Measuring economic sustainability of nations : Singapore as case study

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Measuring Economic Sustainability of Nations

- Singapore as Case Study

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Summary

Concerns on economic sustainability started in the early 1800's with the Malthusian theory on mankind's possible collapse back to subsistence-level conditions due to population growth outpacing agricultural production. Though subsequent technological progresses have largely debunked this 'doomsday' scenario, the spectra of unsustainable development of modern global economy has gradually been revived in the last few decades; but this time is due to scientifically verified realization that planet Earth is unlikely to be ecologically sustainable in face of the massive depletion of natural resources and the environmental damage brought about by over-zealous and short-sighted economic development. Various piecemeal actions are being undertaken by various nations and international organizations to bring about a more responsible and greener form of sustainable development, with varying degrees of successes.

There is also a growing realization that a holistic approach to sustainable economic development by each nation is necessary to bring underdeveloped nations out of poverty, to maintain sustainable economic growths in developed nations, and at the same time to ensure the global physical sustainability of the Earth in the long run. We termed this as **economic sustainability** and such a holistic approach may be guided by C.Y. Lim's 'Trinity' development theory. There is also the need to develop a holistic **index of economic sustainability** of each nation which also reflects its contribution to global physical sustainability. The development of such an index is the main contribution of this thesis.

An economic system is sustainable in the long term only if it accommodates the production eco-systems of the economy. Over expansion, unbalanced and pre-mature growth of the economy can lead to bottlenecks and structural strains, ultimately decreasing the net prosperity of the people. In the extreme, the eco-systems of production may be irreparably damaged, leading to economic collapse. An intuitive way to study the complex inter-relationships of the production eco-systems is based on the '*EGOIN*' concept in the 'Trinity' development theory, which comes from the first letters of the five main domestic co-determinants of economic development: **E**ntrepreneurship, **G**overnment, **O**rdinary labour, **I**nterest and **N**atural resources. The main outcome of this research is a framework for the computation of the proposed EGOIN Composite Index. The core model of the index is a root-mean-square deviation weighted summation of five component indices for the Entrepreneurship, Government, Ordinary Labor, Investment and Natural Resource eco-systems respectively. The proposed equations allow the weights to be automatically adjusted in favor of any economy whose production eco-systems are developing in balanced tandem and with global sustainability as one of its objective functions. The key variables for each of the five components have been identified and sample data sets have been collected and analyzed. The selected sets of variables are grouped under several main factors for each

component index. The weights for each factor can be found using economic regression analysis. For E, G, O and I eco-systems, the objective functions are more related to economic performance, while that for the N eco-systems is more related to ecological sustainability. The composite index can thus served as an indicator of economic sustainability.

For the E Index, the variables are grouped under the factors of market access, business environment, knowledge capital and entrepreneurial culture. For the G Index, the major factors are under governance institutions, political accountability, corruption freedom, and safety and security. The major factors for the O Index are labor market, education, health and social capital. The major factors for the I Index are domestic savings, foreign direct investments, infrastructural capital and macro-economic environment. For the N index, the variables are environmentally relevant and grouped under water sustainability, environmental pollutants, energy sustainability and climate change, and sustainable consumption.

The EGOIN Composite Index has been computed for a selected group of over 100 countries including Singapore. The results are found to be consistent with generally accepted classifications of nations in terms of their economic sustainability, and with the S-Curve concept and the Triple-C concept of the ‘Trinity’ development theory. While Singapore is currently ranked relatively high according to its EGOIN Composite Index, the study revealed potential weaknesses in its Ordinary Labour (O) and Natural Resources (N) areas which may lower Singapore’s economic sustainability in future and which therefore should deserve careful attention from its policy makers.

The economic sustainability of individual nations collectively affects the global ecological sustainability of whole world. If the global ecology is becoming unsustainable, it would drag down the N (natural resources) indices of all nations, and thus lowering the EGOIN composite indices of most nations. Nations which are most responsible for the deterioration of global ecology would see a larger decrease in their EGOIN composite indices. The EGOIN Composite Index of economic sustainability can serve as a useful tool for policy makers to plan sustainable economic development which is holistic and inclusive of ecological (environmental) sustainability. Having said this, it should also be noted that even if every nation is improving its economic sustainability, it does not necessary imply the ecological sustainability of the entire planet is improving. A more sophisticated dynamic tracking of ecology with time and apportioning of global ‘diswelfare’ may need to be included in the computation of N indices of individual nations.

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Chapter One

Introduction

1.1 Background and Motivation

My country Singapore has long been described as a nation of insecurities, perhaps due to its small physical size, its lack of natural resources and the unfortunate brevity of existence of similar small city states in the history of mankind so far. Ancient Athens was a center for the arts, learning and philosophy; it was the birthplace of Socrates, of Plato and of Aristotle; it was long regarded as the cradle of Western Civilization and the birthplace of democracy; but it lasted only a couple of hundred years. Ancient Rome grew from a city state to one of the finest and largest empires the world has seen, but it too was not sustainable in that form and has since passed into history. Ancient China is still around today in its modern form, but it has been through many cycles of up and down. All these facts have prompted one oft-asked question: Is Singapore sustainable? A more focused version of the question would be: Is the economy of Singapore sustainable?

Sustainability is at times regarded as a rhetorical word and the concept of sustainability can be likened to an iceberg. One needs to delve deeper into it to uncover the really big issues. In the style of Socrates, we raise essential questions which became the doorway to understanding this research topic. These questions are never answered in a single

sentence; rather they raise other important questions. This way, learning is anchored in cycles of questions-answers-questions, such as:

- What is to be sustained? Is this a social-politic or an economic question?
- Why do some nations which were economically strong have since declined?
- Why do some nations remain economically weak after many years of existence?
- Is Singapore an economic success, and if so, is this success sustainable?
- What is sustainable development and how is it defined?
- Is there a limit to growth of each nation or of the entire world?
- How do developed and developing countries compare in terms of their wealth composition?
- What is the difference between economic sustainability and global sustainability, and can such sustainability be measured?

