity-based performance (mean $r = .35$) and intrinsic motivation to have effect for both quality (mean $r = .24$) and quantity-based (mean $r = .33$) performance, but Garbers & Konradt (2014) found financial incentives to relate stronger to quality-based performance (mean $r = .39$) than quantity-based performance (mean $r = .28$), and tasks with higher complexity (mean $r = .37$) to exhibit higher PFP relation than low complexity tasks (mean $r = .19$), a big contradiction to the results of Cerasoli et al. (2014) and precepts of goal-setting theory (Wood, Mento, & Locke, 1987).

Highly cited reviews, such as that of Jenkins, Mitra, Gupta, & Shaw (1998) revealed that PFP works on increasing quantity (mean $r = .32$) but not so for quality (mean $r = .08$), and that the effect is larger for studies for simulation (mean $r = .53$) and field studies (mean $r = .46$)

than laboratory studies (mean $r = .23$), with similar findings replicated later in Garbers and Konradt (2014). Surprisingly, Jenkins et al. (1998) found that in such studies, theoretical explanation used significantly affects the observed effects, where studies explained by goal-setting (mean $r = .22$) and CET (mean $r = .21$) showed much smaller financial incentives to performance than those by expectancy and reinforcement (mean $r = .49$). The authors suggest this finding could reflect different research designs, but given differences in theories' emphases, such as CET, this however could have been a file-drawer effect.

Studies exploring the multi-faceted effects of PFP have shown, for instance, end-of-period determination of performance standards linked to bonuses led to lower performance than goals pre-determined/self-set (Wood, Atkins, & Bright, 1999); individual incentives kept accident rates low in the context of low work interdependence but had negligible effects when interdependence was high (Shaw, Gupta, & Delery, 2002); individuals in pay-for-performance incentive scheme performed well (compared to fixed wage) in discovering a novel profitable business strategy but individuals in PFP-like schemes coupled with tolerance for early failure and rewards for long-term success fared even better (Ederer & Manso, 2013); and between two types of incentives, tournament-competitive incentives led individuals to take up and perform better on effortful but less cognitively demanding tasks (Bracha & Fershtman, 2013). These nuanced findings on PFP extend well to the group context as well. PFP linked to team or departmental outcomes may reduce the line-of-sight effect and encourage social loafing (Wageman, 1995), yet two meta-analyses (Condly et al. 2003, Garbers & Konradt, 2014) showed team incentives to relate more to performance than individual incentives. Still other reviews suggested unequal distribution of rewards among group members are linked to lower productivity for small teams (Honeywell-Johnson & Dickinson, 1999). To hedge against potential problems and gain the benefits of both (Gerhart, Trevor, & Graham, 1996), several researchers and consultants have recommended a variable pay mix that contains individual and

team components (e.g., Pearsall, Christian, & Ellis, 2010; DeMatteo, Eby, & Sunstrom, 1998; Welbourne & Gomez-Mejia, 1995; Heneman & von Hippel, 1995; Pearce & Ravlin, 1987), yet other studies have shown such hybrid PFP schemes fail to yield expected benefits (e.g., Wageman, 1995; Barnes, Hollenbeck, Jundt, DeRue, & Harmon, 2011).

Known Mechanisms of Pay for Performance

Despite above explanations of the opponents and contradictions, mechanisms explaining pay for performance are grounded on well-established theories from psychology, management and economics domains.

Reinforcement Theory has Skinnerian roots positing humans can be conditioned with rewards and stimuli, classical or operant, to initiate, direct, and maintain/repeat their behavior (Komaki, Coombs, & Schepman, 1996). Expanded by Luthans and Kreitner (1975, 1985) as the principles behind organizational behavior modification (OB-Mod), practitioners are taught that because presence, valence, and schedule of reinforcements/consequences are crucial to sustain or increase desired behavior. PFP by administering rewards, possessing instrumental and symbolic value, ostensibly work via the route. When rewards provide benchmark information on one's performance as well as that of his/her peers', Control Theory (Carver & Scheier, 1981 & 1998), a cybernetic-inspired motivation theory, explains that because humans are self-regulating, they constantly compare their current performance with some standard set by the system or a normative one. The performance management processes that accompany PFP, such as performance appraisal, and performance meetings and updates, provide critical inputs for such behavioral adjustments.

Moving to more frequently-invoked theories, Bandura's (1986, 1997) social cognitive theory has been used to explain how PFP-related processes increase self-efficacy hence

subsequent behavior. When rewards serve as informational cue of one's success, an individual increases his/her collection of mastery experiences for that task. When reward not to self but others signals potential to accomplish on a goal and obtain a desired reward, vicarious influence/learning occurs. When managers negotiate goals or discuss allocation of bonus managers helps and persuasively influence subordinates they have the ability to accomplish a task. More specifically, when self-efficacy increased and short-term successes are achieved, in a reinforcing loop manner, self-efficacy continues to build-up leading to greater motivation for a task.

When goals and performance standards are central to PFP, then Locke and Latham's (1990) Goal-setting Theory is vital to explain the workings of PFP. Goal-setting Theory places goals before effort in nomological sequence to state goals are the stimulants of incentive-induced effort (Bonner & Sprinkle, 2002). While generally assumed that specific and challenging goals lead to greater effort, Locke, Shaw, Saari, and Latham (1981) showed three ways that incentives affect effort via goal setting. First, incentives may cause people to set goals when they otherwise would not. Second, incentives might cause people to set more challenging goals than they otherwise would, where these harder goals in turn lead to higher effort. Third, incentives contribute to higher goal commitment (and thus greater effort) than non-contingent incentives or no incentives conditions (reviewed in Bonner & Sprinkle, 2002; and Buchner, 2007).

Finally, the four major theories most commonly linked to PFP are that of expectancy theory, equity theory, agency theory, and tournament theory. Expectancy Theory (Lawler, 1973; Vroom 1964) argues that the product of reward valence, instrumentality of performance in getting the reward, and the expectancy that one's effort will lead to the intended performance, determines the effort one will put in for a task. Accordingly, PFP programs such as broad-based ESOP have been shown to have low expectancies (distant line-of-sight) for

mid-low level personnel as increasing effort in their job may not necessarily lead to better company performance or reaching the performance threshold for release of options; and low instrumentality as the company performance may not necessarily lead to higher stock returns as stock prices are jointly determined by market forces and business cycles.

Equity theory (Adams, 1963a,b, 1965), detailed in above section, explains how people modulate their effort levels or perceptions to achieve equity. This tendency known as Inequity Aversion (Fehr and Schmidt, 1999) to economists is applicable whenever PFP leads to comparison between peers, especially when effort and reward are transparent in the workplace. Despite its importance to discussion of compensation, pay dispersion, and PFP, equity theory *does not specify an increase in motivation from incentives* (Kanfer, 1990; Jenkins, et al., 1998; Parnell & Sullivan, 1992), rather it is often used to explain conditions why certain bonus schemes may backfire, and how PFP scheme may serve to reduce inequity arising from pay structure inefficiencies. As Vecchio (1981) puts it clearly, while “expectancy theory holds that persons seek to maximize their positive outcomes” (p.471), equity theory explains only the restoration of self-others balance.

One of two theories favored by economists, Tournament Theory developed by Lazear and Rosen (1981), argues that higher wages awarded to the top few in a collective or organization serve to motivate lower level employees who will strive to attain the large prizes at the top. Required are not just visibility of the rewards of those at the top but also a promotional system to facilitate sorting or a non-linear payment scheme (including variations of PFP plans). Because rewards tended to be deferred and comparisons tended toward inferences of unfairness (Gupta, Conroy, & Delery, 2012), homogeneity of employees KSAOs exacerbates this effect leading to greater motivation (Backes-Gelner & Pull, 2013), predictions of which run counter to equity theory.

The other theory influencing economics (and accounting and finance) studies of compensation and PFP is Agency Theory (Jensen & Meckling, 1976; Holmstrom, 1979). Agency Theory in the form most used by management scholars, also known as Positive Agency Theory (Eisenhardt, 1989; Jensen, 1983), assumes that (1) principals are risk-neutral and agents are risk-averse, and (2) agents are rational and utility maximizers with preferences for wealth and leisure. Because of diverging goals, self-interests, informational asymmetry, and the assumptions above, the role of the employer (principal) is to align the interests of employees (agents) with whom they have a contract with. PFP is one such way to assist the employer in aligning the interests of employees, and prevent them from shirking in effort or refrain from taking sufficient risks. The success of such a plan in the eyes of agency theorists is efficiency, the minimization of agency costs (conflicts of interests) defined as the sum of monitoring expenditures, bonding expenditures, and the residual loss in welfare (Pepper & Gore, 2012). Opening a door to pure economics domain, agency theory has often been extended via detailed studies on the design of incentives and contract. Broadly, such extensions attempt to find the optimal incentive or contract design between principal-agents and agents-agents taking into game-like strategies agents may engage in (Bolton & Dewatripont, 2005). These searches into optimal designs tending to be problem specific have given rise to Contract Theory and Mechanism Design.

The above theories, mostly at the individual levels, are certainly varied and aplenty. In an attempt to organize the diverse explanations, Gerhart and colleagues (Gerhart, Rynes, & Fulmer, 2009; Rynes, Gerhart, & Parks, 2005) established two categories of effects that the above theories culminate, namely incentive effect and sorting effect.

Making reference to likes of expectancy, reinforcement, and goal-setting theory, Gerhart et al. (2009) and Gerhart and Fang (2012) posited that such theories illustrate PFP benefiting an organization through an *incentive effect*. That is the “impact of PFP on

performance via its impact on current employees' motivational states" and "how pay influences the level or intensity of individual and aggregate motivation, holding attributes of the workforce constant." (Gerhart et al., 2009, p. 254). Invoking the studies of Lazear (2000, 1986) which showed half of productivity improvements attributable to manpower replacement, Gerhart et al. (2009) referred to Schneider's attraction-selection-attrition model to show how a firm benefits through the self-selection of workers who prefer PFP and the attrition of workers may not benefit from PFP. This second effect of PFP is referred to as the *sorting effect*. Hence the benefits to an organization from sorting effects comes from the performance of its present and future workforce. This sorting effect is synonymous with several arguments of tournament theory, and had been illustrated in recent studies as well (Fang & Gerhart, 2012; Cadsby, Song, & Tapon, 2007).

To adjoin with most of existing literature, this research focuses on the most widely studied category of PFP (Gerhart et al., 2009), incentive effect, with attention to the manner pay for individual performance crosses level to affect performance at the collective level.

Chapter 4

RESEARCH QUESTIONS^{4.1}

Sufficient Condition for Pay for Performance

With two camps possessing sound theories, arguments, and impressive meta-analyses, it is unsurprising PFP's controversy continued and HR practice remains perplexed. This tension allows theorizing of PFP via ABM and the abductive route (Poole and Van de Ven, 1989; Mantere & Ketokivi, 2013; Locke, Golden-Biddle, & Feldman, 2008; Weick, 2005), where distinct from the hypothetico-deductive paradigm, it focuses on uncovering new insights, questions, and hypotheses for *future*, rather than the present, studies (Carley, 1999; Alvesson & Sandberg, 2011; Locke et al., 2008; Mantere & Ketokivi, 2013).

Taking the orientation of Tajfel (1970) in identifying the minimal conditions for intergroup behaviors to manifest, or Axelrod's (1984, 1997) and Nowak's (2006) work for the emergence of cooperation, I ask if similar attempt for workplace motivation could be initiated to better understand PFP's cross-level incentive effect on collective performance. Because amongst theories explaining PFP's incentive effect, Equity Theory is one that makes "no specific predictions regarding the relationship of incentives and performance" (Jenkins, et al., 1998, p. 778; also Kanfer, 1990; see Grant & Shin, 2012, for a related point), and one that has not been well explicated to explain PFP's cross-level incentive effect, I extract Equity Theory here to ask.

- Can concerns for fairness, not wealth, goals, or self-interest, be a *sufficient condition* for PFP's positive cross-level incentive effect to arise?

^{4.1} This section highlights theoretical aims motivating this research. Hypotheses are not stated here due to theoretical approach employed.

Equity Theory through Time and Social Space

Contracts are seldom static, interactions seldom one-off, and mobility seldom unconstrained by opportunities and capital. Though equity theory was theorized as a process, it was mostly formalized and studied in a static manner (Vecchio, 1982). At its base, this theory can predict what happens between co-workers or exchange partners in the next period. But what will happen in *numerous successive periods* after all adjustments have taken place? What if adjustments are *concurrently* made by multiple parties?

Many attempts have been made to theorize or study the evolution of justice/fairness perception over time (e.g., Jones & Skarlicki, 2013; Kim, Lin, Leung, 2013; Holtz & Harold, 2009), but few so for equity theory. Some attempted to conceptualize and test equity theory's predictions over time (e.g., Cosier & Dalton, 1983; Huesmann & Levinger, 1976) while some attempted to expand prediction onto multiple comparison others (e.g. Ronen, 1986; Carrell & Dittrich, 1978). Possibly due to data fidelity and study design issues, few equity and justice studies went beyond individual or dyadic analysis (commented in Brass, 2012; Shapiro, Brass, & Labianca, 2008), and most did not show or explain the dynamism of effort adjustments across time and social space (where in one's group of comparison other only partially overlaps one another at any one time). Hence, questions of equity theory's prediction across time and space remains and I ask, within the context of PFP,

- What can Equity Theory predict for the performance of a collective after numerous successive periods of adjustments?
- What can Equity Theory predict for the performance of a collective after repeated mutual adjustments of all members in a collective?

Incorporating Cognitive and Social Aspects

Numerous extensions to Equity Theory have been made with several considering effects of memory (e.g., Cosier & Dalton, 1983) and even more ruminating over the exact formulaic manner humans compute perceptions of outcome-input into evaluations of equity (e.g., Anderson, 1991; Anderson & Farkas, 1975). But few have extended it to the study of equity theory in a multi-level manner, working from individual-level adjustments to effect collective level outcome (Kozlowski & Chao, 2012). Even rarer were attempts to assess the cross-level dynamics taking into account differing levels of cognitive capabilities and inherent biases. Yet such micro-level differences, reflecting the boundedly rational nature of humans, are ever present. Hence starting from employees' ability to recall past information, I ask,

- How does memory affect Equity Theory's prediction for performance of a collective over time and social space?

Giving consideration to differences in asymmetrical serial recall of past information, I ponder the influence of recency effect to ask

- How does recency effect affect Equity Theory's prediction for performance of a collective over time and social space?

Considering individuals may differ not just in their recollection of the past, but also in their tendency to compare with more or fewer others, I ask

- How does the number of comparison others affect Equity Theory's prediction for performance of a collective over time and social space?

Chapter 5

INTRODUCTION TO AGENT-BASED MODELING

Economies, societies, communities, industries, organizations and their workplaces are examples of complex adaptive systems at different scales (Anderson, 1999; Hulin & Ilgen, 2000; Ball, 2012; Lopez-Paredes, Edmonds, and Klugl, 2012; Helbing, 2012; Troitzsch, 2012a & b; Carley, 2001, Collins, 1981; Nikolic & Kasmire, 2013; Schneider & Somers 2006; Morel & Ramanujam, 1999; Holland, 1995; Piotrowski, 2006; McGrath, Arrow, & Berdahl, 2000; Fang, Lee, & Schilling, 2010). Commonality shared by these systems is humans as constituents, be they economic, social, or productive agents (Troitzsch, 2012a & b; Bonabeau, 2002). They exhibit complexities and relationships distinct from linear systems, where classical analytic techniques are no longer feasible, such to the extent socio-physics has emerged to analyze non-linear phenomena in social systems (López-Paredes, Edmonds & Klugl, 2012, p. 4; Sen & Chakrabarti, 2013; von Randow, 2003). This inquiry of an HR phenomenon brings together economic, social, and I/O psychology, to inform OB, general management, and Total Rewards research. From actions of individual workers, the emergent phenomena of collective/group-level performance and productivity is investigated using agent-based modelling, a modelling paradigm where analytical and mathematically intractable social phenomena can be experimentally “observed” and examined (Macal & North, 2005; Moretti, 2002; Grüne-Yanoff, 2009).

Agent-based Modelling

Agent-based modelling (ABM) is often referred to as Individual-Based Modelling, Multiagent Systems, Multi-Agent Behavioral Systems, Interaction-based Computing/System, and Agent-based Modelling System in different domains with varied emphases and goals. Having origins in game theory, complexity science, and distributed artificial intelligence

(Elsenbroich & Gilbert, 2014; Gilbert & Troitzsch, 2005; Macy & Willer, 2002; Smith & Conrey, 2007), ABM is defined as the computational study of systems of heterogeneous agents interacting with each other and their environment guided by rules (Salgado & Gilbert, 2013; Heckbert, Baynes, & Reeson, 2010; Goldstone & Janssen, 2005). It is a relatively new modeling paradigm (Castiglione, 2009) useful in studying emergent properties of real-life systems via in-vitro replication of relations and mechanisms proposed to exist in reality (Nikolic & Kasmire, 2013). It is aptly the right tool (Moretti, 2002) and the right mathematics (Borrill & Tesfatsion, 2011) for working out complexities in a world with ever greater connections and interdependencies (Macal & North, 2005; Gilbert & Troitzsch, 2005)

Generally, an agent-based model in social science has no desired global state or goals to be achieved (Nikolic & Kasmire, 2013). It is a mere description, computation, and observation of macro patterns as entities interact and change over time (Grimm et al., 2005). Two components of ABM, agents and environment, are involved as a model runs through three run steps: initialization of starting conditions, run execution of interactions and state transitions according to programmed rules, and measurement and/or visualization of generated data (Salgado & Gilbert, 2013; Gilbert & Troitzsch, 2005).

Agents

Agent, the main component in ABM, can be considered simply as “entit[y] that encapsulate data as well as methods that act on this data” (Borrill & Tesfatsion, 2011, p. 232), “encapsulated computer system that is situated in some environment, and that is capable of flexible, autonomous action in that environment” (Jennings, 2000, p. 280), or an “autonomous entity having its own internal state reflecting its perception of the environment and interacting with other entities according to more or less sophisticated rules” (Castiglione, 2009, p. 118). As with emerging fields, there is no universal agreement on what agent means

(Macal & North, 2005). They can be proxies for cells, tissues, insects, animals, humans, traders, truck drivers, organizations, and nations or more. Some modelers consider any type of independent component (software, model, individual, etc.) to be an agent (Bonabeau 2001), while others insist a component's behavior must be adaptive (Mellouli et al. 2003) containing both rules and adaptive meta-rules (Casti, 1997) for it to be considered an agent. This definitional conundrum is best disentangled with Sawyer's (2003) differentiation of cognitive versus reactive agents, or with Chen's (2011) review of agents in ACE, showing an agent's design and complexity as dependent on the modellers purpose and ontological origin. Varying in complexity, agents can be classified as within one of three broad categories of simple-programmed agents, human-written programmed agents, or autonomous agents, or in one of the following smaller categories.

- Zero intelligence agents
 - Near zero intelligence agents
 - Regime-switching agents
 - Calibrated artificial agents
 - Calibrated heterogeneous agents
 - Calibrated agents with incremental cognitive capacity
 - Calibrated financial agents
 - Artificial agents with personal traits
 - Artificial agents with working memory
- Compiled from Chen (2011)

Whatever the classification, key design aspects of agents center around attributes, rules, states, actions and interactions, in a fashion similar to object-oriented languages.

Attributes, also referred to as properties or variables, are aspects or constructs encapsulated within an agent. They can be nominal such as gender, ordinal such as strength of ties (e.g., Hamill & Gilbert, 2009), or ratio such as information about a product (e.g., Osinga, Kramer, Hofstede, Beulens, 2013).

Rules, also referred to as internal models (Holland, 1995), decision rules, mechanism, or transformation functions, formalize how agents process or compute information and dictates how they act on this information. From simple choices of cooperate or defect, forecasting of expected portfolio returns, to meta-rules that dictate how lower-level rules evolve, they are often used in the context of decisions, actions, and behaviors. They can be elemental nested if-then-else structures, weighted multiple criteria, of evolutionary nature of genetic algorithm, or more computationally demanding inference engine and machine learning. Much of social science in ABM is a version or hybrid of the first three structures, with varied elaboration of the information and formula involved in computation.

States, also referred to as internal states in Nikolic and Kasmire (2013), is the culmination of all properties encapsulated by an agent at a point in time (Wooldridge & Jennings 1995). States is often path dependent and/or Markovian, and can range from binary to continuous, providing the basis for an agent to choose which rule or computation to execute. They could be the adoption of an innovation, adulthood, or purchase made. They dictate differential instructions to execute at different states, and model different priorities and action-criteria influencing an agent at different times of the agent's existence.

Actions, or behaviors, are executions an agent take that make changes to its own or others' attributes. They could be the depletion of resources, an increase in metabolic rate, or simply movement within a grid. **Interactions**, as a subset of actions, can be between agents or between a focal agent and its environment. For the former, examples include the transfer of funds or commodities, marriage, or cooperation; for the latter, examples include depletion of resources, increase of CO₂, and voting. In direct interaction (compared to indirect interaction) it commonly refers to actions of an agent that alters or influence the computation

of another agent within the same time period or without a mediating entity. (for indirect interactions, see stigmergic interactions below)

Environment

Environment provides the “virtual world” (Salgado & Gilbert, 2013) through which agents are situated and act. Similar to agents, most aspects of environment can be specified and can possess variables, states, and rules. To disambiguate, they are usually pre-fixed with “global-” to distinguish them from similar terms in the context of agents. Differing from other reviews (see Nikolic & Kasmire, 2013), four aspects of environment warranting elaboration are medium, structure, time, and the observer-modeler.

The environment serves as a *medium* from which information flows. It is the only basis from which distance can be judged, be they degrees of separation, pseudo-physical distance, or abstract hierarchical levels. It can be a neutral medium with little or no effect on the agents as in most ABM models based on game theory (Salgado & Gibert, 2013), or a vital medium from which agents interact actively, drawing and distributing resources in an abstract or pseudo-physical space, and behaving differently based on its location in space.

The *structure* of an ABM environment determines how agents are “linked” to other agents. The common ABM structure types include (1) cellular automata, be they 2-D square, hexagonal, or n-dimensional; (2) network, be they small world, random, or preferential attachment; (3) geographical information systems, where real-life geographical data are used in initialization and bound agents interactions.

Where complex systems are modeled and emergence is of interest, *time* is undoubtedly the most important factor. No modelling of emergence can occur without consideration of time. To be explicit, time is the other dimension of any space, and it is only

through time, that a descriptive system becomes dynamic. In ABM, concerns of time include, but are not limited to, timescale approximation and sequential versus concurrent updating.

For the first, units of time in a model must ideally match or be at most one order smaller than the theoretical mechanism at play. For the second, because agents in reality behave and operate in parallel, while computers compute sequentially, analytical and/or modelling workarounds have to be made. The model to be built incorporates both to develop a program showing equity theory's dynamical nature.

The last and often overlooked aspect is the *observer-modeler*. Not referring only to model development, but also after the model is fully programmed; it is the modeler and observer who decides what to focus, measure, and interpret. The same model with identical runs and results can generate different computed metrics depending on what the observer chooses to combine and use for his/her subsequent analysis. Consistency and relevance to research question is key. For this research production of agents will be consistently monitored.

Characteristics of Agent-based Modelling

Summarizing the above with views of Goldstone and Janssen (2005), Epstein (2006a, b), Windrum, Fagiolo, and Moneta (2007), and Heckbert, Baynes, and Reeson (2010), we could infer that ABM's distinguishing features are its focus on heterogeneity, autonomy, explicit space, local and stigmergic interactions, bounded rationality, formalism at the level of agents, and ultimately bottom-up emergence (see Table 5.1).

Table 5.1

General Characteristics of ABM

Heterogeneity	Agents possess properties different from one another. Properties can dynamic or static (Epstein, 2008). Referring to properties such as sensitivity to surroundings, gender, and race for the former, and wealth, information, and strategic preferences for the latter. Such properties can include rules, states, and types of interactions an agent can make with another. Such differences can quantitative or qualitative.
---------------	---

Autonomy	Referring to the absence of central control, agents are not pre-programmed the exact action to execute at which time period. Rather they respond to information or “stimulus” from another agent or environment via rules which define a range of behaviors to adopt, or at times behavior chosen randomly. Narrower definition of autonomy requires agents to possess ability to ‘write’ or ‘choose’ their own rules.
Explicit Space	Agents are situated in some environment, whether on a grid, geographical terrain, or more abstractly, organisational structure or network. It defines the ‘distance’ one agent is from another, enabling the other ABM characteristics.
Local Interactions	Agents basing their behavior on the information obtained from those closer than farther from them. It mirrors the differential influence and information one can obtain from agents closer rather than further away. It suggests a network-like interaction one agent has with its neighbours than those further away either on a grid or graph.
Stigmergic Interactions	Where interactions are not direct, interaction with non-local agent can occur indirectly. This indirect communication, a stigmergy, includes examples such as traders interacting via stock prices. Hence, an agent does not directly influence another agent, nor obtain information about another. Rather their actions, such as leaving a pheromone trail, or signaling of intent reservation prices in auctions, are responded to by other agents.
Bounded Rationality	Agents do not possess or process global information about all agents in the system. Instead they act on a smaller subset of information, mostly obtained from their local environment, processing only part of all information.
Formalism at Level of Agents	Mathematical and logical language is required when designing agent architecture, such as the computation to perform when agents “process” information and transit from one state to another. This formalism often rigorously tests the logical and interpretational boundaries of existing theories of interactions between agents.
Bottom-up Emergence	Without pre-programmed macro results to generate, lower level entities (agents) are left to interact and evolve over time. Through large numbers of agents and numerous time periods, macro-level pattern emerges, even if the link between the each interaction to macro-results becomes intractable.

These unique characteristics set ABM clearly apart from other investigative methods in social sciences. Comparing simulation to statistical methods, the latter is the method of choice in a hypothetico-deductive paradigm. Statistical modelling, or the oft used general linear models, is focused on covariations between variables. Fundamental is the assumption of central tendency of individuals’ measured attributes, thereby allowing the modeler to assume in-group homogeneity of attributes. Apart from this focus on variables and the assumption of homogeneity (Smith & Conrey, 2007), the difficulty (not impossible) in modelling recursive, repeated interactions, is characteristic to statistical modelling. However, it need not be seen as a limitation, as statistical modelling can be combined at a later stage with simulation results for hypothesis testing and model validation. (Heckbert, Baynes, & Reeson, 2010).

Among simulation methods two major classes (Cioffi-Revilla, 2014; Van Dyke, Parunak et al., 1998; Axelrod, 2004) exist, namely the variable-oriented models (also referred to as equation-based models, top-down models, aggregate models, or macro-simulations) and object-oriented models (also referred to as bottom-up model or individual-based model in Crooks & Heppenstall, 2012). Variable-oriented models, most-used simulation in the natural sciences (Helbing, 2012) were the earliest forms of simulation in computational social science (Cioffi-Revilla, 2014) and include methods such as system dynamics (Forrester 1958, 1968), computable general equilibrium (Jones 1965), and dynamic systems (Rosenberg & Karnopp 1983). Exemplified by systems dynamics, techniques in this class focus on system-level observables or variables of the system and the relationship between them (Grüne-Yanoff & Weirich, 2010). In the case of systems dynamics, levels and rate of change of variables in a system are often represented as differential equations that are mostly non-linear, which may be deterministic or partly stochastic (Cioffi-Revilla, 2014). Causal connections between variables are explicitly programmed into the simulation, and many a times central coordination and lower-level homogeneity (Rahmandad & Sterman, 2004) are assumed. Such simulation is used in systems with interdependent variables characterized by feedback loops. Examples of system dynamics use in daily life are weather forecasts (Elsenbroich & Gilbert, 2014), and in the business domain, the adoption of phone in British market (Lyons et al., 1997).

Object-oriented models are exemplified by ABM, microsimulation and multi-agent simulation. While all these three methods focus on elemental entities of a population, they differ from ABM either in their agent architecture or purpose. Microsimulation is dominantly a data-driven approach, used mostly in the public policy domain. It uses data from a specific real-life population, rules of each agent, citizens, households or firms, are imputed based on its characteristics, such as age, gender, and socioeconomic status. Key difference of

microsimulation then, is the lack of interaction between agents, and that the interactions between agents and environment are usually one-directional (Grüne-Yanoff & Weirich, 2010). This method's dominant focus is on forecasting effects of policy changes than explanation of a phenomenon. Conversely, multi-agent simulation, while similar to ABM in its emphasis on behaviour and interactions, is different in its purpose as they seek optimization via the design of ever-better rules (with agents and environment). In the views of Elsenbroich and Gilbert (2014), multi-agent simulation focuses on a smaller population of highly complex agents with social cognition "hard-wired" into its agent architecture. This method seeks to find the best combination of rules to achieve a desired emergent phenomena, such as the absence of traffic congestion, e-commerce agents, and cellular network usage.

When to use ABM?

Granted ABM is "different" and relatively novel (Castiglione, 2009; Cioffi-Revilla, 2014), what commanding benefits are there to harnessing ABM for social research? When should we use them? Surely there are caveats?

Indeed. Once computationally intensive, affordable computing power and programming kits now allow social scientists to experiment ABM with as much ease as they do with statistical modelling (Rand & Rust, 2011). Technically simple, but "conceptually deep" (Bonabeau, 2002, p. 7286, see also similar comments in Fioretti, 2012), the uninformed are easily led to its improper use (Basak, Mazumdar, & Yadav, 2012). Beyond mere programming and model design, researchers need to first be aware of the scenarios appropriate for ABM. While literature on this is vast (at times seemingly repetitive), the following typical scenarios, flowing from characteristics of ABM, are where ABM ought to make a difference.

1. Number of elemental/constituent/lower-level entities (agents) of a population is medium to large, such as that of residents in a city, cars on a freeway system, or traders in a market. In situations of just a handful of agents, game-theoretic analysis would be more appropriate.
2. Agents' behaviors are non-linear and/or discontinuous (characterized by threshold or if-then rules)
3. Agent's interactions with peers (with network effects) and environment are local and boundedly rational. No agent possesses the ability to base decisions or actions on information from all other agents in the system.
4. Non-interest in assuming a typical or average agent with a distribution described by standard deviations. Instead, agents are endogenously and/or exogenously heterogeneous in terms of its own agent architecture (rules, traits, etc) or its interaction/endowment from the environment.
5. Actions of agents or phenomenon of interest occur over time dynamically.
6. Locality of agent with respect to its environment is non-trivial.
7. Little is known about the interdependencies of global phenomena, but clear understanding of how lower-level behaves exists.
8. Processes and relationships between agents can be reliably represented in abstract formal logical manner, and researcher is willing to detail theories and assumptions explicitly for testing and validation
9. Mathematically intractable
10. Emergent properties of the population or system is the outcome phenomenon of interest, where emergent properties refer to higher level construct that does not exist at the lower level *and* cannot be deductively predicted from properties of individual agents.
11. Randomness/stochasticity is modeled at the level of agent's actions than a noise term added to an aggregate measurement or equation.
12. Agent behavior exhibits memory, hysteresis, non-markovian behavior, or temporal correlations.

Summarized from Casti (1995), Holland (1995), Rand & Rust (2011), Carley (2002), Borshchev & Filippov (2004), Oliver (2013), Basak, Mazumdar, & Yadav, (2012), Axtell (2000), Macal & North (2005), Axelrod & Tesfatsion (2005), Epstein (2006, 2008); Bonabeau, Hunt, Gaudiano (2003), Hughes, Clegg, Robinson, and Crowder, 2012

Note: Except for temporal and dynamical aspects, published ABM models vary in the extent they represent each scenario.

In the above scenarios, ABM as a mode of social science simulation can be seen as a computational laboratory (Burton, 2003), a language for expressing theories, a tool for studying complex systems, and a tool for experimenting on theory (Moretti, 2002). Or in the view of Axelrod (2005), a tool for prediction, performance, training, proofing, and discovery. This flexibility (Bonabeau, 2002) is possibly the core strength of ABM where it can be productively used for both explanation and prediction.

Questions about boundaries to theory are now supplemented with attempts to understand the consequences of theory (Latane, 1996b). Instead of partialling-out or controlling extraneous variables, social scientists now control theories/mechanisms at the level of processes. It is seen as the third way of doing science (Axelrod, 2007 & 1997b; Ilgen & Hulin, 2000), a generative way (Epstein, 2006; Ball, 2007) where a model is built deductively but regularities (generated by micro-level mechanisms) are analyzed inductively through data of simulation runs. For social science, it encourages interdisciplinary dialogue and theoretical fusion (Epstein, 2006a, b; Marietto, David, Sichman, & Coelho, 2003). For bridging the research-practice gap, traditional investigation of what-is and what-was is now augmented with *what-if* (Borrill & Tesfatsion, 2011, p. 236). The kind of questions businesses want answered.

The motivation behind what-if questions are often the desire for prediction and control. When business or policy-makers adopt ABM for prediction, it is likely for the promise of better fidelity-match and richness of ABM (Bonabeau, 2002). Through repeated scenario analyses, modelers and would-be users aim to locate the optimal levels of intervention, or forecast the magnitude of change of an emergent phenomenon, such as unemployment or interest rates. However, point-prediction is not the forte of ABM for prediction (Grüne-Yanoff & Weirich, 2010). Seen in Bonabeau's bank studies, it is the

explorations of scenarios (the set of conditions) and path dependence analysis (tracking agents' interactions and states turn-by-turn backwards) that ABM's prediction comes in useful. It helps discover unexpected tradeoffs, and how likely one scenario may evolve to another, and which sets of conditions are not co-tenable and can be taken out of further contingency planning. As a modelling proxy closer to natural descriptives of social systems (Bonabeau, 2002), ABM enable easier client communication and identification of conditions in real-life systems than through aggregated equations.

However, the aims of social scientists are slanted more toward explanation and ultimately theoretical advancement. The former, as argued by many (e.g., Epstein, 2006 & 2008; Macy & Willer, 2002; Axelrod, 1997ab, Elsenbroich & Gilbert, 2014; Troitzsch, 2009; Cederman, 2005), has been where ABM in social science has made its greatest contribution. Generative explanations (Epstein, 2006a, b) in ABM models provide a reductionist account for a phenomenon (rather than theoretical reduction, as in Garfinkel, 1991). These explanations and models can be considered as offering *full explanations*, as in Dean et al.'s (2000) Anasazi population and culture change; *partial explanation*, where significant factors to a phenomenon are idealized or held constant to illustrate effects of a focal theory/mechanism; or *potential explanation*, where, neither full nor partial, a model works backwards to uncover possible mechanisms to a phenomena, such as the origin of currency (Grüne-Yanoff & Weirich, 2010; Epstein, 1999). Apart from accepting trade-offs of generality vis-à-vis realism (McGrath, 1981), social science modelers would need to appreciate the futility of modelling all possible explanations in any form of ABM. Even in full explanations, assumptions and idealizations are commonplace and necessary (Burton, 2003).

For theoretical advancement, the process of modelling compels not just a microscopic view of lower-level entities, but a revealing look at theories (Adner, Polos, Ryall, & Sørensen, 2009; Davis, Eisenhardt, & Bingham, 2007; Hughes, Clegg, Robinson, & Crowder, 2012). By reorganizing the sub-processes of an interaction or decision (such as whether agents compares action-choices against their beliefs first or desire first in a BDI agent cognitive architecture) differential outcomes can be observed, as was in Wilensky and Rand's (2007) replication of Axelrod and Hammond's (2006) model. This differential outcome from seemingly similar verbal descriptives forces researchers to revisit assumptions and take a detailed look at theories being modeled (Weinhardt & Vancouver 2012; Hulin & Ilgen, 2000; see also Sastry, 1997, as an example). Reflecting on the views of management scholars such as Suddaby (2010), the problems of construct fallibility plaguing management research (Osigweh, 1989), the ignorance of levels (Klein, Deansereau, & Hall, 1994) and time scale and sequence (George & Jones, 2000), will enormously benefit from the process of microscopic level specification, modelling, and simulation. Be it revisits of long held management theories or pitting competing theories in a model, this exposition and theorizing (Weick, 1995) as strong forms of "disciplined imagination" (Weick, 1989) can accelerate the pace of theoretical evolution and alleviate the problems of incommensurability in organizational studies (McKinley & Mone, 1998).

Some Known Uses of ABM

Sampling broadly, ABM has been employed in the study of geography and ecology (lake pollution: Carpenter, Brock, & Hansen, 1999; Balinese water temple on rice production, Lansing & Kremer, 1993), criminology (burglary: Malleon, See, Evans, & Heppenstall, 2014; deterrence: Elffers & Van Baal, 2008; civil violence: Epstein, 2002; drug law enforcement: Dray, Mazerolle, Perez, Ritter, 2008; career in crime: Makowsky, 2006;

corruption: Situngkir & Khanafiah, 2006), public policy and demography (disease spread from socioeconomic stressors: Alam, Meyer, Ziervogel, & Moss, 2007; marriage patterns: Todd, Billari, & Simao, 2005; tax evasion: Hashimzade, Myles, Page, & Rablen, 2014; Hokamp 2014; drinking behavior: Gorman, Mezic, Mezic, & Gruenewald, 2006), politics (elections: Kollman, Miller, & Page, 1992; wars: Cederman, 2003; Johnson, Weidmann, Cederman, 2011), terrorism (Bulleit & Drewek, 2011), biology (immune systems: Fachada, Lopes, & Rosa, 2007; glucose-insulin metabolism: Amigoni & Schiaffonati, 2008; genetic relatedness: Pepper, 2000), agriculture and food supply (agriculture subsidies: Happe, Kellermann & Balmann, 2008); history and archaeology (Anasazi: Axtell et al., 2002; civil service exam in imperial China, Yang et al., 2009); tourism (Galapagos Islands: Pizzitutti, Mena, & Walsh, 2014).

Economics

In economics, Agent-based Computational Economics (ACE) studies explored technological lock-ins (Janssen & Jager, 1999, see also, Arthur, 1989), double auction markets (Chen & Tai, 2010; Gode & Sunder, 1993a & b), taxation on GDP (Ogibayashi & Takashima, 2012), the cobweb model of commodity prices (Arifovic, 1994; Chen & Yeh, 1996), unemployment rate (Hedstrom, 2005; Topa, 1997), trade networks (Tsfatsion, 1995; Wilhite, 2001), co-evolution of production and economic firms (Padgett, Lee, & Collier, 2003), real effects of inflation (Ashraf, Gershman, & Howitt, 2012), labor market (Tassier & Menczer, 2001; Dawid, Gemkow, Harting, & Neugart, 2009), electricity market (Weidlich & Veit, 2008; Ketter, Collins, & Reddy, 2013; Bunn & Oliveira, 2007). These studies signal a reconsideration of the dynamic stochastic general equilibrium or Walrasian paradigm (Tsfatsion, 2005) to accept economies as perpetually changing (Arthur, 2013).

ACE models garnering attention from the business arena are particularly those modelling financial markets (LeBaron, 2006), with the Santa Fe Artificial Stock Market as one landmark model spawning numerous experiments and modified models. Palmer, Arthur, Holland, LeBaron, and Taylor's (1994; 1997) Santa Fe Artificial Stock Market had agents that exhibit indirect stigmergic relationships. Agents in their model decide at each time period the holdings of each stock for the next time period mediated by sales and purchase of stock, where stock price and availability is contingent on demand and supply of each stock counter. Agents have available 60 'condition-action rules' to guide their decision to increase/decrease/hold constant holdings of a stock for the next time period. Based on each rule's correspondence with the market condition ('market state'), and hence the success/failure of the rule, the probability of using the rule increase/decreases. In a 1997 paper, Arthur and colleagues followed-up with an experimentation and showed clearly how regimes of agents with low 'rate of exploration of alternative forecasts' led to market with efficient market characteristics (favored by fundamentalists), and regimes of agents with medium-high rate of exploration, led to market with temporary bubbles and crashes (favored by technical analysts). Other studies of financial markets include Portfolio Insurance Model by Kim and Markowitz (1989) where they compared agents who maintain their value-proportion of stock in their portfolio, and agents who aim not to lose beyond a constant percentage within a time period; and Lux and Marchesi's (2000) model where they compared Fundamentalists and Chartists, and noise traders sub-divided into optimists and pessimists.

Less noted within management, but relevant to our purpose are ABM studies of aggregate production and wealth inequality. For the former, aggregate production is often analyzed as one of an array of data generated from ACE models. While no review exists of ACE's treatment and analyses of aggregate production, indicative reading suggest such macroeconomic indicator have been largely studied in the context of innovation and

technology-induced economic growth with production pre-aggregated at the firm-level (e.g., Gatti, Guilmi, Gallegati, & Landini, 2012; Dosi, Fagiolo, & Roventini, 2010; Squazzoni, & Boero, 2002; Wersching, 2007). For the latter, ABM studies, or Ising models, of income inequality have been dealt with most by econophysicists (Chatterjee, Yarlagadda, & Chakrabarti, 2005) who applied ideal-gas concepts to simulate exchange of money in a closed economy (Dragulescu & Yakovenko, 2000), or further modified with uniform or diverse savings rate (Chakraborti & Chakrabarti, 2000; Chatterjee, Chakrabarti, & Manna, 2004). Adaptations to account for social behaviors include network distance (DiMatteo, Aste, Hyde, 2004), increased interaction if node belong to similar social class (Risau-Gusman, Laguna, & Iglesias, 2005), amongst numerous other variations. Typical features in these studies would be conservation of money supply unless specifically modelled to increase/decrease (such as through taxation), and wealth distribution and accumulation occurring as a result of exchange during interaction, savings, or asset speculation (see Chakraborti, Toke, Patriarca, & Abergel, 2011). Either of these models would fall onto the continuum of conservative models (where number of agents and resources are constant) versus multiple noise models where number of agents and resources may change, and time-evolution may occur continuously rather than discretely (Scalas, Gallegati, Guerci, Mase, & Tedeschi, 2006).

Studies that concurrently investigate wealth inequality and aggregate production too exist (e.g., Ciarli, Lorentz, Savona, & Valente, 2010). From econophysics models of agents with no utility or production functions in a four sector economy (Kinsella, Greiff, & Nell, 2009), to a Keynesian inspired economy with banks, investment options, consumers, and producers (Brunn & Luna, 2000; Dosi, Fagiolo, & Roventini, 2010; Damaceanu, 2011), to the highly cited Sugarscape model (Epstein & Axtell, 1996), these models show how endogenous wealth inequality can emerge out of different mechanisms creating pareto-like distributions of wealth. The more generic model of Sugarscape has agents, in hunter-gatherer

similar scenario, with vision, metabolism, and a rule to move around looking for resources (“sugar”) in its environment, else they “die” of starvation. Interactions with environment depletes resources available which replenishes after a randomly programmed time period. With the ability to accumulate sugar, agents who were initially “born high” or were lucky to stumble upon a large resource pile would accumulate more and be able to subsequently travel further distances to look for resources without slowing down the speed. This seemingly artificial society of ant-like behavior parallels wealth concentration and factor endowment effects in real life for individuals and nations.

Psychology

Given the encapsulated and interactive nature of agents, it is natural that much of ABM’s application in social science is found in the domain of personality and social psychology, with more applications in the latter. Such works have extended ABM to the study of mate search and intergender behaviors (Saglam, 2014; Kalick & Hamilton, 1989; Thom & Dytham, 2012; Billari, Prskawetz, Diaz, & Fent, 2007), social influence and opinion dynamics (Axtell, 1996, Nowak, Szamrej, & Latané, 1990; Jager & Amblard, 2005; Latane and Nowak 1997, Galam 1999, Weisbuch et al. 2002, Deffuant et al. 2002, Hegselmann and Krause 2002, Centola, Willer, & Macy, 2005; Elsenbroich & Xenitidou, 2012; Castellano, Marsini, Vespignani, 2000; Baldassarri & Bearman, 2007; Melatagia Yonta & Ndoundam, 2009), persuasion via elaboration likelihood model (Mosler, 2006), self-regulation (Vancouver, Weinhardt, & Schmidt, 2010; Vancouver, Weinhardt, & Vigo, 2014), group movement, discussion, information sampling, and decision processes (Koster, Seitz, Trembl, Hartmann, Klein, 2011; Stasser, 1988, Stasser & Titus, 1985; Stasser & Taylor, 1991; Deffuant & Huet, 2007), optimal distinctiveness theory (Pickett, Smaldino, Sherman, & Schank, 2011), self-categorization theory (Salzarulo, 2006), altruism, trust, and cooperation (Axelrod & Hamilton, 1981; Bosse, Schut, Treur, & Wendt, 2008; Nowak & Sigmund, 1998;

Riolo, Cohen, & Axelrod, 2001; Galance & Huberman, 1993; Nowak, 2006; Macy & Sato, 2010), collective memory (Luhmann & Rajaram, 2013), culture (Axelrod, 1997; Mesoudi, 2011; Bryson, 2014; Ali, Salhieh, Snaieh, & Reynolds, 2012; Chung & Reynolds, 1998), coordination (Durfee & Montgomery, 1991; Miller & Page, 2004), religion (Iannaccone & Makowsky, 2007) and individual attitudes and behavioral intentions (Richetin et al., 2009).

Different categorizations of ABM models in psychology exists. Some focus on building ever better, and mostly complex, agent-cognitive architectures, while others focus on testing and delineating the implications of well-known psychological theories. The former category, mostly from the domain of artificial intelligence and multi-agent systems (differentiating from ABM), includes SOAR (Laird, Newell, & Rosenbloom, 1987, Newell, 1990) with an aim to create a unified theory of cognition for computational-based systems, BDI architecture (Rao & Georgeff, 1995; Georgeff, Pell, Pollack, Tambe, & Wooldridge, 1999) modelling agent's reasoning around sequential modules of belief-desire-intention, and BOID architecture (Broersen, Dastani, Hulstijn, & Van Der Torre, 2002) resolving social conflicts commonplace in BDI's implementation by inserting the obligations module, amongst others. This pursuit in perfecting agent architecture has led to major cross-pollination between computer science and psychology. While Sun et al.'s (2001 & 2006) CLARION model infused theories of neural networks into each social agent, Anderson and Lebiere's (1998) ACT-R and Meyer and Kieras's (1997) EPIC who initially borrowed developments in structural neuroscience in its architecture, cross-influenced psychological theories with its integrated information processing propositions. Due to inherent complexity and computational demands of these production systems, excluding theories who borrowed the integrated information processing assumptions (but not the computational aspect), their application remains external to the interpersonal aspect of personality and social psychology (Sun, 2006, Richetin et al., 2009, Read & Monroe, 2008), focusing mostly on mimicking

humans' decision making on ever shorter time scale. (See Duch, Oentaryo, & Pasquier, 2008; Langley, Laird, and Rogers, 2009 for more review and applications)

For the latter category, also classified as socio-cognitive (Marietto, David, Sichman, & Coelho, 2003) and intellective (Carley, 1996), studies include Nowak, Szamrej, and Latané's (1990) dynamic model of Latané's (1981) Social Impact Theory, Bertie, Himmelweit & Trigg's (2006) and Mosler's, (2002) interpretation of Festinger's Cognitive Dissonance Theory (1957) predicting social influence and driving speeds, Huang and Wen's (2014) model of pluralistic ignorance, and Aguiar and Parravano's (2013) study on Heider's Balance Theory. In Nowak, Szamrej, & Latané (1990), the authors created a new cellular automata where each cell represents an individual with four attributes of attitude, persuasiveness, support, and immediacy (distance on the grid). They showed the proportion of minority to exist at the beginning of simulation for a minority view to survive, and how in certain runs, clusters of one opinion can shift-spatially as a highly persuasive and strong attitude individual was initially position on the fringe of its clusters, suggesting role network brokers play in ensuring survivability of minority views even if initial group has dissolved. In Bertie, Himmelweit & Trigg (2006), the authors extended Axelrod's (1997c) homophily-based model of culture dissemination, with resolution of symmetric and asymmetric cognitive dissonance events. They showed in the context of governmental intervention, if a dominant mode of dissonance resolution is attitude-changing, "not too frequent" but regular intervals of promotion and broadcast will be effective; a similar infrequent but random intervals of broadcast will be effective if dominant mode of dissonance resolution is behavior-changing. In Huang and Wen (2014), the authors radically modified Hegselmann and Krause's (2002) continuous opinion model to incorporate agents with expressed versus private opinions. They showed as agents have differing uncertainty levels for expressed versus private opinions, the diversity of opinion groups led to stable discrepancy between expressed and private opinion

(i.e. pluralistic ignorance) at the group level. In Aguiar and Parravano (2013), the authors experimented with agents of two groups and two levels of tolerance, with actions determined by the triad configuration an agent is in. From a small system of 5 agents to 150 agents, they found amongst a host of results, that level of tolerance does not only affect system-level conflicts but also between-individual conflicts.

These above studies highlight social psychologists' interests in collective behavior and social influence even if domain of application differs. In the view of Macy and Willer (2002) and Goldstone and Janssen (2005) these studies most usually focus on emergent social structure (e.g., clustering, differentiation, and segregation), emergent social order (e.g., trust and cooperation), social contagion (e.g., diffusion, spillovers, and opinion dynamics). Corroborating them, a recent manifesto for computational social science (Conte, Gilbert, Bonelli, Cioffi-Revilla, Deffuant, Kertesz, ... & Helbing, 2012, p. 328) noted that "although phenomena like civil violence and rebellion have been investigated, computational modelling has so far been mainly applied to behaviors like altruism, cooperation and norm conformity" In sum, this latter group of studies serves to *explain and illustrate a phenomena for theory development* than prediction or optimization.

It is important to distinguish game theoretic based studies within this latter group. Game theoretic based ABM studies is a large enterprise applying tenets of game theory closely, and used mostly to illustrate how various phenomena, such as emergence of norms, can manifest from different game-like interactions and strategies. Unlike game theories and mechanism design using on closed form mathematical representation of strategies, these ABM studies have illustrated stability of cooperative norms or the emergence of cooperation and fair play, extending from models simulating dyadic strategies/decisions cooperation as equivalent to social actions. They often start with a simple (prisoners-dilemma or public

goods game) model, borrowed or newly developed, and gradually augmented with memory, learning, emotions, reputation, reciprocity, homophily, space, networks, and contagion/diffusion mechanisms, with or without a payoff maximization function (e.g., Szolnoki, Perc, Szabo, 2012; Schotter & Sopher, 2003; Roos, Gelfand, Nau, & Carr, 2014; Doebeli & Hauert, 2005; Chatterjee, Zufferey, & Nowak, 2012; Ohtsuki, Hauert, Lieberman, & Nowak, 2006; Boyd & Richerson, 2009; Nahum, Harding, & Kerr, 2011). In the scheme of Lemos, Coelho, and Lopes (2013), such game-like ABM studies would be considered as using the rational-behavior model (where maximization of some utility function is sought) as opposed to non-game-like studies using threshold in a rule-based mechanism. Exemplar studies of these game-like ABM studies, out of an enormous quantity, include Axelrod's (1986) emergence of norms via iterated prisoner's dilemma game, Coen's (2013) reinforcement of intragroup cooperation in presence of intergroup competition, and Nowak (2006) who summarized his previous game-theoretic based ABM studies to distill five mechanisms leading to cooperation between agents: kin selection, direct reciprocity, indirect reciprocity, network reciprocity, and group selection. In a notable recent example, Roos, Gelfand, Nau, and Lun (in press) built on their earlier model (Roos, Gelfand, Nau, & Carr, 2014) to show the emergence of stronger strength of norms when faced with greater, rather than lower threats. They illustrate this through a two-phase model (game and punishment phases) and replicated robust qualitatively similar patterns even with different games.

Business

A decade ago, Bonabeau (2002) gave an overview of ABM's industrial and consulting use in large pharmaceuticals, banks, and IT companies, with academic research communities, in fields such as marketing, operations research and IS having leveraging the utility of this research method as well.

In marketing, ABM's use has been encouraging. ABM has been used to study viral marketing (Bampo, Ewing, Mather, Stewart, & Wallace, 2008), online community on product purchase (Ren, Kiesler, & Kraut, 2007; Miller, Fabian, & Lin, 2009), competition on online advertising markets and distributors (Chang, Oh, Pinsonneault, & Kwon, 2010), multiple theory based ABM of consumer behavior (Jager, Janssen, & Vlek, 1999), in-store customer experiences (Siebers, Aickelin, Celia, & Clegg, 2011), innovation diffusion (Goldenberg, Han, Lehmann, & Hong, 2009; Van Eck, Jager, & Leeflang, 2011; Delre, Jager, Bijmolt, & Janssen, 2010; Rahmandad & Sterman, 2008; Van den Bulte & Joshi, 2007, Delre, Jager, & Janssen, 2007; Goldenberg, Libai, & Muller, 2001; see also Garcia, 2005 for a review), moral behavior in marketing exchange relationships (Watkins & Hill, 2009), decoy effect (Zhang & Zhang, 2007), technological lock-ins (Arthur, 1989; Janssen & Jager, 1999), impact of influential in social network (Watts & Dodds, 2007), target and scheduling of promotional activities (Delre, Jager, Bijmolt, & Janssen, 2007), J-pop CD sales (Makoto, 2000), and cross-country cultural differences on box office success (Broekhuizen, Delre, & Torres, 2011). These studies, particularly those on technological adoption/diffusion, leveraged ABM's ability to model between-individual interactions such as word-of-mouth effects. Closer to industrial application includes works such as an ABM-based virtual market learning lab project between Proctor & Gamble and the Argonne National Laboratory (North, Macal, Aubin, Thimmapuram, Bragen, Hahn, ..., Hampton, 2010), an artificial intelligence inspired ABM model of apparel purchase decisions with manufacturers and retailers included (Brannon, Ulrich, Anderson, Presley, & Thommesen, 2000), and pay-TV subscription model (Twomey & Cadman, 2002).

In information systems and operations research (management and organizational perspective), studies have explored using genetic algorithms for to enhance alternatives generated in decision support systems (Fazlollahi & Vahidov, 2001), agent-based theorizing

of IT-use processes (Nan, 2011) and virtual teams (Curseu, 2006), computer-mediated communication on organizational culture and performance generic team processes (Rao, Chaudhury, & Chakka, 1995), work systems design of outer space exploration using Brahms (Sierhuis, Clancey, Seah, Trimble, & Sims, 2003), organizational structure on innovation in a retail chain (Chang & Harrington, 2000), bullwhip effect in the classic supply chain beer distribution game (O'Donnell, MaGuire, McIvor, & Humphreys, 2006), and information sharing and coordination in a supply chain (Datta & Christopher, 2010). These selected studies shows where ABM has been applied, but disparity exists. While operations research embrace ABM (possibly owing to previous usage of multi-agent systems and artificial intelligence), information systems research has been surprisingly slow to adopt ABM, as reflected in a recent count of simulation studies in information systems research (Spagnoletti, Za, & Winter, 2013).

The preceding brief survey reveals that while ABM, may still be the methodological minority in these business fields bordering management, they are flourishing and showing promise on many pertinent topics. The same nascent adoption can be said of management, HR, OB and I/O psychology (DeShon, 2012; Fioretti, 2012), albeit simulation in forms alike ABM have been influencing organizational discourse for some time. March's (1991) study of exploration and exploitation, a discrete event simulation (Dooley, 2002), brought attention to inherent tradeoffs in firms' exploration and exploitation activities (Smith, Gupta, & Shalley, 2006). Cohen, March, and Olsen's (1972) Garbage Can Model focuses researchers on how access and choice structures in organizations influences intra-organizational decision making; showing how previous models of decision making ignoring role specialization and expertise were insufficient to explain decision-making in organizations..

Despite this simulation heritage, March (2001) unambiguously opined computer simulation entered a long period of intellectual lull, “settled into a tiny niche, mostly on the periphery of mainline social and organizational science” (March, 2001, p. xi) where it was tolerated but never fully accepted nor embraced (Lomi & Larsen, 2001). Perhaps referring to the empiricism school that dominated the organization science field (especially that of HR and OB), this point is certainly valid, a view iterated by recent works of OB and I/O psychologists, Kozlowski and Chao (2012), Rousseau (2011), and Hackman (2012). A sub-domain of organizational science that has bucked this neglect were studies originating from coastal business schools (Carnegie, Stanford, and Berkeley, per se) investigating population ecology of organizations. These studies, melded industrial-financial-organizational economics, with networks (interfirm and directorships), principle-agent relationships, and competitive advantage to inform theories of strategic management.

ABM studies of this sub-domain, mostly modeled agents at the firm-level via Kauffman’s (1993) biology-inspired NK model and cellular automata (e.g. Lomi & Larsen, 2000 & 1996; see later section for in-depth discussion of cellular automata). Models adopting NK rugged landscape approach (Kauffman, 1993; Levinthal, 1997; see Sorenson, 2002, for a review) deviate slightly from common ABM approaches seen in other social science fields. They typically have minimal interactions between agents, model firms’ exploration of activities/routine mix then comparing them to a pre-programmed performance landscape, and often experiment with the adjacency/interdependence matrix as a proxy to organization’s design. Despite high levels of abstraction and reliance on strong assumptions, they have shown how centralization-decentralization impacts exploration and adaptation (Siggelkow & Levinthal, 2003; Kollman, Miller, & Page, 2000), how high interdependency between activities make imitation by competitors difficult thereby retaining position on optima (Rivkin, 2000), the role hierarchy and decomposability plays in search for optima

organization structure (Ethiraj & Levinthal, 2002), the outcomes and conducive conditions for high interorganizational learning and intraorganization interdependence (Sorensen, 2003), the value of experience and analogical reasoning when organizations face novel situations (Gavetti, Levinthal, & Rivkin, 2005), the interplay between interdependencies, governance structures, and firms' search capabilities on coordination and exploration (Aggarwal, Siggelkow, & Singh, 2011), how different organizational forms help mitigate selection pressures (Levinthal & Posen, 2007), how incomplete guides can prove more useful in coordinating behaviors than complete representations (Ethiraj & Levinthal, 2009), and how in industries with high interfirm interdependencies, entry and exits are fewer (Lenox, Rockart, & Lewin, 2007). Non-NK based models in strategic management and population ecology include Chang & Harrington's (2000) model of retail stores of different structures with vector of activities and practices in search of a local optima, Garcia-Sanchez, Mesquita, and Vassolo's (2013) economic model on entry-order advantages on firms survivability under macroeconomic distress, and Bruderer and Singh's (1996) use of the genetic algorithm in ABM to explain evolution of organizational forms.

ABM studies modelling agents at the individual level are constrained to a further smaller group of researchers, developing what Carley (1996) considers as emulation models, or what Chang and Harrington (2006) counts as organizational engineering. These studies tend to involve multiple levels of agent types such as individuals, managers, departments, and organizations, and include studies such as Carley's (1992) model of binary classification tasks in exploring team versus hierarchical structure; Carley and Lin's (1997) model of organisational structures, procedures, and information distortion on radar detection task; Carley and Svodoba (1996) model of dynamically adapting organizational structure with employee turnover, recruitment, and re-tasking; Jin and Levitt's (1996) model of virtual design teams managing large scale projects studying impact on time, costs, and project

quality; Raghu, Jayaraman, and Rao's (2004) work to model salesforce incentives on information flow and decisions in a typical sales process; Kogut, Colomer, and Belinky's (2014) work on ratio of females on corporate boards as a result of mandated compliance, and social mechanisms such as homophily; Wu, Hu, Zhang, Spence, Hall, and Carley's (2009) model of structural centralization and configuration on organizational adaptation; just to name a few.

Where studies of agents at individual level do not fall under organizational engineering, they include studies such as Hofstede, Jonker and Verwaart's (2010) model of cultural dimensions within the context of trade negotiations (replicated in Graca & Coelho, 2012); Epstein's (2003) model showing how organization hierarchy emerges as a result of coordinating for task allocation; Miller's (2001) simple model of random networks showing need for synchronization in large organizations in solving distributed problems; Singh, Dong, and Gero's (2012) model of how social learning is beneficial to team communication and performance but sensitive to initial conditions; Wang, Gwebu, Shanker, and Troutt's (2009) model of cost-benefits decisions in knowledge sharing on knowledge accumulation; Hoenigman, Bradley, and Lim's (2011) study of team and personal performance in a professional cycling circuit; and Ekmekci and Casey's (2011) usage of memory to explain emergence of organizational identification in contingent workers. Owing to the seminal discrete event simulation piece by March (1991), recent researchers have applied ABM techniques to extend the theory further. Particularly, Miller, Zhao, and Calantone (2006) expanded March's proposition to incorporate proximity-mediated interpersonal learning and Polanyi's (1962) concept of tacit knowledge, Kim and Rhee (2009) added environmental turbulence, and Xu, Liu, and Liu (2014) considered the influence of individual bias towards a preferred position.

The foregoing sampling of management and organizational studies above, though non-exhaustive is representative of the ABM works available. The view of March (2001) that simulation is neglected and tolerated, is reiterated by other recent reviews within HR, OB, and I/O Psychology stating ABM as “vastly underutilized” (Hughes, Clegg, Robinson, and Crowder, 2012; Harrison, Lin, Carroll, & Carley, 2007) and “rare” (Weinhardt & Vancouver, 2012). And indicated in top management journals, simulation conducted “did not address social or behavioral issues” (Harrison, Lin, Carroll, & Carley, 2007, p. 1231).

I contend that this perception while arguably true, may have missed several ABM attempts at explaining HR, OB and I/O classic phenomena. For instance, Yamanoi and Sayama (2013) developed a social network based ABM of individual-level agents with 10 corporate cultural dimensions simulating two firms in a merger. Using zero intelligence agents and structural measures as proxies for organizational turnover and conflict, they showed high pre-merger within-firm concentration of ties leads to higher turnover, lower interpersonal conflict, and lower communication effectiveness. Rather than the rule-based threshold model in Yamanoi and Sayama, the rational model in Takahashi et al (2013) integrated a NK model of individual and organizational utility function (i.e. rational mechanism) to show how organizational inertia is a result of low organizational diversity. An oft-missed classical ABM can be found in Burton and Obel’s (1980 & 1985) model of divisions as agents in a simulation testing key tenets of Ouchi’s interpretation of M-form Hypothesis in Williamson’s (1975) Transaction Cost Economics. Their model showed multi-divisional organizational form to be much superior, in terms of profit, to functional divisional structure regardless of technological decomposability, and that such superiority requires lesser assumptions than that stated in Williamson’s original theory.

OB researchers are starting to adopt ABM as a technique too, most so in the area of leadership emergence and complexity leadership (Uhl-Bien & Marion 2008; see Hazy, Goldstein, & Lichtenstein, 2007 for a review), though at times the usage of complexity leadership and interpretation of ABM results err on the side of metaphorical extensions. ABM studies of classic OB phenomena included Dupouet, and Yildizoglu's (2006) study who showed communities of practice as more efficient in the search of solutions for problems as opposed to hierarchical assignment; Grow and Flache's (2011) study showing the missing dimension of social influence and attitudinal flux in non-ABM studies of demographic faultline theory; Mas, Flache, Takacs, and Jehn (2013) who extended Grow and Flache's (2011) and Flache and Mas's (2008) model to show because of social influence across faultlines, stronger faultline lead to faster consensus than weaker faultlines, and that in the long run, stronger faultlines may be beneficial; Miller, Pentland, and Choi's (2012) study showing how three types of memory (declarative, procedural, and transactive) affect organizational routines change and outcomes; Sayama, Farrell, and Dionne's (2010) model of team mental model via information sharing when seeking optimal solution for problem; Prasad's (2012) attempt at comparing effects of servant versus transformational leadership on group task satisfaction, Black, Oliver, and Paris's (2009) work showing a general indifferential effect of leadership styles except when memory effect is modeled; Clemson and Evans, (2012) work showing the emergence of leadership in social dynamic network of agents playing the minority game; Schrieber and Carley's (2006) comparison of leadership styles on organizational functioning using dynamic network analysis; and Vancouver, Weinhardt & Schmidt's (2010) application of systems dynamics based Dynamic Control Theory of Self-Regulation onto a ABM-like environment of seven agents.

Rather than a siloed academic field, ABM studies in HR showed proportionally greater involvement by industry, military, and cross-disciplinary academics. Studies have

investigated naval personnel performance and manpower planning (Garagic, Trifonov, Gaudio, & Dickason, 2007), extended social segregation onto workplace segregation through hiring and promotional processes (Abdou & Gilbert, 2009; Martell, Emrich, & Robison-Cox, 2012), seek optimal solution for the secretary problem/dilemma common in hiring instances (Seale & Rapoport, 1997), explored spatial job search patterns in Minnesota as an agentic function optimizing wages and job fit (Tilahun & Levinson, 2011), integrated DES and ABM to investigate effect of people management practices on staff proactiveness at two departments of a UK retail chain (Sieber & Aickelin, 2011, Sieber, Aickelin, Celia, & Clegg, 2011), questioned the myth-like Peter's Principle (Fetta, Harper, Knight, Vieira, & Williams, 2012; Pluchino, Rapisarda, Garofalo, 2010), integrated SD and ABM to investigate effect of top-down distinct HRM policies on turnover and organizational performance (Block & Pickl, 2013), explored the effects of different promotion systems on organizational performance in a four-tier hierarchical structure (Phelan & Lin, 2001), illustrated superiority of random to meritocratic promotional strategies (Pluchino, Rapisarda, & Garofalo, 2011); showed effects of mild gender bias in the context of promotion and appraisal on gender segregation in organizations (Robison-Cox, Martell, Emrich, 2007; Martell, Lane, & Emrich, 1996), balanced effects of expertise and boredom to model benefits of task rotation with five complex agents (Zoethout, Jager, & Molleman, 2006); showed how promotional assumptions underlying the Peter's principle may not necessarily mean a detrimental decline in organizational efficiency (Fetta, Harper, Knight, Vieira, & Williams, 2012); and explained how high vs. low power incentives may affect quality of ideas in a firm, the only rigorous ABM study focally designed for compensation design (Baumann & Steiglitz, 2014). In this recent study, the authors explicated the classic tournament theory to have agents "chasing" after rewards linked to projects in a creative agency-like environment. With only 100 agents, several arbitrary parameter values and a self-interpreted mechanism of tournament theory

(therefore none of established formula from the thread of Lazear and Rosen, 1981), the authors showed counter-intuitively that while high-powered incentives (operationalized by high rewards and limited opportunities) generate more exceptional ideas than low-powered incentives, resource constraints limit the development of these many exceptional ideas, curtailing the gains from their numerical advantage.

Proximal ABM Works

In the broad applications of ABM, there exists a decade's effort by mathematicians such as Merlone and Dal Forno to model the 'problem' of effort and production in organisations. Much like the abated reception of Vancouver's systems dynamics work in OB and HR (Vancouver & Weinhardt, 2012; Weinhardt & Vancouver, 2012; Vancouver, Weinhardt, & Schmidt, 2010; & Vancouver, 2008), their ABM work were neglected despite the prescriptive and explanatory relevance to management practice.

Starting from a closed-form analytical tradition, their research on effort and production comes in three distinct periods. In the early 2000's, Dal Forno and Merlone (2002) created a model of nine agent-types who adjust their effort based on a pre-configured strategy analogous to strategies in the prisoner's dilemma paradigm. Their model contains agents moving in a toroidal environment, and forming two-person teams with another agent for a single time-period if the other agent happens to be facing itself. The production and "profit" functions were joint and no higher authority/supervisors were modeled. However only results of a few parameter combination were shown, with the aim of showing the applicability of ABM to the study of workforce via the diversity of 'profit-seeking' strategies. In 2004, Dal Forno and Merlone leveraged the same base model and joint production functions with 15 agent-types by adding global agent rules (rules applied homogeneously to

all agents) for selection and turnover. The ‘problem’ was to identify the corresponding hiring and firing threshold that would lead to “high effort full occupation” (Dal Forno & Merlone, 2004) in the organization. Though potentially limitless combinations of agent types and levels of hiring and firing threshold could be compared in their model, they focused on a handful to show that in homogenous agent population there exist neither hiring nor firing levels that would lead an organization to achieve high levels of employment and effort. Only in a heterogeneous population could a solution exist, and even if so, high level of contingency was exhibited.

After a moderately simple rule-based model, Dal Forno and Merlone (2003) updated it radically to consider a hierarchical module in the programming, consisting of subordinate agents overlooked by a managing agent. Their module consisted of two agents managed by a manager with hierarchical levels that can be built by increasing horizontal and vertical depth. While agents still operate in pair, their joint output is now determined by a Cobb-Douglas production function and each agent is configured to have fixed maximum capacity they can allocate with their teammate or manager. Their ‘salary’ consists of a fixed component and a variable component dependent on total team production and effort allocated to the manager. Despite this proof-of-concept paper to illustrate what the model could do, it took another several years to resurface this model (Dal Forno & Merlone, 2007), and report the results of experiments and further modifications to this model (Dal Forno & Merlone, 2009). Unfortunately, this modular idea was not further developed in an ABM manner in the later works of Dal Forno and Merlone (2010a, 2010b, 2013). In these recent studies, they adopted numerical analysis approaches to a two agent one manager team, and found production and efficiency levels to be maximum when individual incentives are low or null.

Views of ABM in this area of Social Science

This non-exhaustive survey above shows that ABM, while commented to be scarce (e.g., Kozlowski & Chao, 2012; Harrison, Lin, Carroll, & Carley, 2007), is present and thriving nascently within the domains of HR, OB, and I/O psychology; and in these domains modelers tended towards theoretical “illumination” than predictive modelling. Models herein often build, re-look and incorporate one or a handful of classical theories to show the emergence of an un-programmed organizational phenomenon, their boundary conditions, and (at times) providing a parsimonious refinement.

In the words of Harrison, Lin, Carroll, and Carley (2007), Fioretti (2012), Weinhardt and Vancouver (2012), Carley (1996), Salt (1993), Dooley (2002), Fleenor (2001), and Smith and Conrey (2007) the unfamiliarity and absence of specialized training have contributed to the comparatively small community and ABM studies in management, HR, OB, and I/O psychology. As a matter of fact, if management researchers are indeed concerned about multi-level theorizing (Kozlowski & Chao, 2012; Huselid & Becker, 2011; Staw and Sutton, 1993), avoiding anthropomorphic (Morgeson & Hofmann, 1999) and atomistic fallacies (Klein & Kozlowski, 2000a), and radically advancing theory (Aguinis & Edwards, 2014, Harrison, Lin, Carroll, & Carley, 2007; Van Maanen, Sørensen, & Mitchell, 2007, Davis, 2010, Adner, Polos, Ryall, & Sørensen, 2009; Kozlowski & Chao, 2012), ABM-linked studies need to be incorporated into its theoretical enterprise.

Cellular Automata

Given the close interactive environment at the workplace, the relatively fixed job-person positioning and colleague-to-colleague network, cellular automata is the form of agent-based modelling adopted here. The following section reviews this method, technicalities, and applications in related domains.

While some researchers with valid reasons classify Cellular Automata (CA) as distinct from ABM (Cioffi-Revilla, 2014; Crooks & Heppenstall, 2012), CA is generally seen as a subset of multi-agent systems (Payette, 2012; Davidsson & Verhagen, 2012; Rand & Rust, 2011; Smith & Conrey, 2007; Moretti, 2002; Dooley, 2002; Heckbert, Baynes, & Reeson, 2010; Laubenbacher, Jarrah, Mortveit, & Ravi, 2008), in the sense that individual agents (cellular automaton) are arranged on an array, grid, or lattice, and may assume one of a finite number of states for each variable/property/attribute. Usually considered as a class of spatially and temporally discrete mathematical system (Iltanen, 2012; Ilachinski, 2001), they are characterized by local interactions (where agents interact with neighbors around themselves) and updated through time via simple rules. Variations and different definitions to cellular automata exists (see Ganguly, Sikdar, Deutsch, Canright, and Chaudhuri, 2003; Cioffi-Revilla, 2014), but typical cellular automata model is characterized by (much in similar ways to other ABM methods)

- One to three topological dimensions
- Pseudo-synchronous updating of states
- Local interactions with adjacent neighbors
- Updates state using deterministic rules (IF_THEN conditionals)
- Updates in discrete time based on information from preceding time step
- Infinite or toroidal space
- Uniform rules applied iteratively across time and space

(Moretti, 2002; Gilbert & Troitzsch, 2005; Mayer & Sarjoughian, 2009; Grüne-Yanoff & Weirich, 2010; Chen, 2012; Schiff, 2008; Macal & North, 2005; Kari, 2005; Macy & Willer, 2002; Benenson and Torrens 2004; Hegselmann & Flache, 1998)

Taken as a system, CA is a network of automaton with each automaton having ties to its immediate neighbors (Cioffi-Revilla, 2014; Alam & Geller, 2012; Mayer & Sarjoughian, 2009, Huang, Tsai, Wen, 2010, Kari, 2005; Ilachinski, 2001; Mason, Conrey, & Smith,

2007), with Von Neumann neighborhood and Moore neighborhood representing two common network structures of different densities.

Beyond the general utility ABM brings (discussed above), cellular automata offers added benefits, namely in the mode of *visualization*, both in the distribution of agent collectives and state transitions of agents through time. Such visualizations and emergent patterns not only allow modelers to analyze state transitions and troubleshoot bugs in algorithms, but also *facilitate communication* between modelers, fellow scientists and practitioners who are able to grasp the findings adequately clear with the aid of visuals (Iltanen, 2012; Mayer & Sarjoughian, 2009; Moretti, 2002; Macy & Willer, 2002; Nowak & Lewenstein, 1996). As noted by Hagselmann and Flache (1998), the qualitative and macro insights that can be obtained from such visualizations can offer new theoretical explanations, and/or uncover unintended consequences of theoretical assumptions present in discourse for time long past.

Given its simplistic elegance, it is little wonder that cellular automata was one of the earliest tools of ABM (Grüne-Yanoff & Weirich, 2010; Chen, 2012). With roots from biological sciences, Von Neumann under suggestion from Stanislaw Ulam began exploring abstract models of self-reproduction. Initially concerned with 3D factories formalized by partial differential equations, he soon realized that 2D should suffice, and created a cellular automata of 20,000 cell configuration with 29 possible states linked to complicated rules (see Wolfram, 2002, p. 876 for more details). Since then, interests in cellular automata have waxed and waned (Wolfram, 2002), with different fields developing similar yet distinct cellular automata-like structures, such as the Ising model from Physics, and 1D cellular arrays used for cryptography. Throughout this time, three important cellular automata studies

propelled the significance of cellular automata as a tool for a broad range of scientific inquiry.

Conway, with the help of Gardner (1970) in *Scientific American*, popularized a model sometimes seen as for recreational mathematics (Gardner, 1970; Wolfram, 2002) with two states (life and death) and three rules.

Survivals. Every counter with two or three neighboring counters survives for the next generation.

Deaths. Each counter with four or more neighbors dies (is removed) from overpopulation. Every counter with one neighbor or none dies from isolation.

Births. Each empty cell adjacent to exactly three neighbors--no more, no fewer--is a birth cell. A counter is placed on it at the next move.

(adapted from Gardner, 1970)

After several updates of all cells in the grid, distinctive and interesting patterns emerge, and in some cases these patterns can sustain themselves indefinitely throughout the simulation. They are sometimes described as ‘life forms’ that appears to move on the grid (Iltanen, 2012; see also Dennett, 1995 for a thorough discussion Conway’s work on *Game of Life*).

A decade later, Wolfram (1983) published the first of a series of papers systematically investigating 1-dimensional cellular automata, often stacking them up visually over time to reveal how simple rules can lead to four classes of evolutionary behaviors.

Class I – (Fixed) – CA evolve to the homogenous state after a finite number of time steps. This process is generally irreversible, which means that after a certain convergence point where all the cells have the same value, it loses all the information from the initial state. Class 1 CA is comparable with dynamical systems that tend to a fixed-point attractor.

Class II – (Periodic) – CA evolve to periodic structures that repeat after a fixed number of time steps. The size of the possible periods increases while the number of possible states increases. This class is naturally analogous with periodic behavior in dynamical systems.

Class III – (Chaotic) – CA evolve to aperiodic patterns almost regardless of the initial states. In these chaotic automata, the number of initial cells that affect the value of a particular cell

increases as new generations evolve. This class is analogous with chaotic dynamical systems that are converging to strange attractors (Wolfram, 1984).

Class IV – (Complex, or Localized Structure) – CA evolve to complex localized structures. The definition for this class is not as rigorous as for the other classes. Localized structures that arise as the automaton progresses can move and interact, but the exact prediction of this behavior is impossible. For this class, no equivalent can be found in dynamical systems.

(adapted from Martinez, 2013, and Iltanen, 2012)

Wolfram's (1983, 1984a, 1984b, 1984c, 1994, 2002) classification brought rigor and provided terms CA modelers can use in describing behaviors observed in CA. In his comments from his book, "A New Kind of Science", Wolfram (2002) argues that it is possible for all CA to be divided based on these four classes.

Much as Wolfram and Conway contributed to CA's fundamental development. The work that radically provided the impetus for social scientist to leverage CA was that of Schelling's (Macal & North, 2005). In a series of publications between 1969 and 1978, Thomas Crombie Schelling (see Schelling 1969a; 1969b; 1971; 1972a; 1972b; 1978), sought answers to the question if it was possible to get highly segregated settlement patterns even if most individuals are, in fact, color-blind. (Schelling 1971). In many well-known versions of his own studies, his model has the following characteristics.

1. A checkerboard of size 13×16 cells.
2. There are two groups of agents (people), physically operationalized as coins, chips, counters, aspirins, as people, belonging to two ethnic groups, blacks and whites. Other interpretations are possible, e.g. as boys and girls. The groups may be of different size. However, equal size is often the starting point for analysis.
3. Normally the whole population gets scattered throughout the board randomly. Each cell can be inhabited by one and only one individual, or none. About 25-30% of the cells remain empty to give enough clearance for movement.
4. All individuals define their neighbourhood in terms of neighbouring cells that surround their actual position. The standard neighbourhood are the eight other cells in the 3×3 area around the cell in the centre of that area (Moore neighbourhood).
5. All individuals have a neighbourhood preference that determines—in absolute or relative terms—the colour composition that they want to have in their neighbourhood.

The preferences are defined in a variety of ways: The standard case is a minimum demand (ratio or count) for like coloured neighbours.

6. All individuals evaluate their neighbourhoods. Individuals whose neighbourhood does not accord with their preference are in a state of discontent. Otherwise they are content.
7. Individuals can move within the grid.
8. Content individuals always stay where they are, but a discontent individual move to "the nearest spot that surrounds him with a neighbourhood that meets his demand".

(adapted from Hegselmann, 2012)

Amongst other findings, Schelling found that even when the population is typified by non-racist type preference (to be near to at least one-third of similar people), it is *sufficient* for macro-level segregation to emerge (Schelling, 1971). Experimenting with similar rules, but different initial configurations, Schelling showed this pattern to be robust in revealing similar ‘macrobehaviors’ (Schelling, 1978).

Worthy of a mention, but often un-cited, is the work of Sakoda (1971), who independently and possibly much earlier (Sakoda, 1949), explored the use of cellular automata (also in the form of a checkerboard) to understand group formation after repeated interactions. His “Checkerboard Model of Social Interactions”, possibly developed in the 1940’s, allowed agents to have positive, neutral or negative attitudes towards one another; and each agent could move to a cell in its Moore neighborhood where the sum of attitude values was maximized (see Beltran, Salas, & Quera, 2006; Hegselmann & Flache, 1998).

Following these landmark works, many social science researchers begun to consider CA as a tool for emergent evolutionary phenomena. From Schelling’s domain emerged the field of agent-based computational economics (ACE), where Albin (1975) first labelled such checkerboard-like studies as cellular automata for economics (see Testfason & Judd, 2006; Chen 2012; for a review). ACE is undoubtedly a big and flourishing field, as described

above, of which notable CA modeled economies and phenomena such as asset pricing (Keenan & O'Brien, 1993) and firm-level knowledge spillovers (Meagher & Rogers, 2004).

In social psychology, studies using CA include some described earlier, and those modelling evolution of attitudes and emergence of public opinions via Latane's Social Impact Theory (Nowak, Szamrej, & Latané, 1990; Nowak & Latane, 1994; Nowak & Lewenstein, 1996; Nowak & Vallacher, 1998a,b), dynamics and evolution of cooperation via utility rules (Hegselmann, 1996; Liebrand & Messick, 1996; Nowak & May, 1992), impression formation via Kenny's (1994) Social Relations Model (Smith & Collins, 2009), emergence of identity and personality (Nowak, Vallacher, & Zochowski, 2005), norm enforcement (Centola, Willer, & Macy, 2005), and social exchange (Macy, 1991). At the cross-road of social psychology, cross-cultural psychology, and organizational culture, the well-designed evolutionary game theoretic study of Roos, Gelfand, Nau, and Lun (in press) is also implemented in a cellular automata environment. More generally, CA has also been used to investigate theories about language shifts (Beltran, Herrando, Ferreres, Estreder, Adell, & Ruiz-Soler, 2009), human mating strategies (Kenrick, Li, & Butner, 2003), crowd evacuation and pedestrian dynamics (Burstedde, Klauck, Schadschneider, & Zittartz, 2001), traffic (Helbing & Molnar, 1995; Nagel & Schreckenberg, 1992), innovation diffusion (Goldenberg, Libai, & Muller, 2001; Guseo & Guidolin, 2008; Kiesling, Günther, Stummer, & Wakolbinger, 2012; Nan, Zmud, & Yetgin, 2013), Balinese irrigation systems (Lansing, 1991), and interfirm network structure (Lomi & Larsen, 1998).

With origins and applications from varied fields, it is unsurprising ABM modelers face huge diversity in methods. Though CA is chosen as the modelling framework, no single development standard exists (Bruch & Atwell, 2013; Goto & Takahashi, 2013). Numerous ABM models were either modifications or re-implementations of established "seed" models

for the purpose of shortening development time or for keeping a focus on theoretical extensions. “Seed” models include those such as Sugarscape (Epstein & Axtell, 1996), SIM-NORM (Castelfranchi, Conte, Paolucci 1998); SITSIM (Nowak & Latane, 1994), Virtual Design Team (Jin & Levitt, 1996), just to name a few. Given an exhaustive search for published models with mechanisms close to this dissertation’s focus (equity theory and PFP on work production) drawing up an empty set, a new agent-based model of fairness comparison-restoration will be developed.

Chapter 6

COMPUTATIONAL EXPERIMENT 1 (BASE MODEL)

Model Design

To answer the research questions, I develop an ABM model to observe, analyze, and infer the cross-level effects of PFP working specifically via equity theory's formula. The model has n agents, i , where $i \in \{1, 2, \dots, n\}$, interacting in a $N \times N$ toroidal cellular automata, representing social spaces amongst individuals in a department, organization, or community (Hall, 1966; Hilliard & Penn, 1992, cited in Nowak, Vallacher, & Borkowski, 2000). Agents are overlaid on a similar shaped and sized grid with each cell on the grid representing job positions, j , which the agents are assigned to. Each job position is time invariant and its production tasks are fully independent of other job positions. The production tasks of each job differs only by difficulty levels, $D_j \in \{1, 2, \dots\}$. For simplicity, no joint production function is assumed in this model. This is, thus, a two-layer cellular automata with workers at the upper level fully mapped onto jobs at the lower level in a one-to-one relationship. No turnover or mobility between positions is assumed.

When the simulation begins, all agents are identical in terms of effort an agent is willing to contribute to the firm, $W_{i,(t=0)}$. Because Adams (1965) posited input is resultant of felt discrepancy leading to changes away from previous period's input levels. The effort an agent is willing to contribute at a point in time $W_{i,t}$, is dependent on its motivation to adjust effort $M_{i,t}$ at that point in time, and the effort the agent was willing to contribute to the firm in its immediate past period $W_{i,(t-1)}$. As auxiliary assumption, $W_{i,t}$ is constrained within a lower and upper limit of zero and twice the initial effort levels^{6.1}, respectively, $0 \leq W_{i,t} \leq 2W_{i,(t=0)}$.

^{6.1} As robustness check the model was modified with $0 \leq W_{i,t} \leq 3W_{i,(t=0)}$ qualitatively similar results were obtained. See Perlow (1999), Barnes, Wagner, & Ghumman (2012), and Merriman (2014) for discussions and examples of limit on work hours in a typical work day.

The lower limit implies that the minimum effort is simply not to work, while the upper limit corresponds to a worker committing twice the amount of effort at work.

$$W_{i,t} = M_{i,t} \times W_{i,(t-1)} , \text{ for } t \in \{1, 2, \dots\} . \quad (1)$$

When agents work on their assigned jobs, agents produce individual output $P_{i,t}$, based on the amount of effort they are willing to contribute $W_{i,t}$, the difficulty of the task D_j , and a uniform multinomial random component, $s_{ij,t} \in \{-1, 0, 1\}$. The random component simulates everyday random fluctuations that may increase or decrease worker's output for reasons beyond their control (such as urgent requests or diversions). Considering that each unit of production requires sufficient amount of effort to be produced, notwithstanding $s_{ij,t}$, individual output is thus a floor function of $W_{i,t}$ and D_j . Formally, individual production function is given as

$$P_{i,t} = \left\lfloor \frac{W_{i,t}}{D_j} \right\rfloor + s_{ij,t} , \text{ for } t \in \{1, 2, \dots\} . \quad (2)$$

At the end of each period, agents are remunerated an amount $R_{i,t}$. To prevent ambiguities, Lazear (2000) and Cadsby, Song, and Tapon (2007) are followed to refer to PFP as a reward scheme. To understand the effect of PFP, we contrast it with the classic salaried alternative of pay for time (PFT). Accordingly, when agents are paid for performance, their remuneration is the product of their output $P_{i,t}$ and a time-invariant fixed piece-rate payment G . When agents are paid for time, their remuneration is a fixed salary L .

$$R_{i,t} = \begin{cases} P_{i,t} \times G & , \text{ agents are paid for performance} \\ L & , \text{ agents are paid for time} \end{cases} \text{ for } t \in \{1, 2, \dots\} , \quad (3)$$

where $G > 0$, $L > 0$, and since $P_{i,t}$ can be zero from equation 2, agents can receive zero remuneration when being paid for performance.

This model discerns between the amount of effort an agent is willing to contribute $W_{i,t}$ and the amount the agent actually expended $E_{i,t}$. The latter represents the amount of energy or effort involved in the actual production of individual output and is calculated after output is produced. This distinction avoids the naïve assumption that intention or willingness to contribute will translate into performance unaffected by contextual influences. Thus it addresses both non-perfect divisibility of effort for task production, and, as Bonabeau (2002) argued, introduces randomness (operationalized as $s_{ij,t}$, in equation 2) at the process rather than variable/aggregate level.

Following equation 2, the actual amount of effort expended by an agent at a point in time $E_{i,t}$ will be the simple product of job difficulty D_j of the job the agent is working on and the output the agent produced at that period. Across all experimental conditions, when no output is produced, a minimal single unit of energy is assumed as cost for agent to remain in organization.

$$E_{i,t} = \begin{cases} P_{i,t} \times D_j & , \text{ if } P_{i,t} \geq 1 \\ 1 & , \text{ else} \end{cases} \quad \text{for } t \in \{1, 2, \dots\} . \quad (4)$$

With effort expended and remuneration received, each agent begins to form an evaluation of its own outcome-input ratio (Adams, 1965), $Q_{i,t}$, at the end of each period.

$$Q_{i,t} = \frac{R_{i,t}}{E_{i,t}} \quad , \text{ for } t \in \{1, 2, \dots\} . \quad (5)$$

The extent to which past rewards and effort have on future performance depends largely on the comparison an agent makes with its peers. Should one's own outcome-input ratio be greater or smaller than its peers or comparison others, agents will be motivated to increase or decrease effort the next time period so as to reduce this discrepancy (Adams,

1965; see detailed discussion above). The model here follows Cosier and Dalton (1983) and Carrell and Dittrich (1978, p. 206) to construe Adams (1965) theory that the motivation to restore inequity is a function of the discrepancies of the agent's own outcome-input ratio and comparison others' outcome-input ratio. To quantify this discrepancy for each agent, the model (1) considers that humans tend to perceive difference in a relative sense (Tversky & Kahneman, 1981) than absolute terms as suggested in Adams original formulation, and (2) aims to overcome sensitivity to effects of measurement metrics (Pandelaere, Briers, & Lembregts, 2011), by computing this discrepancy as a ratio-of-ratios. Formally this discrepancy ratio $\Phi_{i,t}$ is given by

$$\Phi_{i,t} = \frac{Q_{it}}{(Q_{Nt} + Q_{St} + Q_{Et} + Q_{Wt})/4} \quad \text{for } t \in \{1, 2, \dots\} \quad , \quad (6)$$

where Q_{Nt} , Q_{St} , Q_{Et} , and Q_{Wt} , refers to outcome-input ratio of agents to the north, south, east, and west of the focal agent, in a Von Neumann neighborhood^{6.2}, respectively.

^{6.2} The use of static Von Neumann neighborhood as a fixed comparison group with equal weights lies between what Galan et al. (2009) calls as core and accessory assumptions. It is an accessory assumption, because it is needed for the model to run and can be changed and altered without affecting the main crux of the model's referent theory. It is core because in Adams's (1965) theory it is necessary to have comparison others. Accordingly, in Experiment 4 and in additional robustness tests conducted, such as with neighborhood of radius-2, the qualitative trajectory for PFP alone, and with PFT as comparison, is largely similar. This similarity in structural stability (Cioffi-Revilla, 2002) supports robustness of inference.

While models such as "randomly selecting one of 4 neighbors", "giving more weights to neighbors in the same state (aka. homophily)" can be added and programmed. A key question to be answered is why would a base model start off with comparing four neighbors equally and in a static manner. Two explanations can be made.

First, static network has been implemented in numerous models (e.g., Saito & Kurahashi, 2013; Nowak, Vallacher, Tesser, & Borkowski, 2000), and equal weights and Von Neumann neighborhood is a common topology to start off (e.g., Hegselmann, Flache, & Moller, 2000; Gong & Socolar, 2012; Boccara & Fuks, 1999; Hammond & Axelrod, 2006; Axelrod, 1997; Miller, Zhao, & Calatone, 2006). In choosing alternatives such as homophily, one would also have to rationalize against heterophily or assumption-free comparison. Hence, the reason here would be similar to those of past models such as that of Schelling (1971a & b), Nowak (2006), Flache and Macy (2011b), and Axelrod (1997), where models are kept simple, to identify workings of each mechanism, and incrementally relaxed in future model developments. Specifically, keeping a fixed network topology with equal weights for all connected nodes avoids additional mechanism, reduces unnecessary stochasticity, and increases tractability of the model. This theoretical control (than statistical control) is critical for a first model and to increase generalizability via higher abstraction (McGrath, 1981).

Second, real world networks are conclusively, without exception, to be changing and dynamic (e.g., Kossinets & Watts, 2006; Wellman, Wong, Tindall, & Nazer, 1997) yet there are some empirical and theoretical works which suggest humans persist and tend to compare with the same group of others or hold relatively stable

Whether this discrepancy is sufficient to motivate an agent to adjust the effort it is willing to contribute in the next time period $W_{i,t+1}$ depends largely on the magnitude of this discrepancy. Following Adams (1965), the discrepancy or tension has to be sufficiently large, crossing a threshold, for an individual to be motivated to reduce the discrepancy. This motivation M , to be used in the next time period for determining effort levels, is computed from a step function incorporating threshold levels η ^{6.3}.

relationships (e.g., Gartrell, 2002; Krackhardt & Handcock, 2007; Krackhardt, 1998; Zukin & DiMaggio, 1990; Mariolis & Jones, 1982; Stets & Burke, 2014, p. 48). Even, proponents of Self-Evaluation Maintenance Theory, which traditionally posits that individuals seek out strategies (which include changing of referent group) to enhance self-evaluation, do also acknowledge the work of Swann's Self-Verification Theory by stating, "persons choose other people and situations that verify their view of self even when that view of self is negative." (Beach & Tesser, 2000, p.124) Hence people, even when in negative inequity state, may persist than shift in their pay referent group.

Summatively for the above, implementation in CA is an abstract representation that does not just refer to social ties, but also locus and the psychological proximity of comparison group. Fully acknowledging that individuals do change comparison groups, one needs to ask if there is also a select group of individuals who one tends to anchor comparisons with every now and then? We compare with colleagues who are seated close to us more often than those far apart, we think more about "the Jones" living next to us than those a city away, and unless they move, they will continue to be a main comparison group (Martin & Yeung, 2006; Marmaros & Sacerdote 2006; Bidart & Lavenu, 2005; Feld, 1981). Hence, while this can also be seen as a form of homophily (same district/boss), in the presence of infinite other variables that can count as homphily or heterophily, the CA implementation here follows the entropy-maximization approach to agent design (Chen, 2012) and does not assume or make claims about homophily nor attempt to model it. Entropy-maximization approach meant full disclosure of agent's rules, imposing as little accessory assumptions as possible, thereby maximizing unique information that can be obtained from the coded mechanism. Hence confidence can be gain that the results/patterns seen emanates from the minimal theoretically required mechanism. This follows the KISS approach closely. (Chen, 2012)

^{6.3} Though alternative conceptualizations exist (such as Meller, 1982), the treatment of positive inequity as an index above 1 and negative inequity as from zero to 1, is argued in Vecchio (1982, p. 105) to follow Adams's (1965), Walster, Berscheid, and Walster's (1976), and Anderson and Farkas's (1976) conceptualization closely.

For simplicity^{6.4} the model assumes symmetrical threshold levels, and a common log to represent decreasing increase of willing effort in state of overreward, such that it will require a large discrepancy (such as $\Phi=10$) to see an agent willing to adjust effort upwards by twice its previous effort level, and a maximum underreward condition ($\Phi=0.1$) where an agent will reduce its effort towards the firm to null value^{6.5}. Accordingly,

$$M_{i,(t+1)} = \begin{cases} \log_{10}\Phi_{i,t} + 1 & , \text{ if } \Phi_{i,t} > (1 + \eta) \text{ or } 0.1 < \Phi_{i,t} < (1 - \eta) \\ 1 & , \text{ else} \end{cases} \quad \text{for } t \in \{1, 2, \dots\}. \quad (7)$$

At the end of each period, all agents' output are summed to form aggregate output U_t , operationalizing collective performance of organization at a point in time.

$$U_t = \sum_{i=1}^n P_{i,t} \quad \text{for } t \in \{0, 1, 2, \dots\} . \quad (8)$$

Schematically, all agents start off at Step 1 and iterates through the following steps pseudo-concurrently with other agents at each time period (Figure 6.1).

^{6.4} Core assumptions, unlike auxiliary or accessory assumptions (Galán, et al., 2009) can be tested with subsequent models, they are assumed from theory or for simplification, rather than computational convenience, such as the maximum energy levels in most ABM models. Considering Adams (1965), and reiterated by subsequent researchers (e.g., Huseman, et al, 1987; Miles et al, 1989; Leventhal, Weiss, & Long, 1969; Cosier & Dalton, 1983), suggest that the threshold levels for over-reward can be higher than that for under-reward, new computational studies can be designed to test the effect of asymmetrical response threshold to inequity. In the absence of exact quantification of positive/negative threshold levels, and the non-conclusiveness of response threshold for positive inequity, symmetrical response is assumed and made explicit here.

^{6.5} As robustness check, and to address potential contentions that the response function of equation being log-based reflects a much more rapid decline in effort for discrepancy ratio less than $1 - \eta$, the model was modified with a linear response function, equation 7a (below), with qualitatively similar results.

$$M_{i,(t+1)} = \begin{cases} \Phi_{i,t} & , \text{ if } \Phi_{i,t} > (1 + \eta) \text{ or } 0.1 < \Phi_{i,t} < (1 - \eta) \\ 1 & , \text{ else} \end{cases} \quad \text{for } t \in \{1, 2, \dots\} . \quad (7a)$$

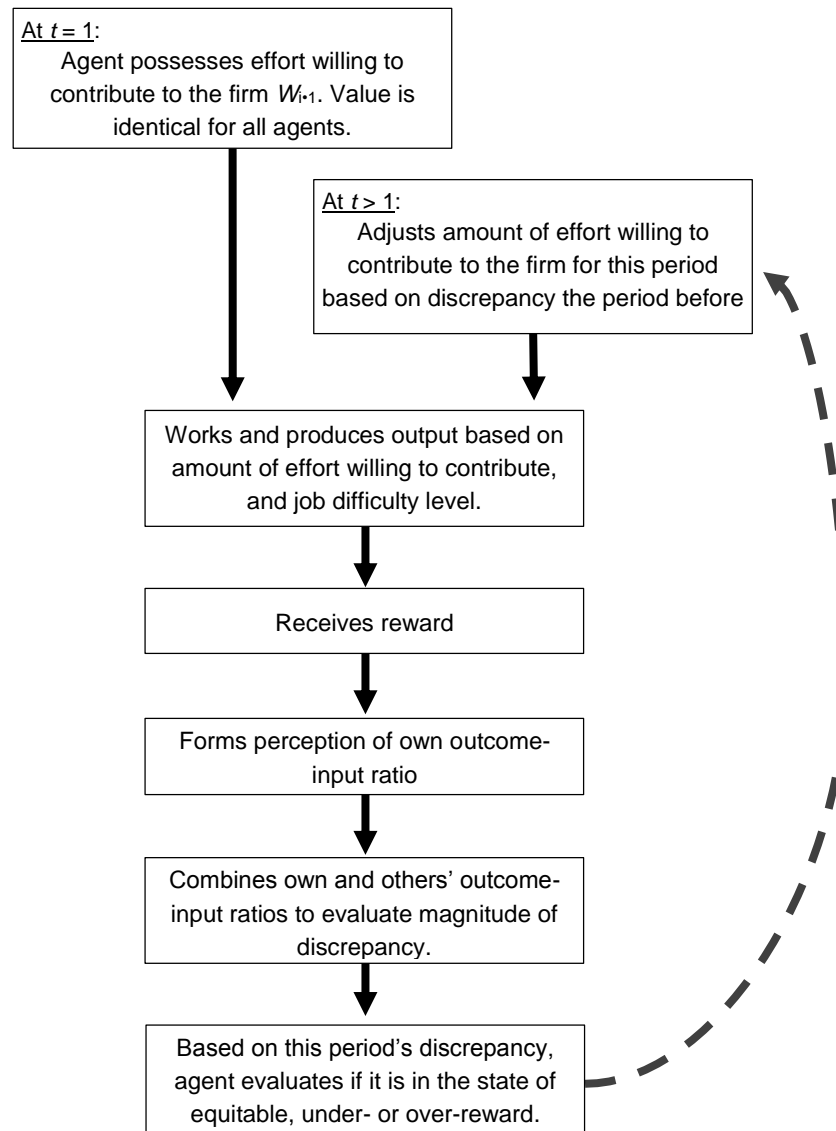


Figure 6.1. Agent processes for Base Model

Model Verification

The model is developed through multiple versions of Netlogo (Wilensky, 1999), and implemented in Netlogo 5.1.0. Following Railsback and Grimm (2013), Canessa & Riolo (2003) and Sargent (1988), prior to data generation, the computational model is verified with the theoretical model (Gilbert, 2008) using both the top-down and bottom-up approach (Canessa & Riolo, 2003), with emphasis on the latter as the emergent effect is the object of exploration. In the bottom-up approach, the model is checked at the level of each module for

each agent akin to unit testing (Beck, 2002), and two-person code walkthroughs are performed (North & Macal, 2007). Where stigmergic interaction is involved, the modules are tested by manual calculation of two, three, four, and eight agents. Tests involved using fixed and varied random seed as required for tracing and comparisons. When sufficient certainty was gained in terms of the match between code and theory, the model was scaled to different sizes and parametric responses were observed across long (till $t = 10,000$) and short periods. The final model, conveniently called *Dynamic Equity Theory*, contains modules that account for other organizational and economic phenomena, but as the focus here is on equity theory, reward schemes, and collective performance, these other modules will be ignored for now.

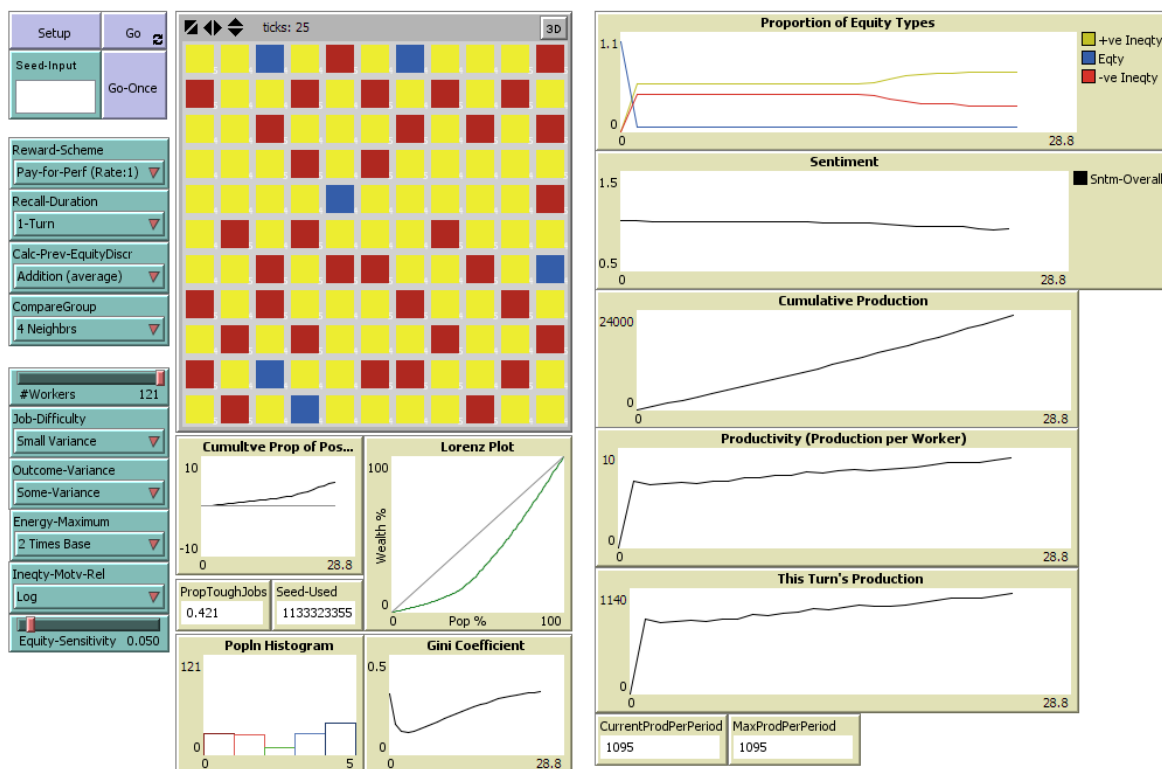


Figure 6.2. Graphical User Interface of Model Implemented on Netlogo 5.1.0

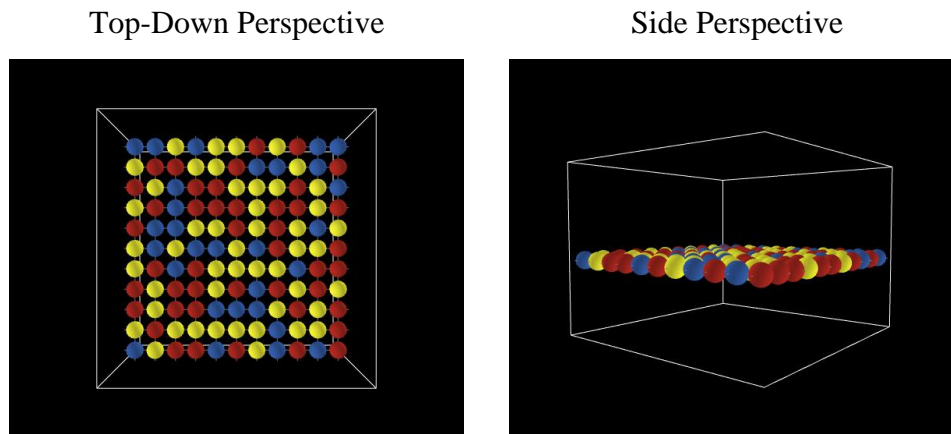


Figure 6.3. Typical Equity States and Motivation Condition at end of $t = 1$

Figure 6.2 shows the user interface of the model in a run while Figure 6.3 shows a 3D rendition^{6.6} of the resultant CA. The z -axis represents the effort an agent is willing to contribute W ^{6.7} at the beginning of each period, while color represents the equity state an agent (represented as spheres) is in at the end of the period. Yellow represents positive inequity or over-reward, blue represents equitable, and red represent negative inequity or under-reward. Accordingly, if an agent is blue at t , its position on the z -axis will be the same at $t+1$ (since there is no discrepancy to increase or decrease effort for the next period). Figure 6.3 shows all agents after all modules are computed at $t=1$, illustrating that at the beginning of simulation, all agents have the same W set at an arbitrary middle value^{6.8} of 30. This starting value is the same through all experiments and parameter combinations.

^{6.6} 3D model is developed and rendered in Netlogo 3D 5.1.0 instead of Netlogo 5.1.0.

^{6.7} Though variable of interest is aggregate output U , effort willing to contribute to the firm W is chosen as metric for z -axis as it represents changes in motivational levels much more clearly. Individual-level output, units produced at a point in time P is not used as metric for the 3D rendering, as it is also a function of job difficulty levels D , making direct interpretation of the effects on motivational levels vague.

^{6.8} This is an arbitrary value that can be changed. Alternative values of 10 and 60 have been explored to show no qualitative effects on the resultant patterns of results.

Data Collection

To understand the effect of PFP on collective performance, an experiment comparing effects of PFP with that of fixed payment (pay-for-time, PFT) is conducted. Aggregate output U_t , the *sum of output produced by all agents at a point in time* is the variable representing collective performance. Under both conditions, identical parameters were applied at initiation (Table 6.1). As per recommendations from Epstein and Axtell (1996), and Railsback and Grimm (2013), data are obtained by taking the average of several replications (with varying random-seed during initiation) to approximate random effects in the real world. This stochasticity affects the distribution of job difficulty level among agents as well as individual output as detailed in above section. Each condition (PFP and PFT) will be run 100 times obtaining an average of outcomes in a monte carlo manner (following Miller, Zhao, & Calatone, 2006; Miller, Pentland, & Choi, 2012; Miller, Fabian, & Lin, 2008; Rouchier, Tubaro, & Emery, 2014; Gao, Qiu, Chiu, & Yang, 2015).

Number of agents in ABM simulations varies widely between studies, depending on the phenomenon of study, domain tradition, and levels of representation; where for example studies such as those on opinion diffusion and evolution of cooperation have been explored with agents of 50 (Rand, Ohtsuki, & Nowak, 2009), 100 (Flache & Macy, 2002, Fu et al., 2012), 200 (Rouchier, Tubaro, & Emery, 2013), 500 (Ohtsuki, Hauert, Lieberman, & Nowak, 2006), 1,000 (Macy & Sato, 2002; Saito & Kurahashi, 2013; Etzion, 2014), 1,600 (Nowak, Szamrej, & Latane, 1990), 2,500 (Hammond & Axelrod, 2006), 2,600 (Chiu & Qiu, 2014), 5,000 (Broekhuizen, Delre, & Torres, 2011), and 27,531 (Robison-Cox, Martell, Emrich, 2007). The 121 agents modeled here follows recent ABM models in key management journals, such as 100 employees in a firm (Baumann & Stieglitz, 2014), 100-per-community (Miller, Pentland, & Choi, 2012), 100 agents in two populations combined (Nan, Zmud, & Yetgin, 2013), 160 agents in a pyramidal organization (Fetta, Harper, Knight, Vieira, &

Williams, 2012), and 20 agents-per-team (Mäs, Flache, Takacs, & Jehn, 2013) and 50 agents per firm (Yamanoi & Sayama, 2013). This number is sufficiently large to cover the scope of agents in above proximal studies, and reasonable for operations of call center, production lines, and departments of MNCs. As this is a toroidal CA^{6,9}, resultant patterns are not likely to differ between models of different agent population size as revealed in model verification discussed in model testing and verification below. For the purpose of monitoring collective performance over time, data on aggregate output U_t was monitored at every time step.

Table 6.1

Parameters Setup for Experiment 1

System	Number of agents n	121
	Number of job positions	121
	Job difficulty levels D_j	4, 5
	Piece-rate payment G (when under PFP)	1
	Fixed salary L (when under PFT)	10
	Variability in output s	-1, 0, 1
Agents, $t=0$	Effort willing to contribute to the firm W	30
	Motivation to adjust effort M	1
	Discrepancy ratio Φ	1
	Inequity threshold η	0.05
Experimental Condition	Payment Scheme	Pay-for-Perf., Pay-for-Time

^{6,9} The most notable example of effects of model size on reported effects comes in Axelrod (1997) seminal paper. In that model, Axelrod was commented by Flache & Macy (2011) to be using a non-toroidal CA. Hence, ratio of network (or topological) edges changes with grid size. Accordingly, for that model, size of agent population or grid exerts an effect above the mechanism of influence. Small sample of runs for all experiments one through four were performed on other larger grid sizes, such as 21 x 21 (441 agents). Shape of trajectories and steady state relative differences were similar.

Results^{6.10}

Taking after Mäs, Flache, Takács, and Jehn (2013), results are presented in stages. First, Bausch (2014), Flache and Macy (2011), Miller, Zhao, and Calatone (2006), and Nowak et al. (1990) are followed to report averaged system behavior over time followed by statistical testing of aggregate output at equilibrium^{6.11}. Because “with 100 simulations per model, the differences in ... outcomes resulting from varying parameter values (will be) generally significant” (Miller et al., 2006, p. 713), the second stage follows Flache & Macy (2011) and Coen (2013) to present exemplars and derive qualitative insights about the dynamics of system and agents.

Figure 6.4 shows the average aggregate output of agents at each point in time for both reward schemes. After around fifty to sixty rounds of comparisons, aggregate output of

^{6.10} As ABM is nascent in the field of I/O psychology, OB, HR, and management (except for NK-type and behavioral school ABM models), several articles are consulted to guide proper interpretation of results. Generative nature of ABM models focuses less on traditional hypothesis testing but more on modeler’s explanation of results and provision of pseudo-code or model for replication by other modelers (Fioretti, 2013). Aim is to provide observations and explanations that can provide direction for future research. Amongst articles consulted are those by Miller, Fabian, and Lin (2009), Mas, Flache, Takacs, and Jehn (2013), Miller, Pentland, and Choi (2012), Miller, Zhao, and Calantone (2006), Axelrod (1997), Abdou and Gilbert (2009), Pluchino, Rapisarda, Garofalo (2011), Baumann and Stiegtlitz (2014), Afshar and Asadpour (2010), Groeber, Schweitzer, and Press (2009), Xu, Liu, and Liu (2014), Mosler (2006), Sutcliffe and Wang (2012), Coen (2013), Nowak, Vallacher, Tesser, and Borkowski (2000), Nowak, Szamrej and Latane (1990), Flache and Macy (2011a & b), and Rand and Rust (2011).

^{6.11} Results at equilibrium refer to monitored emergent property of the system that converges or stays stationary within a small narrow interval, particularly that value when at time t is highly correlated to value at time $t-1$. Depending on tradition in field of publication, it is variously referred to as “converged solutions” (Darabos, Giacobini, & Tomassini, 2007, Mousseau & Sherrington, 1995; Macy, Kitts, Flache, & Benard, 2003), “dynamic equilibrium” (Clauzet & Wiegel, 2010), “stable state” (Roos, Gelfand, Nau, & Lun, in press) “steady state” (Baumann & Stiegtlitz, 2014, John, Schadschneider, Chowdhury, & Nishinari, 2004; Bell, 2002; Fetta, Harper, Knight, Vieira, & Williams, 2012; Cioffi-Revilla, 2002), “stochastic steady state” (Bausch, 2014, Flache & Macy, 2011), or “steady state equilibrium” (Soulie & Thebaud, 2006) just for illustration. In dynamical systems theory, the value to which the system converges to is termed an attractor, of which it can be stable or unstable, but in the context of a fixed point, it cannot be chaotic by definition. While strict tests of stationarity can be performed, most ABM authors adopt a descriptive approach via observation. Such as “each run lasted for 200 time steps to allow sufficient time for the dynamics of search and selection to reach a steady state” (Baumann & Stiegtlitz, 2014, p. 364), “We set the number of iterations at a value large enough for the population dynamics to approach stochastic stability in most conditions” (Flache & Macy, 2011, p. 977), “long enough to reach a stationary state” (Pluchino, Rapisarda, & Garofalo, 2011, p. 3500), “chose time = 200 as the stopping point because ... system is ‘warmed up’ sufficiently to show us the effect” (Ahrweiler, Gilbert, & Pyka, 2011), “using the last sixty data points of each run, where the system is in equilibrium” (Canessa & Riolo, 2003, . 161), “measure at the last simulation step (i.e., after the system has reached an asymptote)” (Nowak, Vallacher, Tesser, & Borkowski, 2000, p. 45).

collectives per period under PFP and PFT have stabilized, with aggregate output of agents under pay for performance stabilizing earlier. Explorative runs to extreme time values ($t=10,000$) revealed that random perturbations in the model are insufficient to nudge the system away from the aggregate output levels reached post stabilization, suggesting convergence to steady state or the reaching of asymptotic regime (Cioffi-Revilla, 2002; Jensen, 1998). Taking a point post stabilization ($t=60$), the aggregate output for collective of agents under PFP ($M_{PFP} = 1,156$ $SD = 37.26$) is significantly higher^{6.12} than agents for under PFT ($M_{PFT} = 0.080$ $SD = 0.394$), $F(1, 198) = 96,297$, $p < .001$, $\eta_p^2 = .99$.

As added analysis, between-runs variance produced under different reward schemes are observed and analyzed. Figure 6.5 shows the standard deviation of aggregate output of collective of agents generated under different reward schemes at various time points. Admittedly, it is uncommon to analyze between-runs variation of an observed emergent property (most ABM studies compare mean values attained at stable state); yet where each run with different random initializations could *represent unique starting conditions of firms*, this variance is informative as it highlights differences in effects that can be observed in firms despite implementing similar reward schemes. Seen in Figure 6.5, we observe the standard deviation of aggregate output of agents under PFP to be mostly higher than that under PFT. This difference is most significant when the system is at equilibrium (stabilized). The peak in variance for PFT just before stabilization corresponds to the gradual decline in averaged aggregate output reported earlier, reflecting the differing time-to-stability (term used in

^{6.12} Effect sizes are evident from corresponding figures and are sufficiently large to preclude a need to perform hypothesis tests (Gigerenzer & Marewski, 2014). Due to the focus on qualitative patterns, ABM studies do not typically perform statistical test nor report the effect sizes. Instead it is the interpretation from the graphs that are reported (e.g., Miller, Zhao, & Calatone, 2006; Baumann & Stieglitz, 2014; Roos, Gelfand, Nau, & Lun, in press). Even in a laboratory-calibrated ABM study, Kennedy and McCombs commented that they “only interpret patterns of results rather than actual values from (their) analyses” (p. 796), leaving future studies “to corroborate on (their) results” (p. 797). Despite the above, hypothesis testing was done stating the confidence interval to not just illustrate the reliability and likelihood of obtain similar results in future runs, but also to attend to general readership of I/O psychology, OB and HR who are more familiar with the NHST.

Axelrod, 1997c) as agents gradually reduce individual output to minimal or near zero levels. While the higher variance for PFP may be attributable to higher aggregate output levels, the fluctuating variance across time meant, post-implementation of either reward scheme, there are periods where the diversity of differences between firms or departments is small (e.g., $t=1$ to $t=10$) and periods where such variance in is large (e.g., $t>10$).

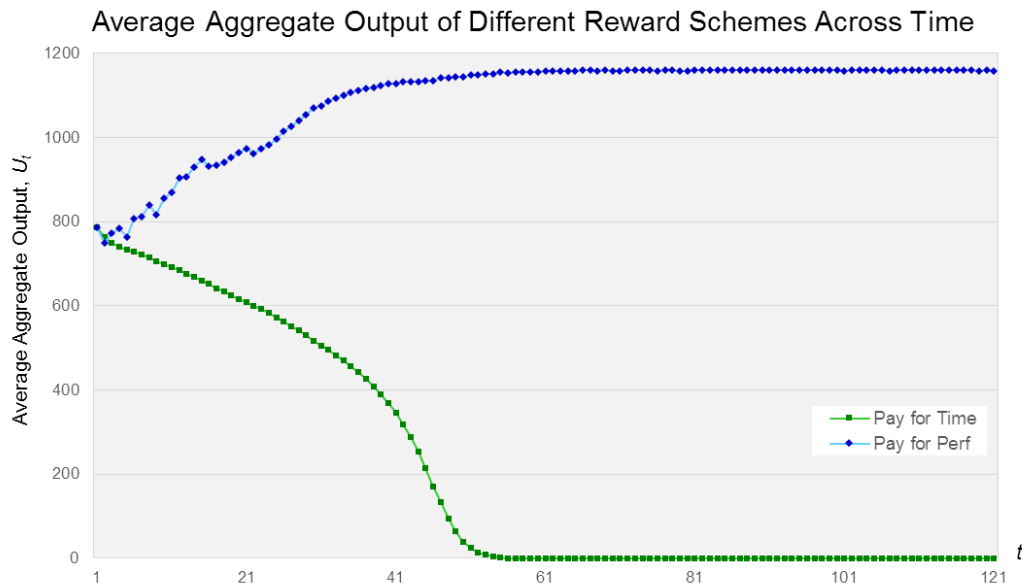


Figure 6.4. Average aggregate output of different reward schemes across time. Time axis begins at $t = 1$, as at $t = 0$, agents are not assumed to have completed any job tasks.

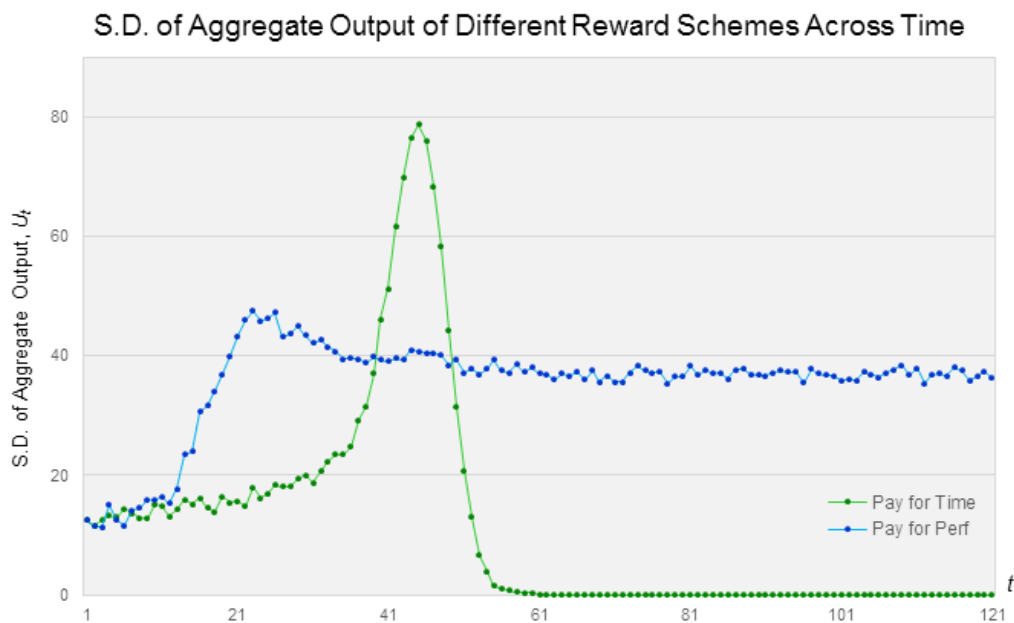


Figure 6.5. Standard deviation of aggregate output of different reward schemes across time. Time axis begins at $t = 1$, as at $t = 0$, agents are not assumed to have completed any job tasks.

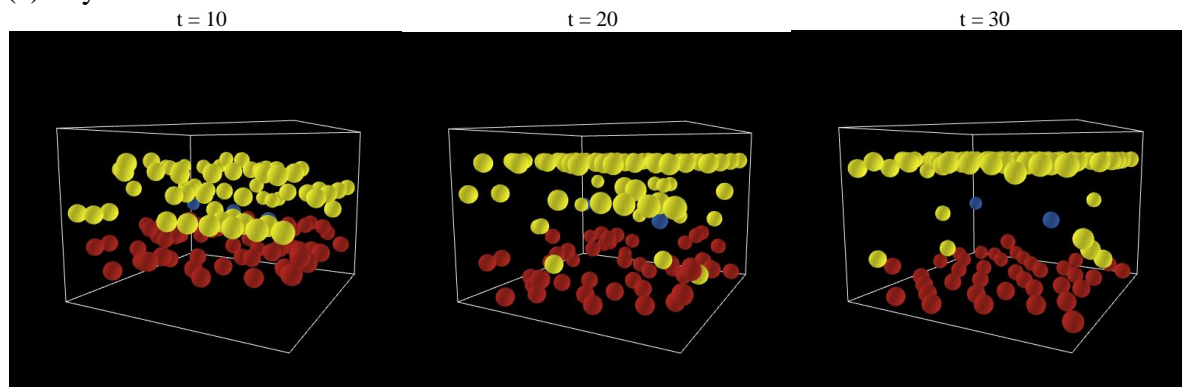
To understand the dynamics leading to PFP's higher aggregate output solely mediated by fairness concerns, multiple investigative runs aided by visualization and simultaneous tracking of surrounding agents were performed. Taking after Roos, Gelfand, Nau, and Lun (in press), typical runs of each condition are shown at specifically chosen time points. Figure 6.6 shows the levels of effort agents are willing to contribute W at different time points. This intermediate variable in the effort-to-production process is monitored as it allows the direct observation of changes in motivation without being confounded by occurring later in the process.

For PFP (Figure 6.6a), in situations when agents (red spheres) notice neighboring agents being paid more as a result of obtaining higher output from a slightly easier job (lower D), they adjust their effort willing to contribute W downwards in an attempt to reach equity. For those agents paid more, they adjust their effort upwards (yellow spheres). These upwards or downwards adjustments to achieve equity may only be transient, as an agent reaching equity state at one time point may be put out of this state in the next time point when neighboring agents adjust their effort again based on their own (different) local set of information. At the aggregate level, the upwards and downwards adjustment of effort by different agents could potentially cancel out, especially since job difficulty D is randomly drawn from a uniform distribution^{6.13}. But as agents adjust through long periods of adjustments the collective under PFP converges to a performance level higher than levels at initialization. This rise at the collective level was not predictable a priori from the Adams's formula nor the theoretical model presented earlier. Because this increase in aggregate output is capped only by the maximum effort any agents can reasonably exert (recall that maximum-to-minimum effort is equidistant to initial starting values), revising the upper limit to W to a

^{6.13} Resultant proportion of easy jobs for 200 runs is normally distributed $N(0.502, 0.002)$ Kolmogorov-Smirnov $p > 0.200$.

higher value (thrice the initial level) led to an almost double increase in aggregate output, but the qualitative pattern remains the same, showing unambiguously the direction of effect PFP has on collective performance. Contrast this with the dynamics for PFT (Figure 6.6b), where agents similarly mutually adjust efforts as per PFP, yet the adjustments are more gradual and the reduction in effort is generally observed for all agents. Such observations would not have been possible when observing equity theory's predictions at a single or two time points, nor possible at the level of the individual or dyad.

(a) Pay-for-Perf



(b) Pay-for-Time

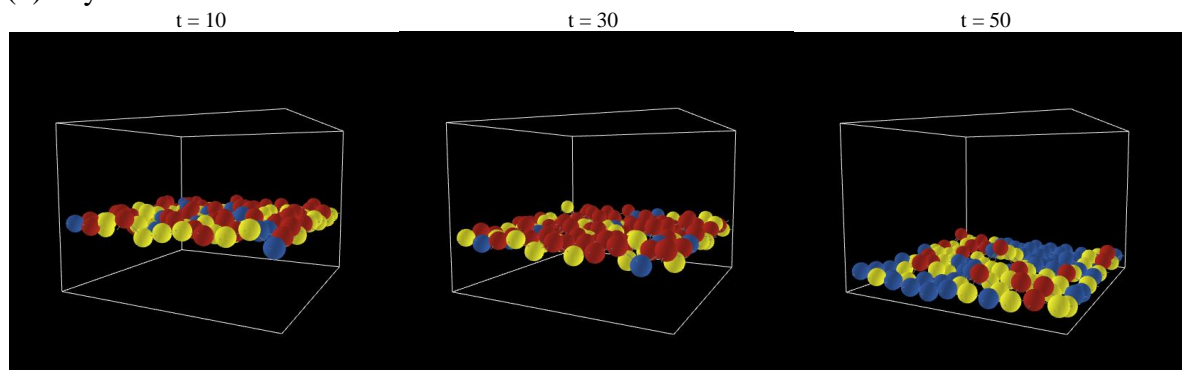


Figure 6.6. Evolution of effort levels across time under different reward schemes (Base Model). Snapshots of model taken at selected perspectives and time points illustrating the motivational dynamics of agents. Z-axis represents the effort an agent is willing to contribute W . Agents in red are in a state of underreward (negative inequity), blue in an equitable state, and yellow in a state of overreward (positive inequity).

In seeking explanations, the rise in aggregate output for PFP could be attributable to the compounding effects of agents persisting in the positive-inequity state as a result of staying in an easier job. Yet there are many periods in time when such “easy job” agents felt

under-rewarded (negative inequity); and more surprisingly, there are agents working on harder jobs experiencing positive inequity state for prolonged periods and continue to increase effort at work to a maximum. Observing the 3-dimensional diagrams and tracking multiple agents individually, it is observed that these can occur when (1) agents are surrounded by more agents working in equally tough jobs, and these neighbors are decreasing their effort in search of their own local inequity with their own neighbors working on easy jobs, or (2) by the unique comparison-adjustment history^{6.14} they underwent, a path dependent (Sydow, Schreyögg, & Koch, 2009; Vergne & Durand, 2011) process. A more important inference is that for PFP, the summed increase in individual output is larger than the summed reduction of individual output, nullifying suggestions of canceling-out effects.

In summary, the general observation that PFP is superior in terms of higher collective performance is shown to be generated by the minimal condition of agents seeking for fairness. There is no need for greater personal gain as mechanism. Figure 6.4 showed that (1) this effect requires time and iterated rounds of comparison for it to be sufficiently large, which is maximum when the system reaches equilibrium/stabilized; and (2) between time periods, there can be decreases in aggregate output despite an overall gradual increase over several periods. Figure 6.5 shows that if each run represents a separate collective/firm, there can be (1) substantial differences between collectives in terms of the changes in aggregate output; (2) such differences can be small at the start of implementation and vary more widely as agents adjust and system evolves; and (3) such differences tend to be larger for collectives implementing PFP. Figure 6.6 shows that (1) under PFT, despite mutual adjustments of

^{6.14} A focal agent may be working on a difficult job compared to its neighbors working on easier job, but due to its neighbors (having a different von Neumann neighborhood) increase in effort occurring earlier and much faster than the focal agents, the focal agent will appear to comparatively have a higher outcome-input ratio, compelling him/her to a positive inequity state, thereby increasing effort accordingly even though he/she is working on a tough job. Several other paths could lead to the similar outcome for but this is one of the more common path.

agents in PFT that are seemingly small and symmetrical at short time and spatial scales, it is a segment of larger decrease over longer and larger scales; (2) under PFP, agents' effort is not just a direct function of job difficulty level, but an outcome of position in network (i.e., neighborhood characteristics) and iterative history of the agents and its neighborhood. Finally, cost-per-unit of output from implementing either reward scheme is a concern for businesses. It is deductively inferable that for PFT, total pay is constant while cost per unit of output increases over time (till steady state), and for PFP, total pay increases while cost-per-unit is kept constant. Hence despite starting at approximately same level, total pay for PFP rises to be higher than PFT, and PFP's cost-per-unit is lower than PFT at steady state.

Discussion

The data generated from the model illustrates that justice and equity concerns alone, without concerns for self-interest, utility, goal-setting, or tournament ranking, is *sufficient* to produce the broad empirical observation that PFP leads to higher collective or firm performance. But beyond that, the model shows why the paradox of PFP may have persisted if equity concerns were salient. In the context of PFP multiple rounds of reward-effort comparisons between self and others are required for the changes in collective performance to be discernible. When measuring the effect of reward scheme implementations at the dyadic or small teams level, what may appear to be minor adjustments of effort by those in underreward and overreward states, are segments of collective performance gradually moving toward higher or lower levels in the long-run. For both reward schemes, what is observable at the short-term and micro-scale is qualitatively different at the long-term and macro-scale. Given that self-determination theory and crowding out effect are individual-level theories, like most other motivational theories, operating at a shorter time scales, their mechanisms are inherently unintended to explain higher level production outcomes over long periods of time.

The key finding here attest and explained the meta-analytic findings of Condly, Clark, and Stolovitch (2003) who found evidence for PFP's *strengthening effect over time* but could not find the reasons for it from the studies they reviewed (p. 53-54).

Similarly, several meta-analyses from Guzzo, Jette, and Katzell (1985) to Jenkins, Mitra, Gupta, and Shaw (1998) and Cerasoli, Nicklin, and Ford (2014), argued for the need to consider numerous moderating factors influencing the “true” effect of PFP. Factors such as quality versus quantity, cognitive versus manual tasks, and study settings have been studied. But large unexplained variance remained and between studies/samples effects are still significant. To the extent that each random initialization represents one firm/collective with its own unique context, the fluctuating and larger variance for PFP meant that random stochasticity non-attributable to any specific factors can result in larger variance observed in the real world. The fluctuations observed in the model's time-based tracking of collective performance also suggest that the point in time where data are collected for empirical studies may yield different results even for the same firm as the number of employees in overreward or underreward state may be considerably different from one time point to another.

For firms and policy-makers, there are several direct implications. First, where tournament effect is mild such as production operators on the same production lines, or for cab drivers without externally imposed interventions such as MBOs, performance appraisal, or forced ranking, equity concerns will still make a sufficient business case for the implementation of PFP. Second, to see the effects of PFP managers require patience as PFP's effect takes time to manifest and will fluctuate, hence there is no need to be quick to exert control or troubleshoot a plan's implementation. Third, identical reward schemes implemented at similar subsidiaries or departments may yield similar effect in the long-run, but exhibit different rates and patterns of increase. For the latter two aspects, it implied

relevant information about PFP and employees' responses would still need to be monitored, but scarce stakeholder and managerial attention (Ocasio, 1997) can be placed on other business and managerial tasks.

Ultimately, the findings are *only* based on simulation data and external validity may be questioned. Yet by making assumptions explicit and exploring equity theory formally while controlling for mechanisms that would have otherwise clouded its effects, equity theory's role in PFP's cross-level influence on collective performance is made clear. While the prescriptive findings recommendation for "patience" and to look away from exerting too much attention/control may not sit well with managers, or even researchers at-large, they are aligned with Hackman's (2012) comments to look beyond causes and effects in group (or social systems) research.

"Groups are not mere assemblies of multiple cause-effect relationships; instead, they exhibit emergent and dynamic properties that are not well captured by standard causal models." (Hackman, 2012, p. 443). Such views are also reflected in what Chiu and Qiu (2014) consider as complexity theory, or more generally, complex systems theory. In this view, Hackman focused research on the "minimum number of conditions which, when present, increase the likelihood (but do not guarantee) that specified normative outcomes" will manifest (p. 435). This perspective is taken here wherein equity-based fairness, operationalized through Adams's (1965) formula is found to be minimally sufficient to generate the outcomes often seen in pay for performance. By 'bracketing' collective-level phenomenon (Hackman, 2012, p. 441) and tracking individual and group level data over time, the temporal dynamics (Hackman, 2012, p. 439) of equity theory were analyzed to yield counter-intuitive but theoretically based recommendations for firms.

To extend the findings further, subsequent chapters explore how human dimensions of memory, cognitive bias, and preference to compare with more or less others may influence the above results^{6.15}. They serve an explorative purpose but showed that when equity concerns are salient, there are (a) conditions where PFT may be superior to PFP in generating higher collective performance, (b) individual-level explanations for past PFP's equivocal findings, and (c) options for managers stuck with legacy PFT schemes to tweak their systems.

^{6.15} Many known psychological mechanisms can be added. While the aim, following the KISS tradition of ABM (Deffuant, Weisbuch, Amblard, & Faure, 2003) is not to make models ever more realistic but models that can inform future empirical and theoretical work, human dimensions of social cognition are incrementally added (Chen, Chie, & Zhang, 2015) to find boundary conditions to the base model. For instance, equity sensitivity (Huseman, Hatfield, & Miles, 1987) is a proximal individual difference related to equity theory. A new and separate research can be undertaken to inform future work on optimal proportions of benevolents, sensitives, and entitleds. But for purpose of looking at more fundamental processes (such as memory), equity sensitivity is explored here as a robustness test (to find limits to inference) leaving opportunities for further extend the model.

In this robustness and exploration, Equity Sensitivity is represented as the extent to which an agent switches states and respond to discrepancies. For simplicity and to keep focus on PFP, Equation 7 is tweaked with η varied from 0.025, 0.10, 20, to 0.30. Hence it is a symmetrical step function, representing the middle spectrum of equity sensitives (Huseman et al., 1987). Higher values of η represents lower sensitivity. To avoid possible random effects, 20 runs per combination of equity sensitivity were conducted for a total of 100 runs (including a re-run of $\eta = 0.05$). Results show PFP's cross-level incentive effect to remain for η values smaller (0.025) and larger (0.10) than the original value of 0.05. But as η gets larger (0.30, meaning that agents are do not respond to equity discrepancies even if others are getting paid nearly 30 percent more than themselves) and agents become less sensitive to discrepancies Φ , the incentive effect diminishes and the agents continue to produce at initial levels. This means there is no disincentive effect nor switching of regimes for PFP, and for equity theory to work, agents must be aware and sensitive to differences in equity ratio of self and peers, a fact congruent with Adams's (1965) postulation. This exploration shows equity sensitivity, symmetrical and asymmetrical, to be a worthwhile future exploration and indicate that below η levels of 0.30, cross-level incentive effect from PFP will be expected. The field correspondence of η levels of 0.30 will be a future matter of empirical calibration.

Chapter 7

COMPUTATIONAL EXPERIMENT 2 (MEMORY)

Memory

Memory broadly refers to the ability to encode, store, retain, and recall information and experiences. Since Ebbinghaus's early works, studies of memory "have concentrated on deriving general laws and capacities for memory ... for the study of memory performance for arbitrary sequences of information" (Ericsson & Kintsch, 1995, p. 212). Conceptual categories guiding research in this area include those such as storage, retrieval, elements, chunks, items, superior performance, memory span, resources, and trace, just to name a few. While appearing metaphorical, these concepts have given rise to rich theories such as the multi-store model of memory (Atkinson & Shiffrin, 1968), working-memory model (Baddeley & Hitch, 1974), and ACT-R production architecture theory (Anderson, 1983). Within various aspects of memory, such as typologies, performance, and encoding processes, one that stands out as antecedent to all these is memory capacity.

Memory capacity was brought to attention when Miller (1956) showed via Information Theory the limits of human information processing. While no mention was made about how the seven (plus or minus two) information chunks should be applied to any contemporary memory types, later researchers tended to consider the limit as applicable to working and short-term memory. In his paper, memory capacity was synonymous with memory span (see also Dempster, 1981). In analytical and computational context^{7.1}, other

^{7.1} Agent-based implementations of human memory have flourished within cognitive science and complex architectures of agents. Such models either represent effect of memory based on processual and multi-store models of memory, example ACT-R agent architecture (Anderson et al., 2004; Reitter & Lebiere, 2011), or neural layer models of production systems, example CLARION (Sun & Peterson, 1998; Sun & Naveh, 2004). Despite fulfilling aspects of ABM, such as inter-agent interactions, Monroe and Read (2008) consider such ABM as connectionist and focusing more on intra-personal phenomena (p. 506). Other than these several other studies have operationalized memory differently and focused on different aspects of memory such as recognition memory (e.g., Aktipis, 2006)

researchers considered memory capacity as discrete recording of information (Miller, Pentland, & Choi, 2012), memory capacity in the light of bounded rationality (e.g., Mullainathan, 2002; Frey, 2005; Arthur, 1994), history length of player (e.g., Gilboa & Samet, 1989; Kalai & Stanford, 1986; Levy, Levy, & Solomon, 1994), and memory length (e.g., Axtell, Epstein, & Young, 2000; Hauert & Schuster, 1997). Though most of these author's linear first-in-first-out perspective of memory as a list does not fit perfectly well with the multi-store model of memory (Atkinson & Shiffrin, 1968), Craik and Lockhart's (1972) levels of processing theory and Brown, Neath, and Chater's (2007) temporal ratio model of memory can be used as theoretical basis for such operationalization. For the former, memory performance is not discontinuous or dependent on separate memory stores, rather capacity and its subsequent performance lie on a continuum (Craik and Lockhart, 1972). For the latter, memory retrieval is scale-similar and continuous throughout a wide range of temporal scales without distinction into different stores. Both these perspectives, combined with LeBaron's (2006) point that "there is no a priori argument for any particular history length" (p. 1197), warrant studying memory capacity as a linearly increasing scalar without any assumption on which memory stores it may involve.

Memory in Business Related Domains

Memory, though a lesser concern within HR, is a topic of interest to organization and finance researchers. Theories such as organizational memory (Walsh & Ungson, 1991), transactive memory^{7.2} (Liang, Moreland, & Argote, 1995; Wegner, 1987), emergent fractal-

^{7.2} In building transactive memory theory, Wegner's early argument (Wegner, Giuliano, & Hertel, 1985) placed transactive memory as "not much different from the notion of individual memory" (p. 256) and that transactive memory is a component of individual memory. Though like many theories in management, Wegner et al. (1985) acknowledged this is an "analogical leap" (p.256, para 2) with its application occurring mostly at the group/team/system level (see Ren & Argote, 2011), transactive memory is mainly concerned with *knowing who knows what*, rather than who did and received what. Hence, for fidelity to the comparison process, this study refrains from discussing the most common memory construct within the domain of OB, focusing only on the basic notion of human memory.

like effects such as long-memory effects in financial markets (e.g., Guth & Ludwig, 2000; Garzarelli, Cristelli, Pompa, Zaccaria, & Pietronero, 2014), and others (e.g., Beran, Feng, Ghosh, & Kulik, 2013; Jagla, Landes, & Rosso, 2014; Yulmetyev et al., 2009) conceptualizes memory at the collective and system level. They explored the stability of routines, coordination of tasks, or recurrence of patterns at different time scales successfully to many contexts. For the present study, however, the aim is not on the emergence of memory, but on how individual-level human memory impacts the emergence of system-level behavior.

Memory and Equity Theory

In reviewing equity theory, it was apparent through several authors (e.g., Carrell & Dittrich, 1978; Vecchio, 1982; Lawler, Koplun, Young, & Fadem, 1968; Huesmann & Levinger, 1976 and Cosier & Dalton, 1983) that despite Adams's (1965) brief consideration of effects of time, researchers tended to consider and test equity theory's prediction in a single comparison induction-to-response experimental design. Even though the above base model showed effects of equity theory across long time periods, individual-level memory, a by-product of time, has had few considerations except for Vecchio (1982) and Cosier and Dalton (1983). Even so both Vecchio (1982) and Cosier and Dalton (1983) gave mostly a theoretical and formulaic discussion.

Vecchio (1982) was concerned about the effect of time post-comparison, in particular the tendency of inequity to approach equity after considerable "passage of time" (p. 108). In this theorizing, comparison of others to self occurs only once to yield a single index of psychological inequity. In Cosier and Dalton (1983), as revealed through their analogy of "the straw that broke the camel's back" (p. 315) effects of inequity ("tension") from all past comparisons are episodic and accumulated over time. Both theories consider time as discrete,

but Cosier and Dalton (1983) added a path dependent explanation fitting of findings often obtainable when tracking individual agents in agent-based models (p. 316, para 3-6).

Given all this, there is sufficient rationale to investigate how memory interacts with equity concerns to affect collective performance. Yet there has been little literature within management and equity theory research to suggest how far back in time one can recall, except for the assumption of unlimited memory in Vecchio and Cosier and Dalton. Hence, rather than exploration of a single memory capacity level, a range of memory capacities will be experimented.

Exploration into a new dimension also meant difficulties in hypothesizing possible effects of memory on collective performance. It can be argued that organizations with members recalling further back in time may “iron out” random fluctuations, hence the difference in stabilized aggregate output seen in the base model will be attenuated. But it could also be argued that inequity effects from differences in job difficulty differences, especially in the case of PFP, will be accentuated as agents are “reminded” of the same inequity from earlier periods. And in the latter case, where those working on easier jobs will produce more and those on difficult jobs produce less, there might be a canceling-out effect. With three possible directions of effect at the collective level, simulation modeling here is the appropriate methodological choice (Harrison, Lin, Carroll, & Carley, 2007).

Hypotheses are not normally offered in simulation research, since the consequences of the complex interactions of the model’s components are not logically obvious (if they were, a simulation would not be necessary); instead, the model’s consequences are determined computationally, and the findings may themselves be regarded as hypotheses or theoretical conclusions. (p. 1233)

To the extent that ABM may be similar in nature to grounded theory (Glaser & Strauss, 1967) in its generative orientation, there is then often “no clean break between collecting and analyzing data” (Suddaby, 2006, p. 636). Accordingly, the model’s mechanism

and formulas are constructed, and parameters of investigation defined in a manner similar to the base model for consistency and subsequent comparison^{7.3}. Data is analyzed iteratively starting from overall effects to further patterns discovered along the way.

Code Modifications

To explore how different memory capacity will work via equity theory, under the implementation of pay for performance, linear non-probabilistic^{7.4} operationalization of memory similar to Arthur (1994), Mullainathan (2002), Huck & Sarin (2004), and LeBaron (2001a,b & 2002) is followed. Therein, players/agents update memory with new information while older information is deleted from memory. To represent this, Equation 6 for equity discrepancy is expanded to a generalized form incorporating memory capacity $K = \{1, 2, \dots\}$. Formally, this effective equity discrepancy ratio, Γ , at time t is defined as

$$\Gamma_{i,t} = \begin{cases} \frac{\sum_{a=t-k+1}^t \Phi_a}{k} & , \text{ when } t \geq k \\ \frac{\sum_{a=0}^t \Phi_a}{t+1} & , \text{ when } t < k \end{cases} \quad (9)$$

where Φ refers to an agent's equity discrepancy of at a point in one of past time periods, k refers to memory capacity. The modified code is similar to that in the base model except for the use of a memory list and subsequent retrieval (Figure 7.1).

^{7.3} The absence of hypotheses is can be found even in domains with a strong positivist orientation. In I/O psychology, such as the work of Steiner and Rain (1989). The authors discussed possible effects, but refrained from making any directional hypothesis as “no current research exists to suggest whether primacy or recency effects occur in performance appraisal or if one effect is stronger than the other.” (p. 137)

^{7.4} See Miller, Pentland, and Choi (2012) for example of ABM in management domain utilizing probabilistic model of memory.

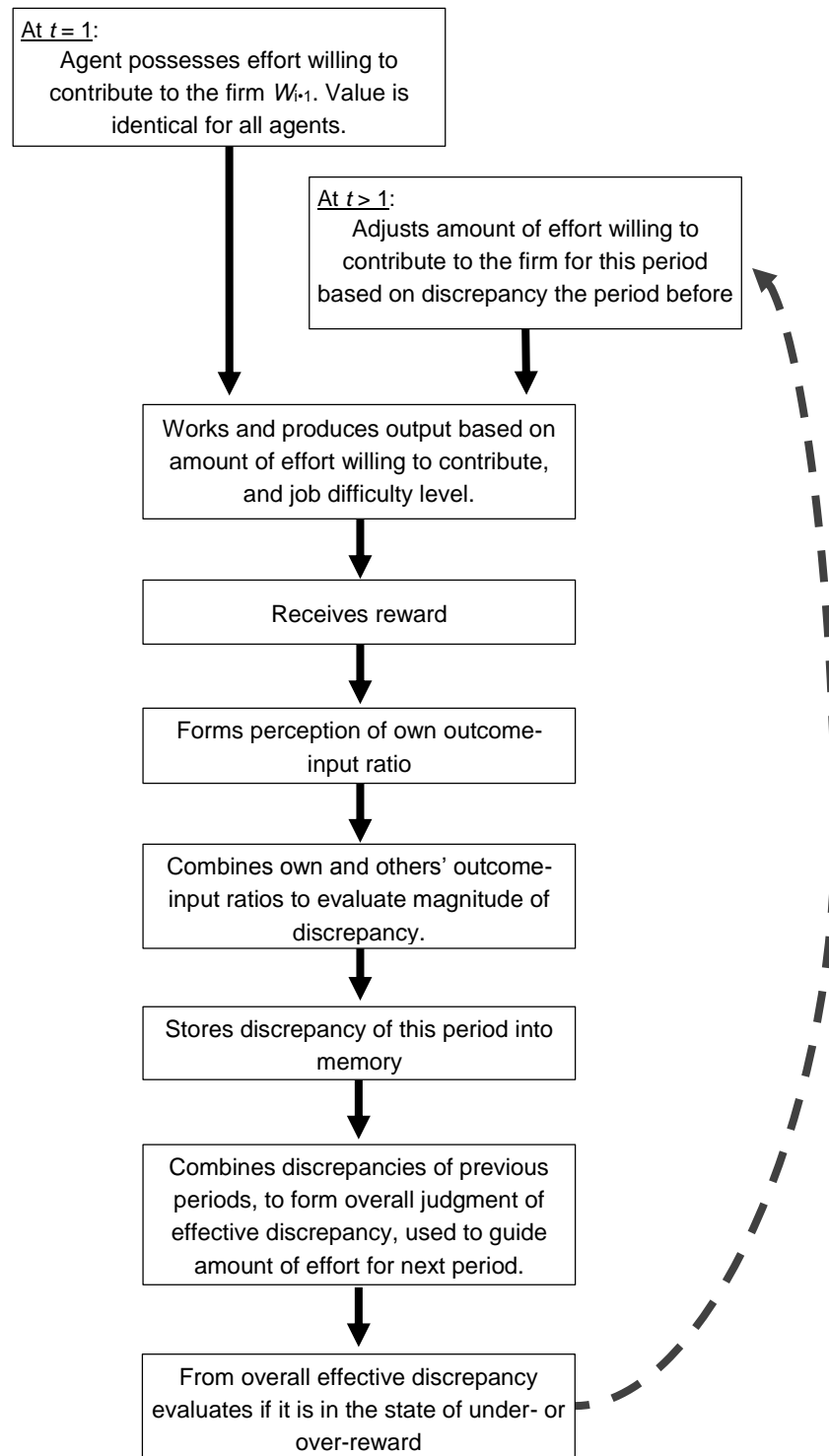


Figure 7.1. Agent processes to account for storage, recollection, and evaluation of discrepancy information.

Data Collection

For purposes of this investigation, discrete memory capacities of 1, 3, 5, 7, 9, and 11 turns are explored with same procedures as the base model forming 1,200 data points (100 runs, per memory capacity levels and two reward schemes). Setup parameters are as in Table 7.1.

Table 7.1

Parameters Setup for Experiment 2

System	Number of agents n	121
	Number of job positions	121
	Job difficulty levels D_j	4, 5
	Piece-rate payment G (when under PFP)	1
	Fixed salary L (when under PFT)	10
	Variability in output s	-1, 0, 1
Agents, $t=0$	Effort willing to contribute to the firm W	30
	Motivation to adjust effort M	1
	Discrepancy ratio Φ	1
	Inequity threshold η	0.05
Experimental Conditions	Memory Capacity	1, 3, 5, 7, 9, 11

Results

Similar to Experiment one, results are presented in stages. Average system behavior and statistical testing are reported followed by analysis of selected typical runs. Figure 7.2 shows the aggregate output through time for combinations of reward schemes and different memory capacities with each point representing the mean of 100 runs of each combination at each time point. While Figure 7.2a shows a monotonic decrease in stabilized aggregate output as PFP agents recall further into the past, Figure 7.2b shows a different picture when

agents are paid for time (also seen in Figure 7.3). In the PFT condition, higher memory capacities lead to higher stabilized long-term aggregate output up till a maximum of five turns, from which further increases in memory correspond to a gradual decrease in long-term aggregate output.

To ascertain if PFP is superior to PFT (in terms of collective performance) after incorporating effects of memory, aggregate output at a point post stabilization ($t = 1,000$) is assessed. Despite stabilized aggregate output of PFP across 600 runs ($M_{\text{PFP}} = 1,132$ $SD = 40.71$) being larger than that of PFT ($M_{\text{PFT}} = 971.52$ $SD = 516.34$) and significant ($CI_{\text{PFT}} [928, 1,015]$, $CI_{\text{PFP}} [1,129, 1,136]$, $p < 0.001$), the large variance of PFT at $t = 1,000$ precludes exploring reward scheme's mean values as a meaningful main effect. Rather explanation of variance lies in the interactions. Table 7.2 details the mean and standard deviation of aggregate output for each combination of reward scheme \times memory capacity level, and Figure 7.3 plots this relationship for each reward scheme separately. Accordingly, a 2×6 ANOVA of reward scheme \times memory capacity interaction effect ($F(5, 1,188) = 14,977$, $p < .001$, $\eta_p^2 = .98$) is shown to be significant. Stabilized aggregate output of agents under PFP decreases as agents recall further back in time while stabilized aggregate output of agents under PFT exhibit a non-monotonic relationship. Considering stabilized output at lower levels of memory capacities, the results show a cross-over interaction.

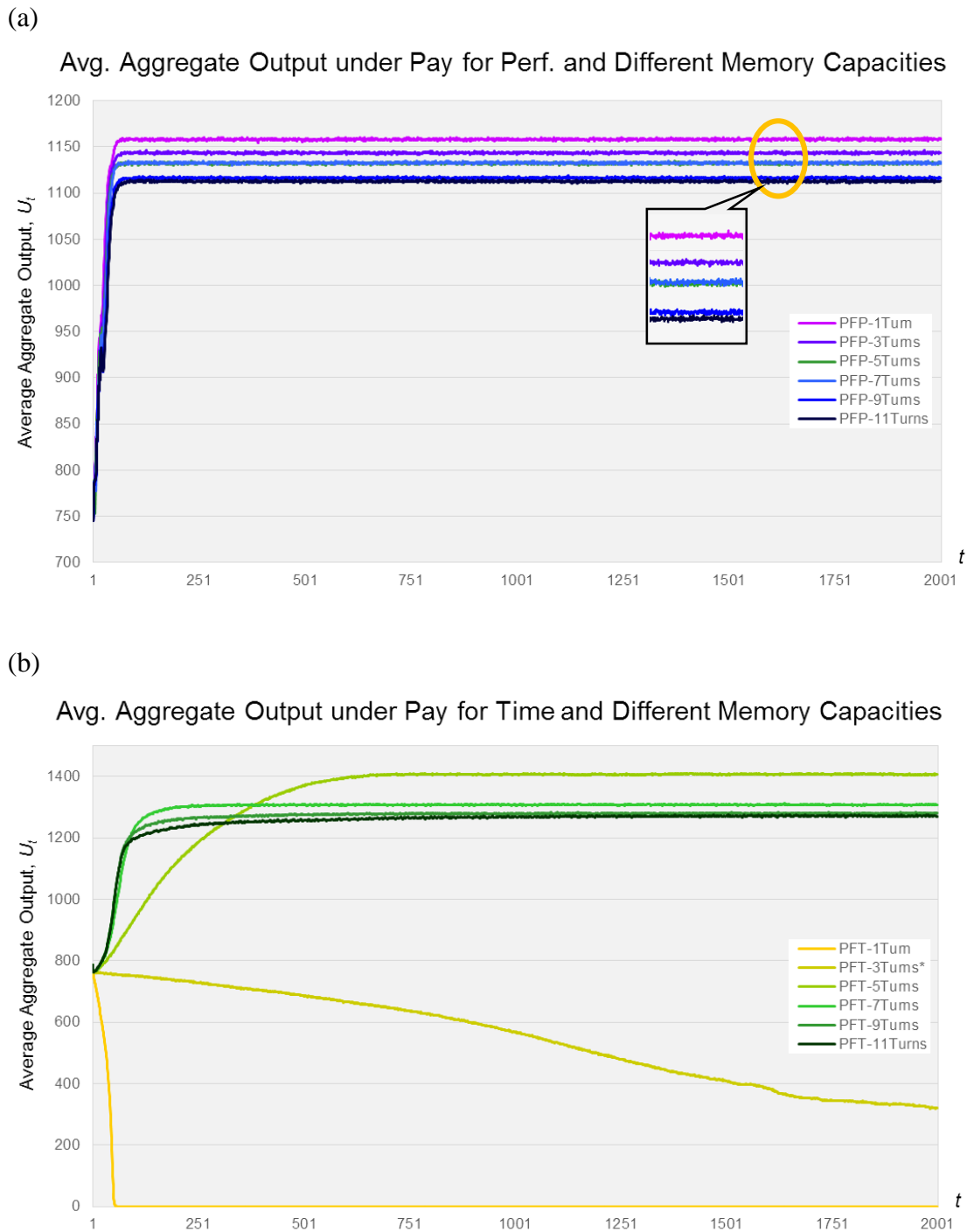
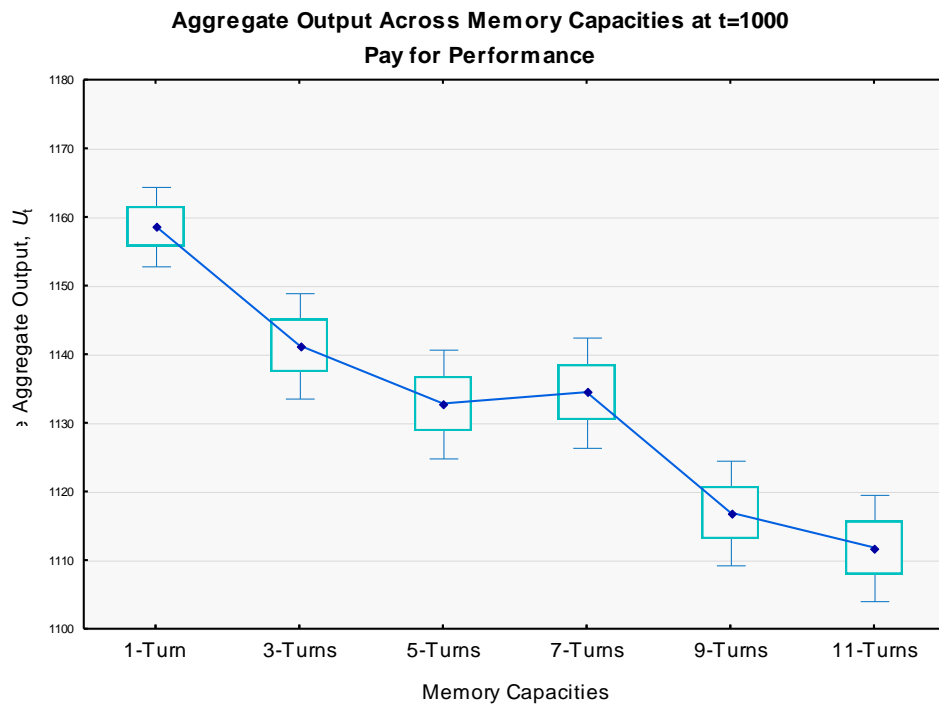


Figure 7.2. Aggregate Output of Different Reward Schemes and Memory Capacities Across Time. Scale of time-axis begins at $t=1$ as at $t=0$ agents are not assumed to have completed any job tasks. Both diagrams above show overlapping lines, such as that for PFP-9Turns with PFP-11Turns, and PFP-5Turns and PFP-7Turns. Figure 7.3 of aggregate output at a selected point in time post stabilization illustrates the overlapping confidence intervals. For PFP-3Turns, see additional analyses in forthcoming text.

(a)



(b)

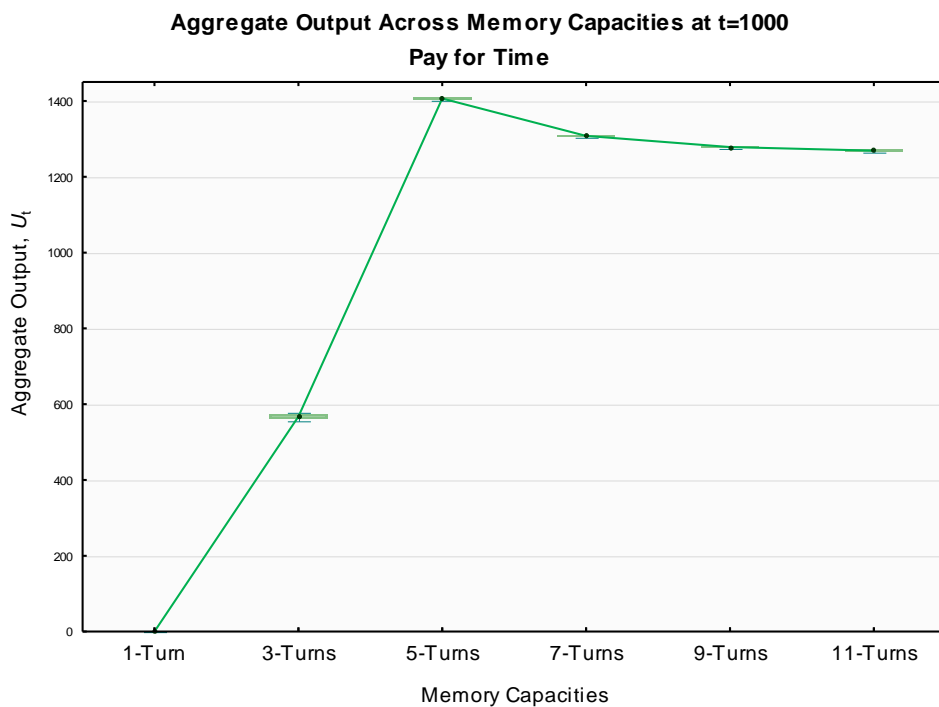


Figure 7.3. Aggregate Output of Different Reward Schemes and Memory Capacities at $t=1000$. Y-axis of two charts are different. The y-axis of pay for time (first chart) is stretched to incorporate the zero aggregate output at $t=1000$, time post stabilization. Results for 1-Turn is similar to that obtained in Experiment one (base model).

Table 7.2.

Aggregate output at $t=1,000$ for different levels of reward schemes and memory capacities

Reward Scheme	1 Turn		3 Turns		5 Turns		7 Turns		9 Turns		11 Turns	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Pay for Time	0.00	0.00	567.35	56.75	1,406.41	22.78	1,307.91	18.57	1,278.50	18.17	1,268.97	20.03
Pay for Performance	1,158.67	29.18	1,141.29	38.67	1,132.82	39.95	1,134.48	40.48	1,116.94	38.42	1,111.84	39.01

The above results goes more than confirming PFP to be superior to PFT, or that memory is a moderator to the effects of reward scheme on aggregate output. Central to agent-based models is its generative nature (Epstein, 2006). In this case Figure 7.2 and Figure 7.3 show there are situations where PFT may lead to higher collective performance than PFP. Though aggregate output for collectives under PFP is higher than PFT when memory capacities of agents are short (like experiment one), Table 7.2 reveals aggregate output of under PFT can be higher than that of PFP when memory capacity goes for back five or more periods. To test such differences to be significant, post-hoc Scheffe's test was performed between aggregate output of PFP 1-turn with PFT 3-turns, PFT 5-turns, PFT 7-turns, PFT 9-turns, and PFT 11-turns, respectively. All pairwise comparisons were significant $p < .001$.

In addition, the results replicated earlier finding in the base model that there are larger between-run variations of aggregate output levels for PFP than for PFT. And lastly, small mutual adjustments between agents in the context of PFT do not necessarily lead to a decrease in aggregate output (compare Figure 6.6 and Figure 7.4). Contrary to results of the base model, performance of collective under PFT increases over time when agents have sufficiently large memory capacities. Illustrating this using parameter combination of PFT

agents remembering only the last five turns, Figure 7.4 shows repeated mutual adjustment at the local level leading to a global increase in effort for all agents in the long run.

Pay-for-time | Memory Capacity: 5-Turns

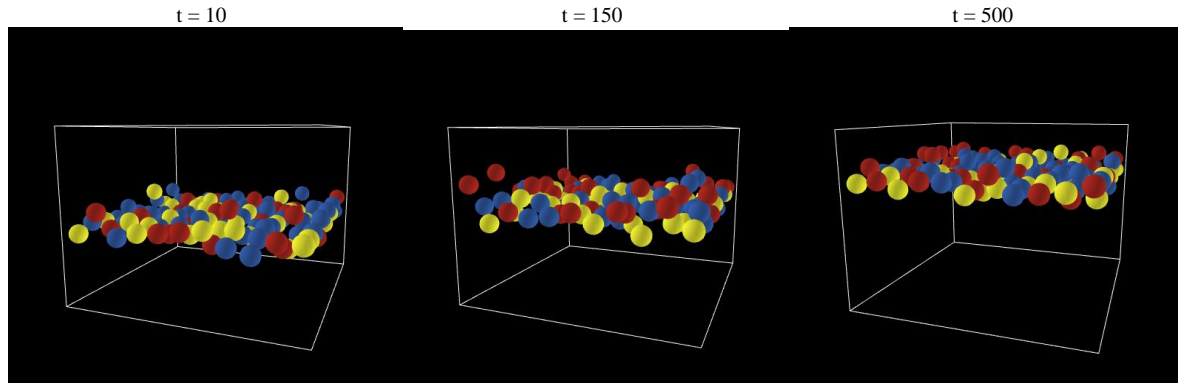


Figure 7.4. Evolution of effort levels across time under PFT 5-Turns. Snapshots of model taken at perspectives and time points illustrating the motivational dynamics of agents. Z-axis represents the effort an agent is willing to contribute W .

Additional Analyses

When exploring the data of aggregate output for each combination, a property for the parameter combination of paid for time agents remembering for three periods back in time (PFT 3-turns) was uncovered. The pattern of averaged aggregate output for this combination across time (Figure 7.2b) is not representative of the trajectory of any typical run for the combination. While it is appropriate and common to mainly focus on mean values (e.g., Axelrod, 1997c) and describe variations via single indices (e.g., Fang, Lee, & Schilling, 2010), when multiple attractors are present, such ensemble averages can be erroneous when translating research insights to real-world applications. Hence there is a need to probe the nature of this property at a finer grain (Kitts, 2003). Figure 7.5 shows aggregate output across time for two typical runs for the combination of PFT 3-turns. Unlike other combinations with only one equilibrium level, there exist two equilibria for PFT 3-turns, with a second-order phase transition preceding the intermediate equilibrium, and a first-order phase transition^{7.5}

^{7.5} Not to be confused with first-order and second-order change typologies (Van de Ven & Poole, 1995) that most management and OB readers would be more familiar with. While first-order change in Van de Ven and

preceding the second and final equilibrium. While the intermediate equilibrium shows asymptotic stability and seemed to be fixed-point attractors (Nowak, Vallacher, Tesser, & Borkowski, 2000; Beutement & Broenner, 2011) in a medium-term, they are transient attractors in the long term.

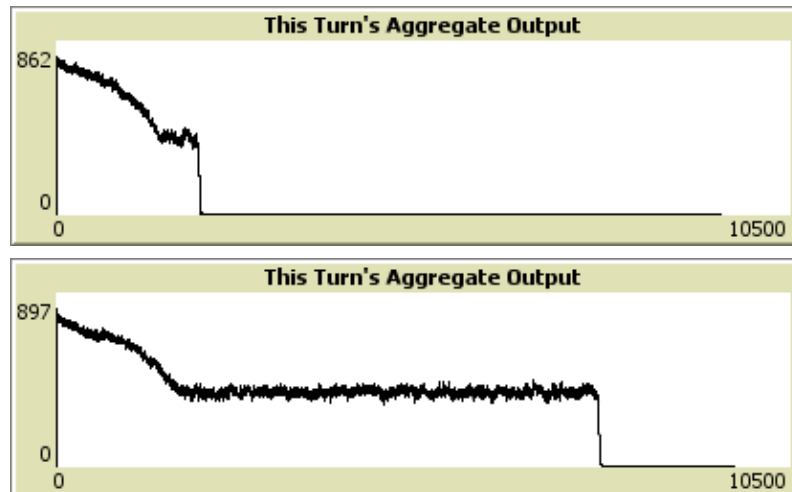


Figure 7.5. Aggregate Output of Two Separate Runs for Parameter Combination of Pay for Time and Memory Capacity of 3-Turns

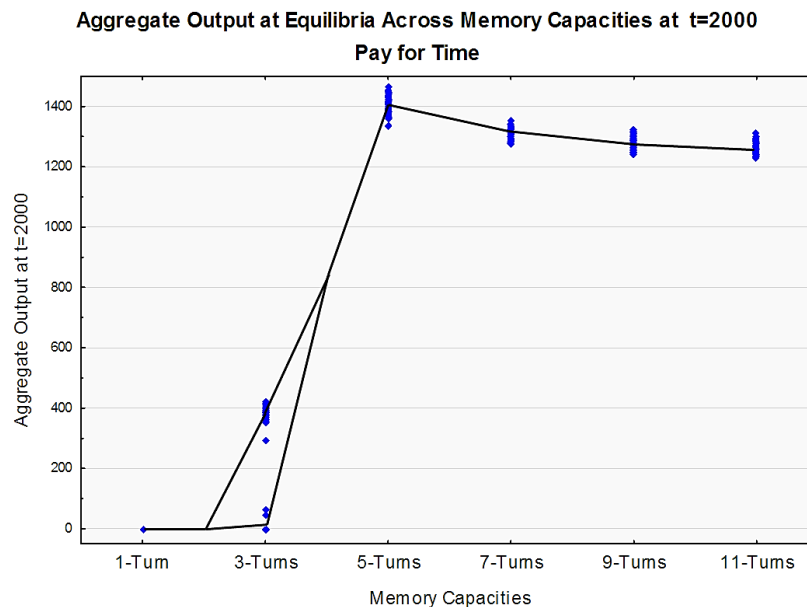


Figure 7.6. Aggregate Output across Memory Capacities at t=2000. At t=2000, the system of agents remembering for 3-Turns can converge to one of two range of equilibrium aggregate output levels.

Poole (1995) denotes incremental change and second-order change to be revolutionary and movements between punctuated equilibrium, here first-order phase transition refers to rapid discontinuous change and second-order phase transition refers to gradual change. See Castellano, Marsili and Vespignani (2000) for an illustration of its use on social science topic.

Accordingly, if aggregate output at a time, for instance $t=2000$, were plotted against memory we would obtain a diagram (Figure 7.6) suggestive of two equilibriums at parameter value of memory capacity 3-turns. To fully understand the nature of this property, 100 new runs for PFT 3-turns were simulated for a time scale of 20,000 periods. In addition local sensitivity analysis as per Railsback and Grimm (2013, p. 293) was also conducted by also obtaining data for neighboring parameter values. Accordingly, PFT 2-turns and PFT 4-turns were conducted and the time taken for system to reach equilibrium levels of zero is calculated. This metric allows us to know both when, and if each parameter combination reach final equilibrium levels of zero.

Table 7.3 shows that for PFT 3-turns, most of the first order transition occur most between $t = 2,000$ to $t = 3,000$ in a positively skew distribution with no runs staying in the intermediate equilibrium beyond $t=20,000$. Comparison with neighboring values, shows the property of PFT 3-turns to be unique. Therefore, 3-turns is the threshold level, where greater than this level of memory capacity, stabilized aggregate output will increase to a level similar to PFT 5-turns, and smaller than this level stabilized aggregate output will decrease to a level similar to PFT 1-turn.

Table 7.3

*Frequency of Time Periods Required to Reach Equilibrium at Zero
(Experiment 2)*

Time Interval		PFT 2-Turns	PFT 3-Turns	PFT 4-Turns
0	1,000	100	0	0
1,000	2,000	0	11	0
2,000	3,000	0	23	0
3,000	4,000	0	17	0
4,000	5,000	0	13	0
5,000	6,000	0	10	0
6,000	7,000	0	11	0

7,000	8,000	0	6	0
8,000	9,000	0	1	0
9,000	10,000	0	3	0
10,000	20,000	0	5	0

Note: PFT 4-Turns has frequency of zeros for all interval up till 10,000 – 20,000 as no runs of this combination converges to an equilibrium level of zero aggregate output. Values for range are obtained by taking the minimum and maximum of the last 500 periods for all runs of each combination.

Such regime shift (not regime switch) occurring near tipping points is not uncommon for complex systems. The results here suggest that the system with same rule at different parameter values transits from Li, Packard, & Langton’s (1990) classification of Class 1 CA at memory capacity less than 3 turns, to Class 6 at memory capacity of 3 turns, to Class 4 at memory capacity of 4 to 5 turns, and Class 3 at memory capacity of bigger than 5 turns. Specifically, the long transient observed reflects the generic observation that “transients grow rapidly in the vicinity of the transition between ordered and disordered dynamics” (Langton, 1990, p. 25).

While it will be intuitive to seek explanation for a collective to be stuck at an intermediate production level, or for its shift in basin of attractor, the strict computational nature of the model does not allow for anthropomorphic contemplation beyond the mechanism modeled. This dilemma for the theorist is not unique to complicated models of agents with memory. The highly revered work of several complex systems modelers do recognize that such emergence could not be easily explained, though through numerous robustness test they gain confidence and insight for their models. For instance, the highly cited zero-memory ABM work of Martin Nowak and Robert May (1992b) not only not try to explain why such pattern can emerge, but are at a lost as to why their results are so robust, by stating, “why the approximation also works for the irregular, spatially chaotic patterns, we do not know.” (p. 828)

Nonetheless, many manual initiation of runs is performed and observations monitored showing that PFT 3-turns's discontinuous change could be a result of random perturbations, and depending on both the perturbation and stochasticity at initialization, the system may be nudged out of its intermediate basin of attraction to the final absorbing state. While this explanation that "the system can always escape from these attractors by any small perturbation" (p. 333) has been used by Klemm, Equiluz, Toral, and Miguel's (2005) for broadly similar phenomena, do note though that here the perturbations are endogenous (instead of exogenous), present at all time points, and identical for all combinations. To gain even further insights, unfortunately not leading to any better explanation, additional data on proportion of each inequity types were collected. Tracking this data with aggregate output, found that for PFT 3-turns, about 50-100 time periods before first order phase transition occurs, there exist a gradual increase in proportion of positive inequities matching a corresponding decrease in negative inequity (Figure 7.7). Apparently, as this gap builds up, it was not sustainable. As all agents continue to seek equity, the system reached to a point where all agents abruptly decrease their effort to near zero levels and global equity is achieved with all agents receiving the same pay for exerting the same near zero effort levels. For the incentive effect uncovered for PFT 5-turns (Figure 7.2b), the proportion of equitables initially decreases to levels below that of positive and negative inequities, before climbing steadily (Figure 7.8). This steady increase corresponds with an increase in aggregate output till aggregate output reaches its asymptotic maximum and equitables are more than either of the other two equity states. In terms, of neighborhood topological conditions, no clustering occurred at any time points, but at higher levels of memory, dynamic stability with phase synchrony was observed as all agents continuously coordinate amongst themselves to achieve equity. Hence as a paradigmatic epistemological distinction, the explanation lies in the model (Carley, 2001; Sawyer, 2003; Carley & Gasser, 1999; Cohen & Cyert, 1965), and the tool

reveals patterns that though deterministic and deductive, cannot be easily explained from a reductionist or linear perspective (Sawyer, 2005; Kwapien, Drozd, 2012; Gell-Mann, 1994; Kauffman, 1993).

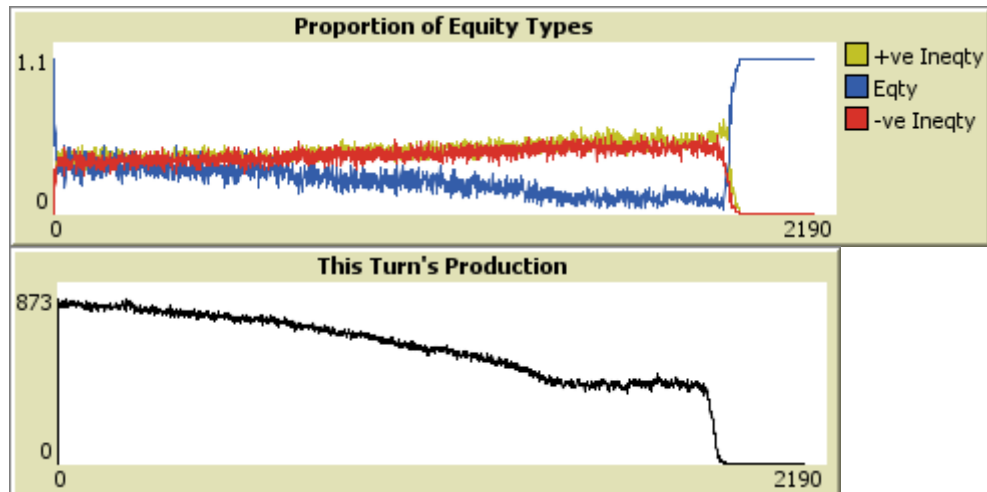


Figure 7.7. Proportion of Equity Types and Aggregate output in a typical run for parameter combination of PFT and Memory Capacity of 3-Turns

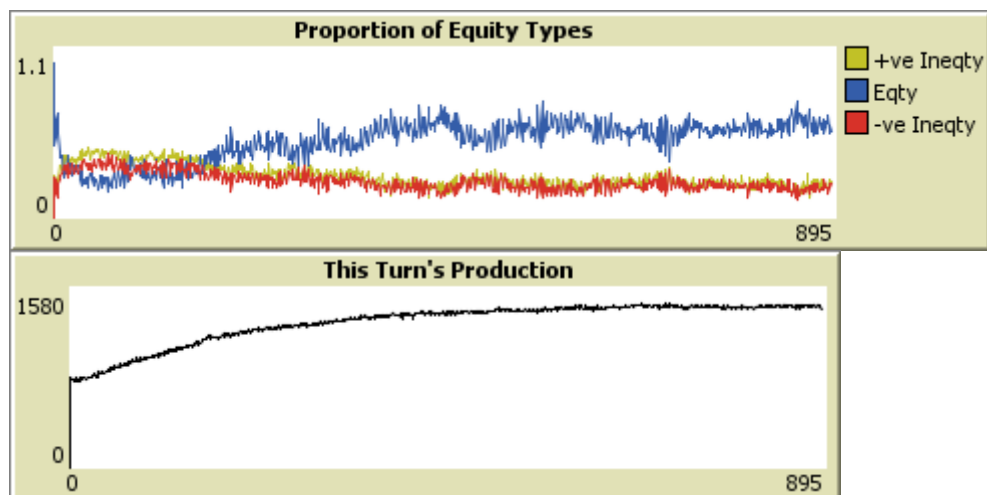


Figure 7.8. Proportion of Equity Types and Aggregate output in a typical run for parameter combination of PFT and Memory Capacity of 5-Turns

Discussion

Statistical tests, analysis of typical runs, and local sensitivity analysis above reveal how aggregate output changes across levels of memory capacity for different reward schemes. More importantly, the incorporation of memory to PFP's cross-level effect and the distribution of trajectories answers a classic concern by Lawler, Koplín, Young, and Fadem (1968) that studies on "effects of inequity on productivity [have] *not* tended to focus on the productivity variance within the different treatments" (p. 256, italics added). Here, the combinational outcome of memory and reward scheme on production under equity theory is analyzed with selective probing of individual runs painting a picture of possible varied trajectories and equilibrium outcomes.

Among the findings, the results showed that agents who remember longer into the past (more information to guide behavior) do not necessarily lead to superior or inferior collective performance. It depends on the manner reward is distributed, and vice versa. Collective performance has a slight negative relationship with memory capacity when agents are paid for performance and a non-linear relationship when agents are paid for time. On top of that, the results show that when memory capacity is varied, there exist a level of memory capacity under PFT where it is conducive for generating high collective performance. This means for organizations where changing from one reward scheme to another is not possible, an alternative will be to adjust availability and presentation of historical performance and pay information^{7.6}. As transition from PFT to PFP is often resisted by unions (Brown & Warren, 2011; Verma, 2005; Gratz, 2009; Zingheim & Schuster, 2008; Krats & Brown, 2013), such

^{7.6} Availability and presentation of pay and performance are emphasized as it is beyond practical means for managers or policy makers to manipulate employees memory or their desire to search for information on a long term basis. Instead, as Adams (1965) argued, comparison of rewards and effort is commonplace, natural, and inevitable, hence availability and provision of information should serve as one means to effect the memory capacity effect observed in the model.

organizations could boost production simply by making performance and pay information available and in a regular manner.

How far back in time should performance and pay information be made available? Is it right to disclose historical performance and pay information of others over time? Concerns over pay secrecy is as much an ethical concern, a labor relations fear, and an institutional-mimetic pressure that depends on specific HR context. Embedded in implementation, however, is the search for the real-world equivalence of memory capacities. As social science agent-based modelling is more concerned with the detection of patterns (Railsback and Grimm, 2013) rather than point estimate (Grüne-Yanoff & Weirich, 2010, Moretti, 2002), “turns” in memory capacity may not exactly equate to performance review of, for instance, one, two, or three months.

Under PFP, provision of pay and performance information further back in time would relate with a decrease in collective performance. Hence it is prescriptive to just reduce information from distant past for personnel with large performance-pay component. Under PFT, however, personnel recalling further back in time will generate higher collective performance up to a point. Hence for organizations wanting to avoid its negative effect and benefit from its upside potential, the above sensitivity analysis showed managers need only increase provision of historical information up to a threshold, where beyond that point firm performance would not be expected to increase. The point before this threshold can be located by identifying the extent of historical information that, when provided, generates collective performance that tends to persist at half its pre-implementation levels (Figure 7.5).

Reasonably, there will be concern to ponder upon the assumptions of past computational scientist such as that by Miller, Pentland, and Choi (2012), Mullainathan, (2002), Arthur (1994), Gilboa and Samet (1989), Kalai and Stanford (1986), Levy, Levy, and

Solomon (1994), Axtell, Epstein, & Young,(2000), and Hauert and Schuster (1997) to model memory as linear and unweighted. Hence, a pervasive memory-based cognitive bias is explored in the next experiment.

Chapter 8

COMPUTATIONAL EXPERIMENT 3 (COGNITIVE BIAS)

Cognitive Bias

Defined in the broadest sense, cognitive bias is termed as deviation from normative evaluations, judgment or thoughts (Caverni, Fabre, & Gonzalez, 1990, p. 8; Kahneman & Tversky, 1972; Wilkinson & Klaes). Such deviations mostly observed with rational norm as baseline, have grown to include a long list of heuristics, perceptual distortions, fallacies, and illusions (see Carter, Kaufmann, & Michel, 2007, and Senders & Moray, 1991). Amongst these, the serial position effect of recency bias/effect is one of the most pervasive (Pinto & Baddeley, 1991; Nisbett & Ross, 1980) and has been implicated with performance evaluation, and to a smaller extent job analysis and job evaluation, of total rewards (Grote, 1996; Steiner & Rain, 1989; Smith, Benson, & Hornsby, 1990).

Recency Effect

Despite its central place in cognitive, behavioral economics, and management research, recency effect is defined differently in different domains. Similarly informed by works of Ebbinghaus, recency effect in memory research has been conceptualized as the comparative ease and more accurate recall of items at the end of a list (McCrary & Hunter, 1953; Baron & Ward, 2004; Greene, 1986; Howard & Kahana, 1999; Baddeley, 2007). In social psychology it has been seen as a phenomenon where recent information is better remembered and given greater weight or preference when forming a judgment than earlier-presented information (e.g., Anderson, 1968; Miller & Campbell 1959). In organizational behavior, I/O psychology, and human resources, recency effect has been commonly defined as the tendency or effect of placing disproportionately more weights on recent information when making judgments (Bond, Carlson, Meloy, Russo, Tanner, 2007; Aguinis, 2013; Lewis

& Zibarras, 2013; Grote, 1996; Armstrong, 2014; Deb, 2009; Murphy & Cleveland, 1991; Steiner & Rain, 1989; Earley & Erez, 1991).

Recency and Equity Theory

An understanding of the ways memory operates with equity mechanism to affect collective performance under two different reward schemes was developed in experiment two. Yet it may seem unrealistic that individuals give equal weights to memory information from previous periods equally. It stands ensue to ask how would recency effect, a widely reported memory-related cognitive bias, influence the results seen earlier? Would a greater emphasis on the recent events lead to higher collective performance for collectives under either of the reward schemes? As formulaically suggested by results from experiment one and two, would PFP continue to be superior to PFT?

To answer these questions, the views of several authors (e.g., Vecchio, 1982; Cosier & Dalton, 1983) integrating memory (pre-cursor to recency effect) with equity theory are consulted. While it seems these authors did not explicitly mention recency effect, they had arguments describing how memory decay could affect inequity evaluations. Vecchio (1982) argued an “exponential decay” to occur with the passage of time (p. 108), while Cosier and Dalton (1983) argued that inequity, being a transitory phenomenon that diminishes overtime (p. 313, citing Carrell & Dittrich, 1978), is, thus influenced by a geometrically declining weighted average of present and past levels of tension. Despite absence of follow-up investigation, these are valuable individual level views that can be leveraged and computationally or empirically explored to understand how recency effect affects collective performance via equity concerns.

I seek to do so via computational means, building on the base model and experiment two. While experience from experiment two and the geometrically declining weighted average operationalization in Cosier and Dalton (1983) suggest computation may lead to outcomes similar to shorter memory periods when recency effect is high and long memory periods when recency effect is low, I follow the position taken in experiment one to refrain from making specific hypothesis given the lack of empirical support for either direction.

Code Modifications

To explore the influence of recency effect, OB and HR's conceptualization is selected as it best aligns with existing theory of Cosier & Dalton (1983). Cosier & Dalton's formula is adapted to equation 9 from computational experiment two to yield the following equation.

Formally, effective equity discrepancy ratio Γ , at time t is,

$$\Gamma_{i,t} = \begin{cases} \frac{\sum_{a=0}^{k-1} \lambda^a \Phi_{t-a}}{\sum_{a=0}^{k-1} \lambda^a} & , \text{ when } t \geq k \\ \frac{\sum_{a=0}^{t-1} \lambda^a \Phi_{t-a}}{\sum_{a=0}^{t-1} \lambda^a} & , \text{ when } t < k \end{cases} \quad (10)$$

where λ refers to a discount weighting ratio $\lambda \in [0, 1]$, Φ refers to an agent's equity discrepancy at a point in one of past time periods, and k refers to memory capacity. A larger λ indicates a small recency effect, while a small λ indicates inequity information from a few turns back is disregarded rapidly. Hence, equation 9 is a special case of equation 10 where λ is fixed at 1. Figure 8.1 illustrates relative weights operationalizing recency effect as

formalized in equation 10. The resultant modified code and agent processes is similar to that in computational experiment 2 except for the use of weights (Figure 8.2).

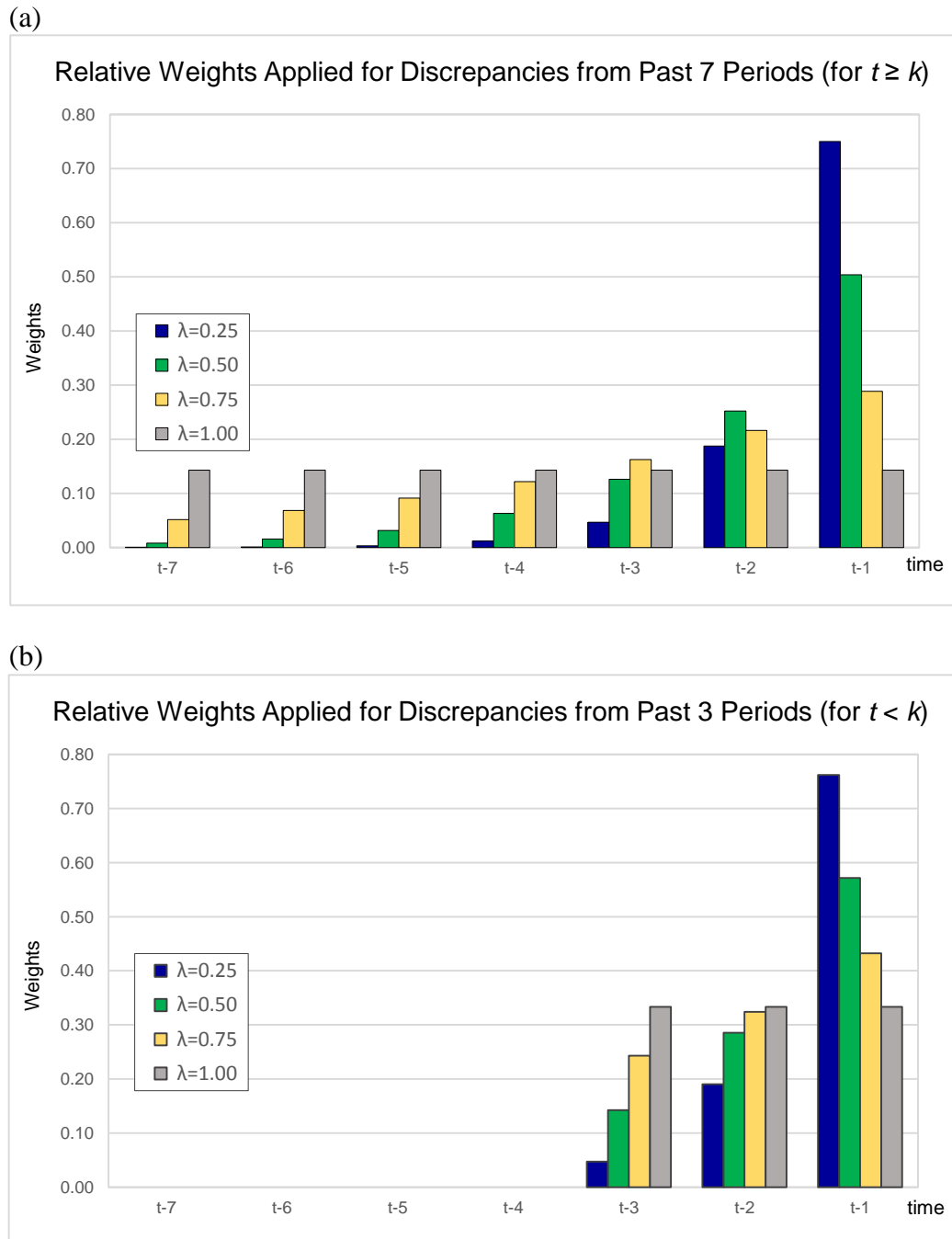


Figure 8.1. Relative Weights Showing Recency Effect when $t \leq k$ and $t < k$. k is fixed at 7 periods for this experiment. Hence figure 8.1a is applied when time steps are greater or equal to 7, and figure 8.1b when $t=4$. $\lambda=1.00$ shows uniform weights as would be obtained in experiment two.

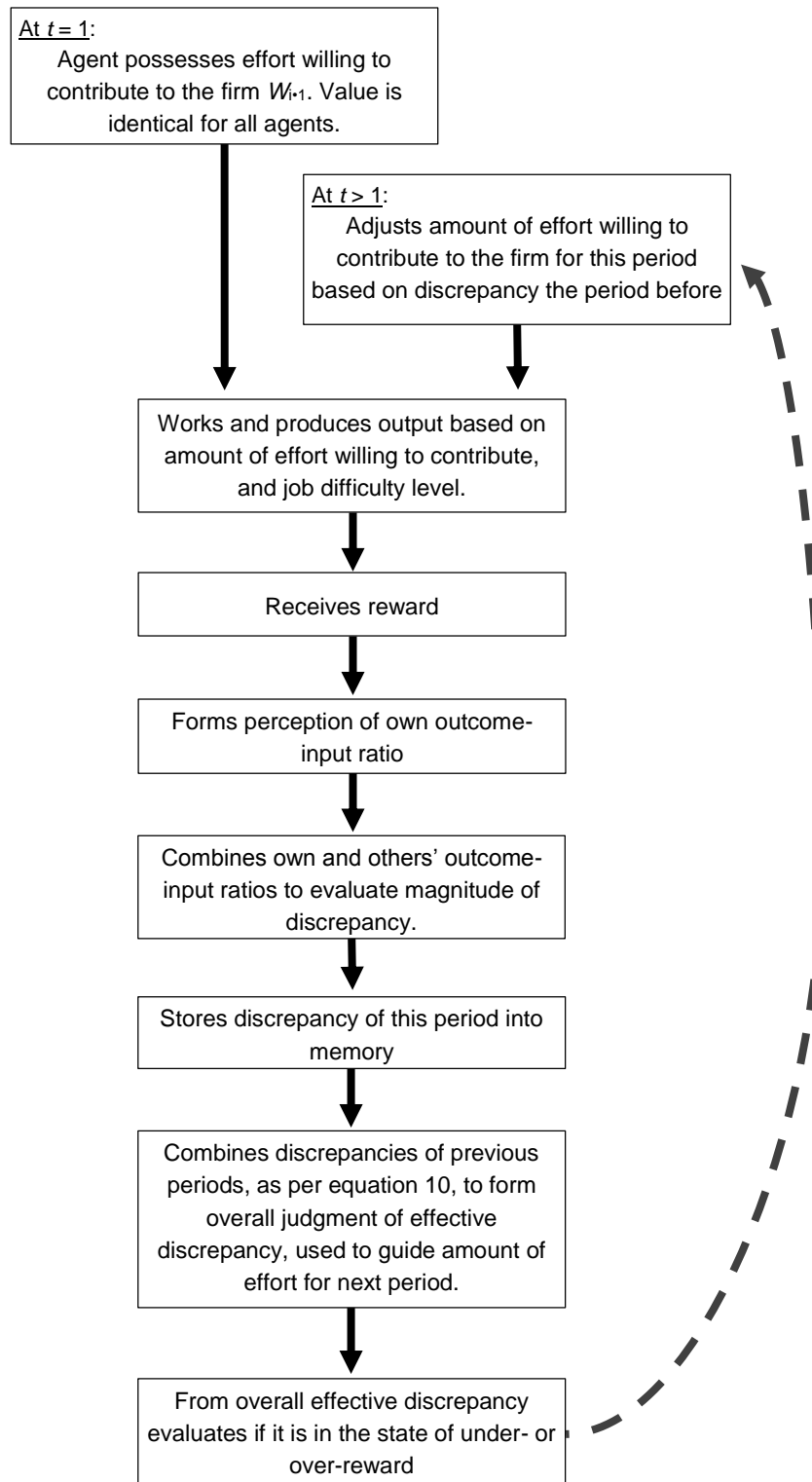


Figure 8.2. Agent processes to account for recency effect.

Data Collection

Though Cosier & Dalton (1983) did not state values λ should take, other researchers such as Zhang and Wu (2012) argued that in most cases the factor “will take a value much higher than 0.5” (p. 427), and varied the factor they used in their experiments between 0.8 to 1 (see also, Alonso-Sanz, 2012). However, to understand response patterns across the full range of possible λ values, this experiment will explore four indicative values ($\lambda = 0.25, 0.50, 0.75, 1.00$). As recency effect requires the assumption of memory, we adopt the oft-cited assumption that agents could recall seven chunks of information (Miller, 1956) holding all others constant for this experiment. Hence, memory capacity is fixed at 7-turns in this experiment. Though $\lambda = 1.00$ has been simulated, new simulation data is obtained for $\lambda = 1.00$, serving as a check for experiment two. Hence, all four values of λ are simulated 100 times for each reward scheme yielding a total of 800 runs. Data is collected in the same manner as the base model with setup parameters as per values in Table 8.1.

Table 8.1

Parameters Setup for Experiment 3

System	Number of agents n	121
	Number of job positions	121
	Job difficulty levels D_j	4, 5
	Piece-rate payment G (when under PFP)	1
	Fixed salary L (when under PFT)	10
	Variability in output s	-1, 0, 1
Agents, $t=0$	Effort willing to contribute to the firm W	30
	Motivation to adjust effort M	1
	Discrepancy ratio Φ	1
	Inequity threshold η	0.05
	Memory Capacity	7
Experimental Conditions	Discounting Weight Factor λ	1.00, 0.75, 0.50, 0.25

Results

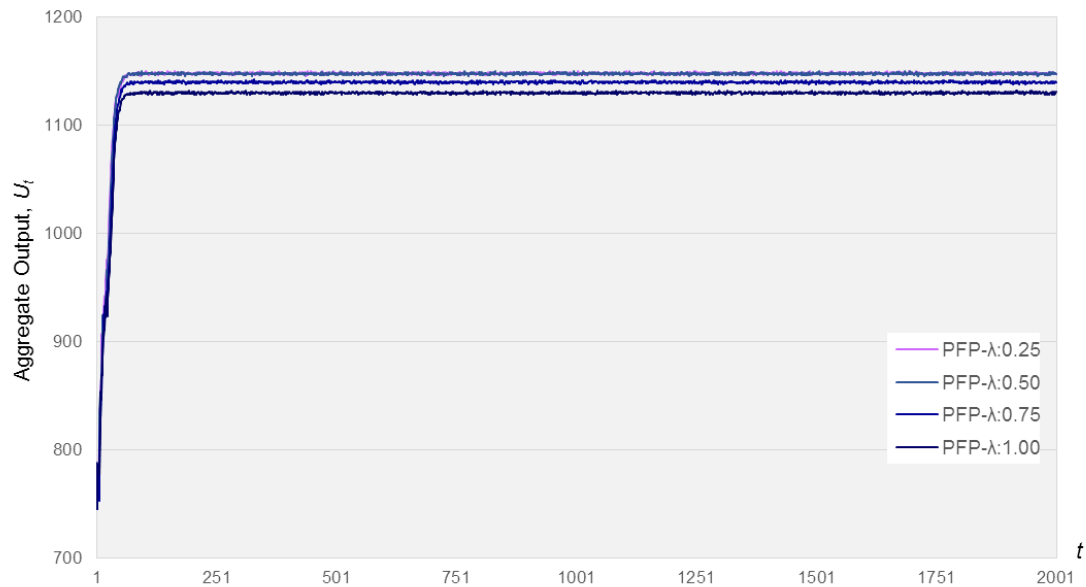
Similar to Experiment 1 and 2, results are presented in stages. Average system behavior and statistical testing is first reported followed by additional analysis. Figure 8.3 shows the aggregate output over time for combinations of reward schemes and different extent of recency effects (with memory capacity fixed at seven turns) with each point representing the mean of 100 runs of each combination at each time point. Recall that the lower the λ (from 1.00 to 0.25) the larger the recency effect is for agents. Hence seen in Figure 8.3a where agents are paid for performance, small increases in stabilized aggregate output is observed when recency effect increases up till $\lambda=0.50$ where it becomes largely indifferent from that of $\lambda=0.25$. In Figure 8.3b where agents are paid for time, stabilized aggregate output for agents is highest when $\lambda=0.75$, followed closely by $\lambda=0.50$. At large recency effect ($\lambda=0.25$) and at zero recency effect ($\lambda=1.00$), stabilized aggregate output is much less, with the former approaching zero. The inverted-U relationship (seen also in Figure 8.4b) suggests, there appears to be a Goldilocks region for λ value where aggregate output agents paid for time is maximized.

To ascertain if PFP is superior to PFT in terms of collective performance, the aggregate output at a point post stabilization ($t=2,000$) is assessed. The large variance of PFT at $t=2,000$ ($M_{PFT} = 1,072$ $SD = 621$, $M_{PFP} = 1,141$ $SD = 37$) precludes reward scheme as a meaningful main effect despite 95% confidence interval ($C.I._{PFT}$ [1,009, 1,130], $C.I._{PFP}$ [1,138, 1,145]) showing significance ($p < 0.001$). Rather explanation for the observed variance likely lies in the interactions. Table 8.2 details the mean and standard deviation of aggregate output for each combination of reward scheme \times recency effect, and Figure 8.4 plots this relationship for each reward scheme separately. A 2×4 ANOVA showed significant reward scheme \times recency effect interaction term ($F(3, 792) = 26,336$, $p < .001$, $\eta_p^2 = .99$). Accordingly, the stabilized aggregate output of agents under PFP increase as agents

possess stronger recency effect, but stabilized aggregate output of agents under PFT exhibiting a non-monotonic relationship.

(a)

Aggregate Output under Pay for Performance and Different Levels of Recency



(b)

Aggregate Output under Pay for Time and Different Levels of Recency

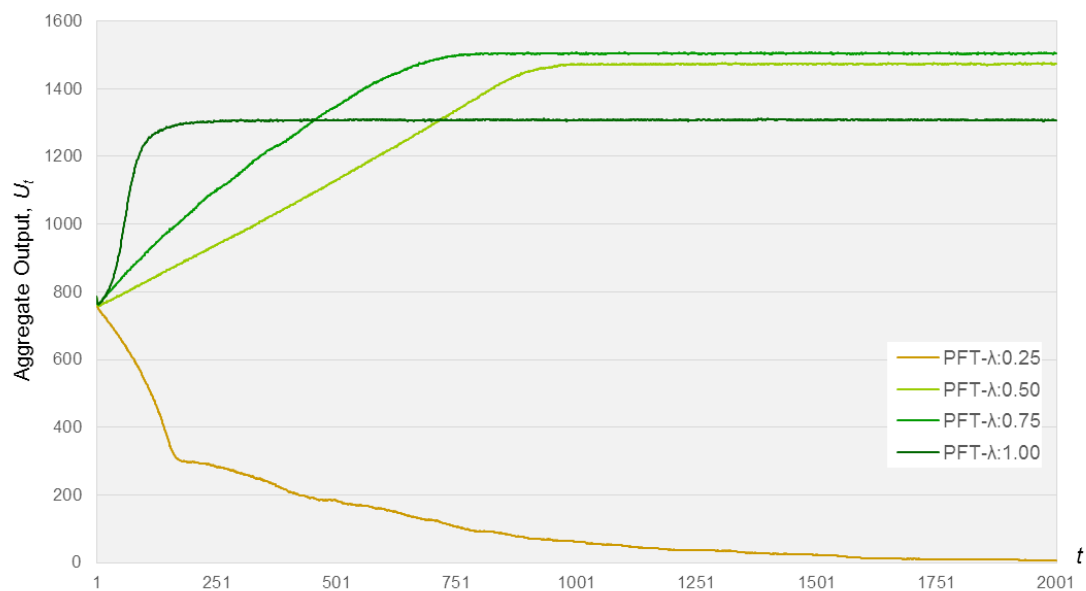
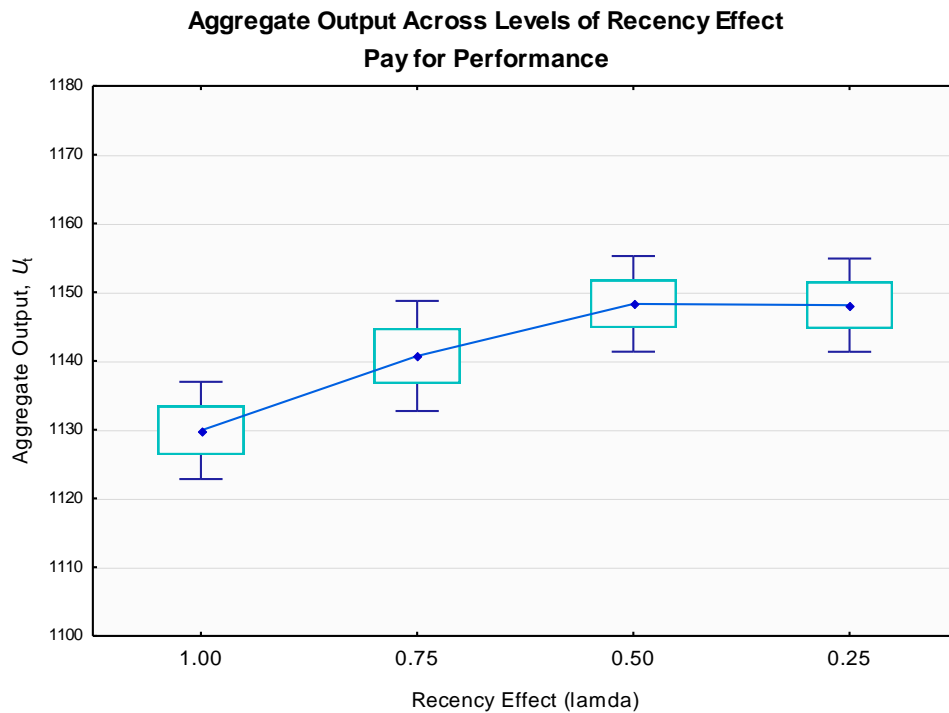


Figure 8.3. Aggregate Output of Different Reward Schemes and Recency Effect Across Time. Scale of time-axis begins at $t=1$ as at $t=0$ agents are not assumed to have completed any job tasks.

(a)



(b)

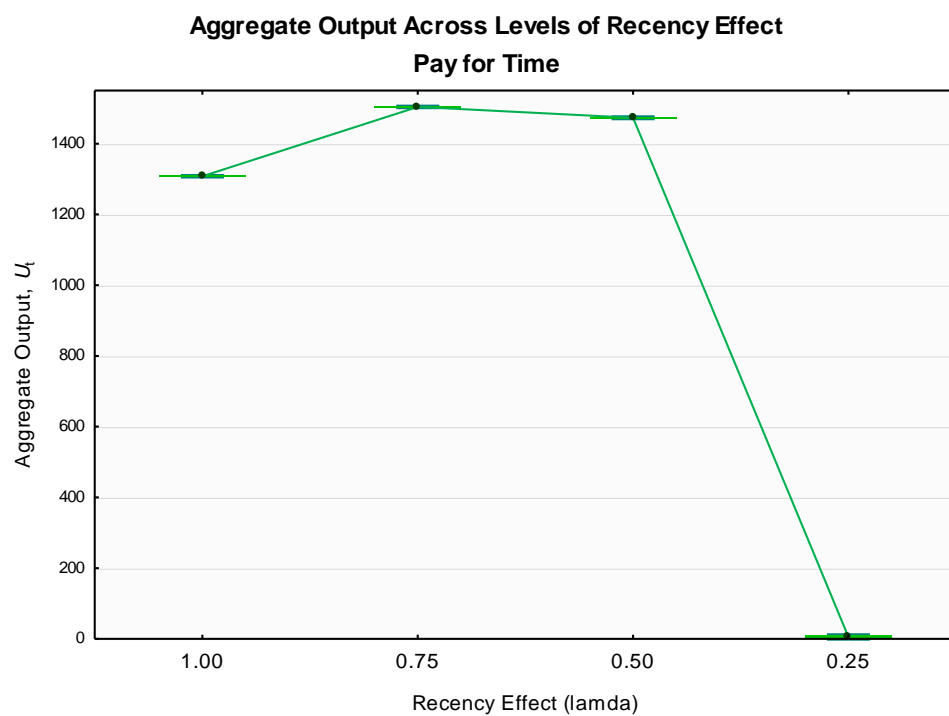


Figure 8.4. Aggregate Output of Different Reward Schemes and Recency Effect at $t=2000$. Y-axis of two charts are different. The y-axis of pay for time (second chart) is stretched to incorporate the zero aggregate output at $t=2000$, time post stabilization. Smaller the λ stronger the recency effect.

Table 8.2.

Aggregate output at $t=2,000$ for different reward schemes and levels of recency effect

Reward Scheme	$\lambda = 1.00$		$\lambda = 0.75$		$\lambda = 0.50$		$\lambda = 0.25$	
	M	SD	M	SD	M	SD	M	SD
Pay for Time	1,307.84	17.54	1,503.90	18.37	1,473.24	21.49	5.45	38.38
Pay for Performance	1,129.90	35.64	1,140.73	40.34	1,148.30	35.07	1,148.11	34.19

Results above and Figures 8.3 and 8.4 reiterates experiment two's finding that there are points along the parameter space of recency effect where pay for time can lead to higher collective performance than pay for performance. In fact, reflecting earlier results where PFT's stabilized aggregate output is higher when agents recall beyond 3-turns, Table 8.2 shows that the lesser the recency effect (hence a more even consideration of historically distant events), the higher PFT's collective performance. Post-hoc Scheffe's test showed that (1) aggregate output of PFT $\lambda=0.75$ to be higher than all other combinations in this experiment, (2) aggregate output PFT $\lambda=1.00-050$ to be higher than any combinations of PFP.

On top of mean-level differences, across all levels of recency effect, between-run variations in aggregate output is higher under PFP than under PFT. This reflects that even without other mechanisms at work, equity concerns appears to reproduce the extreme success and failure cases common in PFP's roll-out. This finding was present in experiment one and two and reiterated here even when memory is fixed and recency effect is varied.

Additional Analysis

As with experiment two, extensive comparisons across time and runs of the model were made for each parameter combination. Through that, a property similar to the finding

for PFT memory of 3-turns is found for the parameter combination of PFT $\lambda=0.25$. The trajectory of averaged aggregate output for this combination across time is not representative of the trajectory of any typical runs for PFT $\lambda=0.25$. Hence, rather than focusing on the averages from different runs, there is a need to probe further to guide appropriate interpretation. Figure 8.5 shows aggregate output across time for two typical runs for the combination of PFT $\lambda=0.25$. Similar with PFT 3-turns, there exist two equilibriums. The two trajectories are different from the smoothed gradient seen in Figure 8.3b for PFT $\lambda=0.25$. Though it is only suggestive that the first phase transition is of the second-order and the second is of the first-order, the reasons for moving from one equilibrium to another is likely similar, self-organized change mediated by equity-based adjustments. Revisiting the explanation from complex systems, the basin of attraction for the first attractor (intermediate equilibrium) is shallow and susceptible to random perturbations to nudge the system out towards the final absorbing state.

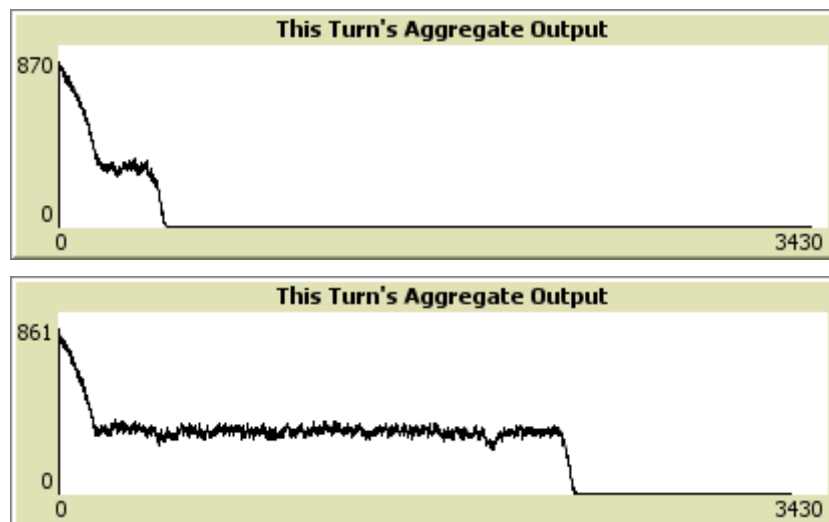


Figure 8.5. Aggregate Output of Two Separate Runs for Parameter Combination of Pay for Time and Recency Effect of $\lambda=0.25$

This finding brings caution to the interpretation of the averaged trajectory of PFT $\lambda=0.25$ in Figure 8.3b. To understand this multi-attractor phenomena further, it will be appropriate to conduct a sensitivity analysis to reveal (not confirm or test any hypothesis) any

yet known characteristic. Following Railsback and Grimm (2013), simulation was conducted for neighboring values for the same model. Six values of λ (0.20, 0.25, 0.30, 0.35, 0.40, 0.45) were taken and run, including also a new set of 100 runs for $\lambda=0.25$ as there is a need to simulate to $t=60,000$ to be certain the stability of the attractor, or if asymptotic regime has been reached. Table 8.3 shows the frequency of the time taken for system to reach equilibrium levels of zero (time-to-stability) for four of λ values explored, with Figure 8.6 showing typical trajectories of the six values.

Table 8.3

Frequency of Time Periods Required to Reach Equilibrium at Zero (Experiment 3)

Time Interval	PFT $\lambda=0.20$	PFT $\lambda=0.25$	PFT $\lambda=0.30$	PFT $\lambda=0.45$
0	100	0	0	0
100	200	100	0	0
200	300	0	8	0
300	400	0	20	0
400	500	0	11	0
500	600	0	10	0
600	700	0	3	0
700	800	0	7	0
800	900	0	7	0
900	1,000	0	9	0
1,000	2,000	0	21	0
2,000	3,000	0	3	0
3,000	4,000	0	1	0
4,000	5,000	0	0	0
6,000	7,000	0	0	0
8,000	9,000	0	0	0
9,000	10,000	0	0	0
10,000	20,000	0	0	0
20,000	30,000	0	0	0
30,000	40,000	0	0	0
40,000	50,000	0	0	0

Note: PFT $\lambda=0.30$ and PFT $\lambda=0.45$ has frequency of zeros for all interval up till 50,000 as no runs of this combination converges to an equilibrium level of zero aggregate output.

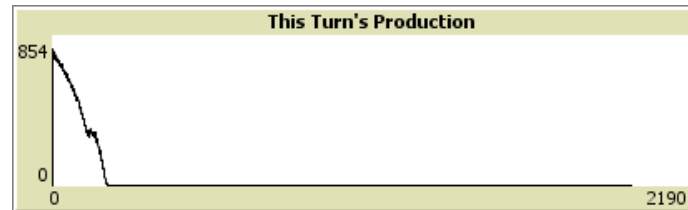
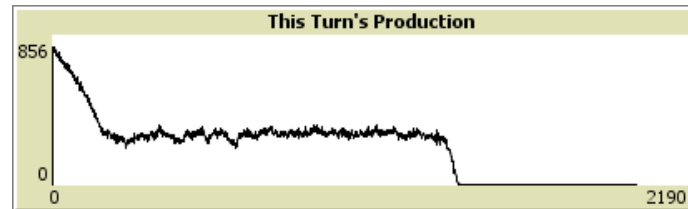
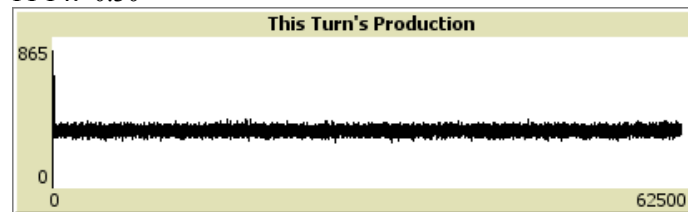
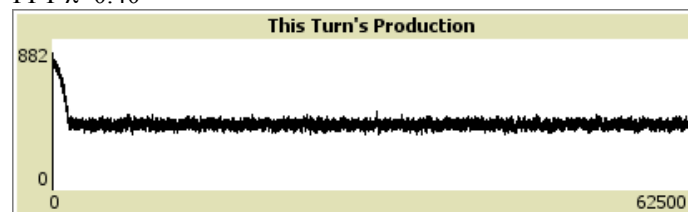
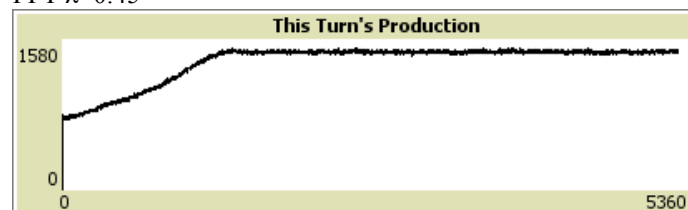
PFT $\lambda=0.20$ PFT $\lambda=0.25$ PFT $\lambda=0.30$ PFT $\lambda=0.35$ PFT $\lambda=0.40$ PFT $\lambda=0.45$ 

Figure 8.6. Aggregate output of typical runs of PFT with various values of λ . Time scale of PFT $\lambda=0.20$ and PFT $\lambda=0.25$ are shortened to show the equilibrium which would otherwise suffer lower visual resolution in a longer time scale.

Table 8.3 clearly shows a bi-modal distribution for the time required for the system to reach equilibrium levels at zero for PFT $\lambda=0.25$. While this regularity could suggest a deeper underlying order, it is pragmatic to recognize that, for most managers and policy-makers, this information does not yield actionable points where intervention can be made or designed upon. Still for future theoretical exploration, investigation may be warranted. Looking across values of λ , for PFT $\lambda=0.30$, PFT $\lambda=0.35$, and PFT $\lambda=0.40$, the system appears to converge to a dynamic equilibrium maintained by random perturbations without ever transiting to zero aggregate output levels (Figure 8.6). This level is however slightly less than half the aggregate output levels at initiation. Moving further, the level of λ to be related to an increase of aggregate output under PFT would seem to be around 0.45 or larger. Combinatively, it means for organizations with PFT with every agent exhibiting similar recency effect, there is (1) a threshold level of λ that must be crossed to result in increased rather than decrease collective performance, (2) a low-range of λ where collective performance is sub-optimal and resistant to intervention effort, and (3) a high-range of λ where sub-optimal collective performance is temporary and would decrease to near zero levels in due time.

Experiment 3A

Primacy effect is equally pervasive and present in the link between memory and judgment (Hastie & Park, 1986; Steiner & Rain, 1989; Hogarth & Einhorn, 1992; Page & Page, 2010). Given above finding on recency effect, it is important to also explore how cross-level incentive effect of fairness comparison and adjustment may moderate when primacy effect is considered. Doing so aids in developing a better understanding the effects of memory-related cognitive biases on collective performance.

Generally, primacy effect is defined as the better recollection for the stimuli at the beginning of a list. Or when applied to downstream cognition and evaluation, it is seen when “a person best remembers the initial information that he or she receives, and having a greater impact on attitude formation” (Garnefeld & Steinhoff, 2013, p. 67), when “information that is initially available will be weighted more heavily than the information that comes later” (Cropanzano, Fortin, & Kirk, 2015), when “first action is expected to have a disproportionately large effect on subsequent actions” (Shteingart, Neiman, & Loewenstein, 2013, p. 477), when “message presented first exerts a disproportionate impact on an individual's opinion” (Crano, 1977, p. 87), and when “[judg[ment] are disproportionately influenced by evidence presented earlier than later” (Highhouse & Gallo, 1997, p.31) or “are biased heavily by information that comes earlier than later” (Kwong & Wong, 2014, p. 1559). It is apparent from the above definitions that primacy can be viewed either as a large weight salience applied to the first (not second or subsequent) item or simply as a primacy gradient. The first interpretation is supported by works such as those of Shteingart, Neiman, and Loewenstein (2013) and Lind, Kray, and Thompson (2001), while the second interpretation the works of including Farrell and Lewandowsky (2004), Murdock (1962), Davelaar, Goshen-Gottstein, Ashkenazi, Haarmann, and Usher (2005), Cowan, Sauls, Elliott, and Moreno (2002), for instance. It is clear no consensus on either exist except that both of these are seen as modes of primacy effect with good empirical support.

Primacy and Equity Theory

Within the context of performance measurement, primacy effect is frequently discussed as a rater error affecting workplace outcomes (e.g., Ambrose & Kulik, 1994; Wareing & Stockdale, 1987; Jones, Rock, Shaver, Goethals, & Ward, 1968). However, unlike recency effect with specific formulation linking to equity theory (Cosier & Dalton, 1983), an

broad search showed primacy effect has not have direct formulation to equity theory. The closest perspective of primacy effect with equity theory will have to be drawn upon the organizational justice literature on Fairness Heuristics Theory (FHT: Lind, 1995; Van den Bos, Lind, & Wilke, 2001). With most relevance to FHT's first phase of justice judgement process, Lind (2001) discussed previous empirical work to sum that "fairness judgments will be formed hurriedly, with the *first* relevant information exercising greatest influence on feeling of overall fair treatment... show[ing] strong primacy effects." (p.71, italics added). Indeed, several other works such as those by Bauer, Maertz, Dolen, and Campion (1998), and Gavin, Green, and Fairhurst (1995) have found persistence of initial impressions on fairness evaluation.

Though the above does not refer directly to equity theory, the salience of primacy effect in justice judgment process, does suggests possible effects that may manifest when such memory bias repeats iteratively with multiple peers working concurrently with concerns for equity-based fairness. As such, an additional experiment is conducted under the category of cognitive bias to probe the effects of primacy effect on reward schemes and equity theory when expanded through time and partially over-lapping peers at work.

Code Modifications

In the above literature search, it was found that there exist no ABM study with an encapsulated coding of primacy effect. The handful of studies considering primacy effect tended to focus on how information filtering lead to the emergence of primacy bias from interactions (Huet & Deffuant, 2008; Deffuant & Huet, 2010), its distinction from confirmation bias as a result of repeated interactions (Allahverdyan & Galstyan, 2014), and the duration of primacy effect from agent-agent interactions (Ekmecki & Casey, 2011). Such

interaction-based emergence of primacy effect is distinct from the traditions of primacy effect seen as a within-individual cognitive process which is the aim of the model here. The apparent means to model primacy effect is to operationalize as the sequential inverse of the recency effect. Yet such modeling would entail (1) large computational memory for each agent storing a list for length of $t-1$, and (2) simulation freezing as even a minor decaying factor of just 0.9 would result in negligible change in discrepancy within 30 turns. The latter factor (rather than the first) is probably the main reason why no ABM model till date, has modeled primacy effect as an individual-based inverse gradient parameter to vary. Yet, given primacy effect's importance, and that established models of memory capacities, such as those that Experiment 2 modeled after, adopted a moving average with a cliff-like ignorance of information beyond agent's stipulated memory capacity, this experiment shall undertake an *indicative exploration* of primacy effect following this tradition^{8.1}.

^{8.1} There are several means to operationalize primacy effect as encapsulated within an agent. First broad category is to remember all of an agent's past till time t and apply a multiplier for the first item or to apply a decay function that spreads though out all items in a reverse sequence. The former in this broad category meant a decreasing primacy strength as t increases, while the latter meant the summed evaluation for items between two adjacent time periods will be the same when t is large, rendering no change in agent's evaluation. The second category assumes a fixed memory capacity and either add information from $t=1$ to the list, or apply decay function to the items in the constrained memory. The former in the second category appeared to mimic primacy, but implicitly incorporates recency effect as evident from zero weights given to item $t=2, \dots, t-k-1$, and the abrupt increase of weights for $t=t-k, \dots, t-1$. The latter in the second category does mimic primacy effect but also implicitly models in recency effect from the zero weights given to items from $t=0, \dots, t-k-1$. The operationalization chosen for this experiment also falls under the second category, and has recency effect implicitly modeled. Hence, this experiment should *not* be interpreted as a close representation of real-world manifestation. Rather it serves to give a broad direction of possible direction of cross-level incentive effect when primacy effect influences equity-based adjustments of individual workers.

Formally incorporating primacy effect, effective equity discrepancy ratio Γ at time t is,

$$\Gamma_{i,t} = \begin{cases} \frac{\delta \cdot \Phi_{t-k+1} + \sum_{a=t-k+2}^t \Phi_a}{\delta + k - 1}, & \text{when } t \geq k \\ \frac{\delta \cdot \Phi_1 + \sum_{a=2}^t \Phi_a}{\delta + t - 1}, & \text{when } t < k \end{cases} \quad (11)$$

where $\delta, \delta \in [1, \dots]$, refers to the multiplier applied to the weight of earliest equity discrepancy Φ in a memory list with items updated similar to that in experiment two and three. k refers to agents memory capacity. Since δ is greater than one and applies only to the first item, the larger the δ the stronger the primacy effect. Accordingly when $\delta = 1$, there is no primacy effect, and equation 9 can be seen as a special case of equation 11. Similar to experiment 2 and 3, such conceptualization of serial position effect on judgement and evaluation follows the Information Integration tradition of Norman Anderson (1981, 1996). Figure 8.7 shows the relative weights operationalizing primacy effect as formalized in equation 11.

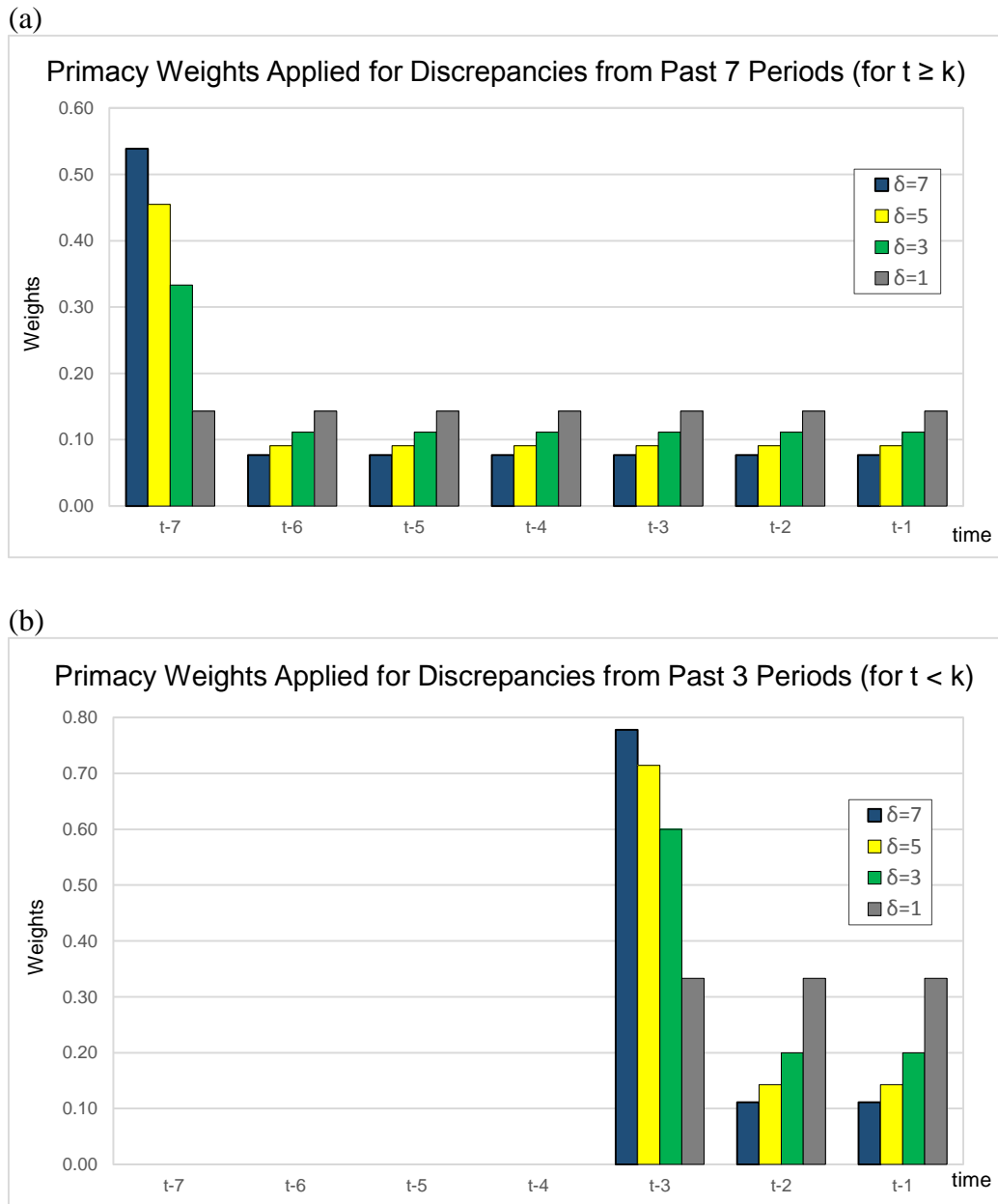


Figure 8.7. Relative Weights Showing Primacy Effect when $t \geq k$ and $t < k$. k is fixed at 7 periods for this experiment. Hence figure 8.7a is applied when time steps are greater or equal to 7 and figure 8.7b for $t = 4$.

Data Collection

Similar in rationale to Experiment 3, Experiment 3a will explore a range of parameter values to gain an understanding of primacy effect's direction of effect. As δ can range from 1 to infinity, four values of 1, 3, 5, and 7 are explored, where $\delta = 7$ would mean a

considerably strong primacy effect of an agent giving weight to first item in memory list that is seven times more than that of any other items in the list. Memory capacity is similarly held constant at 7-turns. Though $\delta=1$ is a repetition of $\lambda = 1.00$ in experiment 3 and memory 7-turns in Experiment 2, a new set of simulation run is performed including $\delta=1$, serving also as a computational (not robustness) check for result of Experiment 2 and 3. All four values of δ are simulated 100 times for each reward scheme yielding a total of 800 runs. Data is collected in the same manner as the base model with setup parameters as per values in Table 8.4.

Table 8.4

Parameters Setup for Experiment 3a

System	Number of agents n	121
	Number of job positions	121
	Job difficulty levels D_j	4, 5
	Piece-rate payment G (when under PFP)	1
	Fixed salary L (when under PFT)	10
	Variability in output s	-1, 0, 1
Agents, $t=0$	Effort willing to contribute to the firm W	30
	Motivation to adjust effort M	1
	Discrepancy ratio Φ	1
	Inequity threshold η	0.05
	Memory Capacity	7
Experimental Conditions	Primacy Multiplier Weight Factor δ	1, 3, 5, 7

Results

Similar to Experiment 1, 2, and 3, results for Experiment 3a are presented in stages. Figure 8.8 shows the aggregate output over time for combinations of reward schemes and different extent of primacy effect (with memory capacity fixed at seven turns) with each point representing the mean of 100 runs of each combination at each time point. Recall that the higher the δ (from 1 to 7) the larger the recency effect is for agents. Hence seen in Figure 8.8a and 8.9a where agents are paid for performance, there is a monotonic decrease in mean stabilized aggregate output as primacy effect increases, with significant decrease between $\delta = 3$ and $\delta = 5$. In Figure 8.8b and 8.9b, where agents are paid for time, stabilized aggregate output for agents is highest when $\delta = 3$, followed by a linear decline in stabilized aggregate output levels. Like Experiment 2 and 3, the inverted-U relationship between primacy effect and stabilized aggregate output obtained under PFT suggests a region for δ where aggregate output can be maximized when agents are paid for time.

Table 8.5 details the mean and standard deviation of aggregate output for each combination of reward scheme \times primacy effect. Accordingly, the stabilized aggregate output of agents under PFP decreases as agents possess stronger primacy effect, but stabilized aggregate output of agents under PFT exhibiting a non-monotonic relationship, with no cross-over interaction observed for the range of parameter explored.

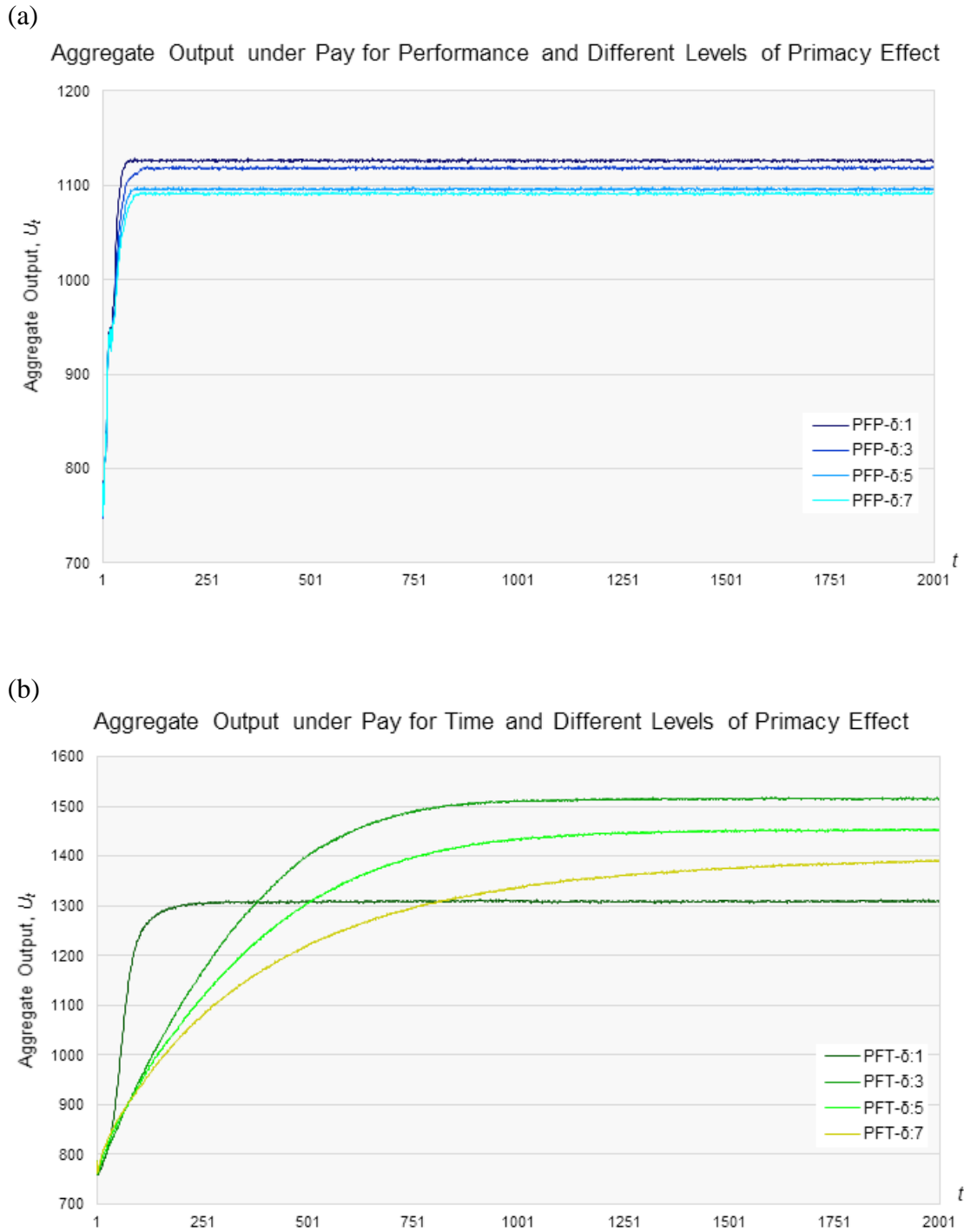
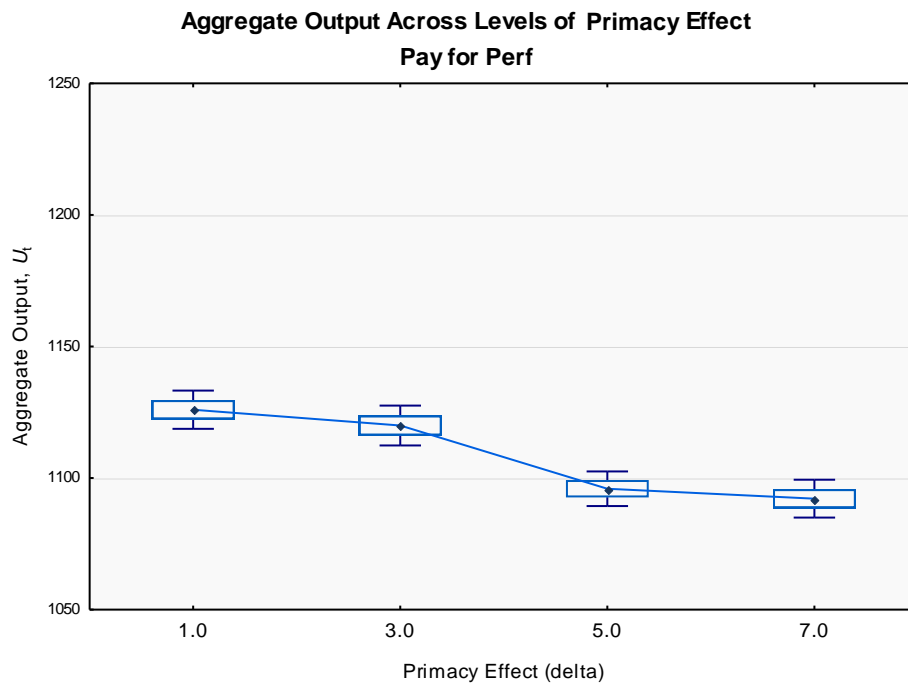


Figure 8.8. Aggregate Output of Different Reward Schemes and Primacy Effect across Time. Scale of time-axis begins at $t=1$ as at $t=0$ agents are not assumed to have completed any job tasks. Larger the δ stronger the primacy effect.

(a)



(b)

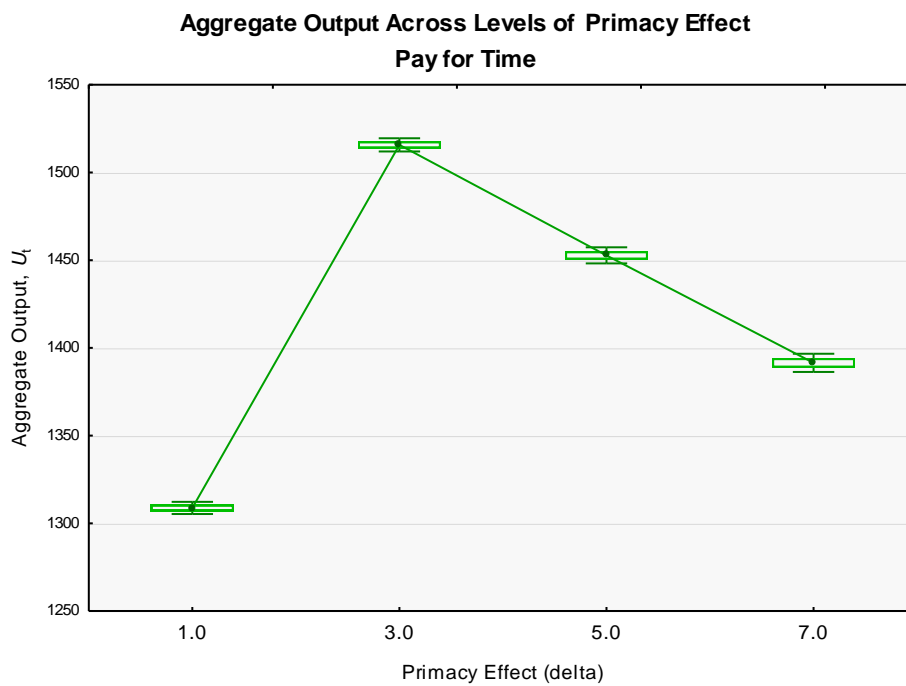


Figure 8.9. Aggregate Output of Different Reward Schemes and Primacy Effect at $t=2000$. Y-axis of above two charts are different. Larger the δ stronger the primacy effect.

Table 8.5.

Aggregate output at $t=2,000$ for different reward schemes and levels of primacy effect

Reward Scheme	$\delta = 1$		$\delta = 3$		$\delta = 5$		$\delta = 7$	
	M	SD	M	SD	M	SD	M	SD
Pay for Time	1,308.78	17.68	1,515.75	19.12	1,452.74	23.48	1,391.47	26.58
Pay for Performance	1,125.99	35.56	1,119.98	38.10	1,095.94	33.16	1,092.19	36.20

Discussion

The first experiment in this chapter, Experiment 3, showed that as agents give greater weights to recent events in a manner stipulated by Cosier and Dalton (1983), collective performance, measured as aggregate output, under two different reward schemes differ. Namely collective performance under PFP increase as recency effect increases, while collective performance of agents under PFT showed an inverted-U relationship. The relationship between recency effect and performance of collective under PFT is more complex with tipping points and metastable intermediate equilibrium detected in the additional analysis performed. Crossing the tipping point ($\lambda = 0.25$) to weaker levels of recency effect, the disincentive effect observed in experiment one for PFT becomes an incentive effect for the entire collective. In the added exploration of primacy effect in Experiment 3a, performance for collective under PFP decreases, while that for PFT increases up till a point before a linear decline as primacy effect increases.

Taken together Experiment 3 reinforces the inference for Experiment 2 where individual agents considering more information from its own and others' past will generate a decrease in aggregate output at the collective level when under PFP, and an increase in

aggregate output when under PFT up till a maximum point in one-dimensional parametric space. While operationalization of primacy effect in Experiment 3a is not conclusive as largely different ways of coding exist, it serves as a good indication of the likely direction of effect. In this case, even with a less than ideal representation of primacy effect, Experiment 3a, despite not showing a cross-over interaction, shows similar results with those of Experiment 2 and 3.

The three experiments (2, 3 and 3a) looked at memory and serial position effect and offered robustness testing for each other especially between experiment 2 and 3. Generally, memory have at times been modeled by computational scientists as a moving FIFO list and as a decay function. The implementation of both operationalizations strengthens the case that greater consideration of past information by individuals will result in significant cross-level effects, and Experiment 3a strengthens it with a seldom implemented serial position effect in encapsulated agent.

The findings have implications for managers and policy makers who are stuck in one or deliberating between reward schemes. While it is difficult to control the cognitive processes of employees, the mere provision and supervisor-subordinate discussion of past equity-based information could provide the conditions to nudge the basin of attraction from one region to another, or in the case of fixed salary, a collective rise in performance from giving greater weights to distant historic events.

Lastly, the probing of metastability and sensitivity analysis of tipping point for Experiment 3 revealed properties of equity-mediated complex systems not yet uncovered. While it is common to discuss steady state results, the presence of metastable equilibriums and phase transition may yield important implications both for future theoretical research as well as managerial insights. Particularly, first order phase transition to minimal effort levels,

when firms pay employees a fixed base pay, mimics the emergence of labor walk-out occurring abruptly from mere repeated equity adjustments with peers. Where such transition is of importance for a firm or society, if agents are seen as inhabitants, the bimodal distribution of time points where such transition tended to occur could offer great predictive insights and be probed further in future works.

Chapter 9**COMPUTATIONAL EXPERIMENT 4 (SOCIAL COMPARISON)****Social Comparison**

Social Comparison defined as the “process of thinking about information about one or more people in relation to the self” (Wood, 1996, p. 520-521) is commonly seen as consisting of three stages: (1) acquisition of social information, (2) thinking about the social information, (3) reacting to social comparisons (Wood, 1996). This process-based view of social comparison was present in Festinger’s (1954) original conceptualization, major reviews (Goodman, 1977; Kruglanski & Mayseless, 1990; Wood, 1996), and up till recent research (see special issue Goodman, 2007, and Corcoran, Crusius, & Mussweiler, 2011). Social comparisons serve to reduce uncertainty, create meaning, and provide ongoing social information (Festinger, 1954; Suls and Wheeler, 2000; Buunk & Gibbons, 2007) in a much more efficient manner than absolute feedback information (Mussweiler & Epstude, 2009). By recent times, neural correlates of social comparisons and its consequences have been illustrated (see Swencionis & Fiske, 2014; Fliessbach et al., 2007; and Chiao, 2010), its role in mitigating erroneous evaluation and decision-making explained (Christopoulos, Kokkinaki, Harvey, & Sevdalis, 2011), and its evolutionary function (mostly in terms of pursuing higher rewards) found in human and non-human species as well (see discussion in Brosnan, 2011; Brosnan & De Waal, 2014; and Gilbert, Price, & Allan, 1995).

The importance of social comparison lay in that it underlies “many important mediators of behavior such as self-esteem, judgments of fairness, and outcome and efficacy expectancies” (Locke, 2003, p. 619). Beyond just a “central feature of human social life” (Buunk & Gibbons, 2007, p. 3) and “a ubiquitous social phenomenon” (p. 16), it is a “basic human process that pervades all aspects of our lives” (Goodman, 2007, p. 1), a “basic aspect

of human experience” (Brown, Ferris, Heller, & Keeping, 2007, p. 57), and an “inevitable element of social interaction” (Brickman & Bulman, 1977, p. 150).

Modern day social comparison research has developed greatly beyond Festinger’s (1954) early focus on opinion, abilities, self-evaluation motives and the “unidirectional drive upwards”, towards greater variety of distinctions and applications (Kruglanski & Mayseless, 1990; Corcoran et al., 2011; Buunk & Gibbons, 2007; Goodman & Haisley, 2007). Domains of comparisons have now included health status, body image, emotions, values, and lifestyles (Kruglanski & Mayseless, 1990), mere comparison of performance shown to lead to less pro-social behavior (Riyanto & Zhang, 2013), and subject of comparisons have been expanded (Buunk, Carmona, Peiro, Dijkstra, & Dijkstra, 2011; Harris, Anseel, & Lievens, 2008) to include those who are similar (lateral comparisons), better off (upward comparisons), or worse off (downward comparison) with effects and motives of each directional comparisons found to vary. This latter view holds that when the dominant motive for social comparison is self-improvement, individuals engage in upward comparisons (Suls & Wheeler, 2000; Blanton, Buunk, Gibbons & Kuyper, 1999) correlating with greater activation in the dorsolateral prefrontal cortex and anterior insula (Lindner et al., 2014); when motive is self-enhancement, individuals engage in downwards comparison (Wills, 1981; see also Wood, 1989) it correlates with greater activation in the ventral striatum, the medial orbitofrontal cortex and the ventral anterior cingulate cortex (Lindner et al., 2014; see also, Swencionis & Fiske, 2014); and when motive is self-evaluation, individuals engage in lateral comparisons (Festinger, 1954; Buunk et al., 2011; Harris et al., 2008).

Social Comparison in the Workplace

While it is surprising that numerous authors stated “there is relatively little research on social comparison in work settings” (Buunk, Carmona, Peiro, Dijkstra, & Dijkstra, 2011,

p. 23) or that “social comparison processes remain largely neglected by organizational scholars” (Brown, Ferris, Heller, & Keeping, 2007, p. 59), a close look at compensation research, a sub-domain of organizational studies, especially in the study of pay dispersion/variation (see Shaw, 2014; Gupta, Conroy, & Delery, 2012; and Trevor, Reilly, & Gerhart, 2012) and pay equity (see Cowherd & Levine, 1992; and Berkowitz, Fraser, Treasure, & Cochran, 1987) would reveal social comparison as the key enabler of phenomena studied therein.

For instance, pay equity perception is a function of comparisons with people in similar (and different) positions within the organization, comparisons with people in similar positions outside the organization, and comparisons with one’s own pay in the past (Martin & Peterson, 1987). Social comparison’s concern with comparing with similar or dissimilar others resonates in compensation researchers’ concern with choice of relevant internal-external pay referents. Achieving pay equity via numerous means is a fundamental objective of compensation structure design (Milkovich, Newman, & Gerhart, 2013) and has been linked to job performance (Bretz & Thomas, 1992; Pritchard, Dunnette, & Jorgenson, 1972), employee theft (Greenberg, 1990), turnover (Summers & Hendrix, 1991; Telly, French, & Scott, 1971), and extra-role behaviors (Scholl, Cooper, & McKenna, 1987; see also Trevor & Wazeter, 2006).

The fact that “social comparisons are so central to how people react to pay” (Trevor & Wazeter, 2006, p. 1260) and that in “individual pay-for-performance systems, pay will inevitably vary across employees, generating frequent pay comparisons” (Larkin, Pierce, & Gino, 2012, p. 1201), social comparison and its relations to equity theory and other PFP theories, such as tournament theory (Folger & Kass, 2000; Crosby & Gonzalez-Intal, 1984, see discussion in chapter 2) are undisputed. Adam’s (1965) Equity theory, and even its

subsequent modifications (e.g., Walster, Berscheid, & Walster, 1973 & 1978) has social comparison as a prerequisite. The three stage process of social comparison (discussed above) is similarly found in equity theory, where perceptual information of self and other is collected, evaluated, and subsequently acted on if required to restore equity (Adam, 1965). Tournament theory (Lazear & Rosen, 1981), the other major PFP theory mostly applied to top management team theory (TMT) and professional vocations, to a large extent leveraged the “upward drive” (Festinger, 1954) explanation of social comparison as a motivational tool driving self-improvement and self-evaluation. Eddleston (2009) found both male and female managers to engage in more upwards than downwards comparison when evaluating their career progress, while Buunk, Zurriaga, Peiro, Nauta and Gozalvez (2005) showed physicians to engage more often in upward comparisons than downward comparisons with colleagues. For studies proximal to social comparison’s domain, Brown, Ferris, Heller, and Keeping (2007) showed longitudinally that upward comparison has a positive indirect effect on job search behavior, a sorting effect (Fang & Gerhart, 2012; Cadsby, Song, & Tapon, 2007), and John, Loewenstein, and Rick (2014) showed that when given opportunity to misreport, subjects in a low performance-based pay-rate were more likely to cheat *only* when an ostentatiously higher pay-rate was made salient for the subjects to make comparisons with.

Consideration of Individual Differences

Traditionally, social comparison researchers have focused more on situational influences on various aspects of social comparison (such as referent choices) than with individual/gender differences in social comparison, or how individual differences affect social comparison (Wheeler, 2000, p. 141; Hemphill & Lehman, 1991). To the extent that gender differentiates, females have been shown to engage in social comparison slightly more frequently (Gibbons & Buunk, 1999) and this difference is moderated in ways, such as target

gender and organizational context (Buunk, Carmona, Peiro, Dijkstra, & Dijkstra, 2011). For individual difference that was born out of social comparison research and had gained some traction, Gibbons & Buunk's (1999) Social Comparison Orientation (SCO) is a candidate. Though no definition of the construct was given in the original paper, subsequent researchers have construed it to refer to "the *tendency* to make (or not to make) social comparisons" (Buunk & Gibbons, 2007, p.13), the "*extent* to which and the *frequency* with which people compare themselves with others" (Buunk & Dijkstra, 2014, p. 2), or simply "*propensity* to engage in individual level social comparison" (Guimond, 2006, p. 329). Hence, the instrument measuring SCO (Gibbons & Buunk, 1999) focuses heavily on frequency of social comparison than the size of comparison group.

SCO has been shown to vary significantly between participants of eight countries, with USA, UK, and Malaysia scoring the highest (Guimond, 2006) and moderate a range of behaviors. For instance, Gibbons, Lane, Gerrard, Pomery, & Lautrup (2002) found college students high in SCO to be more susceptible to manipulation of peer influence to adopt risky or non-risky behaviors, and Garcia and Tor (2009) found N-effect (the opposite of motivation gain in social facilitation context) to heighten for participants high in SCO. Additionally, Buunk and Dijkstra (2014) found participants high in SCO to relate more towards unfamiliar others in the context of a traffic accident victim, Buunk (2005) found only men and women high in SCO responded positively when an experimental target spoke of romantic relationship stereotypical of gender preferences, and Buunk and Brenninkmeijer (2001) found that only depressed patients high in SCO experienced an improved mood when presented with a low-effort comparison target. In sum it appears that SCO sensitizes one and amplifies the effect (positive or negative) of information and status of others for a focal individual. The bi-directional nature of SCO clearly makes it distinct from other constructs, such as Communal Orientation (Clark, Oullette, Powell, & Milberg 1987) which focuses on sensitivity to needs

of others, Interpersonal Orientation (Swap & Rubin, 1983; cited in Vogt & Colvin, 2003 and Buunk & Gibbons, 2007) focusing on desire to have close interpersonal relationships and tendency to be influenced by moods and criticism of others, and Equity Sensitivity focusing on preferred reward-outcome ratios (Huseman, Hatfield, & Miles, 1987), or tolerance for inequity (King, Miles, & Day, 1993), the second stage of social comparison. SCO is the closest within-domain construct towards understanding the impact of number of comparison others.

To the extent that cultural paradigms influence individual level attention, perception, thought, and attribution (Lehman, Chiu, & Schaller, 2004), Self-Construals (Markus & Kitayama, 1991), a set of individual difference constructs (Cross, Hardin, & Gercek-Swing, 2011, p. 143-144; Singelis, 1994, p. 580; Moorman & Blakely, 1995) consisting of Independent Self-Construal, Collective Interdependent Self-Construal, and Relational Self-Construal, may help distinguish individuals who compare with a greater or smaller number of comparison others. Researchers generally subsumed collective interdependent self-construal and relational self-construal under Interdependent Self-Construal (Cross et al., 2011), and define interdependent self-construal as the view of self “being part of an encompassing social relationship and recognizing that one’s behavior is determined, contingent on ... the thoughts, feelings, and actions of others in the relationship” (Markus & Kitayama, 1991, p. 227), and independent self-construal as the view of self primarily with reference to “one’s own internal repertoire of feelings, and action” (p. 226).

At risk of over-simplifying within country variations, considerable number of researchers had taken the culturalist paradigm approach (Morris, Chiu, Liu, 2014) focusing on the East-West dichotomy or nationality as proxies for differences in self-construals. While some meta-analyses showed equivocal findings on Markus and Kitayama’s (1991) original

argument that individuals from Asian origin score higher in terms of interdependent construal than individuals dominantly influenced by Western culture, such as European Americans (Levine et al., 2003, Matsumoto, 1999), other meta-analyses combining related measures of collectivism and individualism at the individual level appeared to lend some support (see Oyserman, Coon, & Kimmelmeier, 2002).

This points to the fact that independent and interdependent self-construals fall under and potentially represent the self-concept component within the constellations of individual-level distinctions linked to societal-level individualism-collectivism. Be it referring to “internalized values, attitudes, scripts, (or) norms” (Oyserman, Kimmelmeier, & Coon, 2002, p. 114), various terms have since emerged. From independent self-construals and idiocentrism linked with individual values of individualism, to interdependent self-construals and allocentrism linked with individual values of collectivism (Oyserman, Coon, & Kimmelmeier, 2002; Brewer & Chen, 2007). The first of these two worldviews, individualism, emphasizes individuals as independent of one another with a focus on rights above duties, agency, personal autonomy and self-fulfilment and accomplishments. The second worldview, collectivism, emphasizes communion, social embeddedness, and obligations bounded by groups and relationships (Oyserman, Coon, & Kimmelmeier, 2002; Brewer & Chen, 2007, Sedikides, Gaertner, & Toguchi, 2003).

Social comparison research using this distinction as explanation, have found Asian Canadians to seek more social comparisons (particularly upward) than European Canadians (White & Lehman, 2005a, b), interdependent self-construal (but not independent self-construal) to correlate with increase in positive self-evaluations after task of upwards social comparison, showing effects of assimilation effect (Kimmelmeier & Oyserman, 2001), and higher collectivism scores to associate with increased desire to compare, increase desire for

upward comparisons and decrease desire for downward comparison (Chung & Mallery, 1999). In firmer evidence of differences between participants from different cultural origins, Koreans were found to be more affected by another's income, correlating with greater ventral striatum and ventromedial PFC activations toward relative income compared to that of Americans (Kang, Lee, Choi, & Kim, 2013).

In sum, given individuals high in interdependent self-construals reflect extraindividual self-views concerned with relationships, roles, and social duties, and individuals high in independent self-construals concern more with their own thoughts, feelings, and goals (Heine, 2001; White & Lehman, 2005a), White & Lehman (2005a) argued that individuals high in interdependent self-construals are more attuned to information from these others and would seek out validating information via social comparison processes with others. Though I take the side that independent and interdependent self-construals are separate dimensions, the conceptualization in this experiment does not suggest either a unidimensional or bi-dimensional approach, but use the above discussion to ground arguments looking at humans as having relatively stable preferences for comparing with more/less comparison others, whatever the underlying drive. Though acknowledging independent or interdependent self-construals can be activated and made salient under different context, as in the arguments for situated cognition, this experiment assumes homogeneous context for all agents for purpose interpretation and tractability.

Number of Comparison Others

The review above shows comprehensively potential individual differences in social comparison. SCO focuses on frequency while self-construals suggest scope of focal information obtained from social networks. Such relatively stable differences allow extension of theorizing of individuals who tended to compare themselves against numerous others or

just with a few. This construct is distinct from SCO and self-construals, and definitionally distinct from network measures such as centrality and social capital, for the reason that one may have a large network (advice or familial), but do not necessarily compare themselves with many people.

This tendency, situated in the first stage of a typical social comparison process, may be considered a higher-order construct driven by basic lower-order epistemic needs (Kruglanski, 1989; Kruglanski & Webster, 1996; De Dreu, 2004) as suggested in the discussion of Kruglanski and Mayseless (1987), or be a resultant top-down influence of cultural paradigms (Lehman, Chiu, & Schaller, 2004). As search for existing construct representing this tendency yields null, the review above strongly suggests the utility and relevance in going beyond memory and cognitive bias to understand how *repeated comparisons with a large or small number of comparison others*, may impact a collective over time.

Possible Effects

Computationally and empirically, it is difficult to clearly predict how comparing with a larger group may affect collective performance as mediated by equity-based social comparisons.

Computationally, there is no programmed preference for direction of effect one way or the other. The model here designs social comparison to be uniformly implemented with perception symmetrical upwards and downwards, hence there is no indication if larger comparison group may lead to higher collective performance. Comparison with more others only imply more information obtained by the agent and a reduction in rationality's bounded

limits. Yet with more information, changes to collective performance may occur faster, or be slower due to a more “tempered” response from an averaging of inequities.

Past empirical works such as that by Wagner, Humphrey, Meyer, and Hollenbeck (2012) found greater collectivism, as well as how a mix of high collectivistic and high individualistic, is associated with higher performance on shared tasks. On more general definitions of group performance, Taras, Kirkman, and Steel (2010) in their review found higher individualism to be correlated negatively with group performance ($\rho = -.15$). In addition, if arguments from a dominant PFP-linked theory, tournament theory (reviewed in chapter 3, see also Connelly, Tihanyi, Crook & Gangloff, 2014; Foss & Stea, 2014; Neckermann & Frey, 2013) can be extrapolated, one can predict that organizations, or workplaces, with individuals comparing with more people (especially if homogeneously competent) to accentuate effects of upward drive and comparison leading to an increase in motivation and performance. However, counter evidence and argument exist. Strube (2005) convincingly casted doubt on Triplett’s (1898) finding on social facilitation and the well-known Kohler effect, while Tor and Garcia’s (2009) N-effect have also provided the evidence that increasing the number of others in a group decreases felt motivation. But none of the above arguments extend directly from the Adams’s (1965) theory.

As per rationale of Harrison, Lin, Carroll, & Carley (2007, p. 1233), this lack of apparent hypothesis strengthens the case for agent-based computational modelling. To compare effect of comparing with more others on performance of collectives under PFP versus PFT, aggregate output is tracked. Stabilized aggregate output will be the basis of comparison. And as *added insight*, the time to reach stabilized aggregate output (time-to-stability) will also be analyzed.

Code Modifications

For modeling small versus large number of comparison others, a condition is added to the base model. Two fixed levels are used as contrasts, namely the modeling of individuals who compare with four versus eight others. Accordingly, agents are instructed to compare with their Von Neumann neighborhood for the condition of four comparison others, or the new Moore neighborhood with radius 1 for the condition of eight comparison others (Figure 9.1).

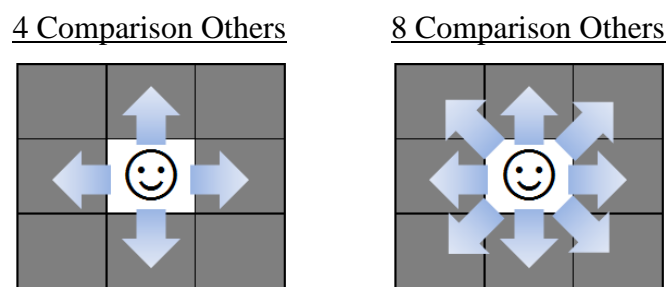


Figure 9.1. Von Neumann versus Moore neighborhood

For this added condition, the equity discrepancy ratio $\Phi_{i,t}$, is computed conceptually similarly to equation 6 of the base model.

$$\Phi_{i,t} = \frac{Q_{i,t}}{(Q_{N,t} + Q_{NE,t} + Q_{E,t} + Q_{SE,t} + \dots + Q_{NW,t})/8} \quad \text{for } t \in \{1, 2, \dots\} \quad , \quad (12)$$

where $Q_{N,t} + Q_{NE,t} + Q_{E,t} + Q_{SE,t} + \dots + Q_{NW,t}$ refers to the sum of outcome-input ratios of all agents in the Moore neighborhood of the focal agent. The computational steps taken by each agent in this experiment is similar to that for the base model. Figure 6.1 is reproduced here for reference.

To derive time-to-stability (Axelrod, 1997c) or the point in time where fluctuation in aggregate output is dominantly the result of random processes, the following stopping condition is programmed in the model. Given a chronological sample of aggregate output levels of past C periods divisible by $h \in \{2, 3, \dots, C\}$ equal time segments, the model will

stop at t_{stop} when $t > C$, and when the absolute difference between each pair of segment's mean aggregate output levels do not exceed a criteria b . Accordingly, the point in time where aggregate output reaches stability t_{stable} is given as $t_{\text{stop}} - C$. For this experiment, we let the moving time sample C be 200 periods, h segments be 5, and absolute difference criteria be 0.01. In simple terms, time to reach stationary is a back count of the time when five equal segments of the past two hundred periods do not differ from each other by one percent.

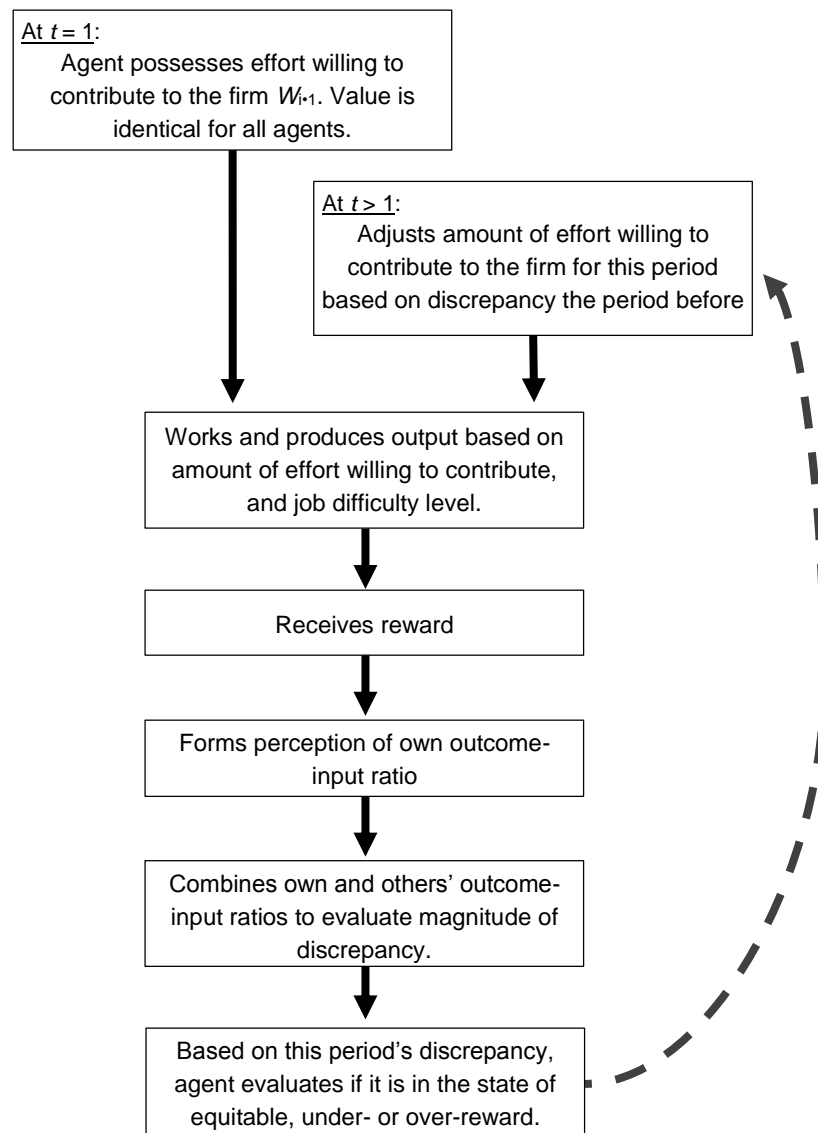


Figure 6.1. Agent processes (reproduced from earlier chapter)

Data Collection

For purposes of this exploratory investigation, only two considerably distinct levels of the parameter are varied, resulting in 400 runs (100 per combination). Data is collected in the same manner per previous experiments. Setup parameters are as in Table 9.1.

Table 9.1

Parameters Setup for Experiment 4

System	Number of agents n	121
	Number of job positions	121
	Job difficulty levels D_j	4, 5
	Piece-rate payment G (when under PFP)	1
	Fixed salary L (when under PFT)	10
	Variability in output s	-1, 0, 1
Agents	Effort willing to contribute to the firm W	30
	Motivation to adjust effort M	1
	Discrepancy ratio Φ	1
	Inequity threshold η	0.05
Experimental Conditions	Number of Comparison Others	4, 8

Results

Figure 9.2 shows the aggregate output through time for all four combinations with each point representing the mean of runs. Similar to base model of agents with memory of only one previous turn, most runs reach equilibrium well within 100 rounds of comparisons. Runs to extreme time values ($t=10,000$) revealed that random perturbations in the model are insufficient to nudge the system away from the stabilized aggregate output levels reached at equilibrium. To assess stabilized aggregate output, a time point ($t=100$) when aggregate output is stable is taken. Aggregate output at $t=100$ for collective of agents comparing with

eight others ($M_{8\text{others}} = 578.58$ $SD = 580.66$) is not significantly higher than collective of agents comparing with four others ($M_{4\text{others}} = 616.60$ $SD = 618.72$), $F(1, 398) = .401$, $p < .527$, $\eta_p^2 = .00$. Yet, Figure 9.2 clearly shows a boundary condition where number of comparison appears to have an effect on stabilized aggregate output for collectives under PFP. A 2×2 ANOVA of reward scheme \times number of comparison others shows significant interaction ($F(1, 396) = 51.0$, $p < .001$, $\eta_p^2 = .11$), specifically aggregate output at $t=100$ for collectives under PFP comparing with eight others ($M_{\text{PFP-8others}} = 1,233$ $SD = 37.84$) is significantly higher than those comparing with four others ($M_{\text{PFP-4others}} = 1,157$ $SD = 38.38$), $F(1, 198) = 199$, $p < .001$, $\eta_p^2 = .50$.

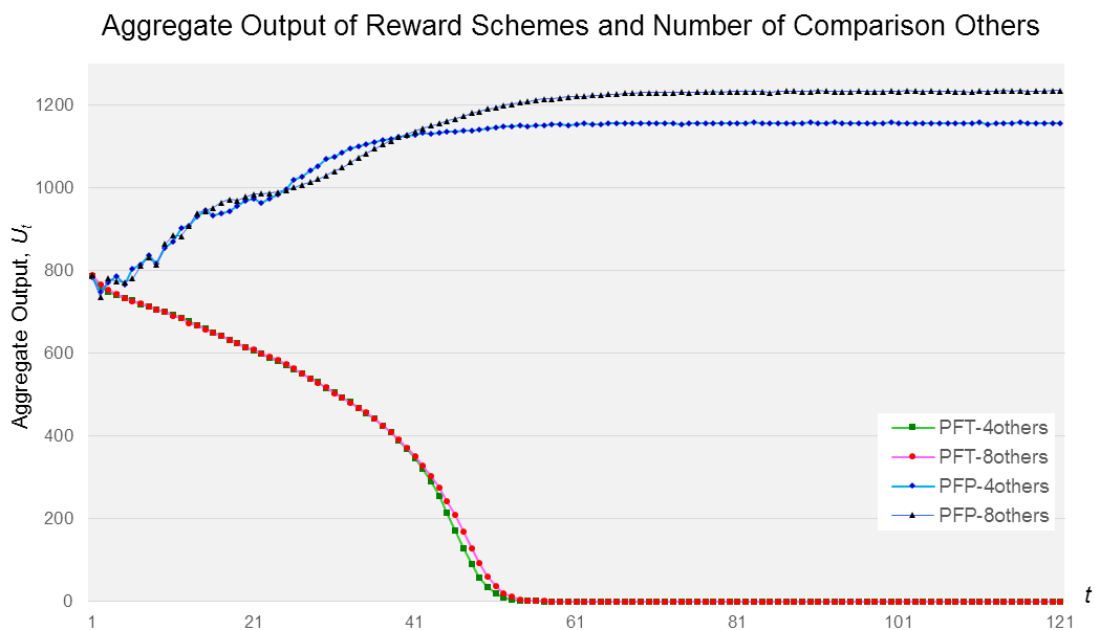


Figure 9.2. Aggregate Output of Different Reward Schemes and Number of Comparison Others Across Time. Scale of time-axis begins at $t=1$ as at $t=0$ agents are not assumed to have completed any job tasks. PFP-4others, PFP-8others, PFT-4others, and PFT-8 others refers to mean data series of runs of agents under PFP comparing with four others, under PFP comparing with eight others, under PFT comparing with four others, and under PFT comparing with eight others, respectively

To assess differences on time-to-stability, t_{stable} is obtained for all runs in the manner described above and subjected to a 2×2 ANOVA. Main effects on time-to-stability were evident when comparing between reward schemes ($F(1, 398) = 539.93$, $p < .001$, $\eta_p^2 = .58$)

and number of comparison others ($F(1, 398) = 58.84, p < .001, \eta_p^2 = .13$), as well as the Reward Schemes \times Number of Comparison Others interaction term ($F(1, 396) = 163.65, p < .001, \eta_p^2 = .29$). The significant interaction together with Table 9.2 and Figure 9.3 shows that number of comparison others has effect on time to reach stability only when agents are paid for performance.

Table 9.2

Time to Stability for Different Reward Schemes and Number of Comparison Others

Reward Scheme	Four Comparison Others		Eight Comparison Others	
	M	SD	M	SD
Pay for Time	53.42	2.24	54.60	2.18
Pay for Performance	34.28	5.46	46.15	5.49

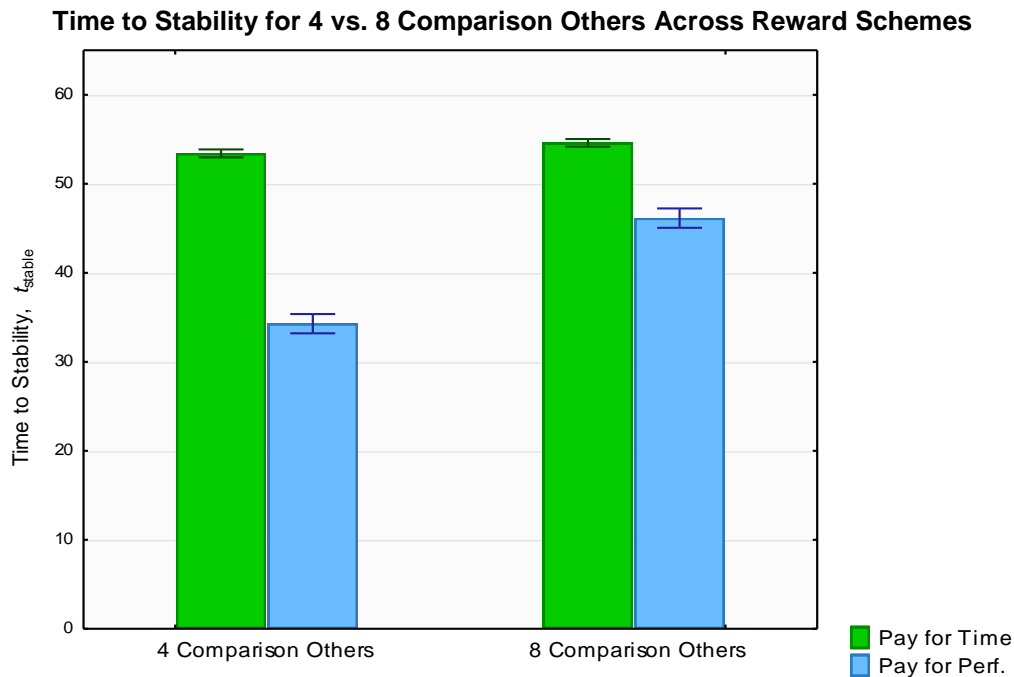


Figure 9.3. Time to Stability for Different Reward Schemes and Number of Comparison Others. Error bars refer to 95% confidence intervals.

Discussion

Results above showed that larger number of comparison others has an effect on collective performance only when agents are paid for performance and inconsequential when they are paid for time. Specifically, higher collective performance is achieved when agents paid for performance make equity-based comparison with more, rather than less, others. The reduction of boundedness of rationality in individual agents did not lead to faster convergence towards equilibrium levels for the system/collective. In fact, it seemed the longer time to reach stability reflects the longer time for the system to climb towards a higher peak.

Implications from these two findings are multifaceted. For socio-economic research, to the extent that individuals from different nations and ethnicity differ in independent and interdependent self-construals, results here (cumulative and time series) may explain growth

in wealth (more specifically GDP) and the work effort (working hours), pre- and post-transition to a capitalist-like economy. In the context of number of comparison others between urban versus rural dwellers, the findings in this experiment may also explain geospatial economic differences. For management research, the results in this experiment reveal (and emphasized) the importance to explore not just the identity of pay referents, well studied in pay equity research, but to also focus on the number of others individuals compare with. This is an area of human resource and equity research that is untapped. Should equity theory predict effects of social comparison better than other motivational theories, then empirical studies of such phenomenon will reveal firms or departments with members who are rewarded for individual performance will fare better in production-based outcomes when members compare themselves more others.

This finding may also shed light and interest onto the “contentious” (p. 55) domain of pay secrecy, where Colella, Paetzold, Zardkoohi, and Wesson (2007), argues the need to go beyond a micro perspective to look at system and even community level effects of pay secrecy. Undoubtedly with equity theory argued as a mechanism of influence (Colella et al., 2007, p.60), this model shows that if effect is constrained to those of Adams’s (1965) then pay secrecy may impede rather than aid aggregate production-linked performance, when pay for performance is dominantly enforced. On the applied front, managers may have a natural preference for pay secrecy due to concerns of surrendering informational power to the workforce. Yet, results here strongly suggest that in departments, firms, or even professions where pay for performance forms a large component of the pay mix, it may be advisable to share information regularly and objectively, rather than keep them hidden. Insurance agents, bankers, property brokers, and taxi drivers are suitable candidates.

Chapter 10

GENERAL DISCUSSION

Adams's (1963, 1965) equity theory influenced management thinking greatly (Miner, 2003 & 2006; Ambrose & Kulick, 1999; Bolino & Turnley, 2008) and contributed to the understanding of work motivation as a consequent of total rewards (Milkovich, Newman, Gerhart, 2013; Henderson, 2005; Goodman & Friedman, 1971; Weick, 1966). Imbued in this theory is the concern for equity-based fairness. Numerous studies have attested to the robustness of Adam's theory (e.g., Andrews, 1967; Garland & Judd, 1978; Dittrich & Carrell, 1979; Suls & Miller, 1977; Gerhart, Minkoff, & Olsen, 1995), but so too is the research community aware of its limitations. On a more applied domain, pay for performance (PFP) controversies have lasted four decades owing to heated arguments between proponents and opponents. PFP is deemed to have strong motivational effects (Young, Beckman, & Baker, 2012; Shaw & Gupta, 2007; Lazear, 2000; Fang & Gerhart, 2012; Cameron, Banko, & Pierce, 2001) but such perspective is derided by popular and scientific opinion leaders (Pink, 2009; Pfeffer, 1998; Ariely, Gneezy, Loewenstein, & Mazar, 2009; Deci, Ryan, & Koestner, 1999; Frey, Homberg, & Osterloh, 2013; Magee, Kilduff, & Heath, 2011; Greenberg, 2003; Baker, Jensen, & Murphy, 1988).

To address these dual issues, this dissertation studied equity theory within the context of total rewards with a focus on collective performance. Computational modeling is the formal theoretical approach taken (Adner, Polos, Ryall, & Sorenson, 2009, Harrison, Lin, Carroll, & Carley, 2007). From an initial base experiment comparing two reward schemes, to additional variations elaborating effects of memory, cognitive bias, and number of comparison others, three groups of findings were established (Table 10.1).

Table 10.1

Summary of Findings

Collective performance

1. Under equity theory assumptions, Pay for Performance generates *higher* collective performance over time. (cross-level incentive effect)
2. Under equity theory assumptions, Pay for Performance generates *higher* collective performance compared to Pay for Time.
3. Pay for Performance generates *lower* collective performance the further back in time agents remember. Pay for Time generates *higher* collective performance the further back in time agents remember. There exist a level of memory capacity beyond which collective performance under pay for time is higher than that under pay for performance (cross-over interaction).
4. Pay for Performance generates *higher* collective performance the more weights agents give to recent information, approximating short durations of recall. Pay for Time generates *lower* collective performance when recency effect crosses a threshold value.
5. Number of comparison others has a positive effect on collective performance for agents paid for performance but no effect for agents paid for time.

Agent Dynamics and System Trajectories Across Time

1. Effects of reward schemes on collective performance require time between individuals to manifest. Difference between reward schemes can only be discernible after sufficient adjustments have been made by agents.
2. Pay for Time requires longer time periods to reach stabilized aggregate output levels.
3. Trajectory of aggregate output over time varies even when conditions are similar.
4. Variations in trajectories is larger for Pay for Performance than Pay for Time.
5. Increase/decrease in effort and production of individual agents are transient and negligibly consequential to collective performance at a point in time.

Complex System Characteristics

1. Trajectories (patterns along the time dimension) and response patterns (across parameter range) of aggregate production exhibits weak emergence characteristics of self-organizing systems.
2. As memory of agents paid for time increases, there exist a point where memory levels below that has stabilized aggregate output of zero, and memory levels above that has much higher stabilized aggregate output. Exhibiting a second-order phase transition, and a tipping point at memory of three turns.

3. At that tipping point, collective performance can be “stucked” at an intermediate equilibrium level for a varied time period before sufficient random perturbations nudge the system from the transient attractor towards zero aggregate output.
 4. System behavior similar to above is observed for the response on recency effect. The corresponding tipping point for memory held constant at seven turns is $\lambda=0.25$.
 5. For memory, at tipping-point the distribution of time-steps taken for system to reach terminal equilibrium is unimodal. For recency effect, at tipping-point the distribution of time-steps taken for system to reach terminal equilibrium is bimodal.
-

Main results from Experiment 1 (base model), provided computational evidence for PFP’s *cross-level incentive effect* (Gerhart & Fang, 2012) to manifest from individual and dyadic adjustments to performance at the collective level. Traditional equity theory (Adams, 1965) could not directly predict how collective performance may be affected by the implementation of PFP, the dynamic implementation here illustrates how it could occur and showed *equity theory to be a sufficient theoretical mechanism for higher collective performance to emerge* when individuals are paid for performance. This weak emergence at the collective level surfaced without the presence of other commonly invoked motivational mechanisms, such as expectancy or goal setting theories. [Contribution 1]

But establishing support for proponents of pay for performance is only part of the aim. Equivocal evidences of PFP’s efficacy on firm performance remain to be answered (e.g., Dalton, Daily, Certo, & Roengpitya, 2003; Honeywell-Johnson & Dickinson, 1999). Particularly, all experiments performed showed that *greater variations in terms of trajectories and fluctuations are to be expected for PFP than for PFT*. Even with similar stochasticity underlying simulation for PFP and PFT, such random perturbations are not canceled out across many agents over time but are amplified in the context of PFP. Particularly variations for PFP within-run and between-runs are much larger than PFT, showing this to be an endogenous characteristic of PFP, since external perturbations are not

required to produce such larger variance. And given each trajectory can be seen as a firm/division/department/plant with highly similar initial configuration, this variation in collective performance could provide one reason for past large equivocality in PFP research.

[Contribution 2]

Another finding stretching across all experiments is the necessity of time for system to evolve. Be it for PFP or PFT *substantial periods of comparison and adjustments is required to enable the manifestation of incentive and disincentive effect of PFP and PFT respectively*. As time periods increase, the distinction between PFP and PFT increases. This not only suggests crucial implications for research design in future strategic total rewards studies, but also provides answers to a once bewildering meta-analytic observation of Condly, Clark, and Stolovitch (2003) who found evidence for PFP's strengthening effect over time but could not find the reasons for it from the studies they reviewed (p. 53-54). [Contribution 3]

Apart from new research directions to shed light on PFP's paradox, the many meta-analyses of PFP on individual and firm-level outcomes have shown PFP's effect to vary largely by numerous moderators such as task-type and industry, and at times also show moderately large effect sizes that remain insignificant at the 95% level (Guzzo, Jette, and Katzell, 1985). Hence, with a model capable of modelling reward scheme from micro-level characteristics and interactions, I designed and conducted a set of studies to investigate individual-collective effects of reward scheme. Specifically, *individual-level factors yet to be linked to reward schemes are explored* to gain greater entropy for each new parameter studied. [Contribution 4]

Experiment 2 found memory capacity to negatively affect collective performance of agents paid for performance. The longer PFP agents remember into its past, the lower the

performance for the entire collective. The opposite is shown for PFT collectives. Though the increase in PFT's collective performance is non-monotonic with asymmetrical inverted-U relationship, this higher collective performance level exhibits a cross-over interaction with the collective performance under paid for performance. The cross-over region occurs roughly where agents are able to remember reward-outcome information for more than three periods into the past. This provides the first evidence and indication in this study, where PFT may generate higher collective performance compared to that under PFP.

Experiment 3 explored a related aspect of memory, recency effect. This answers calls to extend Adams's equity theory over time (Vecchio, 1982; Gould, 1979) as well as to serve as a robustness test to results found in Experiment 2. Cosier and Dalton's (1983) theoretical work on equity theory is incorporated for this. Results showed higher recency effect, therefore relatively lesser weights to historically distant events, to positively affect performance of PFP collectives. The converse is shown for PFT collectives, except with an inverted-U relationship. Memory capacity was fixed at seven periods to observe a controlled response of recency effect. The magnitude of changes in collective performance across four parametric levels is evidently smaller than that seen when memory capacity was varied in Experiment 2. Yet, the similar direction of effect found in Experiment 3, affirms findings in therein, and provided further insights into the manner individual differences may affect collective performance in the long-run.

Experiment 3a on primacy effect was added to further probe serial position effects, where recency had been earlier studied. Without suitable prior literature to guide formulation of primacy effect and numerous equally possible operationalizations, the result here is only indicative. Nonetheless, it is shown that as agents place ever greater weight on the first information in their list of memory items, performance of PFP collectives decrease. And as

primacy effect increases from null to strong, an inverted-U relationship is seen for performance of PFT collective.

Across experiments 2, 3, and 3a, via different operationalizations of agents incorporating past equity information, a computationally robust and consistent effect is shown. Specifically, *PFP collectives with agents considering or giving more weight to information further back in time will generate lower collective performance*. And for PFT collectives, considering only very recent information is detrimental to collective performance. While increasing consideration of distant information will increase PFT's collective performance, there exist a critical value upon which further increase in consideration or weightings will not increase collective performance. [Contribution 5]

The experiments on memory and serial position effects, also revealed consistently that the disincentive effect seen in the base model for PFT can switch to an incentive effect when agents consider past information sufficiently. This switch can lead to levels of collective performance higher than that achievable for PFP. Therefore under certain parametric combinations, *PFT can outperform PFP*. [Contribution 6]

Finally Experiment 4 deviates from investigation on information processing differences to probe effects of social psychological differences between individuals. Results showed that *comparing with more versus less others*, operationalized as information obtain from a Von Neumann versus Moore neighborhood, to have no effect on performance of PFT collectives, but *a significantly positive effect under PFP*. While this result may resonate with findings of Wagner, Humphrey, Meyer, and Hollenbeck (2012), and Taras, Kirkman, and Steel (2010: Table 2), or the arguments from tournament theory (e.g., Connelly, Tihanyi, Crook & Gangloff, 2014), their arguments of collectivism are only distally related to the operationalization here, and tournament mechanism does not feature in any part of the model

here. Instead, the results shown here merely require the numerous equity-based social comparison occurring over time with more versus less parties in proximity. [Contribution 7]

The above findings would be hard to realize if not for the research method employed. Such computational method goes beyond that of systems dynamics or mean-field approximation to allow temporal dynamics (Hackman, 2012) of collective and individuals to be observed^{10.1}. The observation of different trajectories at the collective level was discussed earlier and it shed light on how some meta-analytic results were insignificant as well as the requirement of time for cross-level effect to manifest. But observing micro-level dynamics could reveal more. For instance while conventional wisdom would suggest that under PFP, job difficulty levels (required to produce one unit of output) would greatly determine whether an agent/worker equity state. However, this is not the case (Chapter 6). A strong path dependent effect is observed as one agent who may be working on a difficult job for little pay may be in a perpetual state of positive inequity even if a significant proportion of neighbors are working on easy tasks. This can occur when those neighbors have their own set of neighbors who are paid higher reward-per-effort early in the simulation causing those neighbors first degree to the focal agent to reduce effort. This reduction in effort as a result of non-divisibility of output (such as widgets) will lead to low levels of output and hence low reward for these first degree neighbors. As such the focal agent will be in a positive inequity state. Because each agent has its own unique set of neighbors that partially overlap, and small stochasticity is present at each turn, the forward prediction of inequity state for seemingly structurally equivalent agents is difficult. Backwards explanation however shows the equi-

^{10.1} Apart from Hackman (2012), OB researchers aiming to adopt ABM have begun to comment strongly against the dominant interest, such as those studying social dilemma to overemphasize on “level of the emerged property ... but not the process of emergence” (Kozlowski & Chao, 2012, p. 349, citing Axelrod, 2006 as example). Hence this research goes beyond that to explicitly observed, analyse, and interpret the changes in emergent property across various time scales, through time, and attempted to give, albeit cursory, suggestions of how different lower-level conditions (individual differences) and interactions gave rise to the patterns seen at the higher level. This deviation from the usual ABM study, I believe is warranted and useful for both research and practice, as shown in the discussion shedding light on past PFP dilemma.

and multifinality of different and similar paths of evolution. And because these paths are not random but deterministic. The words of management scholars Dooley and Van de Ven (1999) aptly sums this observation that holds many times here:

... chaotic dynamics arise from a stable and deterministic nonlinear system, consisting of a small number of interacting variables, which produces behavior that appears irregular to the degree that it seems random moment-by-moment. Stepping back and viewing the system over a long period of time, however, yields distinctive patterns that clearly are not random. (p. 359-360)

Consequently, the movement between levels and time scales of observation have allowed us to notice the *different motivational dynamics underlying the cross-level incentive and disincentive for PFP and PFT* respectively (Figure 6.6). Particularly one can observe PFT agents tend to oscillate (periodic and aperiodic) between states in frequent succession, while PFP agents maintaining at one state for longer periods and require the seemingly ‘coincidental’ but frequent coordination of neighbors to change from one state to another. [Contribution 8]

Reflecting upon existing literature, one finds several attempts to extend equity theory through time, space, and individual differences, though most were theorized separately or focused solely on dyadic context. Example Huesmann and Levinger (1976) modeled effects of repeated adjustments over time in their formal model RELATE with a focus on maturation of relationship status in a dyad, while Lawler, Koplin, Young, and Fadem (1968) investigated multiple rounds (two rounds) of comparison-effort adjustments in a production context at the dyadic but not co-acting context, and Messe, Vallacher, Phillips (1975) showed equity theory to explain coalition formation patterns in a 4/3/2 triad. Similar good work has meld individual differences with equity theory such as the construct of equity sensitivity (Huseman, Hatfield, & Huseman, 1985; King, Miles, & Day, 1993), Weick and Nessel’s (1968) study of preferences for three different forms of equity, Lawler and O’Gara’s (1967) exploration of

equity theory's prediction with common personality factors, and Brockner, O'Malley, Hite and Davies (1987) study self-esteem and equity-based fairness. Yet expanding equity theory through time and social space simultaneously has not yet been done. Clearly, unlike the claims of Kanfer (1990), Jenkins et al. (1998) and Parnell and Sullivan (1992), equity theory *can* predict directionality of the effect of PFP implementation on collective performance. It is unambiguously shown here. By means of present day computational methods, dynamism of equity theory and its cross-level effect is illustrated. This provides a new predictive and explanatory use for a classic work motivation theory that is important for HR and total rewards research. [Contribution 9]

Implications for Theory

“Model as theory”, a perspective held by most social simulation scientists (Carley, 2001; Sawyer, 2003; Carley & Gasser, 1999; Cohen & Cyert, 1965; Harrison, Lin, Carroll, & Carley, 2007), is certainly far from OBHR's mainstream thought (Rousseau, 2011). By the twin Popperian criteria of falsifiability and parsimony, there exist no empirical data or study here to support the theory, neither do formal rules lend themselves to the appearance of parsimony.

While the above summarized key findings and contributions, that which may contribute to research does not necessarily entail a theoretical contribution. Perhaps it does not fit with dominant perspective of the field, perhaps it is not scientific, or perhaps there is no need for such research. Albeit rhetorical, the following section takes a reflective look at the outcomes of the model and studies, and argues to the best extent possible how the work here may adhere to common criteria of theoretical (not just research) contribution in management domain.

Theoretical Needs in Management and HR Domain.

Management field's emphasis on theory has led to numerous useful guides on evaluating what good theory is and what forms a theoretical contribution. The views of major management journals see theory as "any coherent description or explanation of observed or experienced phenomena" (Gioia & Pitre, 1990, p. 587), an "analytic structure or system that attempts to explain a particular set of empirical phenomena" (Shapira, 2011, p.1313), a "statement of relationships between units observed or approximated in the empirical world" (Bacharach, 1989, p. 496), and an "ordered set of assertions about a generic behavior or structure assumed to hold throughout a significantly broad range of specific instances" (Sutherland, 1975, p. 9, quoted in Weick, 1989). As such Whetten (1989) mandates a complete theory to contain four essential elements of what (variables, constructs, and concepts), how (are they related), why (are they related), and the combined who, where, and when (as boundary conditions of the theory). DiMaggio (1995) classifies three types of theory, namely theory as covering laws, as enlightenment, and as narrative. And given the heritage of Dubin (1978), Hempel (1966), Lakatos (1970), and Popper (1965 & 1979), management theorists have converged upon several aspects a good theory must possess. Accordingly, good theory should,

- Be grounded in the relevant literature
- Be testable and parsimonious
- Be focused and cohesive
- Offer novel insights
- Be interesting
- Be causal
- Be fertile
- Be practical

Compiled from Hong, Chao, Yang, & Rosner (2010); Whetten (1989), Weick (1989), DiMaggio (1995), Corley & Gioia (2011), Higgins (2004 & 2006); Fiske (2004), Shalley (2012), Ferris, Hochwater, & Buckley (2012), Shapira (2011), Klein & Zedeck (2004), Kilduff (2006), Cornelissen (2006)

In view of the above chapters, both organizational and theoretical bases in this research were built on known theory and empirical findings. The absence of empirical data may deem the findings lacking in legitimacy, but extensive effort has been made to *ground* the theoretical built-up via a positivist but non-hypothetic-deductive paradigm. And as Sutton and Staw (1995), McGrath (1994 & 1981), Adner, Polos, Ryall, and Sorenson (2009), Harrison, Lin, Carroll, and Carley (2007) posits, the specific match of method and theorizing implies not a need for empirical data (at least at this stage), rather theoretical representations are to be built upon empirically-based theories, evidences, and assumptions. Accordingly, it is the findings and deductions of the formal model that will lead to subsequent empirical studies (McGrath, 1994, p. 159). Hence, the first-half of discussion not just explicated the alignment of findings with previous empirical findings, but also indicated areas of empirical research. On the criterion of *parsimony*, it is unknown if the model will be considered parsimonious in the general sense. But by using only one theory as mediating mechanism, the control at the level of theory (not at the level of variable) provides a highly reductionistic explanation of cross-level emergent results. With formulaic definitions of how individual production aggregates to collective performance (in this case an additive composition element) embedded in the mechanisms and assumptions, the model is *focused and cohesive* throughout.

On the question of *novelty* and “Aha” moments, it is an opinion one cannot objectively evaluate. The choice of phenomenon and theory have been carefully selected and applied the opinions of Poole and Van de Ven (1989), Alvesson and Karreman (2007), Tsang and Ellsaesser (2011), Smith and Lewis (2011), McGuire (2004), and Alvesson and Sandberg (2011) to “spot gaps” and tensions between theoretical explanations of empirical phenomenon.

In this case, the paradox (or dilemma) of pay for performance is a perennial area of concern to both practitioners and researchers wherein variance and bi-directional explanation continues to be heard. To the extent that the model provided a base level support for the PFP's cross-level incentive effect and propose when PFP may be inferior to PFT, the theory not just satisfies Whetten's (1989) four elements, but also suggests boundary conditions for existing PFP related theories. The attempt in gap-spotting also latched onto the relative silence of equity theory in explaining PFP's effect on performance. While most advocates of PFP rationalize from the perspectives of expectancy theory, tournament theory, and agency theory, it has been difficult to predict how PFP may affect a collective of individuals who mutually adjust effort. The model here provides a, possible first, model of reward scheme's effect solely mediated by equity theory to derive global emergence from dyadic interactions.

Add to that, the unexplored individual-level differences in the context of equity theory, the use of paradox, and the exploration of new dimensions the model may be novel. Yet to be interesting remains an optimistic shot. Even having fulfilled Davis's (1971) canonical "index of the interesting" on item II, IV, VI, and VII, it is likely that only those concerned for the study of human motivation or HR practices may have interests piked by the findings here.

If not interesting, is it *causal* and answers various theoretical calling? I argue yes. The process-based model shows unambiguously the events occurring in sequential time where production is aggregated from individual level to the group level. The experiments controlled effects and alternative mechanisms to show unambiguously the effect of different parametric combinations. For theorizing of time, the findings point to a seldom heeded (Sonnentag, 2012) advice of Mitchell and James (2001) that measurement of an intervention goes through an "equilibration period" (p. 539) where measurement of efficacy is best done after

equilibrium has reached. The findings here affirm that. Signaling researchers studying PFP and/or PFT to expect a considerable time period before obtaining data should they wish to observe the full effects of PFP and/or PFT. This also corresponds closely to Goodman's (2001) call to develop theories considering the effects of "time lags".

For multi-level theorizing, Rousseau (2011) commented that there is no longer an ignorance of levels of analysis issues, but a need to make clear the cross-level mechanisms operating over long periods of time. To do that, she recommended the use of simulation (for its formalizing of mechanisms) to tease out assumptions underlying the complexities in a multi-level system. For the concurrent theorizing of time and multilevel, Kozlowski and Chao (2012) ardently called for OB scientists "to stop relying solely on perception-based surveys!" (p. 349, para 2) for multilevel research and embrace agent-based modelling to move OB research towards the fourth quadrant where "data are collected using dynamics and complexities of ... emergence can be tracked with precision" (p. 349, para 3). The three calls by eminent researchers of OB underscores the importance of ABM in adding a whole new dimension to well studied phenomenon. This set of studies addressed that by stating unambiguously the mechanisms, the assumptions and specification of time sequence at both levels. The findings borrowed observations of steady state comparisons (e.g., Roos et al., in press), augmenting it with time-based analysis to draw insights for past PFP's, at times, equivocal results. This, in sum, argues that the model is *causal and timely with many calls for simulation and multilevel theorizing concurrently answered*.

But, perhaps as Corley and Gioia (2011) argues, the yardstick dominant in the field of management lies in scientific utility, synonymous with *fertility* or fruitfulness of a model/theory. Illustration of effect, even if cross-level and causal may not be sufficiently "fruitful". Generally defined as the extent to which a theory can "provoke constructive

theoretical debate from opposing perspectives”, “generate research ideas”, and derive interests for scientist to test it (Fiske, 2004, p. 135), I argue the findings and method used here has the *potential* to do so^{10.2}. The domain explored here is arable with large number of researchers on both sides PFP’s debate. Though I stand on the side of the proponent, the model and its results provide rich positivist-based evidence able to explain previous equivocal findings and meld points of tension. If equity mechanism is salient in the real-world, the simulation indicates future empirically based studies that can be performed to establish the boundary conditions to both sides of arguments. Considering that the model does not follow the convention to look at how equity concerns moderate effectiveness of PFP, but how equity theory predictions *enable* the emergence of PFP’s superiority in collective performance, the present study and its findings opens a new door of inquiry.

Beyond just theoretical directions, the model (and theory) created, Dynamic Equity Theory, is likely a first cellular automata to link fairness comparison to production under the context of reward schemes. Like Axelrod’s (1986)^{10.3} IPD model of norms emergence that gave rise to a thriving discipline studying social dilemmas and emergence of cooperation (see Galan & Izquierdo, 2005; Binmore, 1998; Nowak, 2006; Hoffman, 2000; Gotts, Polhill and Law, 2003 for comments), Nowak & May’s (1992), Deffuant, Neau, Amblard, and Weisbuch’s (2000), Hegselmann and Krause’s (2002), and Nowak, Szamrej, & Latane’s (1990) model, each inspired hundreds of research and model extensions.

^{10.2} I take a stance that while one could not possibly assess fertility at the outset (Dimaggio, 1995; Higgins, 2006), assessment of fertility can only be done retrospectively. Hence discussion here revolves around “potential” to be fertile or fruitful, but not actual fertility per se.

^{10.3} Axelrod’s earlier studies (1980a & b; 1981; 1984; Axelrod & Hamilton 1981) are more often cited as pioneer works. I do not dispute that. But in terms of implementing IPD game in ABM, it appeared Axelrod (1986) to be the first, wherein he showed not just emergence of norms, but the effects of metanorms. His model have been modified and criticize by many others but the works his model has inspired are in the thousands.

Works like Miller, Zhao, Calantone (2006) and Kim & Rhee (2009) expanded March's (1991) discrete event simulation model with interpersonal learning, tacit knowledge and environmental turbulence, Pentland, Feldman, Becker, and Liu (2012) investigated organizational routines, Scullen, Bergey, Aiman-Smith (2005) and Mulligan and Schaefer (2011) investigated forced-ranking on residual KSAO pools, Kennedy and McComb (2014) leveraged both neural networks and genetic algorithm to investigate timings of process shifts in teams, Phelan and Lin (2001) compared impact of different promotion systems on organizational performance, Ekmekci and Casey (2011) investigated how information and memory artefacts influence organizational identification, and Baumann and Stieglitz (2014) showed the benefits of low powered incentives to the generation of exceptional ideas. But there is still to date, to the best of my knowledge, no ideal-type analogical agent-based model (Gilbert, 2008) that links social (peer-to-peer) comparison with empirically based motivation theory for the purpose of investigating aggregate production. While the models cited above made great contributions as they approach that of emulation models (Carley, 1996), the simplicity of the model here approaches the purpose of Nowak, Szmarej, and Latane (1990) work who modeled a simple theory to investigate opinion distribution. As such, following the rationale of KISS, if a simple theory-focused model can serve as a guide for modelers, future modelers interested in the effects of dyadic social comparisons may now have a reference model to critique and modify than build from scratch.

For the aims of *cross-domain fertilization*, the interdisciplinary nature of ABM (Axelrod, 2006; Christopoulos & Hong, 2013, p. 21) makes this likely. Think, in the domain of social economics, if PFP corresponds to the norms of a capitalist economy and PFT corresponds to that of a socialist economy, would a capitalist economy benefit more with citizens who compare with more others than citizens who compare with less? In two socialist economies or micro-societies, would the collective with people remembering further into

their past experience higher output? What events of evolution may have led to the dominance short-term thinking in the capitalist economy, as shown in the model to be necessary source of its success? Would encouraging socialist economies to be aware of their past really help propel the economy to riches beyond that of capitalist economy? These questions, *prima facie*, go beyond the domain of management (broader fields such economics, e.g, Riyanto & Zhang, 2014), but they attempt to answer AOM's 2013 call to start asking big questions of the world, or as Colquitt and George (2011) argues the “grand challenges” (p. 432) management scientist can answer for societal benefit. With the model here as fundamental as those studying opinion dynamics and altruism via ABM, the findings here open doors for important research in this direction.

Implications for Practice

Practical utility is arguably a vital but ignored area in contemporary management studies (Corley & Gioia, 2011). To what extent will the findings here help managers and business, or in this case HR practitioners? If “nothing is so practical as a good theory” (Lewin, 1945, quoted in Van de Ven, 1989 and Hong, Chao, Yang, & Rosner, 2010), I will assess practical utility from the extent the applied field of HR and total rewards can benefit from this research, and indicate how the findings herein can help managers and firms.

The reviews of compensation researchers revealed that “employee compensation (is a) neglected area of HRM research” (Gupta & Shaw, 2014, p. 1, see also Cascio & Aguinis, 2008) and “there remains much to be learned about the multi- and cross-level effects of compensation systems” (p. 3). These views showed earlier (and similar) calls have been unanswered by majority of the research community (recently in Risher, 2012). Aptly, Wright and Boswell (2002), and Dipboye (2007) had called upon rewards and HR researchers to start leveraging multilevel theorizing and research while Dulebohn and Werling (2007)

commented that “compensation ... has historically been under-researched in comparison to other (HR) activities” (p. 205) and compensation researchers can improve the state of affair by being cognizant of “levels of analysis problem” and avoiding “narrow definition of a broad operational problem” (p. 201).

In a comment most relevant to the domains covered by this research, Deadrick and Gibson (2007) compared 4,356 articles from HR-research versus HR-practice journals to find the two largest research-practice gap to exist between HR research and practice lies in the topics of Compensation and Motivation! The insights of the above authors suggest not just the importance of timely research or alignment to multi-level theorizing for HR and compensation researchers, but if alternative paradigms could indeed excite interest and conversation between practice and research (McKenna, Richardson and Manroop, 2011) then the twin research streams here (reward schemes and equity theory) with the use of complexity and paradox-like research in HR (Dipboye, 2007) could help in bridging the practice-research gap in work motivation and compensation domains.

Admittedly such goals rest on eventual acceptance of research presented here. Yet immediate takeaways for managers exist. Specific pointers have been presented earlier (Chapters 7, 8, & 9). Summarily for firms stuck with either reward schemes, leverage points exist where higher collective performance can be conditioned and nurtured (Hackman, 2012). For managers with the luxury of tweaking the PFP component in their reward mix, managers need to be aware of differing time-to-discernable-effect of different reward schemes. It is crucial for HR practitioners to inform the upper echelons from unrealistically expecting any reward scheme to be exhibit rapid results.

Compared to predictions of expectancy or goal setting theory, equity theory predicts a clear necessity for several rounds of comparison to occur before PFP implementation results

in improved collective performance. When a firm moves to pure PFP, for instance commission-based pay for B2B account managers, variance in trajectories of collective performance between firms/departments implementing identical change is to be expected and likely large for the case of PFP. Hence, HR practitioners ought to be wary in transferring expectations of success/failure from previous a firm/department to that of the current one., however similar they maybe. If conveying results in a way that practitioners can easily comprehend is the lynch pin to conveying scientific findings to firms, then visualizations enabled by ABM and in particular cellular automata (Hegselmann & Flache, 1998) certainly has the opportunity to augment traditional statistical insights. With compensation the largest single cost for the average company (Gerhart, Rynes, and Fulmer, 2009), appropriate management of stakeholders expectations is vital.

On counts of paradox clarification, extension of theory, indication of avenues for empirical studies, re-orienting the role of equity theory in the study of PFP, creation of an ideal-type ABM model, cross-domain fertilization, *and* the timeliness of research for the field of total rewards and HR, I believe this research have the potential to contribute towards new theories.

Limitations of Study

No study or research method is perfect or complete (McGrath, 1981). While the aims of these studies lies in theory development via the generative and paradox abductive route (Epstein, 2006; Poole and Van de Ven, 1989; Mantere & Ketokivi, 2013; Locke at al., 2008; Weick, 2005) where creation of new insights, than hypothesis testing, are key, the theoretical implications made possible by the method exposes the study to potential contentions.

One key contention is whether the results are valid, robust, or if any artefacts may

have led to the results found. This is a valid and appropriate question given numerous authors (e.g., Galan et al. 2009; Richiardi, Leombruni, Saam & Sonnessa, 2006; Goldspink, 2002; Radax & Rengs, 2010; Troitzsch, 2009b; Elsenbroich, 2012), and especially ABM scientists, have lamented the difficulty to make that assessment within a single study. ABM when leveraged has often been criticized on the following grounds:

Your model is too complex
 Your model is too simple
 Your model is not realistic
 Your model is not theory based
 Your assumptions and parameters are arbitrary
 Your results are built into the model
 Your model is a black box
 This is not (the way we do) science!
 Your model is not useful

Compiled from Waldherr & Wijermans (2013)

At the risk of repeating what is mentioned earlier, I shall summarize (without going into details) how the above common criticisms have been addressed in some ways^{10.4}. First, Dynamic Equity Theory is not complex when placed along well-known models such as that of Anasazi ABM (Axtell et al., 2002) which is aimed at recreating history, Polhill, Gotts and Law's (2001) model of land-use change, and Jin and Levitt's (1996) model of virtual design teams which is focus on typification of context (see section on varieties of ABM in various fields, also Boero & Squazzoni, 2005). While not as simple as Ising model or various IPD works, it is on the same, if not lesser, level of complexity, as Nowak, Szamrej, and Latané's (1990) Dynamic Social Impact Theory, Hegselmann and Krause's (2002) continuous opinion

^{10.4} I apologize for repeating. But owing to paradigmatic differences and the relatively new "third way of doing science" I have to re-emphasize some key aspects. Still, space limiting, I am unable to cover or go into a discourse why some papers in ABM operate at the theoretical realm and why some deliberately choose to be empirically grounded. Please forgive me.

diffusion model, and Axelrod's (1997c) culture dissemination model. While the latter two were built on intuitive arguments, Nowak et al's (1990) work was built on Latane's social impact theory from 1981. Dynamic Equity Theory here was built on Adams's (1965) theory of equity theory that have been empirically researched since the 1960s. Effort has also been made to ground each experiment onto existing literature than just relying on intuitive arguments as is at times done for ABM. Even for accessory assumptions, they are disclosed and rationale for them stated. For instance the accessory assumption that an agent starts with W amount of energy willing to contribute and has an upper limit of $2W$ was made to represent a worker may for instance exert 8-9 hours' worth of energy and may maximally double that before exhaustion sets in. This was explicitly stated, and can be subjected to debate, and as robustness test done for $3W$.

In sum the model while highly abstract, and far from realistically representative, is built from theories within the domain of enquiry. Assumptions are arbitrary, but rationalized and disclosed. More importantly, it is not a black box. The entire agent process, environmental setup, and assumptions are explicated in the text, and the model (post publication) will be added to the library on www.openabm.org. Because it is uploaded in Netlogo file than an executable file, the source code is open for all.

Staunchly, none of the assumptions or equations ought to be seen as having allowed the results to be built into. Even for questions on the use of log, step, and floor functions that may have suspiciously caused the rise or fall in aggregate output, such questions are answered when one realizes that (1) the same formula were applied under both reward schemes and that the sheer change of $P_{i,t} \times G$ to L where both produces a single value of R would not directly lead to the patterns observed, and (2) the fact that in subsequent experiments, trajectory and steady state levels and dynamics changes when a parameter

sweep of memory changes is performed, shows that despite the exact same formula new patterns emerge for different parameter values, not code. Certainly the results come from the model, but they are not intuitively foreseeable from the equations nor consciously coded for.

Hence it brings to the last two points. It is agreed that this is not the way science is dominantly done in OBHR, but science must be open to cross-disciplinary pollination in both theory and method, a position McKelvey has been trying to make for management for a long time (Henrickson & McKelvey, 2002; Boisot & McKelvey, 2010; McKelvey, 2002). The justification why Dynamic Equity Theory is timely for total rewards research, and adherence in attempt for theoretical (not just research) contribution is discussed above. But above all the arguments, I would like to add that, if the use of genetics and neuroimaging evidences, has yielded very useful insights for OBHR. It is not time to consider the third way of doing science even if it may seem as a social science epistemological outpost (Squazzoni & Casnici, 2013)?

The above arguments were made in brief, without explanation. I shall use one example to elaborate what has been done to address artefacts. Artefacts and bugs are common in programming, so common that Nigel Gilbert (2007) commented that "You should assume that, no matter how carefully you have designed and built your simulation, it will contain bugs." (p. 38). This view is resonated in Galan et al. (2009) and several others (e.g., Carley, 1996; Polhill, Izquierdo & Gotts, 2005; Hales, Rouchier, & Edmonds, 2003). Accordingly, several programming and unintentional artefacts can creep in the entire process. However unlike, real-world data such as from survey or experiments which is subjected to artefacts such as demand characteristics, or double-barreling of questions, or sampling issues. The explicit nature of object-oriented computational methods, especially ABM renders it a method with very high theoretical precision and internal validity (Davis, Eisenhardt, &

Bingham, 2007; Burton & Obel, 2011; Adner, Polos, Ryall, & Sorenson, 2009, Labro, 2015), and as such, where possible, effort must be made to address artefacts, as would a good experimentalist ensuring counterbalancing of tasks, eliminate practice effects, and minimizing head and eye movements in the case fMRI studies.

Apart from performing two-persons code walk-throughs during the verification stage focusing on the bottom-up approach, unit testing, tracing, and testing the model before scaling up the model from smaller ones (North & Macal, 2007; Canessa & Riolo, 2003; Beck, 2002), numerous robustness tests were also done. For all experiments, except 3a, the results obtained for 121 agents were compared with that obtained for larger and smaller agent numbers with different neighborhood radius. Apart from differences in critical value for PFT and the time required to reach steady state, the trajectories and conclusions that can be drawn are qualitatively the same. Other robustness tests were performed for the base model, such as using linear than log function (footnote 6.6 and equation 7a) and an experimentation of four (plus one) symmetrical equity sensitivity levels were conducted (footnote 6.15). The change from log to linear produced similar results, while the experimentation of equity sensitivity with the aim as a robustness test showed that as agents get increasingly less sensitive to discrepancies, a point is reached where PFP's cross-level incentive effect diminishes and agents produce as what they started off at. This shows a boundary condition intended by the model at the micro-level manifesting at the macro-level.

For uncovering possible artefacts that may lead to the surprising trajectory switch when agents in PFT collectives increase memory from 3-turns to 5-turns, careful verification of code, and the implementation of recency effect and subsequently primacy effect converged on similar patterns. This retrospectively expected convergence was unexpected when the recency experiment was initially coded. That experiment was designed to explore if recency

effect could show a different result, but on hindsight, given the literature have previously coded memory either as a list or as a decaying function (see Alonso-Sanz, 2012) this is now not just a non-surprise, but a confidence gain that the phenomenon of PFT collectives responding positively in phase transition-type pattern is a natural occurrence when equity mechanism is salient. The fact that a further indicative test of primacy effect, coded not as a direct inverse of recency but of first-impression effect, found similar patterns, further strengthens the case, corroborating the trajectory change with three different codes.

Some possible artefacts that were pre-emptively avoided at the outset include those referring to the sequence of code execution by agents, and dichotomous agent response pattern. These simulation artefacts are common in ABM and have been shown to lead to very different results when relaxed. For the former, pseudo-concurrent updating of agents is used as it better approximates parallel actions in the real world, and for the latter a continuous step function, unlike those in game-theory and IPD-based ABM, is used. For concerns of floating-point error, while the best way is to adopt interval arithmetic, the way it is dealt with here is via the use of different computers for a few sample cases. For concerns of random initializations, the way it is dealt with is generating and analyzing via the monte carlo approach.

Despite the effort above, as per the words of Gilbert (2007) it is very likely bugs and artefact remains. To what extent it is consequential is a guess. Hence the best one could do is to perform replication. A whole host of replication (not repetition) techniques, such as docking and aligning, have been suggested (e.g, Carley, 1996; Windrum, Fagiolo Moneta, 2007; Galan & Izquierdo, 2005). But generally, they involve replication by a separate group of researchers, using different toolkit/language, or at times a reinterpretation of the conceptual model. Such model-to-model analysis will likely reveal hidden assumptions

(Hales, Rouchier, & Edmonds, 2003) and may produce different conclusions. Many such attempts has been done on the seminal works of Axelrod, Shelling, Martin Nowak, Andrzej Nowak, and Mike Macy, just to name a few. For the case of my model I have only just started to showcase and make formula walk-throughs at internal and external conferences, including in a consultation session with a agent-based computational economist (Chen Shu Heng). While feedback was unexpectedly positive, much work needs done to get the community interested and sufficiently so for replication. Such replications do not just end in refutation or stronger support, but also possible extensions.

To cast further doubt on the work done here, one need only look at external validity. This is the weakest link for ideal-type or theoretical abstraction type agent-based model. Unlike empirically-grounded ABM, no data has been obtained for validation nor calibration. Instead of citing numerous influential work in this tradition, I shall attempt to look at existing stylized fact (empirical or just analogical, Epstein, 1999, p. 46) that may corroborate some of the findings. Thereafter I delineate ways to expand the theory computationally and validate empirically. Some of them have been discussed in each chapter, but they will be elaborated more here.

Empirical Links^{10.5} and Future Directions

Experiment 1

Experiment 1 found cross-level incentive effect of PFP and this effect increases over time. Positive incentive effect was found in individual-level studies (e.g. Farr, 1976b; London & Oldham, 1977; Bartol & Locke, 2000) and cross-level incentive effect also reported in

^{10.5} Close empirical similarity is difficult to find and any conclusions made with reference to predictions from dynamic equity theory will likely be highly spurious given many other factors operating in the real world may yield even stronger effect, such as expectancy theory (see Vecchio, 1981). So no claim is made on achieving external validity of any form. Prima facie this appears to be a “fishing” expedition but attempts to make empirical links is not just to show feasibility of pursuing empirical study in the direction predicted by dynamic equity theory, but to also suggest that the findings are not entirely improbable.

some organizational-level studies (e.g., Lazear, 2000; Shearer, 2004; Fay & Thompson, 2001, see Chapter 3). Though most meta-analyses tended not to distinguish between individual or organizational performance, the general positive effect of incentives and PFP are shown in reviews of Guzzo, Jette, and Katzell (1985), Garbers and Konradt (2014) Jenkins, Mitra, Gupta, and Shaw (1998), Locke, Feren, McCaleb, Shaw, and Denny (1980), Weibel, Rost, and Osterloh (2010), Stajkovic and Luthans (1997) Condly, Clark, and Stolovitch (2003). Effect sizes of these studies (reviewed in Chapter 3) while varying widely are at least moderate.

If increase over time is indeed a mark of incentive effect, then Condly, Clark, and Stolovitch's (2003) finding that that longer term incentive programs corresponds with an *unexplainable* greater gain in performance; and two of above meta-analyses finding field-based studies to show stronger effect than lab-based studies (Jenkins et al., 1998; Garbers & Konradt, 2014) have been offered explanation and support in findings here. To lend further empirical support, Garbers and Konradt (2014) distinguished equitably distributed team rewards and equality distributed team rewards. Their review of 30 studies showed equitably distributed team rewards to show higher performance than equally distributed rewards. Hence some match of stylized facts to findings of Experiment 1 are found, though I urged that they ought to be interpreted with caution.

While meta-analyses may shed some light on variance of collective performance, of which the findings here claim to be persistently larger than that of PFT, such studies despite its large sample, may have other effects clouding the anticipated equity-mediated effect. Hence a better way to study effects of larger PFP variance could be to obtain performance measure for each division or production plant of a multidivisional firm with broadly similar operations. Such data should be obtained before changes or implementation of reward

scheme (such as increasing the proportion of incentives to base pay) and at various time intervals after implementation. This will reveal not just the trajectory of collective performance expected of cross-level incentive effects but also allow comparison of variance between conditions. Because it is difficult for such field experiment opportunity and practically challenging to impose strict controls to compare implementation of PFT, the research design will have to make do with a contrast of PFT-continuation and adding of PFP. Given the trend in Singapore is to push for variable and performance-based pay, it is easier to find such opportunities than the removal of PFP (where it will mean the implementation of PFT), hence order effects is not fully eliminated. Companies that can be prime targets of such an approach include multiple branch restaurant chains. And where this is outside of Singapore, in places where tipping is the norm, a 3-levels comparison can be made comparing restaurants with waiters getting paid a fixed daily wage, waiters keeping their own tips earn for the day, and waiters gets an equal share of a pool of tips at the end of the day. While the third condition is not represented in the simulation, data obtained could be used as a comparison, to feed into a new simulation of pooled PFP, or provide vital additional data for partialling out effects such as demographic or psychological effects at the individual level, or geographic effects at the restaurant level. Notably, in all conditions, tips from customers will have to be collected before being redistributed as per the conditions. Under the pretext that the restaurant is considering practicing pay transparency, a pay slip containing pay information of current day's pay^{10.6} for self and a constant subset of colleagues will be given. While the above manipulation may be sufficient given pervasiveness of social comparison and feedback seeking behavior, for purpose of added insight and statistical control, individual difference measure of Gibbons & Buunk's (1999) SCO can be measured before intervention (masked within a battery of items such as experience and goal orientations), and subjects will

^{10.6} Current day's pay will become t-1 the second day. Hence memory of 1-turn.

make estimation of each of subset's colleague's effort at the end of each week (though not a better solution, but daily measurement may induce a Hawthorne or demand characteristics effect).

The use of daily paid waiter for experiment will allow for faster accumulation of data points in a context where labor and rewards line-of-sight can be easily manipulated. Measurement of aggregate output in this case may not just be sales, but for a closer correspondence to the simulation, a proximate outcome can be the sum of customer satisfaction scores for each waiter obtained at the end of a meal.

The choice for a single-firm multi-team design is not just to control for between-firm differences which will be salient considering policies, pay level, and organizational cultural influences, but also to increase external validity and relevance to business owners. If interest is just to assess simulation's finding on real-life subjects, a computer mediated study can be conducted in a distributed manner (for logistic ease), where a classic task of proofreading can be administered daily, and subject are informed how others in their group are performing. Data of individual performance are aggregated to groups. Groups with subjects paid a flat compensation are compared to groups with subjects whose payment is a function of errors detected. Because the task is still a performance task, some relevance to business context can still be made.

If, however, relevance to education (barring ethics approval) is intended, then a high stakes field experiment can be carried out in school. Imagine a course with 750 students with each class having 25 students. There are 15 lessons per semester, with specific learning goals for each lesson. For the experiment, in 10 randomly selected classes, students are awarded grades based on individual performance in an end-lesson quiz, in another 10 classes students are awarded equal grades determined by average class performance in the same end-lesson

quiz, and the final 10 classes, despite having to do the quiz students are awarded a fixed daily grade based on attendance. Using data from the middle group to help to partial out (albeit not totally) effects of other extrinsic motivational factors, findings of experiment 1 can be falsified. Admittedly the sample size of 10 classes per condition might lead to insignificance unless effect size is known to be large a priori, given constraints for such team-based research, it might be an inevitable tradeoff. A real-life context similar to that describe exist in northern Singapore.

Experiment 2 & 3

Experiment 2 & 3 found greater memory and consideration of past equity information to lead to lower collective performance for PFP collectives and higher collective performance for PFT collectives. Empirical work incorporating memory and equity is far and few and, where considered, it tends to be at the individual and cognitive level (e.g. Vecchio, 1982). Owing to choosing a parameter that has not been widely studied for cross-level incentive effect and PFP, despite extensive searching, no stylized facts that can be appropriately stated.

To cast the net beyond information processing, if consideration of time distal information can be considered as a form of culture difference manifesting at the individual level, then Kluckhohn and Strodtbeck's (1961) value orientation framework's past time orientation^{10.7} can be used to shed some light. Generally, as noted in Fulmer, Crosby, & Gelfand (2014) Asian countries tend to have more past-oriented societies (Block, Buggie, & Matsui, 1996; Guo, Ji, Spina, & Zhang, 2012; Rojas- Méndez, Davies, Omer, Chetthamrongchai, & Madran, 2002; Spadone, 1992), and Western countries tend to be more

^{10.7} More common cultural dimensions such as Hofstede's Long Term Orientation and Globe's Future Orientation are avoided here for the former is high problematic, contentious, and lumps present focus with past focus as short-term orientation, and the latter focuses on consideration and planning for the future versus present. Zimbardo's Time Perspective considered differential consideration of past information, which the findings here do not differentiate, hence Zimbardo's construct is not reviewed.

present-oriented (Brislin & Kim, 2003; Sundberg, Poole, & Tyler, 1983). This has close relevance to the operationalization of memory and serial position effects. In addition, Guo with advisor and collaborators (Guo, Ji, Spina, & Zhang, 2012; Ji, Guo, Zhang, & Messervey, 2009) have found via intracultural design that Chinese place more value to past events than similarly distant future events. This inverse of Caruso, Gilbert, and Wilson's (2008) temporal value asymmetry effect for Chinese has also been earlier illustrated from a behavioral economics perspective in Levinson and Peng's (2007).

While the simulation here predicts that consideration of more recent memory (present focused) will benefit capitalist-based economies, to reconcile the same set of findings with those of Kluckhohn and Strodtbeck's (1961) past orientation would suggest Chinese socialist economy faring better than a western-influenced socialist one; and Chinese socialist economy faring better than a capitalist one. Yet remembrance of the Great Leap Forward and comparison of Chinese-influenced North and South Korea paints an opposite picture. It seems any inference to broad national economy would be affected more strongly by other factors such as technology, education, politics, as well as other psychological mechanisms. If calibration of model's parameter to proxies of memory can be made from a representative spread of individuals of such economies in the past, calibrated time series simulation data can added to existing economics models to assess amount of new variance explained.

Due to the in-vitro nature of simulation, a closer correspondence would be through experiments be they field, online, or lab. Following the same development process of the model, the restaurant chain experiment can be modified with memory condition of 3-levels (1-turn, 3-turns, 5-turns). In the pay slip each waiter gets at the end of each day, beyond their own and others' pay information for the day, the pay slip contains information about previous two day's pay, forming information for three previous periods the next day they start work

(e.g., sample in Figure 10.1). If waiters are paid the same base pay, then the pay slip will show identical pay for all periods for all waiters.

Pay Advice				
<u>JACK CHAN</u>				
	Jack	Pat	Lim	Imran
6 Aug (Today)	\$XX.XX	\$XX.XX	\$XX.XX	\$XX.XX
5 Aug	\$XX.XX
4 Aug	\$XX.XX

Figure 10.1. Sample Pay Slip for Experimental Condition of Memory 3 Turns in a Multi-Outlet Restaurant Chain

Though mere provision of information may not correspond to actual information processing, and daily manipulation check may introduce unwanted experimental artefacts, this is likely the maximum manipulation without being excessively obtrusive. Other field experimental setting that may be less obtrusive but requiring a longer term horizon, includes property sales agencies, insurance agencies, production operators of factories, or just simply firms with divisions having at least quarterly performance reviews for their employees.

Experiment 4

Experiment 4 found that comparing with more others than less others have no effect for a collectives under fixed pay, but enhances the cross-level incentive effect for PFP collectives. As argued earlier many close proxies for number of comparison others exists and while construed as an individual difference in the model, comparing with more versus less others may also be domain specific. Commonly invoked construct of independent-interdependent self-construals and individualism-collectivism show some similarity, as would network centrality, there are, however, non-trivial conceptual differences (Chapter 9). Hence, though some support can be obtained from Taras, Kirkman, and Steel (2010) review of nine firms showing higher individualism to be correlated negatively with group performance ($\rho = -.15$), such match must be interpreted with caution. Because the payment method for individuals of groups in those studies are unknown (assuming it contains both PFP and PFT), only the main effect of number of comparison others (combining PFP and PFT) of experiment 4 can be used to infer correspondence.

To gain appropriate empirical support for Experiment 4's finding, a third condition of number of comparison others with two levels (less vs. more others) can be added to the previous field experiment example. Using the same pay slip as example, a larger subset of fellow employees' pay information can be added to the right and distributed along with their pay. Should findings be supportive, restaurant outlets using PFP and having employees comparing with more people should have higher aggregate satisfaction score (and possibly repeat customers) than PFP outlets having employees comparing with less others.

Overall

Justification with empirical data is a key step to establish external validity. But beyond that and replication, much more can be done to expand the use of model. Some may

consider it as making the model more realistic. But if a model is internally valid and with core of the model (Experiment 1) found to meet some stylized facts, such as Schelling's (1971) model with stylized fact of segregation and polarization patterns in Flache and Macy's (2011a & b), then it is suitable to start exploring (Burton, 2003) and deriving new directions for future work. Such exploration has been done here with memory, serial position effect, and number of comparison others, more can be done.

First in the list of future exploration would be the individual difference of equity sensitivity (King, Miles, & Day, 1993; Huseman, Hatfield, & Miles, 1985, 1987, & 1994). Because in the initial construct, equity sensitivity is defined as unidimensional with greater sensitivity by means of threshold levels to underreward (entitled), overreward (benevolent), and indifference (sensitive), a change to equation 7 can be made to reflect this.

Second avenue of exploration considers that individual and cultural differences are seldom static or homogenous, and may develop over time (Hong & Mallorie, 2004; Chernyshenko, Stark, & Drasgow, 2011). Hence instead of fixed parameter values homogeneously applied to all agents, a distribution of agents of different levels can be created in the system. This can be done in at initiation where each agent have different probability to be assigned as entitled or benevolent, or in the case of memory have turns in memory assigned from a Gaussian distribution with seven turns as the mean, or to account for intra-individual variability or even development, a stochastic element can be added to alter, for instance, number of comparison others at each time step.

Third avenue of exploration is to allow for labor mobility between positions and a separate coding allowing for turnover. While the former just adds stochasticity, the latter mimics real-world context that if an employee is sufficient unmotivated, especially for PFP, they may choose to leave the company. And in its place a new employee (agent) will fill the

grid and start-off with the same initial effort willing to contribute W . To mimic another HR concern, time-to-fill can be model by allowing each cell to be empty for two periods before it is filled.

Fourth avenue would be to consider homophily. Homophily can be modeled by giving greater weights for similar agents in Equation 6, in terms of job or state similarity, or if agents is changed to compare with only one agent per turn, then it can be modeled as the probability of comparing with a similar agent.

Fifth avenue would be to apply the same rules and mechanism to a scale-free network. Because toroidal CA are commonly known to show phase transitions within a smaller parametric ranges, applying this to a scale free network may not just reveal different dynamics, but may also amplify the impact of highly connected agents occupying critical network positions. While this would make the explanation of trajectories and cross-level incentive effect more difficult, the possible new insights may be worthwhile.

Sixth avenue will be to refocus on the industrial stakeholders of this model: managers, HR departments, and business owners. Total reward practitioners are accustomed to working with diverse reward mix emanating from mimetic and coercive influences of competitors, labor unions, and the state. Hence, to derive findings applicable to them would mean exploring various aspects of the pay mix. There can be two ways to proceed. One, explore proportion of PFP to fixed base pay to create a hybrid pay condition, and two to model different forms of PFP with distal line-of-sight such as gainsharing programs or spot awards. Some excellent field experiment by behavioral economists have recently been done on the latter (e.g., Bareket-Bojmel, Hochman, & Ariely, 2014).

Seventh avenue may be to combine all the experiments (except CA with scale-free network) to create a highly “realistic” model. Such model will usually involve using steady

state values for analysis. Nonetheless for the system to evolve to steady state and to combine all factors, considerable computing capacity will be required. Ignoring new factors suggested, for factors explored, a full factorial will render $96E+6$ ($2 \times 6 \times 4 \times 4 \times 2 \times 2500$ steps \times 100 runs) data points. The analysis for such data would be that of multiple regression to reveal main and interaction effect of each variable under the parametric range explored. With assumptions of linearity and numerous possible 3-way or more interactions, interpretation and use of model will have to be selective, theoretically informed, and proceeded with care.

In sum, future directions are aplenty and can occur with the aim to validate the model, uncover more interesting factors, or to increase variations as an approximation to real-world scenarios. All of them being useful future directions highlights that a model's choice of "seed" context and core mechanism to be highly important for a model to be able to initiate a new area of research. Martin Nowak, Axelrod, illustrated use of evolutionary game theory with ABM, and for the former within CA to dawn a new enterprise on the emergence of altruism and cooperation. Axelrod and Hammond mixed games, mortality, evolution theory, and tags to show emergence of ethnocentrism. LeBaron, Palmer, Arthur, Gode, and Sunder showed the flaws of efficient market hypothesis through the comparative use of chartist, fundamentalist and zero-intelligence agents. And more close to this model is Andrzej Nowak's whose creation of Dynamic Social Impact Theory showed the influence of minority. Each of the above were timely. Each of them started off simply.

Axelrod's (2006) once commented for social science (and even biological) ABM and ACE that,

even if the reviewer is satisfied with the range of parameter values that have been tested, he or she might think up some new variations of the model to inquire... mak[ing] the review process seem almost endless. (p. 1581-1582)

I agree, but for an exploratory mindset, I as a new researcher have benefitted from such suggestions (as was the case for primacy and several robustness checks). Such comments help identify new areas neglected by myself and allow for a greater theoretical sampling for the model to flourish in the long run.

Conclusion

The research and its findings here answers some questions in the discourse of PFP, and highlights equity theory as a useful explanation for PFP's influence on firm performance. This was previously not possible. A new ABM model was developed enabling future simulation-based theorizing of social comparison, fairness restoration, motivation, and collective performance in a complex-system manner. Though more questions were raised, much more new theoretical directions from this research were uncovered as a result of the abductive and generative paradigm employed. At this junction, it may be apt to ask if the main question motivating this research have been answered.

- Are concerns for fairness a sufficient condition for PFP's positive cross-level incentive effect to arise?

Based on the computational findings here, yes.

Many mechanisms may be equifinal to PFP's superiority, but borrowing the words of Delbridge and Fiss (2013, p. 329), equity concerns are now shown to be *sufficient* to enable the emergence of PFP's positive cross-level incentive effect. Boundary conditions exist in terms of individual-level variables, such as memory, cognitive bias, and number of comparison others. And the findings here will most likely manifest when fairness restoration is salient. Yet, the controversy (or paradox) prompting this research has now been offered

new explanations, while the utility of Adams's (1965) equity theory expanded to the collective level and across time scales.

I claim that in this model and its future developments, Equity theory is not an old-age baroque music (Davis, 2010), but the harmony underlying a dynamical view of fairness, crossing disciplinary boundaries in OB, HR, and organizational sciences.

REFERENCES^A

- Abdou, M., & Gilbert, N. (2009). Modelling the emergence and dynamics of social and workplace segregation. *Mind and Society*, 8(2), 173-191.
- Adams, J. S. (1963a). Toward an Understanding of Inequity. *J Abnorm Psychol*, 67(5).
- Adams, J. S. (1963b). Wage Inequities, Productivity and Work Quality. *Industrial Relations*, 3(1), 9-16.
- Adams, J. S. (1965). Inequity in Social Exchange. *Advances in experimental social psychology*, 2(4), 267-299.
- Adams, J. S. (1968). Effects of overpayment: Two comments on Lawler's paper. *J Pers Soc Psychol*, 10(3), 315-316.
- Adams, J. S., & Freedman, S. (1976) Equity Theory Revisited: Comments and Annotated Bibliography. Vol. 9. *Advances in experimental social psychology* (pp. 43-90).
- Adams, J. S., & Jacobsen, P. R. (1964). Effects of wage inequities on work quality. *Journal of Abnormal and Social Psychology*, 69(1), 19-25.
- Adams, J. S., & Rosenbaum, W. B. (1962). The relationship of worker productivity to cognitive dissonance about wage inequities. *Journal of Applied Psychology*, 46(3).
- Adner, R., Pólos, L., Ryall, M., & Sorenson, O. (2009). The case for formal theory. *Academy of Management Review*, 34(2), 201-208.
- Afshar, M., & Asadpour, M. (2010). Opinion formation by informed agents. *JASSS*, 13(4).
- Aggarwal, V. A., Siggelkow, N., & Singh, H. (2011). Governing collaborative activity: Interdependence and the impact of coordination and exploration. *Strategic Management Journal*, 32(7), 705-730.
- Aguiar, F., & Parravano, A. (2013). Tolerating the Intolerant: Homophily, Intolerance, and Segregation in Social Balanced Networks. *Journal of Conflict Resolution*.
- Aguinis, H. (2013). *Performance Management*. Pearson Education, Limited.
- Aguinis, H., & Edwards, J. R. (2014). Methodological wishes for the next decade and how to make wishes come true. *Journal of Management Studies*, 51(1), 143-174.

^A No intention is made for this research to be a qualitative or quantitative review, the large number of references is a result of crossing domains. Effort is made to introduce to readers the perspectives and sources of terms and concepts that may better known in one domain or other.

- Ahrweiler, P., Gilbert, N., & Pyka, A. (2011). Agency and structure: A social simulation of knowledge-intensive industries. *Computational and Mathematical Organization Theory*, 17(1), 59-76.
- Aktipis, C. A. (2006). Recognition Memory and the Evolution of Cooperation: How Simple Strategies Succeed in an Agent-Based World. *Adaptive Behavior*, 14(3), 239-247.
- Alam, S. J., Meyer, R., Ziervogel, G., & Moss, S. (2007). The impact of HIV/AIDS in the context of socioeconomic stressors: An evidence-driven approach. *JASSS*, 10(4).
- Alam, S., & Geller, A. (2012). Networks in Agent-Based Social Simulation. In A. J. Heppenstall, A. T. Crooks, L. M. See, & M. Batty (Eds.), *Agent-Based Models of Geographical Systems* (pp. 199-216): Springer Netherlands.
- Alessio, J. C. (1980). Another Folly For Equity Theory. *Social Psychology Quarterly*, 43(3), 336-340.
- Ali, M., Salhieh, A., Abu Snaieh, R., & Reynolds, R. (2012). Boosting cultural algorithms with a heterogeneous layered social fabric influence function. *Computational and Mathematical Organization Theory*, 18(2), 193-210.
- Alonso-Sanz, R. (2012). Cellular Automata with Memory. In R. A. Meyers (Ed.), *Computational Complexity* (pp. 382-406).
- Alonso-Sanz, R., & Martín, M. (2006). Memory boosts cooperation. *International Journal of Modern Physics C*, 17(6), 841-852.
- Alvesson, M., & Kärreman, D. (2007). Constructing mystery: Empirical matters in theory development. *Academy of Management Review*, 32(4), 1265-1281.
- Alvesson, M., & Sandberg, J. (2011). Generating Research Questions Through Problematization. *The Academy of Management Review*, 36(2).
- Ambrose, M. L., & Kulik, C. T. (1999). Old friends, new faces: Motivation research in the 1990s. *Journal of Management*, 25(3), 231-292.
- Amabile, T. M. (1983). *The Social Psychology of Creativity*.
- Amabile, T. M. (1996). *Creativity in Context: Update to the Social Psychology of Creativity*.
- Ambrose, M. L., & Kulik, C. T. (1994). The Effect of Information Format and Performance Pattern on Performance Appraisal Judgments in a Computerized Performance Monitoring Context¹. *Journal of Applied Social Psychology*, 24(9), 801-823.
- Amigoni, F., & Schiaffonati, V. (2008). A Multiagent Approach to Modelling Complex Phenomena. *Foundations of Science*, 13(2), 113-125.

- Anders Ericsson, K., & Kintsch, W. (1995). Long-term working memory. *Psychological Review*, *102*(2), 211-245.
- Anderson, J. R. (1983). The architecture of cognition. *The Architecture of Cognition*.
- Anderson, J. R., & Lebiere, C. (1998). The atomic components of thought. *The Atomic Components of Thought*.
- Anderson, J. R., Bothell, D., Byrne, M. D., Douglass, S., Lebiere, C., & Qin, Y. (2004). An Integrated Theory of the Mind. *Psychological Review*, *111*(4), 1036-1060.
- Anderson, N. H. (1968). Application of a linear-serial model to a personality-impression task using serial presentation. *J Pers Soc Psychol*, *10*(4), 354-362.
- Anderson, N. H. (1976). Equity judgments as information integration. *J Pers Soc Psychol*.
- Anderson, N. H. (1981). Foundations of information integration theory.
- Anderson, N. H. (1991). *Contributions To Information Integration Theory: Volume 1: Cognition*: Psychology Press.
- Anderson, N. H. (1996). A functional theory of cognition. Mahwah, NJ: Erlbaum.
- Anderson, N. H., & Farkas, A. J. (1975). Integration theory applied to models of inequity. *Personality and Social Psychology Bulletin*, *1*, 588-591.
- Anderson, P. (1999). Complexity Theory and Organization Science. *Organization Science*, *10*(3), 216-232.
- Andrews, I. R. (1967). Wage inequity and job performance: an experimental study. *J Appl Psychol*, *51*(1), 39-45.
- Aon Hewitt (2014, 27 Aug). *New Aon Hewitt Survey Shows 2014 Variable Pay Spending Spikes to Record-High Level*. Retrieved from <http://aon.mediaroom.com>.
- Aquino, K., Griffeth, R. W., Allen, D. G., & Hom, P. W. (1997). Integrating justice constructs into the turnover process: A test of a referent cognitions model. *Academy of Management Journal*, *40*(5), 1208-1227.
- Ariely, D., Gneezy, U., Loewenstein, G., & Mazar, N. (2009). Large stakes and big mistakes. *Review of Economic Studies*, *76*(2), 451-469.
- Arifovic, J. (1994). Genetic algorithm learning and the cobweb model. *Journal of Economic Dynamics and Control*, *18*(1), 3-28.
- Armstrong, M. (2014). *Armstrong's Handbook of Performance Management: An Evidence-Based Guide to Delivering High Performance*: Kogan Page.

- Arthur, W. B. (1989). Competing technologies, increasing returns, and lock-in by historical events. *The Economic Journal*, 99(394), 116-131.
- Arthur, W. B. (1994). Inductive reasoning and bounded rationality. *American Economic Review*, 84(2), 406-411.
- Arthur, W. B. (2013). Complexity Economics: A Different Framework for Economic Thought.
- Arthur, W. B., Holland, J. H., LeBaron, B., Palmer, R., & Tayler, P. (1997). Asset pricing under endogenous expectations in an artificial stock market. *The Economy as an Evolving Complex System II*, 15-44.
- Ashraf, Q., Gershman, B., & Howitt, P. (2012). Macroeconomics in a Self-Organizing Economy. *Revue de l'OFCE*, 124(5), 43-65.
- Ashworth, L., & McShane, L. (2012). Why Do We Care What Others Pay? The Effect of Other Consumers' Prices on Inferences of Seller (Dis)Respect and Perceptions of Deservingness Violation. *Journal of Retailing*, 88(1), 145-155.
- Atkinson, R. C., & Shiffrin, R. M. (1968) Human Memory: A Proposed System and its Control Processes. *Vol. 2. Psychology of Learning and Motivation - Advances in Research and Theory* (pp. 89-195).
- Axelrod, R. (1984). *The Evolution of Cooperation*.
- Axelrod, R. (1986). An Evolutionary Approach to Norms. *American Political Science Review*, 80(4), 1095.
- Axelrod, R. (1997a). The complexity of cooperation: Agent based models of competition and collaboration.
- Axelrod, R. (1997b). Advancing the art of simulation in the social sciences. *Simulating Social Phenomena*(456), 21-40.
- Axelrod, R. (1997c). The dissemination of culture: A model with local convergence and global polarization. *Journal of Conflict Resolution*, 41(2), 203-226.
- Axelrod, R. (2005). Agent-based modeling as a bridge between disciplines. *Handbook of Computational Economics*, 2.
- Axelrod, R. (2006) Chapter 33 Agent-based Modeling as a Bridge Between Disciplines. *Vol. 2. Handbook of Computational Economics* (pp. 1565-1584).
- Axelrod, R. (2007). Advancing the art of simulation in the social sciences. *Handbook of Research on Nature Inspired Computing for Economy and Management*, 90-100.

- Axelrod, R., & Hamilton, W. D. (1981). The evolution of cooperation. *Science*, 211(4489), 1390-1396.
- Axelrod, R., & Tesfatsion, L. (2006). A guide for newcomers to agent-based modeling in the social sciences. *Handbook of Computational Economics*, 2, 164-1659.
- Axtell, R. (2000). Why Agents? On the Varied Motivation for Agent Computing in the Social Sciences. *The Brookings Institution Center on Social and Economic Dynamics Working Paper*.
- Axtell, R. L., Epstein, J. M., Dean, J. S., Gumerman, G. J., Swedlund, A. C., Harburger, J., . . . Parker, M. (2002). Population growth and collapse in a multiagent model of the Kayenta Anasazi in Long House Valley. *Proc Natl Acad Sci U S A*, 99(SUPPL. 3), 7275-7279.
- Axtell, R., Epstein, J. M., & Young, H. P. (2000). The emergence of classes in a multi-agent bargaining model.
- Bacharach, S. B. (1989). Organizational theories: Some criteria for evaluation. *Academy of Management Review*, 14(4), 496-515.
- Backes-Gellner, U., & Pull, K. (2013). Tournament compensation systems, employee heterogeneity, and firm performance. *Human Resource Management*, 52(3), 375-398.
- Baddeley, A. (2007). *Working memory, thought, and action*: Oxford University Press.
- Baddeley, A. D., & Hitch, G. (1974) Working Memory. *Vol. 8. Psychology of Learning and Motivation - Advances in Research and Theory* (pp. 47-89).
- Baker, G. P., Jensen, M. C., & Murphy, K. J. (1988). Compensation and incentives: Practice vs. theory. *Journal of Finance*, 43(3), 593-616.
- Ball, P. (2007). Social science goes virtual. *Nature*, 448(7154), 647-648.
- Bampo, M., Ewing, M. T., Mather, D. R., Stewart, D., & Wallace, M. (2008). The Effects of the Social Structure of Digital Networks on Viral Marketing Performance. *Information Systems Research*, 19(3), 273-290.
- Bandura, A. (1986). *Social Foundations of Thought and Action: A Social Cognitive Theory*.
- Bandura, A. (1997). *Self-efficacy: The Exercise of Control*.
- Banker, R. D., Lee, S. Y., Potter, G., & Srinivasan, D. (1996). Contextual analysis of performance impacts of outcome-based incentive compensation. *Academy of Management Journal*, 39(4), 920-948.

- Bareket-Bojmel, L., Hochman, G., & Ariely, D. (2014). It's (Not) All About the Jacksons Testing Different Types of Short-Term Bonuses in the Field. *Journal of Management*.
- Barnes, C. M., Hollenbeck, J. R., Jundt, D. K., DeRue, D. S., & Harmon, S. J. (2011). Mixing individual incentives and group incentives: Best of both worlds or social dilemma? *Journal of Management*, 37(6), 1611-1635.
- Baron, J. N., Dailey, P. R., Gerhart, B., Heneman Iii, H. G., Kochan, T., Ledford Jr, G. E., . . . Cannon, M. D. (2004). "Promise and peril in implementing pay-for-performance" by Michael Beer and Mark D. Cannon: Commentary. *Human Resource Management*, 43(1), 21-48.
- Baron, J. N., Dobbin, F. R., & Jennings, P. D. (1986). War And Peace - The Evolution Of Modern Personnel-Administration In United-States Industry. *American Journal of Sociology*, 92(2), 350-383. doi: 10.1086/228504
- Baron, R. A., & Ward, T. B. (2004). Expanding Entrepreneurial Cognition's Toolbox: Potential Contributions from the Field of Cognitive Science. *Entrepreneurship Theory and Practice*, 28(6), 553-573.
- Bartol, K. M., & Locke, E. A. (2000). Incentives and motivation. *Compensation in Organizations*, 104-147.
- Bartol, K. M., & Martin, D. C. (1988). Influences on managerial pay allocations: A dependency perspective. *Personnel Psychology*, 41(2), 361-378.
- Basak, S., Mazumdar, B., & Yadav, R. (2012). Agent Based Modeling and its Effect in Social. Influence: A Review. *IJCST*, 3(1).
- Bauer, T. N., Maertz Jr, C. P., Dolen, M. R., & Campion, M. A. (1998). Longitudinal assessment of applicant reactions to employment testing and test outcome feedback. *Journal of Applied Psychology*, 83(6), 892.
- Baumann, O., & Stieglitz, N. (2014). Rewarding value-creating ideas in organizations: The power of low-powered incentives. *Strategic Management Journal*, 35(3), 358-375.
- Bausch, A. (2014). Evolving intergroup cooperation. *Computational and Mathematical Organization Theory*, 20(4), 369-393.
- Beach, S. R., & Tesser, A. (2000). Self-evaluation maintenance and evolution. In *Handbook of social comparison* (pp. 123-140). Springer US.
- Beauteament, P., & Broenner, C. (2011). *Complexity Demystified: A Guide for Practitioners*.
- Beck, K. (2002). *Test-driven Development: By Example*: Addison-Wesley.

- Becker, B. E., & Huselid, M. A. (1998). High performance work systems and firm performance: A synthesis of research and managerial implications. *Research in Personnel and Human Resource Management*, 16(1), 53-101.
- Becker, B., & Gerhart, B. (1996). The impact of human resource management on organizational performance: Progress and prospects. *Academy of Management Journal*, 39(4), 779-801.
- Beer, M., & Cannon, M. D. (2004). Promise and peril in implementing pay-for-performance. *Human Resource Management*, 43(1), 3-20.
- Bell, A. M. (2002). Locally interdependent preferences in a general equilibrium environment. *Journal of Economic Behavior & Organization*, 47(3), 309-333.
- Beltran, F. S., Herrando, S., Ferreres, D., Adell, M. A., Estreder, V., & Ruiz-Soler, M. (2009). Forecasting a language shift based on cellular automata. *JASSS*, 12(3).
- Beltran, F. S., Salas, L., & Quera, V. (2006). Spatial behavior in groups: An agent- based approach. *JASSS*, 9(3), 71-86.
- Benenson, I., & Torrens, P. M. (2004). *Geosimulation: Automata-based Modeling of Urban Phenomena*.
- Beran, J., Feng, Y., Ghosh, S., & Kulik, R. (2013). *Long-memory processes*: Springer.
- Berg, T. R. (1991). The importance of equity perception and job satisfaction in predicting employee intent to stay at television stations. *Group & Organization Management*, 16(3), 268-284.
- Berger, J., Fisek, M. H., Norman, R. Z., & Wagner, D. G. (1985). Formation of reward expectations in status situations. *Status, Rewards, and Influence*, 215-261.
- Berkowitz, L., Fraser, C., Treasure, F. P., & Cochran, S. (1987). Pay, Equity, Job Gratifications, and Comparisons in Pay Satisfaction. *Journal of Applied Psychology*, 72(4), 544-551.
- Berman, J. J., Murphy-Berman, V., & Singh, P. (1985). Cross-cultural similarities and differences in perceptions of fairness. *J Cross Cult Psychol*, 16(1), 55-67.
- Bernstein, M., & Crosby, F. (1980). An empirical examination of relative deprivation theory. *Journal of Experimental Social Psychology*, 16(5), 442-456.
- Bertie, A., Himmelweit, S., & Trigg, A. (2006). Social Norms, Cognitive Dissonance and Broadcasting: How to Influence Economic Agents. In C. Bruun (Ed.), *Advances in Artificial Economics* (Vol. 584, pp. 235-252): Springer Berlin Heidelberg.

- Bidart, C., & Lavenu, D. (2005). Evolutions of personal networks and life events. *Social networks*, 27(4), 359-376.
- Billari, F. C., Prskawetz, A., Diaz, B. A., & Fent, T. (2007). The "wedding-ring": An agent-based marriage model based on social interaction. *Demographic Research*, 17, 59-81.
- Biswas, S., Varma, A., & Ramaswami, A. (2013). Linking distributive and procedural justice to employee engagement through social exchange: A field study in India. *International Journal of Human Resource Management*, 24(8), 1570-1587.
- Black, J., Oliver, R., & Paris, L. (2009). Comparing simulation results of leadership style impacts on emergent versus specific task outcomes and required simulation model components. *Multi-level issues in organizational behavior and leadership*, 8.
- Blanton, H., Gibbons, F. X., Buunk, B. P., & Kuyper, H. (1999). When better-than-others compare upward: Choice of comparison and comparative evaluation as independent predictors of academic performance. *J Pers Soc Psychol*, 76(3), 420-430.
- Block, J., & Pickl, S. (2013). A Human Resource Model for Performance Optimization to Gain Competitive Advantage. In D. Huisman, I. Louwse, & A. P. M. Wagelmans (Eds.), *Operations Research Proceedings 2013* (pp. 43-48).
- Block, R. A., Buggie, S. E., & Matsui, F. (1996). Beliefs about time: Cross-cultural comparisons. *The Journal of Psychology*, 130(1), 5-22.
- Bloom, M. (1999). The performance effects of pay dispersion on individuals and organizations. *Academy of Management Journal*, 42(1), 25-40.
- Boccaro, N., & Fuk s, H. (1999). Modeling diffusion of innovations with probabilistic cellular automata. In *Cellular Automata* (pp. 263-277). Springer Netherlands.
- Boero, R., & Squazzoni, F. (2005). Does empirical embeddedness matter? Methodological issues on agent-based models for analytical social science. *JASSS*, 8(4).
- Boettinger, H. M. (1975). Is management really an art. *Harv Bus Rev*, 53(1), 54-64.
- Boisot, M., & McKelvey, B. (2010). Integrating modernist and postmodernist perspectives on organizations: A complexity science bridge. *Academy of Management Review*, 35(3), 415-433.
- Bolino, M. C., & Turnley, W. H. (2008). Old faces, new places: Equity theory in cross-cultural contexts. *Journal of Organizational Behavior*, 29(1), 29-50.
- Bolton, P., & Dewatripont, M. (2005). *Contract Theory*. MIT Press.
- Bonabeau, E. (2002a). Agent-based modeling: Methods and techniques for simulating human systems. *Proc Natl Acad Sci U S A*, 99(SUPPL. 3), 7280-7287.

- Bonabeau, E. (2002b). Predicting the unpredictable. *Harv Bus Rev*, 80(3), 109.
- Bonabeau, E., Hunt, C. W., & Gaudiano, P. (2003). Agent-based modeling for testing and designing novel decentralized command and control system paradigms: DTIC Document.
- Bond, S. D., Carlson, K. A., Meloy, M. G., Russo, J. E., & Tanner, R. J. (2007). Information distortion in the evaluation of a single option. *Organ Behav Hum Decis Process*, 102(2), 240-254.
- Bonner, S. E., & Sprinkle, G. B. (2002). The effects of monetary incentives on effort and task performance: Theories, evidence, and a framework for research. *Accounting, Organizations and Society*, 27(4-5), 303-345.
- Borrill, P., & Tesfatsion, L. (2011). Agent-based modeling: The right mathematics for the social sciences? In J. B. Davis (Ed.), *The Elgar Companion to Recent Economic Methodology*.
- Borshchev, A., & Filippov, A. (2004). *From system dynamics and discrete event to practical agent based modeling: reasons, techniques, tools*. Paper presented at the Proceedings of the 22nd international conference of the system dynamics society.
- Bosse, T., Schut, M., Treur, J., & Wendt, D. (2008). Trust-Based Inter-temporal Decision Making: Emergence of Altruism in a Simulated Society. In L. Antunes, M. Paolucci, & E. Norling (Eds.), *Multi-Agent-Based Simulation VIII* (Vol. 5003, pp. 96-111).
- Bracha, A., & Fershtman, C. (2013). Competitive incentives: Working harder or working smarter? *Management Science*, 59(4), 771-781.
- Brannon, E., Ulrich, P., Anderson, L., Presley, A., Thommesen, S., & Missam, M. (2000). Agent-based simulation of the consumer's apparel purchase decision. *National Textile Centre Annual Report, November, Project*.
- Brass, D. (2012). A social network perspective on organizational psychology. S. Kozlowski, ed: *The Oxford Handbook of Organizational Psychology*.
- Bretz Jr, R. D., & Thomas, S. L. (1992). Perceived Equity, Motivation, and Final-Offer Arbitration in Major League Baseball. *Journal of Applied Psychology*, 77(3).
- Brewer, M. B., & Chen, Y. R. (2007). Where (Who) are collectives in collectivism? Toward conceptual clarification of individualism and collectivism. *Psychological Review*, 114(1), 133-151.
- Brickman, P., & Bulman, R. J. (1977). Pleasure and pain in social comparison. *Social Comparison Processes: Theoretical and Empirical Perspectives*, 149-186.

- Brislin, R. W., & Kim, E. S. (2003). Cultural diversity and people's understanding and uses of time. *Applied Psychology: An International Review*, 52(3), 363-382.
- Brock, R. L., & Lawrence, E. (2009). Too much of a good thing: underprovision versus overprovision of partner support. *Journal of Family Psychology*, 23(2), 181.
- Brockner, J., O'Malley, M. N., Hite, T., & Davies, D. K. (1987). Reward Allocation and Self-Esteem: The Roles of Modeling and Equity Restoration. *J Pers Soc Psychol*, 52(4).
- Broekhuizen, T. L. J., Delre, S. A., & Torres, A. (2011). Simulating the cinema market: How cross-cultural differences in social influence explain box office distributions. *Journal of Product Innovation Management*, 28(2), 204-217.
- Broersen, J., Dastani, M., Hulstijn, J., & Van Der Torre, L. (2002). Goal generation in the BOID architecture. *Cognitive Science Quarterly*, 2(3-4), 428-447.
- Brosnan, S. F. (2011). A hypothesis of the co-evolution of cooperation and responses to inequity. *Frontiers in Neuroscience*(APR).
- Brown, D. J., Ferris, D. L., Heller, D., & Keeping, L. M. (2007). Antecedents and consequences of the frequency of upward and downward social comparisons at work. *Organ Behav Hum Decis Process*, 102(1), 59-75.
- Brown, G. D. A., Neath, I., & Chater, N. (2007). A Temporal Ratio Model of Memory. *Psychological Review*, 114(3), 539-576.
- Brown, K. A., & Huber, V. L. (1992). Lowering floors and raising ceilings: A longitudinal assessment of the effects of an earnings-at-risk plan on pay satisfaction. *Personnel Psychology*, 45(2), 279-311.
- Brown, T. C., & Warren, A. M. (2011). Performance management in unionized settings. *Human Resource Management Review*, 21(2), 96-106.
- Bruch, E., & Atwell, J. (2013). Agent-Based Models in Empirical Social Research. *Sociological Methods & Research*.
- Bruderer, E., & Singh, J. V. (1996). Organizational evolution, learning, and selection: A genetic-algorithm-based model. *Academy of Management Journal*, 39(5), 1322-1349.
- Bruun, C., & Luna, F. (2000). Endogenous Growth with Cycles in a Swarm Economy: Fighting Time, Space, and Complexity. In F. Luna & B. Stefansson (Eds.), *Economic Simulations in Swarm: Agent-Based Modelling and Object Oriented Programming* (Vol. 14, pp. 105-131): Springer US.
- Bryson, J. (2014). The Role of Stability in Cultural Evolution: Innovation and Conformity in Implicit Knowledge Discovery. In V. Dignum & F. Dignum (Eds.), *Perspectives on Culture and Agent-based Simulations* (Vol. 3, pp. 169-187).

- Buchner, T. W. (2007). Performance management theory: A look from the performer's perspective with implications for HRD. *Human Resource Development International*, 10(1), 59-73.
- Bulleit, W. M., & Drewek, M. W. (2011). An agent-based model of terrorist activity. *Proceedings of the 2005 Annual Conference of the North American Association for Computational Social and Organizational Sciences NAACSOS*.
- Bulte, C. V. d., & Joshi, Y. V. (2007). New Product Diffusion with Influentials and Imitators. *Marketing Science*, 26(3), 400-421.
- Bunn, D. W., & Oliveira, F. S. (2007). Agent-based analysis of technological diversification and specialization in electricity markets. *European Journal of Operational Research*, 181(3), 1265-1278.
- Burstedde, C., Klauck, K., Schadschneider, A., & Zittartz, J. (2001). Simulation of pedestrian dynamics using a two-dimensional cellular automaton. *Physica A: Statistical Mechanics and its Applications*, 295(3-4), 507-525.
- Burton, R. M. (2003). Computational laboratories for organization science: Questions, validity and docking. *Computational and Mathematical Organization Theory*, 9(2), 91-108.
- Burton, R. M., & Obel, B. (1980). A Computer Simulation Test Of The M-Form Hypothesis. *Administrative Sciences Quarterly*, 25(3), 457-466.
- Burton, R. M., & Obel, B. (2011). Computational modeling for what-is, what-might-be, and what-should-be studies-And triangulation. *Organization Science*, 22(5), 1195-1202.
- Buunk, A. P. (2005). How do people respond to others with high commitment or autonomy in their relationships? *Journal of Social and Personal Relationships*, 22(5), 653-672.
- Buunk, A. P., & Dijkstra, P. (2014). Social Comparison Orientation and Perspective Taking as Related to Responses to a Victim. *Psychology*, 2014.
- Buunk, A. P., & Gibbons, F. X. (2007). Social comparison: The end of a theory and the emergence of a field. *Organ Behav Hum Decis Process*, 102(1), 3-21.
- Buunk, A. P., Carmona, C., Peiró, J. M., Dijkstra, A., & Dijkstra, P. (2011). Social Comparison at Work: The Role of Culture, Type of Organization and Gender. *Cross-Cultural Communication*, 7(2).
- Buunk, B. P., & Brenninkmeijer, V. (2001). When individuals dislike exposure to an actively coping role model: Mood change as related to depression and social comparison orientation. *European Journal of Social Psychology*, 31(5), 537-548.

- Buunk, B. P., & Van Yperen, N. W. (1991). Referential comparisons, relational comparisons, and exchange orientation: Their relation to marital satisfaction. *Personality and Social Psychology Bulletin*, *17*, 709-717.
- Buunk, B. P., Zurriaga, R., Peiró, J. M., Nauta, A., & Gosalvez, I. (2005). Social comparisons at work as related to a cooperative social climate and to individual differences in social comparison orientation. *Applied Psychology*, *54*(1), 61-80.
- Byron, K., & Khazanchi, S. (2012). Rewards and creative performance: A meta-analytic test of theoretically derived hypotheses. *Psychol Bull*, *138*(4), 809-830.
- Cadsby, C. B., Song, F., & Tapon, F. (2007). Sorting and Incentive Effects of Pay for Performance: An Experimental Investigation. *Academy of Management Journal*, *50*(2), 387-405.
- Camerer, C. F., & MacCrimmon, K. R. (1983). Underground and overpaid: equity theory in practice. In D. M. Messick & a. K. S. Cook (Eds.), *Theories of Equity: Psychological and Sociological Perspectives*.
- Cameron, J., & Pierce, W. D. (1994). Reinforcement, Reward, and Intrinsic Motivation: A Meta-Analysis. *Review of Educational Research*, *64*(3), 363-423.
- Cameron, J., Banko, K. M., & Pierce, W. D. (2001). Pervasive Negative Effects of Rewards on Intrinsic Motivation: The Myth Continues. *Behavior Analyst*, *24*(1), 1-44.
- Campbell, D. J. (1978). Effects Of Psychological Closeness And Type Of Exchange Situation On Perceived Inequity. *Academy of Management Journal*, *21*(2), 307-312.
- Campbell, J. P., & Pritchard, R. D. (1976). Motivation theory in industrial and organizational psychology. *Handbook of Industrial and Organizational Psychology*, 63-130.
- Canessa, E., & Riolo, R. L. (2003). The effect of organizational communication media on organizational culture and performance: An agent-based simulation model. *Computational and Mathematical Organization Theory*, *9*(2), 147-176.
- Cardenas, J. C., Stranlund, J., & Willis, C. (2002). Economic inequality and burden-sharing in the provision of local environmental quality. *Ecological Economics*, *40*(3), 379-395.
- Carley, K. (1992). Organizational learning and personnel turnover. *Organization Science*, *3*(1), 20-46.
- Carley, K. M. (1996). Validating computational models. *Paper available at <http://www.casos.cs.cmu.edu/publications/papers.php>*.
- Carley, K. M. (1999). On generating hypotheses using computer simulations. *Systems Engineering*, *2*: 69-77.

- Carley, K. M. (2001). Computational approaches to sociological theorizing. *Handbook of Sociological Theory*, 69-84.
- Carley, K. M. (2002a). Computational organization science: A new frontier. *Proc Natl Acad Sci U S A*, 99(SUPPL. 3), 7257-7262.
- Carley, K. M. (2002b). Computational organizational science and organizational engineering. *Simulation Modelling Practice and Theory*, 10(5-7), 253-269.
- Carley, K. M. (2002c). Simulating society: The tension between transparency and veridicality. *Social Agents: Ecology, Exchange, and Evolution*, 103-120.
- Carley, K. M., & Gasser, L. (1999). Computational organization theory. *Multiagent Systems: A Modern Approach to Distributed Artificial Intelligence*, 299-330.
- Carley, K. M., & Lin, Z. (1997). A theoretical study of organizational performance under information distortion. *Management Science*, 43(7), 976-997.
- Carley, K. M., & Svoboda, D. M. (1996). Modeling organizational adaptation as a simulated annealing process. *Sociological Methods and Research*, 25(1), 138-168.
- Carmichael, H. L., & MacLeod, W. B. (2000). Worker cooperation and the ratchet effect. *Journal of Labor Economics*, 18(1), 1-19.
- Carpenter, S., Brock, W., & Hanson, P. (1999). Ecological and social dynamics in simple models of ecosystem management. *Ecology and Society*, 3(2).
- Carrell, M. R., & Dittrich, J. E. (1978). Equity theory: The recent literature, methodological considerations, and new directions. *Academy of Management Review*, 3(2), 202-210.
- Carter, C. R., Kaufmann, L., & Michel, A. (2007). Behavioral supply management: a taxonomy of judgment and decision-making biases. *International Journal of Physical Distribution & Logistics Management*, 37(8), 631-669.
- Caruso, E. M., Gilbert, D. T., & Wilson, T. D. (2008). A Wrinkle in Time: Asymmetric Valuation of Past and Future Events. *Psychological Science*, 19(8), 796-801.
- Carver, C. S., & Scheier, M. F. (1982). Control theory: A useful conceptual framework for personality-social, clinical, and health psychology. *Psychol Bull*, 92(1), 111-135.
- Carver, C. S., & Scheier, M. F. (1998). On the self-regulation of behavior. *On the Self-Regulation of Behavior*.
- Castelfranchi, C., Conte, R., & Paolucci, M. (1998). Normative Reputation and the Costs of Compliance. *JASSS*, 1(3).

- Castellano, C., Marsili, M., & Vespignani, A. (2000). Nonequilibrium phase transition in a model for social influence. *Phys Rev Lett*, 85(16), 3536-3539.
- Casti, J. L. (1995). Seeing the light at El Farol. *Complexity*, 1(5), 7-10.
- Castiglione, F. (2009). Agent based modeling and simulation, introduction to *Encyclopedia of Complexity and Systems Science* (pp. 197-200): Springer.
- Cederman, L. E. (2003). Modeling the size of wars: From billiard balls to sandpiles. *American Political Science Review*, 97(1), 135-150.
- Cederman, L. E. (2005). Computational models of social forms: Advancing generative process theory. *American Journal of Sociology*, 110(4), 864-893.
- Centola, D., Willer, R., & Macy, M. (2005). The emperor's dilemma: A computational model of self-enforcing norms. *American Journal of Sociology*, 110(4), 1009-1040.
- Cerasoli, C. P., Nicklin, J. M., & Ford, M. T. (2014). Intrinsic motivation and extrinsic incentives jointly predict performance: A 40-year meta-analysis. *Psychol Bull*, 140(4), 980-1008.
- Chakraborti, A., & Chakrabarti, B. K. (2000). Statistical mechanics of money: How saving propensity affects its distribution. *European Physical Journal B*, 17(1), 167-170.
- Chakraborti, A., Toke, I. M., Patriarca, M., & Abergel, F. (2011). Econophysics review: II. Agent-based models. *Quantitative Finance*, 11(7), 1013-1041.
- Chan, D. (1998). Functional relations among constructs in the same content domain at different levels of analysis: A typology of composition models. *Journal of Applied Psychology*, 83(2), 234-246.
- Chang, E. (2002). Distributive justice and organizational commitment revisited: Moderation by layoff in the case of Korean employees. *Human Resource Management*, 41(2), 261-270.
- Chang, M. H., & Harrington Jr, J. E. (2000). Centralization vs. Decentralization in a Multi-Unit Organization: A Computational Model of a Retail Chain as a Multi-Agent Adaptive System. *Management Science*, 46(11), 1427-1440.
- Chang, M. H., & Harrington Jr, J. E. (2006) Chapter 26 Agent-Based Models of Organizations. *Vol. 2. Handbook of Computational Economics* (pp. 1273-1337).
- Chang, R. M., Oh, W., Pinsonneault, A., & Kwon, D. (2010). A network perspective of digital competition in online advertising industries: A simulation-based approach. *Information Systems Research*, 21(3), 571-593. doi: 10.1287/isre.1100.0302

- Chatterjee, A., K. Chakrabarti, B., & Manna, S. S. (2004). Pareto law in a kinetic model of market with random saving propensity. *Physica A: Statistical Mechanics and its Applications*, 335(1–2), 155-163.
- Chatterjee, A., Yarlagadda, S., & Chakrabarti, B. K. (2005). *Econophysics of Wealth Distributions*.
- Chatterjee, K., Zufferey, D., & Nowak, M. A. (2012). Evolutionary game dynamics in populations with different learners. *J Theor Biol*, 301, 161-173.
- Chen, C. C. (1995). New trends in rewards allocation preferences: A Sino-U.S. comparison. *Academy of Management Journal*, 38(2), 408-428.
- Chen, C. C., Meindl, J. R., & Hui, H. (1998). Deciding on equity or parity: A test of situational, cultural, and individual factors. *Journal of Organizational Behavior*, 19(2), 115-129.
- Chen, C. C., Meindl, J. R., & Hunt, R. G. (1997). Testing the effects of vertical and horizontal collectivism: A study of reward allocation preferences in China. *J Cross Cult Psychol*, 28(1), 44-70.
- Chen, S. H. (2012). Varieties of agents in agent-based computational economics: A historical and an interdisciplinary perspective. *Journal of Economic Dynamics and Control*, 36(1), 1-25.
- Chen, S. H., & Tai, C. C. (2010). The agent-based double auction markets: 15 years on. *Simulating Interacting Agents and Social Phenomena*, 7, 119-136.
- Chen, S. H., & Yeh, C. H. (1996). Genetic programming learning and the cobweb model. *Advances in Genetic Programming*, 2, 443-466.
- Chen, S. H., Chie, B. T., & Zhang, T. (2015). Network-Based Trust Games: An Agent-Based Model. *Journal of Artificial Societies & Social Simulation*, 18(3).
- Chernyshenko, O. S., Stark, S., & Drasgow, F. (2011). Individual differences: Their measurement and validity *APA handbook of industrial and organizational psychology, Vol 2: Selecting and developing members for the organization*.
- Chiao, J. Y. (2010). Neural basis of social status hierarchy across species. *Current Opinion in Neurobiology*, 20(6), 803-809. doi: 10.1016/j.conb.2010.08.006
- Chiu, C. Y. (1988). The Effect Of Personality And Performance On Reward Allocation. *Journal of Social Psychology*, 128(2), 279-280.
- Chiu, C. Y. (1989). Reward Allocation Among Chinese High-School-Students In Hong-Kong. *Journal of Social Psychology*, 129(6), 751-757.

- Chiu, C. Y. (1990a). Distributive Justice Among Hong-Kong Chinese College-Students. *Journal of Social Psychology*, 130(5), 649-656.
- Chiu, C. Y. (1990b). Effects Of Personality And Performance On In-Group Favoritism Among Hong-Kong Chinese. *Journal of Social Psychology*, 130(6), 841-843.
- Chiu, C. Y. (1991a). Responses To Injustice In Popular Chinese Sayings And Among Hong-Kong Chinese Students. *Journal of Social Psychology*, 131(5), 655-665.
- Chiu, C. Y. (1991b). Responses To Injustices By Hong-Kong Chinese College-Students. *Journal of Social Psychology*, 131(2), 205-211.
- Chiu, C. Y., Gelfand, M. J., Yamagishi, T., Shteynberg, G., & Wan, C. (2010). Intersubjective culture: The role of intersubjective perceptions in cross-cultural research. *Perspectives on Psychological Science*, 5(4), 482-493.
- Chiu, C. Y., & Qiu, L. (2014). Communication and culture: A complexity theory approach. *Asian Journal of Social Psychology*, 17(2).
- Christopoulos, G. I., & King-Casas, B. (2015). With you or against you: Social orientation dependent learning signals guide actions made for others. *Neuroimage*, 104, 326-335.
- Christopoulos, G. I., Tobler, P. N., Bossaerts, P., Dolan, R. J., & Schultz, W. (2009). Neural correlates of value, risk, and risk aversion contributing to decision making under risk. *The Journal of Neuroscience*, 29(40), 12574-12583.
- Christopoulos, G., & Hong, Y. Y. (2013). Turning Two Uninvited Guests Into Prominent Speakers: Toward a Dynamic Culture Neuroscience. *Psychological Inquiry*, 24(1).
- Christopoulos, G., Kokkinaki, F., Harvey, N., & Sevdalis, N. (2011). Paying for no reason? (Mis-)perceptions of product attributes in separate vs. joint product evaluation. *Journal of Economic Psychology*, 32(5), 857-864.
- Chung, C.-J., & Reynolds, R. G. (1998). CAEP: an evolution-based tool for real-valued function optimization using cultural algorithms. *International Journal on Artificial Intelligence Tools*, 7(03), 239-291.
- Chung, T., & Mallery, P. (1999). Social comparison, individualism-collectivism, and self-esteem in china and the United States. *Current Psychology*, 18(4), 340-352.
- Ciarli, T., Lorentz, A., Savona, M., & Valente, M. (2010). The Effect Of Consumption And Production Structure On Growth And Distribution. A Micro To Macro Model. *Metroeconomica*, 61(1).
- Cioffi-Revilla, C. (2002). Invariance and universality in social agent-based simulations. *Proc Natl Acad Sci*, 99(SUPPL. 3), 7314-7316.

- Cioffi-Revilla, C. (2014a) On the quality of a social simulation model: A lifecycle framework. *Vol. 229 AISC. Advances in Intelligent Systems and Computing* (pp. 13-23).
- Cioffi-Revilla, C. (2014b). Seeing it coming: A complexity approach to disasters and humanitarian crises. *Complexity*, 19(6), 95-108.
- Clark, M. S., Oullette, R., Powell, M. C., & Milberg, S. (1987). Recipient's mood, relationship type, and helping. *J Pers Soc Psychol*, 53(1), 94-103.
- Clemson, T., & Evans, T. S. (2012). The emergence of leadership in social networks. *Physica A: Statistical Mechanics and its Applications*, 391(4), 1434-1444.
- Coen, C. (2013). Relative performance and implicit incentives in the intergroup prisoner's dilemma. *Organ Behav Hum Decis Process*, 120(2), 181-190.
- Coens, T., & Jenkins, M. (2000). *Abolishing performance appraisals: Why they backfire and what to do instead*.
- Cohen, K. J., & Cyert, R. M. (1965). Simulation of organizational behavior. *Handbook of Organizations*, 305-334.
- Cohen, M. D., March, J. G., & Olsen, J. P. (1972). A Garbage Can Model of Organizational Choice. *Administrative Science Quarterly*, 17(1), 1-25.
- Cohen-Charash, Y., & Spector, P. E. (2001). The role of justice in organizations: A meta-analysis. *Organ Behav Hum Decis Process*, 86(2), 278-321.
- Cohn, A., Fehr, E., Herrmann, B., & Schneider, F. (2014). Social Comparison And Effort Provision: Evidence From A Field Experiment. *Journal of the European Economic Association*, 12(4), 877-898.
- Colella, A., Paetzold, R. L., Zardkoohi, A., & Wesson, M. J. (2007). Exposing pay secrecy. *Academy of Management Review*, 32(1), 55-71.
- Colquitt, J. A., & George, G. (2011). From the editors: Publishing in AMJ - Part 1: Topic choice. *Academy of Management Journal*, 54(3), 432-435.
- Colquitt, J. A., & Rodell, J. B. (2011). Justice, trust, and trustworthiness: A longitudinal analysis integrating three theoretical perspectives. *Academy of Management Journal*, 54(6), 1183-1206.
- Colquitt, J. A., & Zapata-Phelan, C. P. (2007). Trends in theory building and theory testing: A five-decade study of the Academy of Management Journal. *Academy of Management Journal*, 50(6), 1281-1303.

- Colquitt, J. A., Conlon, D. E., Wesson, M. J., Porter, C. O., & Ng, K. Y. (2001). Justice at the millennium: a meta-analytic review of 25 years of organizational justice research. *J Appl Psychol*, *86*(3), 425-445.
- Condly, S. J., Clark, R. E., & Stolovitch, H. D. (2003). The effects of incentives on workplace performance: A meta-analytic review of research studies. *Performance Improvement Quarterly*, *16*(3), 46-63.
- Connelly, B. L., Tihanyi, L., Crook, T. R., & Gangloff, K. A. (2014). Tournament Theory: Thirty Years of Contests and Competitions. *Journal of Management*, *40*(1), 16-47.
- Conte, R., Gilbert, N., Bonelli, G., Cioffi-Revilla, C., Deffuant, G., Kertesz, J., . . . Helbing, D. (2012). Manifesto of computational social science. *European Physical Journal: Special Topics*, *214*(1), 325-346.
- Cook, K. S., & Hegtvedt, K. A. (1983). Distributive Justice, Equity, And Equality. *Annual Review of Sociology*, *9*, 217-241.
- Cook, K. S., & Parcel, T. L. (1977). EQUITY THEORY - DIRECTIONS FOR FUTURE RESEARCH. *Sociological Inquiry*, *47*(2), 75-88.
- Cook, T. D., Crosby, F., & Hennigan, K. M. (1977). The construct validity of relative deprivation. *Social Comparison Processes: Theoretical and Empirical Perspectives*, *307*, 333.
- Corcoran, K., Epstude, K., Damisch, L., & Mussweiler, T. (2011). Fast Similarities: Efficiency Advantages of Similarity-Focused Comparisons. *Journal of Experimental Psychology: Learning Memory and Cognition*, *37*(5), 1280-1286.
- Corley, K. G., & Gioia, D. A. (2011). Building Theory About Theory Building: What Constitutes A Theoretical Contribution? *The Academy of Management Review*, *36*(1), 12-32.
- Cosier, R. A., & Dalton, D. R. (1983). Equity Theory And Time - A Reformulation. *Academy of Management Review*, *8*(2), 311-319.
- Cowan, N., Saults, J. S., Elliott, E. M., & Moreno, M. V. (2002). Deconfounding serial recall. *Journal of Memory and Language*, *46*(1), 153-177.
- Cowherd, D. M., & Levine, D. I. (1992). Product Quality And Pay Equity Between Lower-Level Employees And Top Management - An Investigation Of Distributive Justice Theory. *Administrative Science Quarterly*, *37*(2), 302-320.
- Craik, F. I. M., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior*, *11*(6), 671-684.

- Crano, W. D. (1977). Primacy versus recency in retention of information and opinion change. *The Journal of Social Psychology*, 101(1), 87-96.
- Crawshaw, J. R., Cropanzano, R., Bell, C. M., & Nadisic, T. (2013). Organizational justice: New insights from behavioural ethics. *Human Relations*, 66(7), 885-904.
- Crooks, A. T., & Heppenstall, A. J. (2012). Introduction to agent-based modelling *Agent-Based Models of Geographical Systems* (pp. 85-105): Springer.
- Cropanzano, R., Fortin, M., & Kirk, J. F. (2015). How do We Know When We are Treated Fairly? Justice Rules and Fairness Judgments. *Research in Personnel and Human Resources Management*, Volume 33 Emerald Group Publishing Limited, 33, 279-350.
- Crosby, F. (1976). A model of egoistical relative deprivation. *Psychological Review*, 83(2).
- Crosby, F. (1984). Relative deprivation in organizational settings. *Research in Organizational Behavior*, 6, 51-93.
- Crosby, F., & Gonzalez-Intal, A. M. (1984). Relative deprivation and equity theories *The Sense of Injustice* (pp. 141-166): Springer.
- Cross, S. E., Hardin, E. E., & Gercek-Swing, B. (2011). The What, How, Why, and Where of Self-Construal. *Personality and Social Psychology Review*, 15(2), 142-179.
- Curseu, P. L. (2006). Emergent states in virtual teams: a complex adaptive systems perspective. *J Inf technol*, 21(4), 249-261.
- Dal Forno, A., & Merlone, U. (2002). A multi-agent simulation platform for modeling perfectly rational and bounded-rational agents in organizations. *JASSS*, 5(2).
- Dal Forno, A., & Merlone, U. (2004). Personnel turnover in organizations: An agent-based simulation model. *Nonlinear Dynamics, Psychology, and Life Sciences*, 8(2), 205-230.
- Dal Forno, A., & Merlone, U. (2007). Incentives in Supervised Teams: An experimental and computational approach. *Journal of Social Complexity*, 3(1), 37-52.
- Dal Forno, A., & Merlone, U. (2009). Individual incentives in supervised work groups. From human subject experiments to agent based simulation. *International Journal of Internet and Enterprise Management*, 6, 4-22.
- Dal Forno, A., & Merlone, U. (2010a). Effort dynamics in supervised work groups. *Journal of Economic Behavior and Organization*, 75(3), 413-425.
- Dal Forno, A., & Merlone, U. (2010b). Incentives and individual motivation in supervised work groups. *European Journal of Operational Research*, 207(2), 878-885.

- Dalton, D. R., Daily, C. M., Certo, S. T., & Roengpitya, R. (2003). Meta-analyses of financial performance and equity: Fusion or confusion? *Academy of Management Journal*, 46(1), 13-26.
- Damaceanu, R. C. (2011). *Applied computational mathematics in social sciences*.
- Darabos, C., Giacobini, M., & Tomassini, M. (2007). Performance and robustness of cellular automata computation on irregular networks. *Advances in Complex Systems*, 10(supp01), 85-110.
- Datta, P. P., & Christopher, M. G. (2010). Information sharing and coordination mechanisms for managing uncertainty in supply chains: a simulation study. *International Journal of Production Research*, 49(3), 765-803.
- Davelaar, E. J., Goshen-Gottstein, Y., Ashkenazi, A., Haarmann, H. J., & Usher, M. (2005). The demise of short-term memory revisited: empirical and computational investigations of recency effects. *Psychological review*, 112(1), 3.
- Davidsson, P., & Verhagen, H. (2012). Social Phenomena Simulation. In R. A. Meyers (Ed.), *Computational Complexity* (pp. 2999-3003): Springer New York.
- Davis, G. F. (2010). Do Theories of Organizations Progress? *Organizational Research Methods*, 13(4), 690-709.
- Davis, J. P., Eisenhardt, K. M., & Bingham, C. B. (2007). Developing theory through simulation methods. *Academy of Management Review*, 32(2), 480-499
- Davis, M. S. (1971). That's Interesting: Towards a Phenomenology of Sociology and a Sociology of Phenomenology. *Philosophy of the Social Sciences*, 1(4), 309-334.
- Dawid, H., Gemkow, S., Harting, P., & Neugart, M. (2009). On the effects of skill upgrading in the presence of spatial labor market frictions: An agent-based analysis of spatial policy design. *JASSS*, 12(4).
- De Dreu, C. K. (2004). Motivation in negotiation: A social psychological analysis. *The Handbook of Negotiation and Culture*, 114-135.
- Deadrick, D. L., & Gibson, P. A. (2007). An examination of the research-practice gap in HR: Comparing topics of interest to HR academics and HR professionals. *Human Resource Management Review*, 17(2), 131-139.
- Dean, J. S., Gumerman, G. J., Epstein, J. M., Axtell, R. L., Swedlund, A. C., Parker, M. T., & McCarroll, S. (2000). Understanding Anasazi culture change through agent-based modeling. *Dynamics in Human and Primate Societies*, 179-205
- Deb, T. (2009). *Managing Human Resource And Industrial Relations*: Excel Books.

- Deci, E. L., & Ryan, R. M. (1985). *Intrinsic Motivation and Self-determination in Human Behavior*.
- Deci, E. L., Ryan, R. M., & Koestner, R. (1999). A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation. *Psychol Bull*, 125(6), 627-668.
- Deckop, J. R., Mangel, R., & Cirka, C. C. (1999). Getting more than you pay for: Organizational citizenship behavior and pay-for-performance plans. *Academy of Management Journal*, 42(4), 420-428.
- Deffuant, G., & Huet, S. (2007). Propagation effects of filtering incongruent information. *Journal of Business Research*, 60(8), 816-825.
- Deffuant, G., & Huet, S. (2010). Collective increase of first impression bias. *Complexity*, 15(5), 25-33.
- Deffuant, G., Amblard, F., Weisbuch, G., & Faure, T. (2002). How Can Extremism Prevail? A Study Based on the Relative Agreement Interaction Model. *JASSS*, 5(4).
- Deffuant, G., Neau, D., Amblard, F., & Weisbuch, G. (2000). Mixing beliefs among interacting agents. *Adv. Complex Syst.*, 3, 87-98.
- Deffuant, G., Weisbuch, G., Amblard, F., & Faure, T. (2003). Simple is beautiful... and necessary. *JASSS*, 6(1), 6.
- Delbridge, R., & Fiss, P. C. (2013). Editors' comments:: styles of theorizing and the social organization of knowledge. *Academy of Management Review*, 38(3), 325-331.
- Delre, S. A., Jager, W., & Janssen, M. A. (2007). Diffusion dynamics in small-world networks with heterogeneous consumers. *Computational and Mathematical Organization Theory*, 13(2), 185-202.
- Delre, S. A., Jager, W., Bijmolt, T. H. A., & Janssen, M. A. (2007). Targeting and timing promotional activities: An agent-based model for the takeoff of new products. *Journal of Business Research*, 60(8), 826-835.
- Delre, S. A., Jager, W., Bijmolt, T. H. A., & Janssen, M. A. (2010). Will it spread or not? the effects of social influences and network topology on innovation diffusion. *Journal of Product Innovation Management*, 27(2), 267-282.
- DeMatteo, J. S., Eby, L. T., & Sundstrom, E. (1998). Team-based rewards: Current empirical evidence and directions for future research. *Research in Organizational Behavior*, 20, 141-183.
- Dempster, F. N. (1981). Memory span: Sources of individual and developmental differences. *Psychol Bull*, 89(1), 63-100.

- Dennett, D. C. (1995). *Darwin's Dangerous Idea*.
- Deutsch, M. (1949). A theory of cooperation and competition. *Human Relations*, 2, 129-152.
- Deutsch, M. (1975). Equity, Equality, and Need: What Determines Which Value Will Be Used As The Basis Of Distributive Justice? *The Journal of Social Issues*, 31(3).
- Deutsch, M. (1985). Distributive justice: A social-psychological perspective. *Distributive Justice: A Social Psychological Perspective*.
- Di Matteo, T., Aste, T., & Hyde, S. (2004). Exchanges in complex networks: income and wealth distributions. In F. Mallamace & H. E. Stanley (Eds.), *The Physics of Complex Systems (New Advances and Perspectives)*.
- DiMaggio, P. J. (1995). Comments on "What Theory Is Not". *Administrative Science Quarterly*, 40(3), 391-397.
- Dipboye, R. L. (2007). Eight outrageous statements about HR science. *Human Resource Management Review*, 17(2), 96-106.
- Dittrich, J. E., & Carrell, M. R. (1979). Organizational equity perceptions, employee job satisfaction, and departmental absence and turnover rates. *Organizational Behavior and Human Performance*, 24(1), 29-40.
- Doebeli, M., & Hauert, C. (2005). Models of cooperation based on the Prisoner's Dilemma and the Snowdrift game. *Ecology Letters*, 8(7), 748-766.
- Dooley, K. J. (2002). Simulation research methods. *Companion to Organizations*, 829-848.
- Dooley, K. J., & Van de Ven, A. H. (1999). Explaining complex organizational dynamics. *Organization Science*, 10(3), 358-372.
- Dosi, G., Fagiolo, G., & Roventini, A. (2010). Schumpeter meeting Keynes: A policy-friendly model of endogenous growth and business cycles. *Journal of Economic Dynamics and Control*, 34(9), 1748-1767.
- Drago, R. (1991). Incentives, pay, and performance: a study of Australian employees. *Applied Economics*, 23(9), 1433-1446.
- Dragulescu, A., & Yakovenko, V. M. (2000). Statistical mechanics of money. *European Physical Journal B*, 17(4), 723-729.
- Dray, A., Mazerolle, L., Perez, P., & Ritter, A. (2008). Policing Australia's 'heroin drought': using an agent-based model to simulate alternative outcomes. *Journal of Experimental Criminology*, 4(3), 267-287.
- Driver, G. R., & Miles, J. C. (1952). *The babylonian laws* (Vol. 1): Clarendon Press.

- Dubin, R. (1978). *Theory Building*.
- Dubinsky, A. J., & Levy, M. (1989). Influence of organizational fairness on work outcomes of retail salespeople. *Journal of Retailing*.
- Duch, W., Oentaryo, R. J., & Pasquier, M. (2008). *Cognitive Architectures: Where do we go from here?* Paper presented at the AGI.
- Duffy, J., 2006. Agent-based models and human subject experiments. In: Tesfatsion, L., Judd, K. (Eds.), *Handbook of Computational Economics: Agent Based Computational Economics, vol. 2.*, Elsevier, Oxford, UK, pp. 949–1011
- Duffy, J., and Unver, U. M. (2006) Asset price bubbles and crashes with near-zero-intelligence traders. *Economic Theory*.
- Dulebohn, J. H., & Werling, S. E. (2007). Compensation research past, present, and future. *Human Resource Management Review*, 17(2), 191-207.
- Dupouët, O., & Yıldızoğlu, M. (2006). Organizational performance in hierarchies and communities of practice. *Journal of Economic Behavior & Organization*, 61(4), 668-690.
- Durfee, E. H., & Montgomery, T. A. (1991). Coordination as distributed search in a hierarchical behavior space. *Systems, Man and Cybernetics, IEEE Transactions on*, 21(6), 1363-1378.
- Durham, C. C., & Bartol, K. M. (2000). Pay for performance. *Principles of Organizational Behavior*, 150-165.
- Earley, P. C., & Erez, M. (1991). Time-dependency effects of goals and norms: The role of cognitive processing on motivational models. *Journal of Applied Psychology*, 76(5), 717-724.
- Eddleston, K. A. (2009). The effects of social comparisons on managerial career satisfaction and turnover intentions. *Career Development International*, 14(1), 87-110.
- Ederer, F., & Manso, G. (2013). Is pay for performance detrimental to innovation? *Management Science*, 59(7), 1496-1513.
- Edmondson, A. (1999). Psychological safety and learning behavior in work teams. *Administrative Science Quarterly*, 44(2), 350-383.
- Eisenberger, R., & Aselage, J. (2009). Incremental effects of reward on experienced performance pressure: Positive outcomes for intrinsic interest and creativity. *Journal of Organizational Behavior*, 30(1), 95-117.

- Eisenberger, R., & Cameron, J. (1996). Detrimental Effects of Reward: Reality or Myth? *American Psychologist*, 51(11), 1153-1166.
- Eisenhardt, K. M. (1989). Agency theory: An assessment and review. *Academy of Management Review*, 14(1), 57-74.
- Ekmekci, O., & Casey, A. (2011). Computer simulation exploring organizational identification for contingent workers. *Team Performance Management: An International Journal*, 17(5/6), 279-298.
- Elffers, H., & Van Baal, P. (2008). Realistic spatial backcloth is not that important in agent based simulation research. An illustration from simulating perceptual deterrence. *Artificial crime analysis systems: using computer simulations and geographic information systems*.
- Elsenbroich, C. (2012). Explanation in agent-based modelling: Functions, causality or mechanisms?. *JASSS*, 15(3), 1.
- Elsenbroich, C., & Gilbert, N. (2014). *Modelling norms*: Springer.
- Elsenbroich, C., & Xenitidou, M. (2012). Three Kinds of Normative Behaviour: Minimal Requirements for Feedback Models. *Computational and Mathematical Organization Theory*, 18(1), 113-127.
- Epstein, J. (2006). Generative social science. *Studies in Agent-based Computational Modeling*.
- Epstein, J. M. (1999). Agent-based computational models and generative social science. *Complexity*, 4(5), 41-60.
- Epstein, J. M. (2002). Modeling civil violence: An agent-based computational approach. *Proc Natl Acad Sci U S A*, 99(SUPPL. 3), 7243-7250.
- Epstein, J. M. (2003). Growing Adaptive Organizations: An Agent-Based Computational Approach. *Growing Adaptive Organizations: An Agent-Based Computational Approach*.
- Epstein, J. M. (2006a) Chapter 34 Remarks on the Foundations of Agent-Based Generative Social Science. *Vol. 2. Handbook of Computational Economics* (pp. 1585-1604).
- Epstein, J. M. (2006b). Generative Social Science. *Studies in Agent-based Computational Modeling*.
- Epstein, J. M. (2008). Why model? *JASSS*, 11(4).
- Epstein, J. M., & Axtell, R. (1996). Growing artificial societies. *Social Science from the Bottom Up*.

- Erdogan, B., Liden, R. C., & Kraimer, M. L. (2006). Justice and leader-member exchange: The moderating role of organizational culture. *Academy of Management Journal*, 49(2), 395-406.
- Ernst, W. (2013). State Government Labor Market Definitions. *Compensation & Benefits Review*, 45(4), 210-214.
- Ethiraj, S. K., & Levinthal, D. (2002). *Search for architecture in complex worlds: An evolutionary perspective on modularity and the emergence of dominant designs*.
- Ethiraj, S. K., & Levinthal, D. (2009). Hoping for A to Z while rewarding only a: Complex organizations and multiple goals. *Organization Science*, 20(1), 4-21.
- Etzion, D. (2014). Diffusion as Classification. *Organization Science*, 25(2), 420-437.
- Etzioni, A. (1961). *Complex Organizations: A Sociological Reader*.
- Evans, M. G., & Molinari, L. (1970). Equity, piece-rate, overpayment, and job security: Some effects on performance. *Journal of Applied Psychology*, 54(2).
- Fachada, N., Lopes, V. V., & Rosa, A. (2007). Agent Based Modelling and Simulation of the Immune System: a Review.
- Fall, A., & Roussel, P. (2014). Compensation and Work Motivation: Self-Determination Theory and the Paradigm of Motivation through. *The Oxford Handbook of Work Engagement, Motivation, and Self-Determination Theory*, 199.
- Fang, C., Lee, J., & Schilling, M. A. (2010). Balancing exploration and exploitation through structural design: The isolation of subgroups and organizational learning. *Organization Science*, 21(3), 625-642.
- Fang, M., & Gerhart, B. (2012). Does pay for performance diminish intrinsic interest? *International Journal of Human Resource Management*, 23(6), 1176-1196.
- Farh, J. L., Earley, P. C., & Lin, S. C. (1997). Impetus for action: A cultural analysis of justice and organizational citizenship behavior in Chinese society. *Administrative Science Quarterly*, 42(3), 421-444.
- Farr, J. L. (1976a). Incentive schedules, productivity, and satisfaction in work groups: A laboratory study. *Organizational Behavior and Human Performance*, 17(1), 159-170.
- Farr, J. L. (1976b). Task characteristics, reward contingency, and intrinsic motivation. *Organizational Behavior and Human Performance*, 16(2), 294-307.
- Farrell, S., & Lewandowsky, S. (2004). Modelling transposition latencies: Constraints for theories of serial order memory. *Journal of Memory and Language*, 51(1), 115-135.

- Fay, C. H., & Thompson, M. A. (2001). Contextual determinants of reward systems' success: An exploratory study. *Human Resource Management, 40*(3), 213-226.
- Fazlollahi, B., & Vahidov, R. (2001). A Method for Generation of Alternatives by Decision Support Systems. *Journal of Management Information Systems, 18*(2), 229-250.
- Fedler, F., & Pryor, B. (1984). An Equity Theory Explanation Of Bystanders Reactions To Shoplifting. *Psychol Rep, 54*(3), 746-746.
- Fehr, E., & Schmidt, K. M. (1999). A theory of fairness, competition, and cooperation. *Quarterly Journal of Economics, 114*(3), 817-868.
- Feld, S. L. (1981). The focused organization of social ties. *American journal of sociology, 1015-1035*.
- Feldman, R. E. (1968). Response to compatriot and foreigner who seek assistance. *J Pers Soc Psychol, 10*(3), 202.
- Fernie, S., & Metcalf, D. (1999). It's Not What You Pay it's the Way that You Pay it and that's What Gets Results: Jockeys' Pay and Performance. *Labour, 13*(2), 385-411.
- Festinger, L. (1954a). A theory of social comparison processes. *Am. Psychol., 16*, 1-11.
- Festinger, L. (1954b). A Theory Of Social Comparison Processes. *Human Relations, 7*(2), 117-140.
- Festinger, L. (1957). A theory of cognitive dissonance.
- Festré, A., & Garrouste, P. (2014). Theory and evidence in psychology and economics about motivation crowding out: A possible convergence?. *Journal of Economic Surveys, 29*(2), 339-356.
- Fetta, A., Harper, P., Knight, V., Vieira, I., & Williams, J. (2012). On the Peter Principle: An agent based investigation into the consequential effects of social networks and behavioural factors. *Physica A: Statistical Mechanics and its Applications, 391*(9).
- Fields, D., Pang, M., & Chiu, C. (2000). Distributive and procedural justice as predictors of employee outcomes in Hong Kong. *Journal of Organizational Behavior, 21*(5), 547-562.
- Fioretti, G. (2013). Agent-Based Simulation Models in Organization Science. *Organizational Research Methods, 16*(2), 227-242.
- Fischer, R., & Smith, P. B. (2003). Reward allocation and culture: A meta-analysis. *J Cross Cult Psychol, 34*(3), 251-268.

- Fişek, M. H., & Hysom, S. J. (2008). Status characteristics and reward expectations: A test of a theory of justice in two cultures. *Soc Sci Res*, 37(3), 769-786.
- Fiske, S. T. (2004). Mind the gap: In praise of informal sources of formal theory. *Personality and Social Psychology Review*, 8(2), 132-137.
- Flache, A., & Macy, M. W. (2002). Stochastic collusion and the power law of learning: A general reinforcement learning model of cooperation. *Journal of Conflict Resolution*, 46(5), 629-653.
- Flache, A., & Macy, M. W. (2011a). Local convergence and global diversity: From interpersonal to social influence. *Journal of Conflict Resolution*, 55(6), 970-995.
- Flache, A., & Macy, M. W. (2011b). Small worlds and cultural polarization. *Journal of Mathematical Sociology*, 35(1-3), 146-176.
- Flache, A., & Mäs, M. (2008a). How to get the timing right. A computational model of the effects of the timing of contacts on team cohesion in demographically diverse teams. *Computational and Mathematical Organization Theory*, 14(1), 23-51.
- Flache, A., & Mäs, M. (2008b). Why do faultlines matter? A computational model of how strong demographic faultlines undermine team cohesion. *Simulation Modelling Practice and Theory*, 16(2), 175-191.
- Fleenor, J. (2001). Review of the book, Computational modeling of behavior in organizations: The third scientific discipline. *Personnel Psychology*(54), 248-251.
- Fliessbach, K., Weber, B., Trautner, P., Dohmen, T., Sunde, U., Elger, C. E., & Falk, A. (2007). Social comparison affects reward-related brain activity in the human ventral striatum. *Science*, 318(5854), 1305-1308.
- Floyd, F. J., & Wasner, G. H. (1994). Social Exchange, Equity, and Commitment: Structural Equation Modeling of Dating Relationships. *Journal of Family Psychology*, 8(1), 55-73.
- Folger, R. (1977). Distributive and procedural justice: Combined impact of voice and improvement on experienced inequity. *J Pers Soc Psychol*, 35(2), 108-119.
- Folger, R. (1986). Rethinking equity theory: A referent cognitions model. *Justice in Social Relations*, 145-162.
- Folger, R., & Cropanzano, R. (1998). Organizational justice and human resource management. *Organizational Justice and Human Resource Management*.
- Folger, R., & Kass, E. E. (2000). Social comparison and fairness: A counterfactual simulations perspective. *Handbook of Social Comparison: Theory and Research*.

- Forno, A., & Merlone, U. (2013). Chaotic Dynamics in Organization Theory. In G. I. Bischi, C. Chiarella, & I. Sushko (Eds.), *Global Analysis of Dynamic Models in Economics and Finance* (pp. 185-204): Springer Berlin Heidelberg.
- Forrester, J. W. (1958). Industrial dynamics: A major breakthrough for decision makers. *Harv Bus Rev*, 36(4), 37-66.
- Forrester, J. W. (1968). *Principles of Systems*.
- Forret, M., & Love, M. S. (2008). Employee justice perceptions and coworker relationships. *Leadership and Organization Development Journal*, 29(3), 248-260.
- Foss, N., & Stea, D. (2014). Putting a Realistic Theory of Mind into Agency Theory: Implications for Reward Design and Management in Principal-Agent Relations. *European Management Review*, 11(1), 101-116.
- Freixas, X., Guesnerie, R., & Tirole, J. (1985). Planning under incomplete information and the ratchet effect. *The review of economic studies*, 52(2), 173-191.
- Frey, B. (2005). "Just forget it." Memory distortions as bounded rationality. *Mind & Society*, 4(1), 13-25.
- Frey, B. S. (1997). On the relationship between intrinsic and extrinsic work motivation. *International Journal of Industrial Organization*, 15(4), 427-439.
- Frey, B. S., & Jegen, R. (2001). Motivation crowding theory. *Journal of Economic Surveys*, 15(5), 589-611.
- Frey, B. S., & Oberholzer-Gee, F. (1997). The Cost of Price Incentives: An Empirical Analysis of Motivation Crowding-Out. *American Economic Review*, 87(4), 746-755.
- Frey, B. S., & Osterloh, M. (2012). Stop Tying Pay to Performance. *Harvard Business Review*.
- Frey, B. S., Homberg, F., & Osterloh, M. (2013). Organizational Control Systems and Pay-for-Performance in the Public Service. *Organization Studies*, 34(7), 949-972.
- Fu, F., Nowak, M. A., Christakis, N. A., & Fowler, J. H. (2012). The evolution of homophily. *Scientific Reports*, 2.
- Fu, J. H.Y., Morris, M. W., Lee, S.-l., Chao, M., Chiu, C.-y., & Hong, Y.-y. (2007). Epistemic motives and cultural conformity: Need for closure, culture, and context as determinants of conflict judgments. *J Pers Soc Psychol*, 92(2), 191-207.
- Fulmer, C. A., Crosby, B., Gelfand, M. J. (2014). Cross-cultural perspectives on time. In Shipp, A. J., & Fried, Y. (Eds.), *Time and work: How time impacts groups, organizations, and methodological choices* (Vol., 2, pp. 53-75).

- Gagné, M., & Deci, E. L. (2005). Self-determination theory and work motivation. *Journal of Organizational Behavior*, 26(4), 331-362.
- Gagné, M., & Forest, J. (2008). The study of compensation systems through the lens of self-determination theory: Reconciling 35 years of debate. *Canadian Psychology*, 49(3), 225-232.
- Galam, S. (1999). Application of statistical physics to politics. *Physica A: Statistical Mechanics and its Applications*, 274(1), 132-139.
- Galan, J. M., & Izquierdo, L. R. (2005). Appearances can be deceiving: Lessons learned re-implementing Axelrod's' evolutionary approach to norms'. *JASSS*, 8(3).
- Galán, J. M., Izquierdo, L. R., Izquierdo, S. S., Santos, J. I., Del Olmo, R., López-Paredes, A., & Edmonds, B. (2009). Errors and artefacts in agent-based modelling. *JASSS*, 12(1), 1.
- Ganguly, N., Sikdar, B. K., Deutsch, A., Canright, G. r., & Chaudhuri, P. P. (2003). A Survey on Cellular Automata, Centre for High Performance Computing (Vol. Technical Report 9): Dresden University of Technology.
- Gao, W., Qiu, L., Chiu, C.Y., & Yang, Y. (in press). Diffusion of Opinions in a Complex Culture System: Implications for Emergence of Descriptive Norms. *Journal of Cross Cultural Psychology*.
- Garagic, D., Trifonov, I., Gaudio, P., & Dickason, D. (2007). An Agent-Based Modeling Approach For Studying Manpower And Personnel Management Behaviors.
- Garbers, Y., & Konradt, U. (2014). The effect of financial incentives on performance: A quantitative review of individual and team-based financial incentives. *Journal of Occupational and Organizational Psychology*, 87(1), 102-137.
- Garcia, S. M., & Tor, A. (2009). The n-effect more competitors, less competition. *Psychological Science*, 20(7), 871-877.
- Garcia-Sanchez, J., Mesquita, L. F., & Vassolo, R. S. (2014). What doesn't kill you makes you stronger: The evolution of competition and entry-order advantages in economically turbulent contexts. *Strategic Management Journal*, 35(13), 1972-1992.
- Gardner, M. (1970). The fantastic combinations of John Conway's new solitaire game 'life'. *Sci Am*, 223(4), 120-123.
- Garfinkel, A. (1991). Reductionism. *The Philosophy of Science*, 443-459.
- Garland, H., & Judd, B. (1978). Does equity describe the results of allocation experiments? *Journal of Management*, 4, 7-16.

- Garnefeld, I., & Steinhoff, L. (2013). Primacy versus recency effects in extended service encounters. *Journal of Service Management*, 24(1), 64-81.
- Gartrell, C. D. (2002). The embeddedness of social comparison. Relative deprivation: Specification, development, and integration, 164-184.
- Garzarelli, F., Cristelli, M., Pompa, G., Zaccaria, A., & Pietronero, L. (2014). Memory effects in stock price dynamics: evidences of technical trading. *Scientific Reports*, 4.
- Gatti, D. D., Di Guilmi, C., Gallegati, M., & Landini, S. (2012). Reconstructing aggregate dynamics in heterogeneous agents models: A markovian approach. *Revue de l'OFCE*(5), 117-146.
- Gavetti, G., Levinthal, D. A., & Rivkin, J. W. (2005). Strategy making in novel and complex worlds: The power of analogy. *Strategic Management Journal*, 26(8), 691-712.
- Gavin, M. B., Green, S. G., & Fairhurst, G. T. (1995). Managerial control strategies for poor performance over time and the impact on subordinate reactions. *Organizational Behavior and Human Decision Processes*, 63(2), 207-221.
- Gelbrich, K. (2011). I Have Paid Less Than You! The Emotional and Behavioral Consequences of Advantaged Price Inequality. *Journal of Retailing*, 87(2), 207-224.
- Geli-Mann, M. (1994). Complex adaptive systems. *Complexity: Metaphors, models and reality*, 17-45.
- George, J. M., & Jones, G. R. (2000). The role of time in theory and theory building. *Journal of Management*, 26(4), 657-684.
- Georgeff, M., Pell, B., Pollack, M., Tambe, M., & Wooldridge, M. (1999). The belief-desire-intention model of agency. *Intelligent Agents V*, 1-10.
- Gergen, K. J., Morse, S. J., & Gergen, M. (1980). Behavior exchange in cross-cultural perspective. In H. C. Triandis & R. W. Brislin (Eds.), *Handbook of Cross-cultural Psychology* (Vol. Vol. 5, pp. 121–153).
- Gerhart, B., & Fang, M. (2014). Pay for (individual) performance: Issues, claims, evidence and the role of sorting effects. *Human Resource Management Review*.
- Gerhart, B., & Fang, M. (2015). Pay, Intrinsic Motivation, Extrinsic Motivation, Performance, and Creativity in the Workplace: Revisiting Long-Held Beliefs. *Annual Review of Organizational Psychology and Organizational Behavior*, 2(1).
- Gerhart, B., & Milkovich, G. T. (1990). Organizational differences in managerial compensation and financial performance. *Academy of Management Journal*, 33(4), 663-691.

- Gerhart, B., & Rynes, S. L. (2003). *Compensation: Theory, Evidence, and Strategic Implications*.
- Gerhart, B., Minkoff, H. B., & Olsen, R. N. (1995). Employee compensation: Theory, practice, and evidence. *Handbook of Human Resource Management*, 528-547.
- Gerhart, B., Rynes, S. L., & Fulmer, I. S. (2009). Pay and performance: Individuals, groups, and executives. *Academy of Management Annals*, 3(1), 251-315.
- Ghosh, P., Rai, A., & Sinha, A. (2014). Organizational justice and employee engagement: Exploring the linkage in public sector banks in India. *Personnel Review*, 43(4), 628-652.
- Gibbons, F. X., & Buunk, B. P. (1999). Individual differences in social comparison: Development of a scale of social comparison orientation. *J Pers Soc Psychol*, 76(1), 129-142.
- Gibbons, F. X., Lane, D. J., Gerrard, M., Pomery, E. A., & Lautrup, C. L. (2002). Drinking and driving: a prospective assessment of the relation between risk cognitions and risk behavior. *Risk, Decision and Policy*, 7(03), 267-283.
- Gigerenzer, G., & Marewski, J. N. (2015). Surrogate Science The Idol of a Universal Method for Scientific Inference. *Journal of Management*, 41(2), 421-440.
- Gilbert, N. (2007) *Agent-Based Models. Quantitative Applications in the Social Sciences*. London: SAGE Publications.
- Gilbert, N. (2008). Agent-based models. *Quantitative Applications in the Social Sciences*, 153.
- Gilbert, N., & Troitzsch, K. (2005). *Simulation for the social scientist*: McGraw-Hill International.
- Gilbert, P., Price, J., & Allan, S. (1995). Social comparison, social attractiveness and evolution: How might they be related? *New Ideas in Psychology*, 13(2), 149-165.
- Gilboa, I., & Samet, D. (1989). Bounded versus unbounded rationality: The tyranny of the weak. *Games and Economic Behavior*, 1(3), 213-221.
- Gilliland, S., Skarlicki, D., & Steiner, D. D. (2008). *Justice, Morality, and Social Responsibility*: Information Age Pub.
- Gioia, D. A., & Pitre, E. (1990). Multiparadigm perspectives on theory building. *Academy of Management Review*, 15(4), 584-602.
- Glance, N. S., & Huberman, B. A. (1994). Social dilemmas and fluid organizations. *Computational Organization Theory*, 217-239.

- Glaser, B. G., & Strauss, A. L. (1967). *The Discovery of Grounded Theory: Strategies for Qualitative Research*.
- Gneezy, U., & Rustichini, A. (2000). Pay enough or don't pay at all. *Quarterly Journal of Economics*, 115(3), 791-810.
- Gneezy, U., Meier, S., & Rey-Biel, P. (2011). When and why incentives (don't) work to modify behavior. *Journal of Economic Perspectives*, 25(4), 191-210.
- Gode, D. K., & Sunder, S. (1993a). Lower bounds for efficiency of surplus extraction in double auctions. *The Double Auction Market: Institutions, Theories, and Evidence*, 199-219.
- Gode, D. K., Sunder, S. (1993b). Allocative efficiency of markets with zero-intelligence traders: Market as a partial substitute for individual rationality. *Journal of Political Economy*, 119-137.
- Goldenberg, J., Han, S., Lehmann, D. R., & Hong, J. W. (2009). The role of hubs in the adoption process. *Journal of Marketing*, 73(2), 1-13.
- Goldenberg, J., Libai, B., & Muller, E. (2001). Using complex systems analysis to advance marketing theory development: Modeling heterogeneity effects on new product growth through stochastic cellular automata. *Academy of Marketing Science Review*, 9(9).
- Goldspink, C. (2002). Methodological implications of complex systems approaches to sociality: Simulation as a foundation for knowledge. *JASSS*, 5(1), 1-19.
- Goldstone, R. L., & Janssen, M. A. (2005). Computational models of collective behavior. *Trends Cogn Sci*, 9(9), 424-430.
- Gomez-Mejia, L. R., Berrone, P., & Franco-Santos, M. (2010). *Compensation and organizational performance : theory, research, and practice*.
- Goncalo, J. A., & Kim, S. H. (2010). Distributive justice beliefs and group idea generation: Does a belief in equity facilitate productivity? *Journal of Experimental Social Psychology*, 46(5), 836-840.
- Gong, X., & Socolar, J. E. (2012). Quantifying the complexity of random Boolean networks. *Physical Review E*, 85(6), 066107.
- Goodboy, A. K., Chory, R. M., & Dunleavy, K. N. (2008). Organizational Dissent as a Function of Organizational Justice. *Communication Research Reports*, 25(4).
- Goodman, P. S. (1974). An Examination of Referents used in the Evaluation of Pay. *Organizational Behavior & Human Performance*, 12(2), 170-195.

- Goodman, P. S. (1977). Social comparison processes in organizations. *New Directions in Organizational Behavior*, 97-132.
- Goodman, P. S. (2007). Special issue on social comparison processes, Editorial. *Organizational Behavior & Human Decision Processes*, pp. 1-2.
- Goodman, P. S., & Friedman, A. (1971). An Examination of Adams' Theory of Inequity. *Administrative Science Quarterly*, 16(3), 271-288.
- Goodman, P. S., & Haisley, E. (2007). Social comparison processes in an organizational context: New directions. *Organizational Behavior & Human Decision Processes*, 102(1), 109-125.
- Goodman, P., & Friedman, A. (1968). Examination Of Effect Of Wage Inequity In Hourly Condition. *Organizational Behavior and Human Performance*, 3(3), 340-352.
- Goto, Y., & Takahashi, S. (2013). Agent-Based Modeling and Simulation Validation by Scenario Analysis. In T. Murata, T. Terano, & S. Takahashi (Eds.), *Agent-Based Approaches in Economic and Social Complex Systems VII* (Vol. 10, pp. 3-16).
- Gotts, N. M., Polhill, J. G., & Law, A. N. R. (2003). Agent-based simulation in the study of social dilemmas. *Artificial Intelligence Review*, 19(1), 3-92.
- Gould, S. (1979). An Equity - Exchange Model of Organizational Involvement. *The Academy of Management Review*, 4(1), 53-62. doi: 10.2307/257403
- Graça, J., & Coelho, H. (2012). *Replicating Hofstede's cultured negotiation: A first update*. Paper presented at the Proceedings - 2012 Brazilian Workshop on Social Simulation: Advances in Social Simulation II, BWSS 2012.
- Gratz, D. B. (2009). *The peril and promise of performance pay: Making education compensation work*: R&L Education.
- Grant, A., & Shin, J. (2012-09-18). Work Motivation: Directing, Energizing, and Maintaining Effort (and Research). *Oxford Handbooks Online*.
- Greenberg, J. (1980). Attentional focus and locus of performance causality as determinants of equity behavior. *J Pers Soc Psychol*, 38(4), 579-585.
- Greenberg, J. (1988). Equity and Workplace Status: A Field Experiment. *Journal of Applied Psychology*, 73(4), 606-613.
- Greenberg, J. (1990a). Employee Theft as a Reaction to Underpayment Inequity: The Hidden Cost of Pay Cuts. *Journal of Applied Psychology*, 75(5), 561-568.
- Greenberg, J. (1990b). Looking Fair Vs Being Fair - Managing Impressions Of Organizational Justice. *Research in Organizational Behavior*, 12, 111-157.

- Greenberg, J. (1990c). Organizational Justice: Yesterday, Today, and Tomorrow. *Journal of Management*, 16(2), 399-432.
- Greenberg, J. (2001). Studying organizational justice cross-culturally: Fundamental challenges. *International Journal of Conflict Management*, 12(4), 365-375.
- Greenberg, J. (2003). Creating unfairness by mandating fair procedures: The hidden hazards of a pay-for-performance plan. *Human Resource Management Review*, 13(1), 41-57.
- Greenberg, J. (2010). Organizational injustice as an occupational health risk. *Academy of Management Annals*, 4(1), 205-243.
- Greenberg, J., & Ornstein, S. (1983). High status job title compensation for underpayment: A test of equity theory. *Journal of Applied Psychology*, 68(2), 285-297.
- Greene, C. N., & Podsakoff, P. M. (1978). Effects of Removal of a Pay Incentive: A Field Experiment. *Academy of Management Proceedings*, 1978(1), 206-210.
- Greene, R. L. (1986). Sources of recency effects in free recall. *Psychol Bull*, 99(2), 221.
- Griffeth, R. W., & Gaertner, S. (2001). A role for equity theory in the turnover process: An empirical test. *Journal of Applied Social Psychology*, 31(5), 1017-1037.
- Groeber, P., Schweitzer, F., & Press, K. (2009). How groups can foster consensus: The case of local cultures. *JASSS*, 12(2).
- Gross, S. E. (1995). *Compensation for teams: How to design and implement team-based reward programs*: Amacom.
- Grote, D. (1996). *The Complete Guide to Performance Appraisal*.
- Grow, A., & Flache, A. (2011). How attitude certainty tempers the effects of faultlines in demographically diverse teams. *Computational and Mathematical Organization Theory*, 17(2), 196-224.
- Grüne-Yanoff, T., & Weirich, P. (2010). The philosophy and epistemology of simulation: A review. *Simulation and Gaming*, 41(1), 20-50.
- Guimond, S. (2006). *Social Comparison and Social Psychology: Understanding Cognition, Intergroup Relations, and Culture*: Cambridge University Press.
- Guo, T., Ji, L. J., Spina, R., & Zhang, Z. (2012). Culture, Temporal Focus, and Values of the Past and the Future. *Personality and Social Psychology Bulletin*, 38(8), 1030-1040.
- Gupta, A. K., Smith, K. G., & Shalley, C. E. (2006). The interplay between exploration and exploitation. *Academy of Management Journal*, 49(4), 693-706.

- Gupta, N., & Shaw, J. D. (2014). Employee compensation: The neglected area of HRM research. *Human Resource Management Review*, 24(1), 1-4.
- Gupta, N., Conroy, S. A., & Delery, J. E. (2012). The many faces of pay variation. *Human Resource Management Review*, 22(2), 100-115.
- Guseo, R., & Guidolin, M. (2008). Cellular automata and Riccati equation models for diffusion of innovations. *Statistical Methods and Applications*, 17(3), 291-308.
- Gusman, S. R., Laguna, M. F., & Iglesias, J. R. (2005). Wealth Distribution in a Network with Correlations Between Links and Success. In A. Chatterjee, S. Yarlagadda, & B. Chakrabarti (Eds.), *Econophysics of Wealth Distributions*.
- Güth, S., & Ludwig, S. (2000). How helpful is a long memory on financial markets? *Economic Theory*, 16(1), 107-134.
- Guzzo, R. A., Jette, R. D., & Katzell, R. A. (1985). The effects of psychologically based intervention programs on worker productivity: A meta-analysis. *Personnel Psychology*, 38(2), 275-291.
- Haar, J. M., & Spell, C. S. (2009). How does distributive justice affect work attitudes? The moderating effects of autonomy. *The International Journal of Human Resource Management*, 20(8), 1827-1842.
- Hackman, J. R. (2012). From causes to conditions in group research. *Journal of Organizational Behavior*, 33(3), 428-444.
- Hales, D., Rouchier, J., & Edmonds, B. (2003). Model-to-model analysis. *JASSS*, 6(4).
- Hall, E. T. (1966). *The Hidden Dimension*.
- Hamill, L., & Gilbert, N. (2009). Social circles: A simple structure for agent-based social network models. *JASSS*, 12(2).
- Hammond, R. A., & Axelrod, R. (2006a). Evolution of contingent altruism when cooperation is expensive. *Theor Popul Biol*, 69(3), 333-338.
- Hammond, R. A., & Axelrod, R. (2006b). The evolution of ethnocentrism. *Journal of Conflict Resolution*, 50(6), 926-936.
- Happe, K., Balmann, A., Kellermann, K., & Sahrbacher, C. (2008). Does structure matter? The impact of switching the agricultural policy regime on farm structures. *Journal of Economic Behavior and Organization*, 67(2), 431-444.
- Happe, K., Kellermann, K., & Balmann, A. (2006). Agent-based analysis of agricultural policies: an illustration of the agricultural policy simulator AgriPoliS, its adaptation and behavior. *Ecology and Society*, 11(1), 49.

- Harris, M. M., Anseel, F., & Lievens, F. (2008a). Keeping Up With the Joneses: A Field Study of the Relationships Among Upward, Lateral, and Downward Comparisons and Pay Level Satisfaction. *Journal of Applied Psychology*, 93(3), 665-673.
- Harris, R. J. (1983). Pinning down the equity formula. *Equity Theory: Psychological and Sociological Perspectives*, 207-241.
- Harrison, J. R., Lin, Z., Carroll, G. R., & Carley, K. M. (2007). Simulation modeling in organizational and management research. *Academy of Management Review*, 32(4), 1229-1245.
- Hashimzade, N., Myles, G. D., Page, F., & Rablen, M. D. (2014). The use of agent-based modelling to investigate tax compliance. *Economics of Governance*.
- Hasnain, Z., Manning, N., & Pierskalla, J. H. (2014). The Promise of Performance Pay? Reasons for Caution in Policy Prescriptions in the Core Civil Service. *The World Bank Research Observer*.
- Hastie, R., & Park, B. (1986). The relationship between memory and judgment depends on whether the judgment task is memory-based or on-line. *Psychological review*, 93(3), 258.
- Hauert, C., & Schuster, H. G. (1997). Effects of increasing the number of players and memory size in the iterated Prisoner's Dilemma: A numerical approach. *Proceedings of the Royal Society B: Biological Sciences*, 264(1381), 513-519.
- Hazy, J. K., Goldstein, J., & Lichtenstein, B. B. (2007). Complex systems leadership theory. *New perspectives from complexity science on social and organizational effectiveness*.
- Heckbert, S., Baynes, T., & Reeson, A. (2010) Agent-based modeling in ecological economics. *Vol. 1185. Ann NY Acad Sci* (pp. 39-53).
- Hedström, P. (2005). *Dissecting the Social: On the Principles of Analytical Sociology*.
- Hegselmann, R. (1996a). Cellular Automata in the Social Sciences. *Modelling and Simulation in the Social Sciences from the Philosophy of Science Point of View*, 209-233.
- Hegselmann, R. (1996b). Understanding social dynamics: The cellular automata approach. *Social Science Microsimulation*, 282-306.
- Hegselmann, R. (2012). Thomas C. schelling and the computer: Some notes on schelling's essay "on letting a computer help with the work". *JASSS*, 15(4).
- Hegselmann, R., & Flache, A. (1998). Understanding Complex Social Dynamics: A Plea for Cellular Automata Based Modelling. *JASSS*, 1(3).

- Hegselmann, R., & Krause, U. (2002a). Opinion Dynamics and Bounded Confidence: Models, Analysis and Simulation. *JASSS*, 5(3).
- Hegselmann, R., Flache, A., & Möller, V. (2000). Cellular Automata as a Modelling Tool: Solidarity and Opinion Formation. In *Tools and Techniques for Social Science Simulation* (pp. 151-178).
- Heine, S. J. (2001). Self as cultural product: An examination of East Asian and North American selves. *J Pers*, 69(6), 880-906.
- Helbing, D. (2012). *Social Self-Organization*.
- Helbing, D., & Molnár, P. (1995). Social force model for pedestrian dynamics. *Physical Review E*, 51(5), 4282-4286.
- Hemelrijk, C. K. (2002). Despotic societies, sexual attraction and the emergence of male 'tolerance': An agent-based model. *Behaviour*, 139(6), 729-747.
- Hempel, C. G. (1966). *Philosophy of Natural Science* (Vol. 18): Englewood Cliffs, N.J., Prentice-Hall.
- Hemphill, K. J., & Lehman, D. R. (1991). Social comparisons and their affective consequences: The importance of comparison dimension and individual difference variables. *Journal of Social and Clinical Psychology*, 10(4), 372-394.
- Henderson, R. I. (2005). *Compensation Management in a Knowledge-Based World*: Pearson/Prentice Hall.
- Heneman, R. L., & Von Hippel, C. (1995). Balancing group and individual rewards: Rewarding individual contributions to the team. *Compensation and Benefits Review*, 27(4), 63-68.
- Heneman, R. L., & Werner, J. M. (2005). *Merit Pay: Linking Pay to Performance in a Changing World*.
- Henrickson, L., & McKelvey, B. (2002). Foundations of "new" social science: Institutional legitimacy from philosophy, complexity science, postmodernism, and agent-based modeling. *Proceedings of the National Academy of Sciences*, 99(suppl 3), 7288-7295.
- Herzberg, F. (1964). The motivation-hygiene concept and problems of manpower. *Personnel Administration*.
- Higgins, E. T. (2004). Making a theory useful: Lessons handed down. *Personality and Social Psychology Review*, 8, 138-145.
- Higgins, E. T. (2006). Theory development as a family affair. *Journal of Experimental Social Psychology*, 42, 129-132.

- Hilliard, & Penn. (1992). *The Social Logic of Space*. London.
- Hoenigman, R., Bradley, E., & Lim, A. (2011). Cooperation in bike racing—When to work together and when to go it alone. *Complexity*, 17(2), 39-44.
- Hofmans, J. (2012). Individual differences in equity models. *Psicologica*, 33(3), 473-482.
- Hofstede, G. J., Jonker, C. M., & Verwaart, T. (2008) Individualism and collectivism in trade agents. *Vol. 5027 LNAI. Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*.
- Hogarth, R. M., & Einhorn, H. J. (1992). Order effects in belief updating: The belief-adjustment model. *Cognitive psychology*, 24(1), 1-55.
- Hogeweg, P. (2010) Multilevel cellular automata as a tool for studying bioinformatic processes. *Vol. 2010. Understanding Complex Systems* (pp. 19-28).
- Hokamp, S. (2014). Dynamics of tax evasion with back auditing, social norm updating, and public goods provision - An agent-based simulation. *Journal of Economic Psychology*, 40, 187-199.
- Holland, J. H. (1995). *Hidden Order: How Adaptation Builds Complexity*.
- Holmstrom, B. (1979). Moral hazard and observability. *Bell Journal of Economics*, 10(1), 74-91.
- Holtz, B. C., & Harold, C. M. (2009). Fair today, fair tomorrow? A longitudinal investigation of overall justice perceptions. *J Appl Psychol*, 94(5), 1185-1199.
- Homans, G. C. (1961). *Social Behavior: Its Elementary Forms*.
- Homans, G. C. (1974). *Elementary Forms of Social Behavior*.
- Honeywell-Johnson, J. A., & Dickinson, A. M. (1999). Small group incentives: A review of the literature. *Journal of Organizational Behavior Management*, 19(2), 89-120.
- Hong, Y. Y., & Chiu, C. Y. (2001). Toward a paradigm shift: From cross-cultural differences in social cognition to social-cognitive mediation of cultural differences. *Social Cognition*, 19(3), 181-196.
- Hong, Y. Y., & Mallorie, L. M. (2004). A dynamic constructivist approach to culture: Lessons learned from personality psychology. *Journal of Research in Personality*.
- Hong, Y. Y., Benet-Martínez, V., Chiu, C. Y., & Morris, M. W. (2003). Boundaries of cultural influence: Construct activation as a mechanism for cultural differences in social perception. *J Cross Cult Psychol*, 34(4), 453-464.

- Hong, Y. Y., Chao, M. M., Yang, Y., & Rosner, J. L. (2010). Building and Testing Theories: Experiences from Conducting Social Identity Research. *Acta Psychologica Sinica*.
- Howard, M. W., & Kahana, M. J. (1999). Contextual Variability and Serial Position Effects in Free Recall. *Journal of Experimental Psychology: Learning Memory and Cognition*, 25(4), 923-941.
- Huang, C. Y., & Wen, T. H. (2014). A novel private attitude and public opinion dynamics model for simulating pluralistic ignorance and minority influence. *JASSS*, 17(3), 09.
- Huang, C.-Y., Tsai, Y.-S., & Wen, T.-H. (2010). A Network-based Simulation Architecture for Studying Epidemic Dynamics. *Simulation*.
- Hubbell, A. P., & Chory-Assad, R. M. (2005). Motivating factors: Perceptions of justice and their relationship with managerial and organizational trust. *Communication Studies*, 56(1), 47-70.
- Huck, S., & Sarin, R. (2004). Players with limited memory. *Contributions in Theoretical Economics*, 4(1).
- Huesmann, L. R., & Levinger, G. (1976). Incremental exchange theory: A formal model for progression in dyadic social interaction. *Advances in experimental social psychology*, 9, 191-229.
- Huet, S., & Deffuant, G. (2008). Differential equation models derived from an individual-based model can help to understand emergent effects. *JASSS*, 11(2), 10.
- Hughes, H. P. N., Clegg, C. W., Robinson, M. A., & Crowder, R. M. (2012). Agent-based modelling and simulation: The potential contribution to organizational psychology. *Journal of Occupational and Organizational Psychology*, 85(3), 487-502.
- Hunter, S. T., Cushenbery, L., & Friedrich, T. (2012). Hiring an innovative workforce: A necessary yet uniquely challenging endeavor. *Human Resource Management Review*, 22(4), 303-322.
- Huppertz, J. W., Arenson, S. J., & Evans, R. H. (1978). Application Of Equity Theory To Buyer-Seller Exchange Situations. *Journal of Marketing Research*, 15(2), 250-260.
- Huselid, M. A., & Becker, B. E. (2011). Bridging micro and macro domains: Workforce differentiation and strategic human resource management. *Journal of Management*, 37(2), 421-428.
- Huseman, R. C., Hatfield, J. D., & Miles, E. W. (1985). Test for individual perceptions of job equity: Some preliminary findings. *Percept Mot Skills*, 61(3 II), 1055-1064.

- Huseman, R. C., Hatfield, J. D., & Miles, E. W. (1987). A New Perspective On Equity Theory - The Equity Sensitivity Construct. *Academy of Management Review*, 12(2), 222-234.
- Iannaccone, L. R., & Makowsky, M. D. (2007). Accidental atheists? Agent-based explanations for the persistence of religious regionalism. *Journal for the Scientific Study of Religion*, 46(1), 1-16.
- Ilachinski, A. (2001). *Cellular Automata*: World Scientific.
- Ilgen, D. R., & Hulin, C. L. (2000). *Computational Modeling of Behavior in Organizations*.
- Iltanen, S. (2012). Cellular Automata in Urban Spatial Modelling. In A. J. Heppenstall, A. T. Crooks, L. M. See, & M. Batty (Eds.), *Agent-Based Models of Geographical Systems* (pp. 69-84): Springer Netherlands.
- Jager, W., & Amblard, F. (2005). Uniformity, bipolarization and pluriformity captured as generic stylized behavior with an agent-based simulation model of attitude change. *Computational and Mathematical Organization Theory*, 10(4), 295-303.
- Jager, W., Janssen, M. A., & Vlek, C. A. J. (1999). Consumers in a commons dilemma: Testing the behavioural rules of simulated consumers. *COV report no. 99-01*.
- Jagla, E., Landes, F. P., & Rosso, A. (2014). Viscoelastic effects in avalanche dynamics: a key to earthquake statistics. *Phys Rev Lett*, 112(17), 174301.
- Janssen, M., & Jager, W. (1999). An Integrated Approach to Simulating Behavioural Processes: A Case Study of the Lock-in of Consumption Patterns. *JASSS*, 2(2).
- Jaques, E. (1961). Equitable payment: A general theory of work, differential payment, and individual progress.
- Jasso, G. (1983). Social Consequences of the Sense of Distributive Justice: Small-Group Applications. In D. M. Messick & K. S. Cook (Eds.), *Theories of Equity: Psychological and Sociological Perspectives*.
- Jenkins Jr, G. D., Gupta, N., Mitra, A., & Shaw, J. D. (1998). Are Financial Incentives Related to Performance? A Meta-Analytic Review of Empirical Research. *Journal of Applied Psychology*, 83(5), 777-787.
- Jennings, N. R. (2000). On agent-based software engineering. *Artificial Intelligence*, 117(2), 277-296.
- Jensen, H. J. (1998). *Self-Organized Criticality: Emergent Complex Behavior in Physical and Biological Systems*. Cambridge, U.K.: Cambridge Univ. Press.

- Jensen, M. C. (1983). Organization theory and methodology. *Accounting Review*, 58(2), 319-339.
- Jensen, M. C. (2003). Paying people to lie: The truth about the budgeting process. *European Financial Management*, 9(3), 379-406.
- Jensen, M., & Meckling, W. (1976). Theory of the firm: Managerial behavior, agency costs, and ownership structure. *Journal of Financial Economics*, 3(4), 5-50.
- Ji, L. J., Guo, T., Zhang, Z., & Messervey, D. (2009). Looking into the past: Cultural differences in perception and representation of past information. *Journal of Personality and Social Psychology*.
- Jin, Y., & Levitt, R. E. (1996). The virtual design team: A computational model of project organizations. *Computational and Mathematical Organization Theory*, 2(3), 171-196.
- John, A., Schadschneider, A., Chowdhury, D., & Nishinari, K. (2004). Collective effects in traffic on bi-directional ant trails. *J Theor Biol*, 231(2), 279-285.
- John, L. K., Loewenstein, G., & Rick, S. I. (2014). Cheating more for less: Upward social comparisons motivate the poorly compensated to cheat. *Organ Behav Hum Decis Process*, 123(2), 101-109.
- Johnson, D. D. P., Weidmann, N. B., & Cederman, L. E. (2011). Fortune favours the bold: An agent-based model reveals adaptive advantages of overconfidence in war. *PLoS One*, 6(6). doi: 10.1371/journal.pone.0020851
- Jones, D. A. (2009). Getting even with one's supervisor and one's organization: Relationships among types of injustice, desires for revenge, and counterproductive work behaviors. *Journal of Organizational Behavior*, 30(4), 525-542.
- Jones, D. A., & Martens, M. L. (2009). The mediating role of overall fairness and the moderating role of trust certainty in justice-criteria relationships: The formation and use of fairness heuristics in the workplace. *Journal of Organizational Behavior*, 30(8), 1025-1051.
- Jones, D. A., & Skarlicki, D. P. (2013). How perceptions of fairness can change A dynamic model of organizational justice. *Organizational Psychology Review*, 3(2), 138-160.
- Jones, D. C., & Kato, T. (1995). The productivity effects of employee stock-ownership plans and bonuses: Evidence from Japanese panel data. *American Economic Review*, 85(3), 391-414.
- Jones, E. E., Rock, L., Shaver, K. G., Goethals, G. R., & Ward, L. M. (1968). Pattern of performance and ability attribution: An unexpected primacy effect. *Journal of Personality and Social Psychology*, 10(4), 317.

- Jones, R. W. (1965). The structure of simple general equilibrium models. *The Journal of Political Economy*, 557-572.
- Kahn, A. (1972). Reactions To Generosity Or Stinginess From An Intelligent Or Stupid Work Partner - Test Of Equity Theory In A Direct Exchange Relationship. *J Pers Soc Psychol*, 21(1).
- Kahneman, D., & Tversky, A. (1972). Subjective probability: A judgment of representativeness. *Cognitive Psychology*, 3(3), 430-454.
- Kalai, E., & Stanford, W. (1986). Finite rationality and interpersonal complexity in repeated games. *Discussion Paper*, 397-410.
- Kalick, S. M., & Hamilton Iii, T. E. (1986). The Matching Hypothesis Reexamined. *J Pers Soc Psychol*, 51(4), 673-682. doi: 10.1037/0022-3514.51.4.673
- Kanfer, R. (1990). Motivation theory and industrial and organizational psychology. *Handbook of Industrial and Organizational Psychology*, 1, 75-170.
- Kang, P., Lee, Y., Choi, I., & Kim, H. (2013). Neural Evidence for Individual and Cultural Variability in the Social Comparison Effect. *The Journal of Neuroscience*, 33(41), 16200-16208.
- Karau, S. J., & Williams, K. D. (1993). Social Loafing: A Meta-Analytic Review and Theoretical Integration. *J Pers Soc Psychol*, 65(4), 681-706.
- Kari, J. (2005). Theory of cellular automata: A survey. *Theoretical Computer Science*, 334(1-3), 3-33.
- Karriker, J. H., & Williams, M. L. (2007). Organizational justice and organizational citizenship behavior: A mediated multifoci model. *Journal of Management*.
- Kauffman, S. A. (1993). *The Origins of Order: Self-Organization and Selection in Evolution*.
- Kelley, P., & Hounsell, R. W. (2007). Engaging associates and unleashing productivity: The case for Simplified GainSharing. *Performance Improvement*, 46(2), 30-34.
- Kimmelmeier, M. (2001). Private self-consciousness as a moderator of the relationship between value orientations and attitudes. *Journal of Social Psychology*, 141(1), 61-74.
- Kimmelmeier, M., & Oyserman, D. (2001). The ups and downs of thinking about a successful other: Self-construals and the consequences of social comparisons. *European Journal of Social Psychology*.
- Kennedy, D. M., & McComb, S. A. (2014). When teams shift among processes: insights from simulation and optimization. *J Appl Psychol*, 99(5), 784-815. doi: 10.1037/a0037339

- Kenrick, D. T., Li, N. P., & Butner, J. (2003). Dynamical Evolutionary Psychology: Individual Decision Rules and Emergent Social Norms. *Psychological Review*, *110*(1), 3-28.
- Kerr, S. (1975). On the folly of rewarding A, while hoping for B. *Academy of Management Journal*, *18*(4), 769-783.
- Kessler, I., & Purcell, J. (1992). Performance Related Pay: Objectives And Application. *Human Resource Management Journal*, *2*(3), 16-33.
- Ketter, W., Collins, J., & Reddy, P. (2013). Power TAC: A competitive economic simulation of the smart grid. *Energy Economics*, *39*, 262-270.
- Kiesling, E., Günther, M., Stummer, C., & Wakolbinger, L. M. (2011). Agent-based simulation of innovation diffusion: A review. *Central European Journal of Operations Research*.
- Kilbourne, L. M., & O'Leary-Kelly, A. M. (1994). A Reevaluation of Equity Theory The Influence of Culture. *Journal of Management Inquiry*, *3*(2), 177-188.
- Kim, G. W., & Markowitz, H. M. (1989). Investment rules, margin, and market volatility. *J. Portfolio Management*, *16*(1), 45-52.
- Kim, K. I., Park, H., & Suzuki, N. (1990). Reward allocations in the United States, Japan, and Korea: A comparison of individualistic and collectivistic cultures. *Academy of Management Journal*, *33*(1), 188-198.
- Kim, T., & Rhee, M. (2009). Exploration and exploitation: internal variety and environmental dynamism. *Strategic Organization*, *7*(1), 11-41. doi: 10.1177/1476127008100125
- Kim, T.-Y., & Leung, K. (2007). Forming and reacting to overall fairness: A cross-cultural comparison. *Organizational Behavior & Human Decision Processes*, *104*(1), 83-95.
- Kim, T.-Y., Edwards, J. R., & Shapiro, D. L. (2014). Social Comparison and Distributive Justice: East Asia Differences. *Journal of Business Ethics*, 1-14.
- Kim, T.-Y., Lin, X.-W., & Leung, K. (2013). A Dynamic Approach to Fairness: Effects of Temporal Changes of Fairness Perceptions on Job Attitudes. *Journal of Business and Psychology*, 1-13.
- King, W. C., Miles, E. W., & Day, D. D. (1993). A test and refinement of the equity sensitivity construct. *Journal of Organizational Behavior*, *14*(4), 301-317.
- Kinsella, S., Greiff, M., & Nell, E. J. (2011). Income Distribution in a Stock-Flow Consistent Model with Education and Technological Change. *Eastern Econ J*, *37*(1), 134-149.

- Klaas, B. S. (1999). Containing compensation costs: Why firms differ in their willingness to reduce pay. *Journal of Management*, 25(6), 829-850.
- Klein, K. J., & Kozlowski, S. W. J. (2000a). From Micro to Meso: Critical Steps in Conceptualizing and Conducting Multilevel Research. *Organizational Research Methods*, 3(3), 211-236.
- Klein, K. J., & Kozlowski, S. W. J. (2000b). Multilevel theory, research, and methods in organizations. *Multilevel Theory, Research, and Methods in Organizations*.
- Klein, K. J., Dansereau, F., & Hall, R. J. (1994). Levels issues in theory development, data collection, and analysis. *Academy of Management Review*, 19(2), 195-229.
- Klemm, K., Eguíluz, V. M., Toral, R., & San Miguel, M. (2005). Globalization, polarization and cultural drift. *Journal of Economic Dynamics and Control*, 29(1-2), 321-334.
- Kluckhohn, F. R., & Strodtbeck, F. L. (1961). Variations in value orientations. Evanston, IL: Peterson.
- Kogut, B., Colomer, J., & Belinky, M. (2014). Structural equality at the top of the corporation: mandated quotas for women directors. *Strategic Management Journal*, 35(6), 891-902.
- Kohn, A. (1993a). *Punished by Rewards: The Trouble with Gold Stars, Incentive Plans, A's, Praise, and Other Bribes*.
- Kohn, A. (1993b). Why incentive plans cannot work. *Harv Bus Rev*, 71(5), 54-63.
- Kollman, K., Miller, J. H., & Page, S. E. (1992). Adaptive Parties in Spatial Elections. *American Political Science Review*, 86(4), 929.
- Kollman, K., Miller, J. H., & Page, S. E. (2000). Decentralization and the search for policy solutions. *Journal of Law, Economics, and Organization*, 16(1), 102-128.
- Komaki, J., Coombs, T., & Schepman, S. (1996). Motivational implications of reinforcement theory. *Motivation and Leadership at Work*, 34-52.
- Kopelman, R. E., & Reinharth, L. (1982). Research results: The effect of merit-pay practices on white collar performance. *Compensation & Benefits Review*, 14(4), 30-40.
- Kossinets, G., & Watts, D. J. (2006). Empirical analysis of an evolving social network. *Science*, 311(5757), 88-90.
- Köster, G., Seitz, M., Treml, F., Hartmann, D., & Klein, W. (2011). On modelling the influence of group formations in a crowd. *Contemporary Social Science*, 6(3), 397-414.

- Kozlowski, S. W. J., & Chao, G. T. (2012). The Dynamics of Emergence: Cognition and Cohesion in Work Teams. *Managerial and Decision Economics*, 33(5-6), 335-354.
- Krackhardt, D. (1998). Super Strong and Sticky. *Power and influence in organizations*, 21.
- Krackhardt, D., & Handcock, M. S. (2007). Heider vs Simmel: Emergent features in dynamic structures. In *Statistical Network Analysis: Models, Issues, and New Directions* (pp. 14-27). Springer Berlin Heidelberg.
- Krats, P., & Brown, T. C. (2013). Unionised employee's reactions to the introduction of a goal-based performance appraisal system. *Human Resource Management Journal*, 23(4), 396-412.
- Kruglanski, A. W. (1989). The Psychology of Being "Right": The Problem of Accuracy in Social Perception and Cognition. *Psychol Bull*, 106(3), 395-409.
- Kruglanski, A. W., & Mayseless, O. (1987). Motivational Effects in the Social Comparison of Opinions. *J Pers Soc Psychol*, 53(5), 834-842.
- Kruglanski, A. W., & Mayseless, O. (1990). Classic and current social comparison research: Expanding the perspective. *Psychol Bull*, 108(2), 195-208.
- Kruglanski, A. W., & Webster, D. M. (1996). Motivated Closing of the Mind: "Seizing" and "Freezing". *Psychological Review*, 103(2), 263-283.
- Kruse, D. L. (1993). *Profit Sharing: Does It Make a Difference?*
- Kuhn, K. M., & Yockey, M. D. (2003). Variable pay as a risky choice: Determinants of the relative attractiveness of incentive plans. *Organ Behav Hum Decis Process*, 90(2), 323-341.
- Kwapien, J., & Drożdż, S. (2012). Physical approach to complex systems. *Physics Reports*, 515(3), 115-226.
- Kwong, J. Y., & Wong, K. F. E. (2014). Fair or not fair? The effects of numerical framing on the perceived justice of outcomes. *Journal of Management*, 40(6), 1558-1582.
- Labro, E. (2015). Using simulation methods in accounting research. *Journal of Management Control*, 1-6.
- Laguna, M. F., Risau Gusman, S., Abramson, G., Gonçalves, S., & Iglesias, J. R. (2005). The dynamics of opinion in hierarchical organizations. *Physica A: Statistical Mechanics and its Applications*, 351(2-4), 580-592.
- Laird, J. E., Newell, A., & Rosenbloom, P. S. (1987). SOAR: An architecture for general intelligence. *Artificial Intelligence*, 33(1), 1-64.

- Lakatos, I. (1970). Falsification and the methodology of scientific research programmes. *Criticism and the Growth of Knowledge*, 91-196.
- Lane, I. M., & Messe, L. A. (1972). Distribution Of Insufficient, Sufficient, And Oversufficient Rewards - Clarification Of Equity Theory. *J Pers Soc Psychol*, 21(2), 228.
- Langley, P., Laird, J. E., & Rogers, S. (2009). Cognitive architectures: Research issues and challenges. *Cognitive Systems Research*, 10(2), 141-160.
- Langton, C. G. (1990). Computation at the edge of chaos: phase transitions and emergent computation. *Physica D: Nonlinear Phenomena*, 42(1), 12-37.
- Lansing, J. S. (1991). *Priests and programmers*: Princeton, NJ: Princeton University Press.
- Lansing, J. S., & Kremer, J. N. (1993). Emergent properties of Balinese water temple networks: coadaptation on a rugged fitness landscape. *American Anthropologist*, 95(1), 97-114.
- Lapidus, R. S., & Pinkerton, L. (1995). Customer Complaint Situations - An Equity Theory Perspective. *Psychology & Marketing*, 12(2), 105-122. doi: 10.1002/mar.4220120203
- Larkin, I., Pierce, L., & Gino, F. (2012). The psychological costs of pay-for-performance: Implications for the strategic compensation of employees. *Strategic Management Journal*, 33(10), 1194-1214.
- Latané, B. (1981). The psychology of social impact. *American Psychologist*, 36(4), 343-356.
- Latané, B. (1996a). Dynamic Social Impact: The Creation of Culture by Communication. *Journal of Communication*, 46(4), 13-25.
- Latané, B. (1996b). Dynamic social impact: Robust predictions from simple theory. *Modelling and Simulation in the Social Sciences from the Philosophy of Science Point of View*, 287-310.
- Latané, B. (1996c). The emergence of clustering and correlation from social interaction. *Modelle Sozialer Dynamiken: Ordnung, Chaos und Komplexität*, 79-104.
- Latané, B. (1996d). Strength from weakness: The fate of opinion minorities in spatially distributed groups. *Understanding Group Behavior: Consensual Action by Small Groups*, 1, 193-219.
- Laubenbacher, R., Jarrah, A. S., Mortveit, H., & Ravi, S. S. (2009). Mathematical formalism for agent-based modeling. *Encyclopedia of Complexity and Systems Science*, 160-176.

- Lawler III, E. E., Koplin, C. A., Young, T. F., & Fadem, J. A. (1968). Inequity reduction over time in an induced overpayment situation. *Organizational Behavior and Human Performance*, 3(3), 253-268.
- Lawler, E. E. (1973). *Motivation in Work Organizations*.
- Lawler, E. E. (1990). *Strategic Pay: Aligning Organizational Strategies and Pay Systems*.
- Lawler, E. E., & Cohen, S. G. (1992). Designing pay systems for teams. *ACA Journal*, 1(1), 6-19.
- Lawler, E. E., & O'Gara, P. W. (1967). Effects Of Inequity Produced By Underpayment On Work Output, Work Quality, And Attitudes Toward The Work. *Journal of Applied Psychology*, 51(5 PART 1), 403-410.
- Lawler, E. E., Koplin, C. A., Young, T. F., & Fadem, J. A. (1968). Inequity Reduction Over Time In An Induced Overpayment SituatiON. *Organizational Behavior and Human Performance*, 3(3), 253-268.
- Lazear, E. P. (1986). *Pay equality and industrial politics*.
- Lazear, E. P. (1998). *Personnel Economics for Managers*.
- Lazear, E. P. (2000a). Performance pay and productivity. *American Economic Review*, 90(5), 1346-1361.
- Lazear, E. P. (2000b). Personnel economics and economic approaches to incentives. *HKCER Letters*, 61, 1-8.
- Lazear, E. P. (2000c). Unresolved issues in personnel economics: The power of incentives. *American Economic Review*, 90(2), 410-414.
- Lazear, E. P., & Rosen, S. (1981). Rank-order tournaments as optimum labor contracts. *Journal of Political Economy*, 89(5), 841-864.
- LeBaron, B. (2001a). A builder's guide to agent-based financial markets. *Quantitative Finance*, 1(2), 254-261.
- LeBaron, B. (2001b). Evolution and time horizons in an agent-based stock market. *Macroeconomic Dynamics*, 5(2), 225-254.
- LeBaron, B. (2002). Short-memory traders and their impact on group learning in financial markets. *Proc Natl Acad Sci U S A*, 99(SUPPL. 3), 7201-7206.
- LeBaron, B. (2006) Chapter 24 Agent-based Computational Finance. *Vol. 2. Handbook of Computational Economics* (pp. 1187-1233).

- LeBaron, B. (2006a). Agent-based financial markets: Matching stylized facts with style. *Post Walrasian Macroeconomics: Beyond the DSGE Model*, 221-235.
- Ledford, G. E., Gerhart, B., & Fang, M. (2013). Negative effects of extrinsic rewards on intrinsic motivation: More smoke than fire. *World at Work Quarterly*.
- Lehman, D. R., Chiu, C. Y., & Schaller, M. (2004) Psychology and culture. *Vol. 55. Annual Review of Psychology* (pp. 689-714).
- Lemieux, T., MacLeod, W. B., & Parent, D. (2009). Performance pay and wage inequality. *Quarterly Journal of Economics*, 124(1), 1-49.
- Lemos, C., Coelho, H., & Lopes, R. J. (2013). *Agent-based modeling of social conflict, civil violence and revolution: State-of-the-art-review and further prospects*. Paper presented at the CEUR Workshop Proceedings.
- Lenox, M. J., Rockart, S. F., & Lewin, A. Y. (2007). Interdependency, competition, and industry dynamics. *Management Science*, 53(4), 599-615.
- Lerner, M. J. (1974). The justice motive: "Equity" and "parity" among children. *J Pers Soc Psychol*, 29(4), 539-550.
- Lerner, M. J., Miller, D. T., & Holmes, J. G. (1976) Deserving and the Emergence of Forms of Justice. *Vol. 9. Advances in experimental social psychology* (pp. 133-162).
- Leung, A. K. Y., Kim, Y.-H., Zhang, Z.-X., Tam, K.-P., & Chiu, C. Y. (2012). Cultural Construction of Success and Epistemic Motives Moderate American-Chinese Differences in Reward Allocation Biases. *Journal of Cross Cultural Psychology*, 43(1), 46-52.
- Leung, K., & Bond, M. H. (1984). The impact of cultural collectivism on reward allocation. *J Pers Soc Psychol*, 47(4), 793-804.
- Leung, K., & Park, H.-J. (1986). Effects of Interactional Goal on Choice of Allocation Rule: A Cross-National Study. *Organizational Behavior & Human Decision Processes*, 37(1), 111.
- Leventhal, G. S. (1976) The Distribution of Rewards and Resources in Groups and Organizations. *Vol. 9. Advances in experimental social psychology* (pp. 91-131).
- Leventhal, G. S., & Michaels, J. W. (1969). Extending the equity model: Perception of inputs and allocation of reward as a function of duration and quantity of performance. *J Pers Soc Psychol*, 12(4), 303-309.
- Leventhal, G. S., Weiss, T., & Long, G. (1969). Equity, reciprocity, and reallocating rewards in the dyad. *J Pers Soc Psychol*, 13(4), 300-305.

- Leventhal, G. S., Younts, C. M., & Lund, A. K. (1972). Tolerance For Inequity In Buyer-Seller Relationships. *Journal of Applied Social Psychology*, 2(4), 308-318.
- Levinson, J D. and Peng, K, Valuing Cultural Differences in Behavioral Economics. *ICFAI Journal of Behavioral Finance*, Vol. 4, pp. 32-47, 2007
- Levinthal, D. A. (1997). Adaptation on rugged landscapes. *Management Science*, 43(7), 934-950.
- Levinthal, D., & Posen, H. E. (2007). Myopia of selection: Does organizational adaptation limit the efficacy of population selection? *Administrative Science Quarterly*, 52(4), 586-620.
- Levy, M., Levy, H., & Solomon, S. (1994). A microscopic model of the stock market. Cycles, booms, and crashes. *Economics Letters*, 45(1), 103-111.
- Lewin, K. (1945). The research center for group dynamics at Massachusetts Institute of Technology. *Sociometry*, 8(2), 126-136.
- Lewis, R., & Zibarras, L. (2013). *Work and Occupational Psychology: Integrating Theory and Practice*: SAGE Publications.
- Li, A., & Cropanzano, R. (2009). Do east asians respond more/less strongly to organizational justice than North Americans? A meta-analysis. *Journal of Management Studies*, 46(5), 787-805.
- Li, W., Packard, N. H., & Langton, C. G. (1990). Transition phenomena in cellular automata rule space. *Physica D: Nonlinear Phenomena*, 45(1), 77-94.
- Liang, D. W., Moreland, R., & Argote, L. (1995). Group versus individual training and group performance: The mediating role of transactive memory. *Personality and Social Psychology Bulletin*, 21(4), 384-393.
- Liebrand, W. B. G., & Messick, D. M. (1996a). Computer simulations of sustainable cooperation in social dilemmas. *Modelling and Simulation in the Social Sciences from the Philosophy of Science Point of View*, 235-247.
- Liebrand, W. B. G., & Messick, D. M. (1996b). Game theory, decision making in conflicts and computer simulations: A good-looking triad. *Social Science Microsimulation*, 211-236.
- Lind, E. A. (1995). Justice and authority relations in organizations. *Organizational Politics, Justice, and Support: Managing the Social Climate of the Workplace*, 83-96.
- Lind, E. A. (2001). Fairness heuristic theory: Justice judgments as pivotal cognitions in organizational relations. *Advances in organizational justice*, 56, 88.

- Lind, E. A., Kray, L., & Thompson, L. (2001). Primacy Effects in Justice Judgments: Testing Predictions from Fairness Heuristic Theory. *Organ Behav Hum Decis Process*, 85(2), 189-210.
- Lindner, M., Hundhammer, T., Ciaramidaro, A., Linden, D. E. J., & Mussweiler, T. (2008). The neural substrates of person comparison-An fMRI study. *Neuroimage*, 40(2), 963-971.
- Lindner, M., Rudorf, S., Birg, R., Falk, A., Weber, B., & Fliessbach, K. (2014). Neural patterns underlying social comparisons of personal performance. *Social Cognitive and Affective Neuroscience*, nsu087.
- Locke, E. A., & Latham, G. P. (1990). A theory of goal setting and task performance. *A Theory of Goal Setting and Task Performance*.
- Locke, E. A., Feren, D. B., McCaleb, V. M., Shaw, K. N., & Denny, A. T. (1980). The relative effectiveness of four methods of motivating employee performance. *Changes in Working Life*, 363-388.
- Locke, E. A., Shaw, K. N., Saari, L. M., & Latham, G. P. (1981). Goal setting and task performance: 1969-1980. *Psychol Bull*, 90(1), 125-152.
- Locke, K. D. (2003). Status and solidarity in social comparison: agentic and communal values and vertical and horizontal directions. *J Pers Soc Psychol*, 84(3), 619.
- Locke, K., Golden-Biddle, K., & Feldman, M. S. (2008). Making doubt generative: Rethinking the role of doubt in the research process. *Organization Science*, 19(6), 907-918.
- Lomi, A., & Larsen, E. (1998). Density Delay and Organizational Survival: Computational Models and Empirical Comparisons. *Computational & Mathematical Organization Theory*, 3(4), 219-247.
- Lomi, A., & Larsen, E. R. (1996). Interacting locally and evolving globally: A computational approach to the dynamics of organizational populations. *Academy of Management Journal*, 39(5), 1287-1321.
- Lomi, A., & Larsen, E. R. (2001). *Dynamics of Organizations: Computational Modeling and Organization Theories*.
- London, M., & Oldham, G. R. (1977). A comparison of group and individual incentive plans. *Academy of Management Journal*, 20(1), 34-41.
- López-Paredes, A., Edmonds, B., & Klugl, F. (2012). Special issue: Agent based simulation of complex social systems. *Simulation*, 88(1), 4-6.

- Luhmann, C. C., & Rajaram, S. (2013). Mnemonic Diffusion: An Agent-Based Modeling Investigation of Collective Memory.
- Lujansky, H., & Mikula, G. (1983). Can Equity Theory Explain The Quality And The Stability Of Romantic Relationships. *British Journal of Social Psychology*, 22(JUN), 101-112.
- Luthans, F., & Kreitner, R. (1975). Organizational behavior modification.
- Luthans, F., & Kreitner, R. (1985). *Organizational Behavior Modification and Beyond*.
- Luthans, F., & Stajkovic, A. D. (1999). Reinforce for performance: The need to go beyond pay and even rewards. *Academy of Management Executive*, 13(2), 49-57.
- Lux, T., & Marchesi, M. (2000). Volatility clustering in financial markets: A micro-simulation of interacting agents. *International Journal of Theoretical and Applied Finance*, 3(4), 675-702.
- Lyons, M. H., Burton, F., Egan, B., Lynch, T., & Skelton, S. (1997). Dynamic modeling of present and future service demand. *Proceedings of the IEEE*, 85(10), 1544-1555.
- Macal, C. M., & North, M. J. (2005). *Tutorial on agent-based modeling and simulation*. Paper presented at the Proceedings - Winter Simulation Conference.
- Macy, M. W. (1991a). Chains of Cooperation: Threshold Effects in Collective Action. *American Sociological Review*, 56(6), 730-747.
- Macy, M. W. (1991b). Learning to Cooperate: Stochastic and Tacit Collusion in Social Exchange. *American Journal of Sociology*, 97(3), 808-843.
- Macy, M. W., & Sato, Y. (2002). Trust, cooperation, and market formation in the U.S. and Japan. *Proc Natl Acad Sci U S A*, 99(SUPPL. 3), 7214-7220.
- Macy, M. W., & Willer, R. (2002) From factors to actors: Computational sociology and agent-based modeling. *Vol. 28. Annual Review of Sociology* (pp. 143-166).
- Macy, M. W., Kitts, J. A., Flache, A., & Benard, S. (2003). Polarization in dynamic networks: A Hopfield model of emergent structure.
- Macy, M., & Sato, Y. (2010). The surprising success of a replication that failed. *JASSS*, 13(2).
- Magee, J. C., Kilduff, G. J., & Heath, C. (2011). On the folly of principal's power: Managerial psychology as a cause of bad incentives. *Research in Organizational Behavior*, 31(0), 25-41.

- Makoto, M. (2000). Forecasting Hits in the J-pop market: a practical application of multi-agent simulation in Japan. *SFI Business Network: Tutorial on Complexity and Agent Based Modeling*.
- Makowsky, M. (2006). An agent-based model of mortality shocks, intergenerational effects, and urban crime. *JASSS*, 9(2), 15-23.
- Malleson, N., See, L., Evans, A., & Heppenstall, A. (2014) Optimising an Agent-Based Model to Explore the Behaviour of Simulated Burglars. *Vol. 52. Intelligent Systems Reference Library* (pp. 179-204).
- Mantere, S., & Ketokivi, M. (2013). Reasoning in organization science. *Academy of Management Review*, 38(1), 70-89.
- March, J. G. (1991). Exploration and exploitation in organizational learning. *Organization science*, 2(1), 71-87.
- March, J. G. (2001). Foreword. *Dynamics of organizational societies: Information, structure, and computation*, ix-xvii.
- Marietto, M., David, N., Sichman, J., & Coelho, H. (2003). A Classification of Paradigmatic Models for Agent-Based Social Simulation. In D. Hales, B. Edmonds, E. Norling, & J. Rouchier (Eds.), *Multi-Agent-Based Simulation III* (Vol. 2927, pp. 193-208).
- Mariolis, P., & Jones, M. H. (1982). Centrality in corporate interlock networks: Reliability and stability. *Administrative Science Quarterly*, 571-585.
- Markham, S. E. (1988). Pay-for-performance dilemma revisited: Empirical example of the importance of group effects. *Journal of Applied Psychology*, 73(2), 172.
- Markus, H. R., & Kitayama, S. (1991). Culture And The Self - Implications For Cognition, Emotion, And Motivation. *Psychological Review*, 98(2), 224-253.
- Marsden, D. (2010). The paradox of performance related pay systems: ‘why do we keep adopting them in the face of evidence that they fail to motivate?’. In H. Margetts, P. 6, & C. Hood (Eds.), *Paradoxes of Modernization: Unintended Consequences of Public Policy Reform*
- Martell, R. F., Emrich, C. G., & Robison-Cox, J. (2012). From bias to exclusion: A multilevel emergent theory of gender segregation in organizations. *Research in Organizational Behavior*, 32(0), 137-162.
- Martell, R. F., Lane, D. M., & Emrich, C. (1996). Male-female differences: A computer simulation. *American Psychologist*, 51(2), 157-158.
- Martin, J. E., & Peterson, M. M. (1987). Two-Tier Wage Structures: Implications for Equity Theory. *The Academy of Management Journal*, 30(2), 297-315.

- Martin, J. L., & Yeung, K. T. (2006). Persistence of close personal ties over a 12-year period. *Social Networks*, 28(4), 331-362.
- Martinez, G. J. (2013). A note on elementary cellular automata classification. *arXiv preprint arXiv:1306.5577*.
- Martocchio, J. J. (2012). *Strategic Compensation: A Human Resource Management Approach*.
- Mäs, M., Flache, A., Takács, K., & Jehn, K. A. (2013). In the short term we divide, in the long term we unite: Demographic crisscrossing and the effects of faultlines on subgroup polarization. *Organization Science*, 24(3), 716-736.
- Mason, W. A., Conrey, F. R., & Smith, E. R. (2007). Situating social influence processes: Dynamic, multidirectional flows of influence within social networks. *Personality and Social Psychology Review*, 11(3), 279-300.
- Mattson, M., Torbiörn, I., & Hellgren, J. (2014). Effects of staff bonus systems on safety behaviors. *Human Resource Management Review*.
- Mayer, G. R., & Sarjoughian, H. S. (2009). Composable Cellular Automata. *Simulation*, 85(11-12), 735-749.
- McCrary, J. W., & Hunter, W. S. (1953). Serial Position Curves in Verbal Learning. *Science*, 117, 131-134.
- McFarlin, D. B., & Sweeney, P. D. (1992). Distributive and procedural justice as predictors of satisfaction with personal and organizational outcomes. *Academy of Management Journal*, 35(3), 626-637.
- McGrath, J. E. (1981). Dilemmatics: The Study of Research Choices and Dilemmas. *American Behavioral Scientist*, 25(2), 179-210.
- McGrath, J. E. (1984). *Groups: Interaction and Performance*.
- McGrath, J. E. (1994). *Methodology matters: Doing research in the behavioral and social sciences*. Paper presented at the Readings in Human-Computer Interaction: Toward the Year 2000 (2nd ed.
- McGraw, K. O. (1978). The detrimental effects of reward on performance: A literature review and a prediction model. *The Hidden Costs of Reward*, 33-60.
- McGraw, K. O., & McCullers, J. C. (1979). Evidence of a detrimental effect of extrinsic incentives on breaking a mental set. *Journal of Experimental Social Psychology*, 15(3), 285-294.

- McKelvey, B. (1999). Avoiding Complexity Catastrophe in Coevolutionary Pockets: Strategies for Rugged Landscapes. *Organization Science*, 10(3), 294-321.
- McKelvey, B. (2002). Model-centered organization science epistemology. *Companion to organizations*, 752-780.
- McKenna, S., Richardson, J., & Manroop, L. (2011). Alternative paradigms and the study and practice of performance management and evaluation. *Human Resource Management Review*, 21(2), 148-157.
- McKinley, W., & Mone, M. A. (1998). The Re-Construction of Organization Studies: Wrestling with Incommensurability. *Organization*, 5(2), 169-189.
- Meindl, J. R. (1989). Managing to be fair: An exploration of values, motives, and leadership. *Administrative Science Quarterly*, 34(2), 252-276.
- Melamed, D. (2012). Deriving equity from expectations: A cross-cultural evaluation. *Soc Sci Res*, 41(1), 170-181.
- Melatagia Yonta, P., & Ndoundam, R. (2009). Opinion dynamics using majority functions. *Math Soc Sci*, 57(2), 223-244.
- Mellers, B. A. (1982). Equity judgment: A revision of Aristotelian views. *Journal of Experimental Psychology: General*, 111(2), 242-270.
- Mellers, B. A. (1983). Evidence against "absolute" scaling. *Perception & Psychophysics*, 33(6), 523-526.
- Merriman, K. K. (2014). The psychological role of pay systems in choosing to work more hours. *Human Resource Management Review*.
- Mesoudi, A. (2011). Variable cultural acquisition costs constrain cumulative cultural evolution. *PLoS One*, 6(3), e18239.
- Messe, L. A., Vallacher, R. R., & Phillips, J. L. (1975). Equity and the formation of revolutionary and conservative coalitions in triads. *J Pers Soc Psychol*, 31(6), 1141-1146.
- Messersmith, J. G., Guthrie, J. P., Ji, Y. Y., & Lee, J. Y. (2011). Executive turnover: the influence of dispersion and other pay system characteristics. *J Appl Psychol*, 96(3), 457-469.
- Meyer, D. E., & Kieras, D. E. (1997). A Computational Theory of Executive Cognitive Processes and Multiple-Task Performance: Part 1. Basic Mechanisms. *Psychological Review*, 104(1), 3-65.

- Meyer, H. H. (1975). The pay-for-performance dilemma. *Organizational Dynamics*, 3(3), 39-50.
- Miceli, M. P., & Heneman, R. L. (2000). Contextual Determinants of Variable Pay Plan Design: A Proposed Research Framework. *Human Resource Management Review*, 10(3), 289-305.
- Michaels, J. W., Edwards, J. N., & Acock, A. C. (1984). Satisfaction in Intimate Relationships as a Function of Inequality, Inequity, and Outcomes. *Social Psychology Quarterly*, 47(4), 347-357.
- Middlemist, R. D., & Peterson, R. B. (1976). Test Of Equity Theory By Controlling For Comparison Co-Workers Efforts. *Organizational Behavior and Human Performance*, 15(2), 335-354.
- Mikula, G., & Schwinger, T. (1978). Intermember relations and reward allocation: Theoretical considerations of affects. *Dynamics of group decisions*, 229-250.
- Miles, E. W., Hatfield, J. D., & Huseman, R. C. (1989). The equity sensitivity construct: Potential implications for worker performance. *Journal of Management*, 15(4), 581-588.
- Miles, E. W., Hatfield, J. D., & Huseman, R. C. (1994). Equity sensitivity and outcome importance. *Journal of Organizational Behavior*, 15(7), 585-596.
- Milkovich, G., Newman, J., & Gerhart, B. (2013). *Compensation: 11th Edition*: McGraw-Hill Higher Education.
- Miller, G. A. (1956). The magical number seven, plus or minus two: some limits on our capacity for processing information. *Psychological Review*, 63(2), 81-97.
- Miller, J. H. (2001). Evolving information processing organizations. *Dynamics of Organizations: Computational Modeling and Organization Theories*, 307-327.
- Miller, J. H., & Page, S. E. (2004). The standing ovation problem. *Complexity*, 9(5), 8-16.
- Miller, K. D., Fabian, F., & Lin, S. J. (2009). Strategies for online communities. *Strategic Management Journal*, 30(3), 305-322.
- Miller, K. D., Pentland, B. T., & Choi, S. (2012). Dynamics of Performing and Remembering Organizational Routines. *Journal of Management Studies*, 49(8), 1536-1558.
- Miller, K. D., Zhao, M., & Calantone, R. J. (2006). Adding interpersonal learning and tacit knowledge to March's exploration-exploitation model. *Academy of Management Journal*, 49(4), 709-722.

- Miller, N., & Campbell, D. T. (1959). Recency and primacy in persuasion as a function of the timing of speeches and measurements. *Journal of Abnormal and Social Psychology*, 59(1), 1-9.
- Miner, J. B. (1984). The validity and usefulness of theories in an emerging organizational science. *Academy of Management Review*, 9(2), 296-306.
- Miner, J. B. (2003). The rated importance, scientific validity, and practical usefulness of organizational behavior theories: A quantitative review. *Academy of Management Learning and Education*, 2(3), 250-268.
- Miner, J. B. (2006). *Organizational Behavior Three: Historical origins, theoretical foundations, and the future*: M.E. Sharpe.
- Mitchell, D. J., Lewin, D., & Lawler, E. E. (1989). *Alternative pay systems, firm performance and productivity* (Vol. 165): Institute of Industrial Relations, University of California, Los Angeles.
- Mitchell, T. R., & James, L. R. (2001). Building better theory: Time and the specification of when things happen. *Academy of Management Review*, 26(4), 530-547.
- Mitchell, T. R., & Silver, W. S. (1990). Individual and Group Goals When Workers Are Interdependent: Effects on Task Strategies and Performance. *Journal of Applied Psychology*, 75(2), 185-193.
- Mohrman, A. M., Mohrman, S. A., & Lawler, E. E. (1992). The performance management of teams. *Performance Measurement, Evaluation, and Incentives*, 217-241.
- Monroe, B. M., & Read, S. J. (2008). A General Connectionist Model of Attitude Structure and Change: The ACS (Attitudes as Constraint Satisfaction) Model. *Psychological Review*, 115(3), 733-759.
- Moorman, R. H. (1991). Relationship Between Organizational Justice and Organizational Citizenship Behaviors: Do Fairness Perceptions Influence Employee Citizenship? *Journal of Applied Psychology*, 76(6), 845-855.
- Moorman, R. H., & Blakely, G. L. (1995). Individualism Collectivism As An Individual Difference Predictor Of Organizational Citizenship Behavior. *Journal of Organizational Behavior*, 16(2), 127-142.
- Morand, D. A., & Merriman, K. K. (2012). "Equality Theory" as a Counterbalance to Equity Theory in Human Resource Management. *Journal of Business Ethics*, 111(1), 133-144.
- Moretti, S. (2002). Computer simulation in sociology: What contribution? *Social Science Computer Review*, 20(1), 43-57.

- Morgeson, F. P., & Hofmann, D. A. (1999). The structure and function of collective constructs: Implications for multilevel research and theory development. *Academy of Management Review*, 24(2), 249-265.
- Morris, M. W., Chiu, C. Y., & Liu, Z. (2015) Polycultural psychology. *Vol. 66. Annual Review of Psychology* (pp. 631-659).
- Morris, M. W., Leung, K., Ames, D., & Lickel, B. (1999). Views from inside and outside: Integrating emic and etic insights about culture and justice judgment. *Academy of Management Review*, 24(4), 781-796.
- Mosler, H. J. (2006). Better be convincing or better be stylish? A theory based multi-agent simulation to explain minority influence in groups via arguments or via peripheral cues. *JASSS*, 9(3), 109-126.
- Mosler, H.-J. (2002). *Agent-based simulation of an environmental action campaign: Changing people's behaviour via their inner contradictions*. Paper presented at the Integrated assessment and decision support. Proceedings of the 1st biennial meeting of the International Environmental Modelling and Software Society.
- Mousseau, N., & Sherrington, D. (1995). Role of detailed balance on the phase diagram of frustrated systems; the modified ANNNI model. *Journal of Physics A: Mathematical and General*, 28(23), 6557.
- Mullainathan, S. (2002). A Memory-Based Model of Bounded Rationality. *The Quarterly Journal of Economics*, 117(3), 735-774.
- Mulligan, J. R., & Bull Schaefer, R. A. (2011). A New Hope for Rank and Yank. *Journal of Leadership & Organizational Studies*.
- Murdock Jr, B. B. (1962). The serial position effect of free recall. *Journal of experimental psychology*, 64(5), 482.
- Murphy, K. R., & Cleveland, J. N. (1991). *Performance Appraisal: An Organizational Perspective*.
- Mussweiler, T., & Epstude, K. (2009). Relatively Fast! Efficiency Advantages of Comparative Thinking. *Journal of Experimental Psychology: General*, 138(1), 1-21.
- Nagel, K., & Schreckenberg, M. (1992). A cellular automaton model for freeway traffic. *Journal de Physique I*, 2(12), 2221-2229.
- Nahum, J. R., Harding, B. N., & Kerr, B. (2011). Evolution of restraint in a structured rock–paper–scissors community. *Proceedings of the National Academy of Sciences*, 108(Supplement 2), 10831-10838.

- Nan, N. (2011). Capturing Bottom-Up Information Technology Use Processes: A Complex Adaptive Systems Model. *MIS Quarterly*.
- Nan, N., Zmud, R., & Yetgin, E. (2014). A complex adaptive systems perspective of innovation diffusion: an integrated theory and validated virtual laboratory. *Computational and Mathematical Organization Theory*, 20(1), 52-88.
- Neckermann, S., & Frey, B. S. (2013). And the winner is. . .? The motivating power of employee awards. *Journal of Socio-Economics*, 46, 66-77.
- Newell, A. (1990). Unified theories of cognition. *Unified Theories of Cognition*.
- Nikolic, I., & Kasmire, J. (2013). Theory. In K. H. Van Dam, I. Nikolic, & J. Kasmire (Eds.), *Agent-Based Modelling of Socio-Technical Systems*.
- Nisbett, R., & Ross, L. (1980). *Human Inference: Strategies and Shortcomings of Social Judgment*.
- Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science*, 5(1), 14-37.
- North, M. J., & Macal, C. M. (2007). *Managing Business Complexity: Discovering Strategic Solutions with Agent-Based Modeling and Simulation*.
- North, M. J., Macal, C. M., St. Aubin, J., Thimmapuram, P., Bragen, M., Hahn, J., . . . Hampton, D. (2010). Multiscale agent-based consumer market modeling. *Complexity*, 15(5), 37-47.
- Nowak, A., & Latané, B. (1994). Simulating the emergence of social order from individual behavior. *Simulating Societies: The Computer Simulation of Social Phenomena*.
- Nowak, A., & Lewenstein, M. (1996). Modeling social change with cellular automata. *Modelling and Simulation in the Social Sciences from the Philosophy of Science Point of View*, 249-285.
- Nowak, A., & Vallacher, R. R. (1998a). *Dynamical social psychology*. Guilford Press.
- Nowak, A., & Vallacher, R. R. (1998b). Toward computational social psychology: Cellular automata and neural network models of interpersonal dynamics. *Connectionist Models of Social Reasoning and Social Behavior*, 277-311.
- Nowak, A., Szamrej, J., & Latané, B. (1990). From private attitude to public opinion: A dynamic theory of social impact. *Psychological Review*, 97(3), 362-376.
- Nowak, A., Tesser, A., Vallacher, R. R., & Borkowski, W. (2000). Society of Self: The Emergence of Collective Properties in Self-Structure. *Psychological Review*, 107(1), 39-61.

- Nowak, A., Vallacher, R. R., & Zochowski, M. (2005). The emergence of personality: Dynamic foundations of individual variation. *Developmental Review*, 25(3-4), 351-385.
- Nowak, M. A. (2006). Five rules for the evolution of cooperation. *Science*, 314(5805), 1560-1563.
- Nowak, M. A., & May, R. M. (1992a). Coexistence and competition in HIV infections. *J Theor Biol*, 159(3), 329-342.
- Nowak, M. A., & May, R. M. (1992b). Evolutionary games and spatial chaos. *Nature*, 359(6398), 826-829.
- Nowak, M. A., & Sigmund, K. (1998). Evolution of indirect reciprocity by image scoring. *Nature*, 393(6685), 573-577.
- Notz, W. W. (1975). Work motivation and the negative effects of extrinsic rewards: A review with implications for theory and practice. *American Psychologist*, 30(9), 884.
- Nyberg, A. J., Pieper, J. R., & Trevor, C. O. (2013). Pay-for-Performance's Effect on Future Employee Performance: Integrating Psychological and Economic Principles Toward a Contingency Perspective. *Journal of Management*.
- Ocasio, W. (1997). Towards An Attention-Based View Of The Firm. *Strategic Management Journal*, 18(S1), 187-206.
- O'Donnell, T., Maguire, L., McIvor, R., & Humphreys, P. (2006). Minimizing the bullwhip effect in a supply chain using genetic algorithms. *International Journal of Production Research*, 44(8), 1523-1543.
- O'Dell, C. S., & McAdams, J. (1987). *People, Performance, and Pay: A Full Report on the American Productivity Center/American Compensation Association National Survey of Non-traditional Reward and Human Resource Practices*: American Productivity Center.
- Ogibayashi, S., & Takashima, K. (2013). Influence of government expenditure policies and tax rate on GDP in an agent-based artificial economic system *Agent-Based Approaches in Economic and Social Complex Systems VII* (pp. 147-161): Springer.
- Ohtsuki, H., Hauert, C., Lieberman, E., & Nowak, M. A. (2006). A simple rule for the evolution of cooperation on graphs and social networks. *Nature*, 441(7092), 502-505.
- Oldham, G. R., Kulik, C. T., Ambrose, M. L., Stepina, L. P., & Brand, J. F. (1986). Relations between job facet comparisons and employee reactions. *Organ Behav Hum Decis Process*, 38(1), 28-47.

- Oliver, R. L., & Anderson, E. (1995). Behavior- and Outcome-Based Sales Control Systems: Evidence and Consequences of Pure-Form and Hybrid Governance. *Journal of Personal Selling & Sales Management*, 15(4), 1-15.
- Oliver, R. L., & Swan, J. E. (1989a). Consumer Perceptions of Interpersonal Equity and Satisfaction in Transactions: A Field Survey Approach. *Journal of Marketing*, 53(2), 21-35.
- Oliver, R. L., & Swan, J. E. (1989b). Equity and Disconfirmation Perceptions as Influences on Merchant and Product Satisfaction. *Journal of Consumer Research*, 16(3), 372-383.
- Osigweh, C. A. B. (1989). Concept fallibility in organizational science. *Academy of Management Review*, 14(4), 579-594.
- Osinga, S., Kramer, M., Hofstede, G., & Beulens, A. M. (2013). Multi-dimensional information diffusion and balancing market supply: an agent-based approach. In A. Teglio, S. Alfarano, E. Camacho-Cuena, & M. Ginés-Vilar (Eds.), *Managing Market Complexity* (Vol. 662, pp. 183-194): Springer Berlin Heidelberg.
- Oyserman, D., Coon, H. M., & Kemmelmeier, M. (2002). Rethinking individualism and collectivism: Evaluation of theoretical assumptions and meta-analyses. *Psychol Bull*, 128(1), 3-52.
- Padgett, J. F., Lee, D., & Collier, N. (2003). Economic production as chemistry. *Industrial and Corporate Change*, 12(4), 843-877.
- Page, L., & Page, K. (2010). Last shall be first: A field study of biases in sequential performance evaluation on the Idol series. *Journal of economic behavior & organization*, 73(2), 186-198.
- Palmer, R. G., Brian Arthur, W., Holland, J. H., LeBaron, B., & Tayler, P. (1994). Artificial economic life: a simple model of a stockmarket. *Physica D: Nonlinear Phenomena*, 75(1-3), 264-274.
- Pandelaere, M., Briers, B., & Lembregts, C. (2011). How to Make a 29% Increase Look Bigger: The Unit Effect in Option Comparisons. *Journal of Consumer Research*, 38(2), 308-322.
- Parnell, J. A., & Sullivan, S. E. (1992). When money isn't enough: The effect of equity sensitivity on performance-based pay systems. *Human Resource Management Review*, 2(2), 143-155.
- Parunak, H. V. D., Savit, R., & Riolo, R. L. (1998). Agent-based modeling vs. equation-based modeling: A case study and users' guide. *Lecture Notes in Computer Science*, 1534, 10-25.

- Courty, P. & Marschke, G. (2004). An Empirical Investigation of Gaming Responses to Explicit Performance Incentives. *Journal of Labor Economics*, 22(1), 23-56.
- Patchen, M. (1961). *The choice of wage comparisons*. (Thesis), University of Michigan., Englewood Cliffs, N.J.,.
- Patten, T. (1977). *Pay: Employee Compensation and Incentive Plans*.
- Payette, N. (2012) Agent-based models of science. *Understanding Complex Systems*.
- Peach, E. B., & Wren, D. A. (1991). Pay for Performance from Antiquity to the 1950s. *Journal of Organizational Behavior Management*, 12(1), 5-26.
- Pearce, J. L., & Perry, J. L. (1983). Federal merit pay: A longitudinal analysis. *Public Administration Review*, 315-325.
- Pearce, J. L., Stevenson, W. B., & Perry, J. L. (1985). Managerial compensation based on organizational performance: A time series analysis of the effects of merit pay. *Academy of Management Journal*, 28(2), 261-278.
- Pearsall, M. J., Christian, M. S., & Ellis, A. P. (2010). Motivating interdependent teams: individual rewards, shared rewards, or something in between? *J Appl Psychol*, 95(1), 183-191.
- Pentland, B. T., Feldman, M. S., Becker, M. C., & Liu, P. (2012). Dynamics of Organizational Routines: A Generative Model. *Journal of Management Studies*, 49(8), 1484-1508.
- Pepper, A., & Gore, J. (2012). Behavioral agency theory new foundations for theorizing about executive compensation. *Journal of Management*.
- Pepper, J. W. (2000). Relatedness in Trait Group Models of Social Evolution. *J Theor Biol*, 206(3), 355-368.
- Pfeffer, J. (1998). Six dangerous myths about pay. *Harv Bus Rev*, 76(3), 108-119.
- Pfeffer, J., & Langton, N. (1993). The Effect of Wage Dispersion on Satisfaction, Productivity, and Working Collaboratively: Evidence from College and University Faculty. *Administrative Science Quarterly*, 38(3), 382.
- Phelan, S., & Lin, Z. (2001). Promotion Systems and Organizational Performance: A Contingency Model. *Computational & Mathematical Organization Theory*, 7(3), 207-232.
- Pickett, C. L., Smaldino, P. E., Sherman, J. W., & Schank, J. (2011). Agent-based modeling as a tool for studying social identity processes: The case of optimal distinctiveness theory *Social Cognition Social Identity and Intergroup Relations* (pp. 127-143).

- Pillai, R., Williams, E. S., & Tan, J. J. (2001). Are the scales tipped in favor of procedural or distributive justice? An investigation of the U.S., India, Germany, and Hong Kong (China). *International Journal of Conflict Management*, 12(4), 312-332.
- Pink, D. H. (2009). *Drive: The Surprising Truth about What Motivates Us*.
- Pinto, A. C., & Baddeley, A. D. (1991). Where did you park your car? Analysis of a naturalistic long-term recency effect. *European Journal of Cognitive Psychology*, 3, 297-313.
- Pizzitutti, F., Mena, C. F., & Walsh, S. J. (2014). Modelling tourism in the Galapagos Islands: An agent-based model approach. *JASSS*, 17(1).
- Pluchino, A., Rapisarda, A., & Garofalo, C. (2010). The Peter principle revisited: A computational study. *Physica A: Statistical Mechanics and its Applications*, 389(3), 467-472.
- Pluchino, A., Rapisarda, A., & Garofalo, C. (2011). Efficient promotion strategies in hierarchical organizations. *Physica A: Statistical Mechanics and its Applications*, 390(20), 3496-3511.
- Polanyi, M. (1962). Personal knowledge: Towards a post-critical philosophy. *Personal Knowledge: Towards a Post-Critical Philosophy*.
- Polhill, G., Izquierdo, L., & Gotts, N. (2004). The ghost in the model (and other effects of floating point arithmetic). *JASSS*, 8(1).
- Polhill, J. G., Gotts, N. M., & Law, A. N. (2001). Imitative versus nonimitative strategies in a land-use simulation. *Cybernetics & Systems*, 32(1-2), 285-307.
- Polhill, J. G., Parker, D., Brown, D., & Grimm, V. (2008). Using the ODD protocol for describing three agent-based social simulation models of land-use change. *JASSS*, 11(2).
- Poole, M. S., & Van de Ven, A. H. (1989). Using paradox to build management and organization theories. *Academy of Management Review*, 14(4), 562-578.
- Popper, K. (1965). Normal Science and its Dangers. In Lakatos & Musgrave (Eds.), *Criticism and the Growth of Knowledge*, 1970.
- Popper, K. R. (1979). *Objective Knowledge: An Evolutionary Approach*.
- Powell, L. A. (2005). Cross-cultural variations in distributive justice perception. Special Issue. *J Cross Cult Psychol*, 36, 1-16.
- Prasad, K. (2012). Application of Agent-based Modeling in Studying Leadership Effects on Group Task Satisfaction. *Academy of Management Proceedings*, 2012(1), 1-1.

- Pritchard, R. D. (1969). Equity Theory - Review And Critique. *Organizational Behavior and Human Performance*, 4(2), 176-211.
- Pritchard, R. D., & Curts, M. I. (1973). The influence of goal setting and financial incentives on task performance. *Organizat.Behav.Hum.Perform.*, 10(2), 175-183.
- Pritchard, R. D., Dunnette, M. D., & Gorgenson, D. O. (1972). Effects of perceptions of equity and inequity on worker performance and satisfaction. *Journal of Applied Psychology*, 56(1), 75-94.
- Rablen, M. D. (2010). Tax evasion and exchange equity: A reference-dependent approach. *Public Finance Review*, 38(3), 282-305.
- Radax, W., & Rengs, B. (2010). Prospects and pitfalls of statistical testing: insights from replicating the demographic prisoner's dilemma. *JASSS*, 13(4), 1.
- Raghu, T. S., Jayaraman, B., & Rao, H. R. (2004). Toward an Integration of Agent- and Activity-Centric Approaches in Organizational Process Modeling: Incorporating Incentive Mechanisms. *Information Systems Research*, 15(4), 316-335.
- Rahmandad, H., & Sterman, J. (2004). Heterogeneity and network structure in the dynamics of diffusion: Comparing agent-based and differential equations models. *Massachusetts Institute of Technology Engineering Systems Division*.
- Rahmandad, H., & Sterman, J. (2008). Heterogeneity and network structure in the dynamics of diffusion: Comparing agent-based and differential equation models. *Management Science*, 54(5), 998-1014.
- Railsback, S. F., & Grimm, V. (2013). *Agent-based and Individual-based Modeling: A Practical Introduction*.
- Rand, D. G., Ohtsuki, H., & Nowak, M. A. (2009). Direct reciprocity with costly punishment: Generous tit-for-tat prevails. *J Theor Biol*, 256(1), 45-57.
- Rand, W., & Rust, R. T. (2011). Agent-based modeling in marketing: Guidelines for rigor. *International Journal of Research in Marketing*, 28(3), 181-193.
- Rao, A. S., & Georgeff, M. P. (1995). BDI agents: From theory to practice. *Proceedings of the First International Conference on Multi-Agent Systems*, 312-319.
- Rao, H. R., Chaudhury, A., & Chakka, M. (1995). Modeling Team Processes: Issues and a Specific Example. *Information Systems Research*, 6(3), 255-285.
- Rawls, J. (1971). *A Theory of Justice*.
- Read, D. (2010). Agent-based and multi-agent simulations: coming of age or in search of an identity? *Computational and Mathematical Organization Theory*, 16(4), 329-347.

- Reitter, D., & Lebiere, C. (2011). How groups develop a specialized domain vocabulary: A cognitive multi-agent model. *Cognitive Systems Research, 12*(2), 175-185.
- Ren, Y., & Argote, L. (2011). Transactive memory systems 1985-2010: An integrative framework of key dimensions, antecedents, and consequences. *Academy of Management Annals, 5*(1), 189-229.
- Ren, Y., Kraut, R., & Kiesler, S. (2007). Applying common identity and bond theory to design of online communities. *Organization Studies, 28*(3), 377-408.
- Richetin, J., Sengupta, A., Perugini, M., Adjali, I., Hurling, R., Greetham, D., & Spence, M. (2010). A micro-level simulation for the prediction of intention and behavior. *Cognitive Systems Research, 11*(2), 181-193.
- Richiardi, M. G., Leombruni, R., Saam, N. J., & Sonnessa, M. (2006). A common protocol for agent-based social simulation. *JASSS, 9*.
- Riolo, R. L., Cohen, M. D., & Axelrod, R. (2001). Evolution of cooperation without reciprocity. *Nature, 414*(6862), 441-443.
- Risher, H. (2012). Call for Research on Pay and Performance. *Compensation & Benefits Review, 44*(3), 123-125.
- Risher, H. (2013). It's Not That Simple: Extrinsic Versus Intrinsic Rewards. *Compensation & Benefits Review, 45*(1), 3-6.
- Risher, H. (2014). Performance Management Needs to Be Fixed. *Compensation & Benefits Review, 46*(4), 191-194.
- Rivkin, J. W. (2000). Imitation of complex strategies. *Management Science, 46*(6), 824-844.
- Riyanto, Y. E., & Zhang, J. (2013). The impact of social comparison of ability on pro-social behaviour. *The Journal of Socio-Economics, 47*(0), 37-46.
- Riyanto, Y. E., & Zhang, J. (2014). An Egalitarian System Breeds Generosity: The Impact of Redistribution Procedures on Pro-Social Behavior. *Economic Inquiry, 52*(3), 1027-1039.
- Robbins, J. M., Ford, M. T., & Tetrick, L. E. (2012). Perceived unfairness and employee health: a meta-analytic integration. *J Appl Psychol, 97*(2), 235-272.
- Roberto, K. A., & Scott, J. P. (1986). Equity considerations in the friendships of older adults. *J Gerontol, 41*(2), 241-247.
- Robison-Cox, J. F., Martell, R. F., & Emrich, C. G. (2007). Simulating gender stratification. *JASSS, 10*(3).

- Roch, S. G., & Shanock, L. R. (2006). Organizational justice in an exchange framework: Clarifying organizational justice distinctions. *Journal of Management*, 32(2), 299-322.
- Rohrbaugh, J., McClelland, G., & Quinn, R. (1980). Measuring the relative importance of utilitarian and egalitarian values: A study of individual differences about fair distribution. *Journal of Applied Psychology*, 65(1), 34-49.
- Rojas-Méndez, J. I., Davies, G., Omer, O., Chetthamrongchai, P., & Madran, C. (2002). A time attitude scale for cross cultural research. *Journal of Global Marketing*, 15(3-4), 117-147.
- Romer, D. (1977). Limitations In Equity-Theory Approach - Resolution Of Negative-Inputs Controversy. *Personality and Social Psychology Bulletin*, 3(2), 228-231.
- Ronen, S. (1986). Equity Perception In Multiple Comparisons - A Field-Study. *Human Relations*, 39(4), 333-345.
- Roos, P., Gelfand, M., Nau, D., & Carr, R. (2014). High strength-of-ties and low mobility enable the evolution of third-party punishment. *Proceedings of the Royal Society B: Biological Sciences*, 281(1776).
- Roos, P., Gelfand, M., Nau, D., & Lun, J. (in press). Societal Threat and Cultural Variation in the Strength of Social Norms: An Evolutionary Basis. *Organ Behav Hum Decis Process*.
- Rosenbaum, M. E., Moore, D. L., Cotton, J. L., Cook, M. S., Hieser, R. A., Shovar, M. N., & Gray, M. J. (1980). Group productivity and process: Pure and mixed reward structures and task interdependence. *J Pers Soc Psychol*, 39(4), 626-642.
- Rosenberg, R. R., & Karnopp, D. C. (1983). Introduction to Physical System Dynamics.
- Rouchier, J., Tubaro, P., & Emery, C. (2014). Opinion transmission in organizations: an agent-based modeling approach. *Computational and Mathematical Organization Theory*, 20(3), 252-277.
- Rousseau, D. M. (1997) Organizational behavior in the new organizational era. *Vol. 48. Annual Review of Psychology* (pp. 515-546).
- Rousseau, D. M. (2011). Reinforcing the micro/macro bridge: Organizational thinking and pluralistic vehicles. *Journal of Management*, 37(2), 429-442.
- Rummel, A., & Feinberg, R. (1988). Cognitive Evaluation Theory: A Meta-Analytic Review of the Literature. *Social Behavior and Personality*, 16(2), 147-164.
- Rupp, D. E., Shao, R., Thornton, M. A., & Skarlicki, D. P. (2013). Applicants' and employees' reactions to corporate social responsibility: The moderating effects of

- first-party justice perceptions and moral identity. *Personnel Psychology*, 66(4), 895-933.
- Rynes, S. L., Gerhart, B., & Parks, L. (2005) Personnel psychology: Performance evaluation and pay for performance. *Annual Review of Psychology* (pp. 571-600).
- Saglam, I. (2014). Simple heuristics as equilibrium strategies in mutual sequential mate search. *JASSS*, 17(1).
- Saito, M., & Kurahashi, S. (2013). The Agent-Based Diffusion Model: Simulating Informative and Normative Effects on Consumer Networks. In T. Murata, T. Terano, & S. Takahashi (Eds.), *Agent-Based Approaches in Economic and Social Complex Systems VII* (Vol. 10, pp. 73-84).
- Sakoda, J. M. (1949). Minidoka: An analysis of changing patterns of social interaction.
- Sakoda, J. M. (1971). The Checkerboard Model Of Social Interaction. *The Journal of Mathematical Sociology*, 1(1), 119-132.
- Salgado, M., & Gilbert, N. (2013). Agent-based modeling. *Handbook of Quantitative Methods for Educational Research*.
- Salzarulo, L. (2006). A continuous opinion dynamics model based on the principle of meta-contrast. *JASSS*, 9(1), 65-93.
- Sampson, E. E. (1969). Studies of status congruence. *Advances in experimental social psychology*, 4, 225-270.
- Sampson, E. E. (1975). On Justice As Equality. *The Journal of Social Issues*, 31(3), 45-64.
- Samuel, W. (1978). Toward A Simple But Useful Equity Theory - Comment On Romer Article. *Personality and Social Psychology Bulletin*, 4(1), 135-138.
- Sargent, R. G. (1988). *An overview of verification and validation of simulation models*. Paper presented at the Proceedings of the 19th conference on Winter simulation.
- Sastry, M. A. (1997). Problems and paradoxes in a model of punctuated organizational change. *Administrative Science Quarterly*, 42(2), 237-275.
- Sauley, K. S., & Bedeian, A. G. (2000). Equity sensitivity: Construction of a measure and examination of its psychometric properties. *Journal of Management*, 26(5), 885-910.
- Sawyer, R. K. (2003). Artificial societies multiagent systems and the micro-macro link in sociological theory. *Sociological methods & research*, 31(3), 325-363.
- Sawyer, R. K. (2005). *Social emergence: Societies as complex systems*. Cambridge University Press.

- Sayama, H., Farrell, D. L., & Dionne, S. D. (2011). The effects of mental model formation on group decision making: An agent-based simulation. *Complexity*, 16(3), 49-57.
- Scalas, E., Gallegati, M., Guerci, E., Mas, D., & Tedeschi, A. (2006). Growth and allocation of resources in economics: The agent-based approach. *Physica A: Statistical Mechanics and its Applications*, 370(1), 86-90.
- Schafer, R. B., & Keith, P. M. (1980). Equity and depression among married couples. *Social Psychology Quarterly*, 43(4), 430-435.
- Schelling, T. (1969). Models of segregation. *American Economic Review*, 59(2), 488-493.
- Schelling, T. (1972). Dynamic models of segregation. *Journal of Mathematical Sociology*, 1, 143-186.
- Schelling, T. C. (1971a). Dynamic Models of Segregation. *The Journal of Mathematical Sociology*, 1(2), 143-186.
- Schelling, T. C. (1971b). On the ecology of micromotives. *The Public Interest*, 25, 61-98.
- Schelling, T. C. (1972). A process of residential segregation: Neighborhood tipping. *Racial Discrimination in Economic Life*, 157-184.
- Schelling, T. C. (1978). *Micromotives and Macrobehavior*.
- Schiff, J. L. (2008). *Cellular Automata: A Discrete View of the World*: Wiley.
- Schneider, M., & Somers, M. (2006). Organizations as complex adaptive systems: Implications of complexity theory for leadership research. *The Leadership Quarterly*, 17(4), 351-365.
- Scholl, R. W., Cooper, E. A., & McKenna, J. (1987). Referent selection in determining equity perceptions: Differential effects on behavioral and attitudinal outcomes. *Personnel Psychology*, 40(1), 113-124.
- Schreiber, C., & Carley, K. M. (2006). Leadership style as an enabler of organizational complex functioning. *E:CO Emergence: Complexity and Organization*, 8(4), 61-76.
- Schumm, W. R., & Kirn, J. E. (1982). Evaluating Equity In The Marital Relationship: An Alternative Approach. *Psychol Rep*, 51(3), 759-762.
- Schwarzwald, J., Koslowsky, M., & Shalit, B. (1992). A field study of employees' attitudes and behaviors after promotion decisions. *Journal of Applied Psychology*, 77(4).
- Schwinger, T. (1980). Just allocations of goods: Decisions among three principles. In G. Mikula (Ed.), *Justice and Social Interaction*: Springer-Verlag.

- Scott, K. L., Shaw, J. D., & Duffy, M. K. (2008). Merit pay raises and organization-based self-esteem. *Journal of Organizational Behavior*, 29(7), 967-980.
- Scullen, S. E., Bergey, P. K., & Aiman-Smith, L. (2005). Forced Distribution Rating Systems And The Improvement Of Workforce Potential: A Baseline Simulation. *Personnel Psychology*, 58(1), 1-32.
- Seale, D. A., & Rapoport, A. (1997). Sequential Decision Making with Relative Ranks: An Experimental Investigation of the "Secretary Problem">. *Organ Behav Hum Decis Process*, 69(3), 221-236.
- Sedikides, C., Gaertner, L., & Toguchi, Y. (2003). Pancultural Self-Enhancement. *J Pers Soc Psychol*, 84(1), 60-79.
- Semmler, W. (2011). Agent Based and Evolutionary Modeling of Asset Markets *Asset Prices, Booms and Recessions* (pp. 181-187).
- Senders, J. W., & Moray, N. (1991). *Human error: Cause, prediction, and reduction*: L. Erlbaum Associates Hillsdale, NJ.
- Shao, R., Rupp, D. E., Skarlicki, D. P., & Jones, K. S. (2013). Employee Justice Across Cultures: A Meta-Analytic Review. *Journal of Management*, 39(1), 263-301.
- Shapira, Z. (2011). "I've got a theory paper-do you?": Conceptual, empirical, and theoretical contributions to knowledge in the organizational sciences. *Organization Science*, 22(5), 1312-1321.
- Shapiro, D., Brass, D., & Labianca, J. (2008). Examining justice from a social network perspective. *SW Gilliland, D. Skarlicki, & D. Steiner*, 201-226.
- Shapiro, E. G. (1975). Effect of expectations of future interaction on reward allocations in dyads: Equity or equality. *J Pers Soc Psychol*, 31(5), 873-880.
- Shaw, J. D. (2014). Pay Dispersion. *Annual Review of Organizational Psychology and Organizational Behavior*, 1(1), 521-544.
- Shaw, J. D., & Gupta, N. (2007). Pay system characteristics and quit patterns of good, average, and poor performers. *Personnel Psychology*, 60(4), 903-928.
- Shaw, J. D., Gupta, N., & Delery, J. E. (2002). Pay dispersion and workforce performance: Moderating effects of incentives and interdependence. *Strategic Management Journal*, 23(6), 491-512.
- Shearer, B. (2004). Piece Rates, Fixed Wages and Incentives: Evidence from a Field Experiment. *The review of economic studies*, 71(2), 513-534.

- Shteingart, H., Neiman, T., & Loewenstein, Y. (2013). The role of first impression in operant learning. *Journal of Experimental Psychology: General*, 142(2), 476.
- Siebers, P. O., & Aickelin, U. (2011). A first approach on modelling staff proactiveness in retail simulation models. *JASSS*, 14(2).
- Siebers, P. O., Aickelin, U., Celia, H., & Clegg, C. W. (2011). Towards the development of a simulator for investigating the impact of people management practices on retail performance. *Journal of Simulation*, 5(4), 247-265.
- Sierhuis, M., Clancey, W. J., Seah, C., Trimble, J. P., & Sims, M. H. (2003). Modeling and simulation for mission operations work system design. *Journal of Management Information Systems*, 19(4), 85-128.
- Siggelkow, N., & Levinthal, D. A. (2003). Temporarily Divide to Conquer: Centralized, Decentralized, and Reintegrated Organizational Approaches to Exploration and Adaptation. *Organization Science*, 14(6), 650-669+755.
- Singelis, T. M. (1994). The measurement of independent and interdependent self-construals. *Personality and Social Psychology Bulletin*, 20, 580-591.
- Singh, V., Dong, A., & Gero, J. S. (2012). Computational studies to understand the role of social learning in team familiarity and its effects on team performance. *CoDesign*, 8(1), 25-41.
- Situngkir, H., & Khanafiah, D. (2006). *Theorizing corruption through agent-based modeling*. Paper presented at the Proceedings of the 9th Joint Conference on Information Sciences, JCIS 2006.
- Skarlicki, D. P., & Folger, R. (1997). Retaliation in the workplace: The roles of distributive, procedural, and interactional justice. *Journal of Applied Psychology*, 82(3), 434-443.
- Smith, B. N., Benson, P. G., & Hornsby, J. S. (1990). The effects of job description content on job evaluation judgments. *Journal of Applied Psychology*, 75(3), 301-309.
- Smith, E. R., & Collins, E. C. (2009). Contextualizing person perception: Distributed social cognition. *Psychological Review*, 116(2), 343-364.
- Smith, E. R., & Conrey, F. R. (2007). Agent-based modeling: A new approach for theory building in social psychology. *Personality and Social Psychology Review*, 11(1), 87-104.
- Sonnentag, S. (2012). Time in organizational research: Catching up on a long neglected topic in order to improve theory. *Organizational Psychology Review*, 2(4), 361-368.
- Sorenson, O. (2002). Interorganizational complexity and computation. *Companion to Organizations*, 664-685.

- Sorenson, O. (2003). Interdependence and adaptability: Organizational learning and the long-term effect of integration. *Management Science*, 49(4), 446-463.
- Soulié, J. C., & Thébaud, O. (2006). Modeling fleet response in regulated fisheries: An agent-based approach. *Mathematical and computer modelling*, 44(5), 553-564.
- Spadone, R. A. (1992). Internal-external control and temporal orientation among Southeast Asians and white Americans. *The American Journal of Occupational Therapy*, 46(8),
- Spagnoletti, P., Za, S., & Winter, R. (2013). Exploring foundations for using simulations in IS research.
- Spector, A. J. (1956). Expectations, fulfillment, and morale. *The Journal of Abnormal and Social Psychology*, 52(1), 51-56.
- Spell, C. S., & Arnold, T. (2007). An appraisal perspective of justice, structure, and job control as antecedents of psychological distress. *Journal of Organizational Behavior*, 28(6), 729-751.
- Squazzoni, F., & Boero, R. (2002). Economic performance, inter-firm relations and local institutional engineering in a computational prototype of industrial districts. *JASSS*.
- Squazzoni, F., & Casnici, N. (2013). Is social simulation a social science outstation? A Bibliometric analysis of the impact of JASSS. *JASSS*, 16(1), 10.
- Stajkovic, A. D., & Luthans, F. (1997). A meta-analysis of the effects of organizational behavior modification on task performance, 1975-95. *Academy of Management Journal*, 40(5), 1122-1149.
- Stasser, G. (1988). Computer simulation as a research tool: The DISCUSS model of group decision making. *Journal of Experimental Social Psychology*, 24(5), 393-422.
- Stasser, G., & Taylor, L. A. (1991). Speaking turns in face-to-face discussions. *J Pers Soc Psychol*, 60(5), 675-684.
- Stasser, G., & Titus, W. (1985). Pooling of Unshared Information in Group Decision Making. Biased Information Sampling During Discussion. *J Pers Soc Psychol*, 48(6).
- Staw, B. M., & Sutton, R. (1993). Macro organizational psychology. In J. K. Murnighan (Ed.), *Social Psychology in Organizations: Advances in Theory and Research*.
- Steers, R. M., & Porter, L. W. (1991). *Motivation and Work Behavior*.
- Steiner, D. D., & Rain, J. S. (1989). Immediate and Delayed Primacy and Recency Effects in Performance Evaluation. *Journal of Applied Psychology*, 74(1), 136-142.

- Strube, M. J. (2005). What did Triplett really find? A contemporary analysis of the first experiment in social psychology. *American Journal of Psychology*, *118*(2), 271-286.
- Suls, J., & Wheeler, L. (2000). *Handbook of Social Comparison: Theory and Research*.
- Summers, T. P., & DeNisi, A. S. (1990). In search of Adams' other: Reexamination of referents used in the evaluation of pay. *Human Relations*, *43*(6), 497-511.
- Summers, T. P., & Hendrix, W. H. (1991). Modelling the role of pay equity perceptions: A field study. *Journal of Occupational Psychology*, *64*(2), 145-157.
- Sun, R. (2001). Cognitive science meets multi-agent systems: A prolegomenon. *Philosophical Psychology*, *14*(1), 1-28.
- Sun, R. (2006). The CLARION cognitive architecture: Extending cognitive modeling to social simulation. *Cognition and Multi-Agent Interaction*.
- Sun, R., & Naveh, I. (2004). Simulating organizational decision-making using a cognitively realistic agent model. *JASSS*, *7*(3).
- Sun, R., & Naveh, I. (2007). Social institution, cognition, and survival: A cognitive-social simulation. *Mind and Society*, *6*(2), 115-142.
- Sun, R., & Peterson, T. (1998). Some experiments with a hybrid model for learning sequential decision making. *Information Sciences*, *111*(1-4), 83-107.
- Sundberg, N. D., Poole, M. E., & Tyler, L. E. (1983). Adolescents' expectations of future events—a cross-cultural study of Australians, Americans, and Indians. *International Journal of Psychology*.
- Sutcliffe, A., & di, W. (2012). Computational modelling of trust and social relationships. *JASSS*, *15*(1).
- Sutton, R. I., & Staw, B. M. (1995). What Theory Is Not. *Administrative Science Quarterly*, *40*(3), 371-384.
- Swap, W. C., & Rubin, J. Z. (1983). Measurement of interpersonal orientation. *J Pers Soc Psychol*, *44*(1), 208-219.
- Sweeney, P. D. (1990). Distributive justice and pay satisfaction: A field test of an equity theory prediction. *Journal of Business and Psychology*, *4*(3), 329-341.
- Sweeney, P. D., & McFarlin, D. B. (1993). Workers' Evaluations of the " Ends" and the " Means": An Examination of Four Models of Distributive and Procedural Justice. *Organ Behav Hum Decis Process*, *55*(1), 23-40.

- Swencionis, J. K., & Fiske, S. T. (2014). How social neuroscience can inform theories of social comparison. *Neuropsychologia*, *56*(1), 140-146.
- Sydow, J., Schreyögg, G., & Koch, J. (2009). Organizational path dependence: Opening the black box. *Academy of Management Review*, *34*(4), 689-709.
- Tajfel, H. (1970). Experiments in Intergroup Discrimination. *Sci Am*, *223*, 96-102.
- Takahashi, S., Kobayashi, T., Kunigami, M., Yamada, T., Yamamoto, G., Yoshikawa, A., & Terano, T. (2013). Agent-Based Simulation of Diversity and Organizational Performance *Agent-Based Approaches in Economic and Social Complex Systems VII* (pp. 31-43): Springer.
- Taras, V., Kirkman, B. L., & Steel, P. (2010). Examining the impact of Culture's consequences: a three-decade, multilevel, meta-analytic review of Hofstede's cultural value dimensions. *J Appl Psychol*, *95*(3), 405-439. doi: 10.1037/a0018938
- Taris, T. W., Kalimo, R., & Schaufeli, W. B. (2002). Inequity at work: Its measurement and association with worker health. *Work and Stress*, *16*(4), 287-301.
- Tassier, T., & Menczer, F. (2001). Emerging small-world referral networks in evolutionary labor markets. *Evolutionary Computation, IEEE Transactions on*, *5*(5), 482-492.
- Taylor, E. Z. (2006). The effect of incentives on knowledge sharing in computer-mediated communication: An experimental investigation. *Journal of Information Systems*, *20*(1), 103-116.
- Taylor, M. S. (2001). Reflections on fairness: Continuing the progression of justice research and practice. *Journal of Vocational Behavior*, *58*(2), 243-253.
- Telly, C. S., French, W. L., & Scott, W. G. (1971). The relationship of inequity to turnover among hourly workers. *Administrative Science Quarterly*, 164-172.
- Tepper, B. J. (2001). Health consequences of organizational injustice: Tests of main and interactive effects. *Organ Behav Hum Decis Process*, *86*(2), 197-215.
- Tesfatsion, L. (1995). *A Trade Network Game with Endogenous Partner Selection*.
- Tesfatsion, L., & Judd, K. L. (2006). *Handbook of Agent-Based Computational Modeling*.
- Thibaut, J. W., & Kelley, H. H. (1959). *The Social Psychology Of Groups*.
- Thibaut, J., & Walker, L. (1975). *Procedural Justice: A Psychological Analysis*.
- Thibaut, J., & Walker, L. (1978). A theory of procedure. *California Law Review*, *66*, 541-566.

- Thom, M. D., & Dytham, C. (2012). Female Choosiness Leads To The Evolution Of Individually Distinctive Males. *Evolution*, 66(12), 3736-3742.
- Tilahun, N., & Levinson, D. (2011). Work and home location: Possible role of social networks. *Transportation Research Part A: Policy and Practice*, 45(4), 323-331.
- Tobler, P. N., Christopoulos, G. I., O'Doherty, J. P., Dolan, R. J., & Schultz, W. (2008). Neuronal Distortions of Reward Probability without Choice. *Journal of Neuroscience*, 28(45), 11703-11711.
- Todd, P. M., Billari, F. C., & Simão, J. (2005). Aggregate age-at-marriage patterns from individual mate-search heuristics. *Demography*, 42(3), 559-574.
- Topa, G. (1997). *Social Interactions, Local Spillovers and Unemployment*.
- Törnblom, K. Y. (1992). The social psychology of distributive justice. *Justice: Interdisciplinary Perspectives*, 177-236.
- Törnblom, K. Y., Jonsson, D., & Foa, U. G. (1985). Nationality, Resource Class, And Preferences Among 3 Allocation Rules - Sweden Vs Usa. *International Journal of Intercultural Relations*, 9(1), 51-77.
- Tornow, W. W. (1971). The development and application of an input-outcome moderator test on the perception and reduction of inequity. *Organizational Behavior and Human Performance*, 6(5), 614-638.
- Tosi, H. L., Werner, S., Katz, J. P., & Gomez-Mejia, L. R. (2000). How much does performance matter? A meta-analysis of CEO pay studies. *Journal of Management*, 26(2), 301-339.
- Trevor, C. O., & Wazeter, D. L. (2006). A contingent view of reactions to objective pay conditions: interdependence among pay structure characteristics and pay relative to internal and external referents. *J Appl Psychol*, 91(6), 1260-1275.
- Trevor, C. O., Reilly, G., & Gerhart, B. (2012). Reconsidering pay dispersion's effect on the performance of interdependent work: Reconciling sorting and pay inequality. *Academy of Management Journal*, 55(3), 585-610.
- Triplett, N. (1898). The dynamogenic factors in pacemaking and competition. *American Journal of Psychology*, 9, 507-533.
- Troitzsch, K. G. (2009a). Multi-Agent Systems and Simulation, A Survey from an Application Perspective. *Multi-agent Systems, Simulation and Applications*, 53-76.
- Troitzsch, K. G. (2009b). Not all explanations predict satisfactorily, and not all good predictions explain. *JASSS*, 12(1).

- Troitzsch, K. G. (2009c). *Perspectives and challenges of agent-based simulation as a tool for economics and other social sciences*. Paper presented at the Proceedings of the International Joint Conference on Autonomous Agents and Multiagent Systems.
- Troitzsch, K. G. (2012a). Simulating communication and interpretation as a means of interaction in human social systems. *Simulation*, 88(1), 7-17.
- Troitzsch, K. G. (2012b). Theory reconstruction of several versions of modern organization theories. *Ontology, Epistemology, and Teleology for Modeling and Simulation*.
- Tsang, E. W. K., & Ellsaesser, F. (2011). How Contrastive Explanation Facilitates Theory Building. *The Academy of Management Review*, 36(2), 404-419.
- Tversky, A., & Kahneman, D. (1981). The framing of decisions and the psychology of choice. *Science*, 211(4481), 453-458.
- Tversky, A., & Kahneman, D. (1992). Advances in prospect theory: Cumulative representation of uncertainty. *Journal of Risk and Uncertainty*, 5(4), 297-323.
- Twomey, P., & Cadman, R. (2002). Agent-based modelling of customer behaviour in the telecoms and media markets. *Info*, 4(1), 56-63.
- Tyagi, P. K. (1990). Inequities in organizations, salesperson motivation and job satisfaction. *International Journal of Research in Marketing*, 7(2-3), 135-148.
- Uhl-Bien, M., & Marion, R. (2008). *Complexity leadership* (Vol. 5): IAP.
- Van de Ven, A. H. (1989). Nothing is quite so practical as a good theory. *Academy of Management Review*, 14(4), 486-489.
- Van de Ven, A. H. (2007). *Engaged Scholarship: A Guide for Organizational and Social Research*.
- Van de Ven, A. H., & Poole, M. S. (1995). Explaining development and change in organizations. *Academy of Management Review*, 20(3), 510-540.
- Van den Bos, K., Lind, E. A., & Wilke, H. A. M. (2001). The psychology of procedural and distributive justice viewed from the perspective of fairness heuristic theory. *Justice in the Workplace: From Theory to Practice*, 2, 49-66.
- Van Den Bos, K., Lind, E. A., Vermunt, R., & Wilke, H. A. M. (1997). How do I judge my outcome when I do not know the outcome of others? The psychology of the fair process effect. *J Pers Soc Psychol*, 72(5), 1034-1046.
- Van Den Bos, K., Vermunt, R., & Wilke, H. A. M. (1997). Procedural and Distributive Justice: What is Fair Depends More on What Comes First Than on What Comes Next. *J Pers Soc Psychol*, 72(1), 95-104.

- Van Dierendonck, D., Schaufeli, W. B., & Buunk, B. P. (1998). The evaluation of an individual burnout intervention program: The role of inequity and social support. *Journal of Applied Psychology, 83*(3), 392.
- Van Eck, P. S., Jager, W., & Leeftang, P. S. H. (2011). Opinion leaders' role in innovation diffusion: A simulation study. *Journal of Product Innovation Management, 28*(2).
- Van Maanen, J., Sørensen, J. B., & Mitchell, T. R. (2007). The interplay between theory and method. *Academy of Management Review, 32*(4), 1145-1154.
- Van Yperen, N. W., Hagedoorn, M., & Geurts, S. A. E. (1996). Intent to leave and absenteeism as reactions to perceived inequity: The role of psychological and social constraints. *Journal of Occupational and Organizational Psychology, 69*(4), 367-372.
- Vancouver, J. B. (2008). Integrating self-regulation theories of work motivation into a dynamic process theory. *Human Resource Management Review, 18*(1), 1-18.
- Vancouver, J. B., & Weinhardt, J. M. (2012). Modeling the Mind and the Milieu: Computational Modeling for Micro-Level Organizational Researchers. *Organizational Research Methods, 15*(4), 602-623.
- Vancouver, J. B., Weinhardt, J. M., & Schmidt, A. M. (2010b). A Formal, Computational Theory of Multiple-Goal Pursuit: Integrating Goal-Choice and Goal-Striving Processes. *Journal of Applied Psychology, 95*(6), 985-1008.
- Vancouver, J. B., Weinhardt, J. M., & Vigo, R. (2014). Change one can believe in: Adding learning to computational models of self-regulation. *Organ Behav Hum Decis Process, 124*(1), 56-74.
- Vecchio, R. P. (1981). An individual-differences interpretation of the conflicting predictions generated by equity and expectancy theory. *Journal of Applied Psychology, 66*(4), 470-481.
- Vecchio, R. P. (1982). Predicting worker performance in inequitable settings. *Academy of Management Review, 7*(1), 103-110.
- Vecchio, R. P. (1984). Models of psychological inequity. *Organizational Behavior and Human Performance, 34*(2), 266-282.
- Vecchio, R. P., Griffeth, R. W., & Hom, P. W. (1986). The predictive utility of the vertical dyad linkage approach. *J Soc Psychol, 126*(5), 617-625.
- Vergne, J. P., & Durand, R. (2011). The path of most persistence: An evolutionary perspective on path dependence and dynamic capabilities. *Organization Studies, 32*(3), 365-382.

- Verma, A. (2005). What do unions do to the workplace? Union effects on management and HRM policies. *Journal of Labor Research*, 26(3), 415-449.
- Victor, B., & Blackburn, R. S. (1987). Interdependence: An alternative conceptualization. *Academy of Management Review*, 12(3), 486-498.
- Vogl-Bauer, S., Kalbfleisch, P. J., & Beatty, M. J. (1999). Perceived equity, satisfaction, and relational maintenance strategies in parent-adolescent dyads. *Journal of Youth and Adolescence*, 28(1), 27-49.
- Vogt, D. S., & Randall Colvin, C. (2003). Interpersonal Orientation and the Accuracy of Personality Judgments. *J Pers*, 71(2), 267-295.
- Vroom, V. H. (1964). Work and motivation. *Work and Motivation*.
- Wade, J. B., O'Reilly Iii, C. A., & Pollock, T. G. (2006). Overpaid CEOs and underpaid managers: Fairness and executive compensation. *Organization Science*, 17(5).
- Wageman, R. (1995). Interdependence and Group Effectiveness. *Administrative Science Quarterly*, 40(1), 145.
- Wagner, D. G. (1995). Gender Differences In Reward Preference - A Status-Based Account. *Small Group Research*, 26(3), 353-371.
- Wagner, J. A., Humphrey, S. E., Meyer, C. J., & Hollenbeck, J. R. (2012). Individualism-collectivism and team member performance: Another look. *Journal of Organizational Behavior*, 33(7), 946-963.
- Wagstaff, G. F., & Preece, D. (1997). Is overpunishment fairer than underpunishment? Perceptions of deviations from equity. *Psychology, Crime and Law*, 3(4), 261-274.
- Waldherr, A., & Wijermans, N. (2013). Communicating social simulation models to sceptical minds. *JASSS*, 16(4), 13.
- Waldron, L. (1988). The dilemma of merit pay in the public sector. *Asia Pacific Journal of Human Resources*, 26(3), 8-17.
- Wallace, M. J. F., Charles H. (1983). *Compensation Theory and Practice*.
- Walsh, J. P., & Ungson, G. R. (1991). Organizational memory. *Academy of Management Review*, 16(1), 57-91.
- Walster, E., & Walster, G. W. (1975). Equity And Social Justice. *Journal of Social Issues*, 31(3), 21-43.
- Walster, E., Berscheid, E., & Walster, G. W. (1973). New directions in equity research. *J Pers Soc Psychol*, 25(2), 151-176.

- Walster, E., Walster, G. W., & Berscheid, E. (1978). *Equity: Theory and Research*.
- Walster, E., Walster, G. W., & Traupmann, J. (1978). Equity and premarital sex. *J Pers Soc Psychol*, 36(1), 82-92.
- Wang, J., Gwebu, K., Shanker, M., & Troutt, M. D. (2009). An application of agent-based simulation to knowledge sharing. *Decision Support Systems*, 46(2), 532-541.
- Wareing, R., & Stockdale, J. (1987). Decision making in the promotion interview: An empirical study. *Personnel Review*, 16(4), 26-32.
- Watkins, A., & Hill, R. P. (2009). A simulation of business-to-business decision making in a relationship marketing context. *Industrial Marketing Management*, 38(8), 994-1005.
- Watts, D. J., & Dodds, P. S. (2007). Influentials, networks, and public opinion formation. *Journal of Consumer Research*, 34(4), 441-458.
- Wegner, D. M. (1987). Transactive memory: A contemporary analysis of the group mind. *Theories of Group Behavior*, 185-208.
- Wegner, D. M., Giuliano, T., & Hertel, P. T. (1985). Cognitive interdependence in close relationships *Compatible and incompatible relationships* (pp. 253-276): Springer.
- Weibel, A., Rost, K., & Osterloh, M. (2010). Pay for performance in the public sector - Benefits and (Hidden) costs. *Journal of Public Administration Research and Theory*, 20(2), 387-412.
- Weick, K. E. (1966). The Concept Of Equity In The Perception Of Pay. *Administrative Science Quarterly*, 11(3), 414-439.
- Weick, K. E. (1989). Theory construction as disciplined imagination. *Academy of Management Review*, 14(4), 516-531.
- Weick, K. E. (1995). What Theory Is Not, Theorizing Is. *Administrative Science Quarterly*, 40(3), 385-390.
- Weick, K. E. (2005). Organizing and failures of imagination. *International Public Management Journal*, 8(3), 425-438.
- Weick, K. E., & Nettet, B. (1968). Preferences among forms of equity. *Organizational Behavior and Human Performance*, 3(4), 400-416.
- Weick, K. E., Bougon, M. G., & Maruyama, G. (1976). The equity context. *Organizational Behavior and Human Performance*, 15(1), 32-65.
- Weidlich, A., & Veit, D. (2008). A critical survey of agent-based wholesale electricity market models. *Energy Economics*, 30(4), 1728-1759. doi: 10.1016/j.eneco.2008.01.003

- Weinhardt, J. M., & Vancouver, J. B. (2012). Computational models and organizational psychology: Opportunities abound. *Organizational Psychology Review*, 2(4).
- Weinstein, A. G., & Holzbach, R. L. (1973). Impact of individual differences, reward distribution, and task structure on productivity in a simulated work environment. *Journal of Applied Psychology*, 58(3), 296-301.
- Weisbuch, G., Deffuant, G., Amblard, F., & Nadal, J. P. (2002). Meet, discuss and segregate! *Complexity*, 7(3), 55-63.
- Weitzman, M. L. (1984). The Share Economy. *The Share Economy*.
- Weitzman, M. L., & Kruse, D. L. (1990). Profit sharing and productivity. *Paying for Productivity*, 95-140.
- Welbourne, T. M., & Gomez Mejia, L. R. (1995). Gainsharing: A critical review and a future research agenda. *Journal of Management*, 21(3), 559-609.
- Wellman, B., Wong, R. Y. L., Tindall, D., & Nazer, N. (1997). A decade of network change: Turnover, persistence and stability in personal communities. *Social networks*, 19(1).
- Wersching, K. (2007). Agglomeration in an innovative and differentiated industry with heterogeneous knowledge spillovers. *Journal of Economic Interaction and Coordination*, 2(1), 1-25.
- Wheeler, L. (2000). Individual Differences in Social Comparison. In J. Suls & L. Wheeler (Eds.), *Handbook of social comparison* (pp. 141-158): Springer US.
- Whetten, D. A. (1989). What constitutes a theoretical contribution? *Academy of Management Review*, 14(4), 490-495.
- Whetten, D. A., Felin, T., & King, B. G. (2009). The practice of theory borrowing in organizational studies: Current issues and future directions. *Journal of Management*.
- White, K., & Lehman, D. R. (2005a). Culture and social comparison seeking: The role of self-motives. *Personality and Social Psychology Bulletin*, 31(2), 232-242.
- White, K., & Lehman, D. R. (2005b). Looking on the bright side: Downward counterfactual thinking in response to negative life events. *Personality and Social Psychology Bulletin*, 31(10), 1413-1424.
- Wilensky, U. 1999. NetLogo. <http://ccl.northwestern.edu/netlogo/>. Center for Connected Learning and Computer-Based Modeling, Northwestern University. Evanston, IL.
- Wilensky, U., & Rand, W. (2007). Making models match: Replicating an agent-based model. *JASSS*, 10(4).

- Wilhite, A. (2001). Bilateral Trade and 'Small-World' Networks. *Computational Economics*, 18(1), 49-64.
- Wilkins, P. L., & Timm, P. R. (1978). Perceived communication inequity: A determinant of job dissatisfaction. *Journal of Management*, 4(1), 107-119.
- Williamson, O. E. (1975). *Markets and Hierarchies: Analysis and Antitrust Implications*.
- Wills, T. A. (1981). Downward comparison principles in social psychology. *Psychol Bull*, 90(2), 245-271.
- Windrum, P., Fagiolo, G., & Moneta, A. (2007). Empirical validation of agent-based models: Alternatives and prospects. *JASSS*, 10(2).
- Wolfram, S. (1984a). Cellular automata as models of complexity. *Nature*, 311(5985).
- Wolfram, S. (1984b). Computer software in science and mathematics. *Sci Am*, 251(3).
- Wolfram, S. (1984c). Universality and complexity in cellular automata. *Physica D*, 10, 1-35.
- Wolfram, S. (1994). *Cellular Automata and Complexity*.
- Wolfram, S. (2002). *A New Kind of Science*.
- Wood, J. V. (1989). Theory and Research Concerning Social Comparisons of Personal Attributes. *Psychol Bull*, 106(2), 231-248.
- Wood, J. V. (1996). What is social comparison and how should we study it? *Personality and Social Psychology Bulletin*, 22(5), 520-537.
- Wood, R. E., Atkins, P. W. B., & Bright, J. E. H. (1999). Bonuses, goals, and instrumentality effects. *Journal of Applied Psychology*, 84(5), 703-720.
- Wood, R. E., Mento, A. J., & Locke, E. A. (1987). Task Complexity as a Moderator of Goal Effects: A Meta-Analysis. *Journal of Applied Psychology*, 72(3), 416-425.
- Wooldridge, M., & Jennings, N. R. (1995a). Agent theories, architectures, and languages: A survey. *Proceedings of the Workshop on Agent Theories*.
- Wooldridge, M., & Jennings, N. R. (1995b). Intelligent agents: Theory and practice. *The Knowledge Engineering Review*, 10(2), 115-152.
- Wright, P. M., & Boswell, W. R. (2002). Desegregating HRM: A review and synthesis of micro and macro human resource management research. *Journal of Management*, 28(3), 247-276.
- Wu, J., Hu, B., Zhang, Y., Spence, C., Hall, S. B., & Carley, K. M. (2009). An agent-based simulation study for exploring organizational adaptation. *Simulation*, 85(6), 397-413.

- Wynter-Palmer, J. E. (2012). Is the Use of Short-Term Incentives Good Organization Strategy? *Compensation & Benefits Review*, 44(5), 254-265.
- Xu, B., Liu, R., & Liu, W. (2014). Individual bias and organizational objectivity: An agent-based simulation. *JASSS*, 17(2).
- Yamanoi, J., & Sayama, H. (2013). Post-merger cultural integration from a social network perspective: a computational modeling approach. *Computational and Mathematical Organization Theory*, 19(4), 516-537. doi: 10.1007/s10588-012-9139-5
- Yang, C., Kurahashi, S., Kurahashi, K., Ono, I., & Terano, T. (2009). Agent-Based simulation on women's role in a family line on civil service examination in Chinese history. *JASSS*, 12(2).
- Young, G. J., Beckman, H., & Baker, E. (2012). Financial incentives, professional values and performance: A study of pay-for-performance in a professional organization. *Journal of Organizational Behavior*, 33(7), 964-983.
- Yulmetyev, R., Khusaenova, E., Yulmetyeva, D., Hänggi, P., Shimojo, S., Watanabe, K., & Bhattacharya, J. (2009). Dynamic effects and information quantifiers of statistical memory of MEG's signals at photosensitive epilepsy. *Math Biosci Eng*, 6(1), 189-206.
- Zhang, T., & Zhang, D. (2007). Agent-based simulation of consumer purchase decision-making and the decoy effect. *Journal of Business Research*, 60(8), 912-922.
- Zhang, Y., & Wu, Y. (2012). How behaviors spread in dynamic social networks. *Computational and Mathematical Organization Theory*, 18(4), 419-444.
- Zhang, Z., & Yang, C. F. (1998). Beyond distributive justice: The reasonableness norm in Chinese reward allocation. *Asian Journal of Social Psychology*, 1(3), 253-269.
- Zingheim, P. K., & Schuster, J. R. (1995). Moving one notch North: Executing the transition to new pay. *Compensation and Benefits Review*, 27, 33-39.
- Zingheim, P. K., & Schuster, J. R. (2007). Measuring and rewarding customer satisfaction, innovation and workforce engagement. *WorldatWork Journal*, 16(4), 08.
- Zingheim, P. K., & Schuster, J. R. (2008). Workforce Retention, Pay and Rewards Practices in Tough-Market Cities: Implications for Public-Sector Organizations. *WorldatWork Journal*, 16-27.
- Zoethout, K., Jager, W., & Molleman, E. (2006). Simulating the emergence of task rotation. *JASSS*, 9(1), 133-147.
- Zukin, S., & DiMaggio, P. J. (1990). Structure of capital. Cambridge, UK: Cambridge University Press, 1(3), 5.