To seek a direction in finding the answers to the above questions, we can examine some of the current and general perspectives. Lexicographically, sustainability may be simply defined as the capacity to endure. In ecology, the word describes how biological systems such as wetlands and rain-forests maintain its diversity and proliferation over time. For humans, sustainability is the potential for long-term maintenance of well being, which has environmental, economic, and social dimensions (Adams, 2006). This is frequently illustrated as three overlapping demands of environment, economy and society, as shown in Figure 1.1.

Figure 1.1: The Three Demands of Sustainability

This is a departure from traditional economic theories which view that the efficient allocation of natural resources is enough for achieving a sustainable development, as long as the former is achievable. For instance, in the so-called Solow Sustainability, it only matters that the stock of capital assets should not decrease in order to achieve a sustainable development. This stock is integrated by manufactured capital, natural capital, human capital, ethical capital and cultural capital. Consequently in the Solow Sustainability, natural capital could be depleted as long as the rents deriving from the sale of these resources would be reinvested in other types of capital. This is certainly not sufficient for the current perspective, which is more ‘Hicksian’ in philosophy: “**The practical purpose of income is to serve as a guide for prudent conduct**” (Hicks, 1946). Though expounded by Hicks some fifty years ago, there is much relevance for today’s concern with ecological sustainability. His economic definition of national income is the maximum amount that a person or a nation could consume over some time period and still be as well off at the end of the period as at the beginning. Sustainability and equity notion is thus embedded in his solutions for poverty.

‘Hicksian Sustainability’ or ‘Hartwick-Solow Sustainability’ is defined in terms of maintaining the total capital stock of society (that is *wealth*). Generally, for underdeveloped economies to metamorphose into emerging economies, the commitment to transfer resources to future generations and preservation of ecosystems and biodiversity are now seen as important requisites for their sustainable development. Sustainability interfaces with economics through the social and ecological consequences of economic activity as illustrated in Figure 1.1. Moving towards sustainability is also a social challenge that entails, among other factors, international and national laws, sustainable urban planning and transport, responsible local and individual lifestyles and ethical consumerism. Ways of living more sustainably can take many forms from reorganizing living conditions (e.g., eco-towns, eco-cities and sustainable cities), reappraising economic sectors (environmental-friendly

manufacturing, sustainable agriculture), or work practices (sustainable architecture, green construction), using science to develop new technologies (green technologies, clean and renewable energy, or new and affordable cost-effective practices) to make adjustments that conserve resources and repair environmental damages.

This is the direction of **Green Economics** – a new but loosely defined theory of economics by which an economy is considered to be component of the global eco-system in which it resides and by which it comprises production eco-systems. The most distinguishing feature of **Green Economics** from more conventional fields of economics is the move towards more direct valuation of natural capital and ecological services as having economic values, and towards a full cost accounting regime in which costs externalized onto society via ecosystems can be reliably traced back to, and accounted for as liabilities of, the entity that does the harm or neglects an asset. Hence **measuring sustainable development** is now a pressing issue. For example, in trying to assess the contribution of good governance to economic sustainability, (examples: accountability, political stability, absence of violence, government effectiveness, regulatory quality, rule of law, and freedom of corruption) there are inherent difficulties in measuring governance using any kind of data. Neither is it easy to measure social capital which is so complex and could cover trust and safety, citizen power and proactivity, participation in the community, network bonding and bridging, perception of the community, diversity, and value of life. This author has thus chosen to contribute with further research on **Measuring the Economic Sustainability of Nations** – with Singapore as a case study. It is hoped that the contributions of this research will go some way to answering the original question: Is Singapore sustainable?

1.2 Research Objectives

The broad objective of the research documented in this thesis is to look into the issues of assessing the economic sustainability of nations. More specifically, the focus of this thesis is on developing a measure of economic sustainability. This was accomplished by the following specific objectives:

- Study of theories of sustainable economic development;
- Study of indicators and measurements of sustainability;
- Development of a more comprehensive measuring tool to assess the sustainable economic development of nations with considerations of ecological sustainability, termed here as an index of economic sustainability;
- Assessment and evaluation of economic, social and environmental factors affecting the economic sustainability of nations;
- Study and synthesis of data for the measurements and assessment of economic sustainability;
- Case studies of selected nations including Singapore to evaluate their economic sustainability;
- Pilot implementation of the proposed index of economic sustainability and assessment on the performance of the index.

It should be noted that this thesis is not a policy paper to recommend new policies.

1.3 Major Contributions of the Thesis

The major and original contributions made by the author may be described as follows:

1. A new comprehensive index of economic sustainability using the EGOIN concept of economic development has been proposed and developed. This new index is named here as the EGOIN Composite Index.
2. The framework for the implementation of EGOIN Composite Index, including the theory, computational methodology, factor analysis, data extraction and synthesis and intended applications has been proposed. The core model of the index is a novel weighted summation of five component indices (E, G, O, I, N) for the Entrepreneurship, Government, Ordinary Labor, Investment and Natural Resource eco-systems respectively. The proposed equations for the weights allow the Composite Index to be automatically adjusted to favor any economy whose production eco-systems are developing in balanced tandem and with global sustainability as one of its objective functions.
3. The key factors and variables for each of the five components have been identified and sample data sets have been collected and analyzed. The selected sets of variables are grouped under each main factor, which in turn are grouped for each component index. The weights for the factors can be found using econometric techniques of regression analysis. For Entrepreneurship, Government, Ordinary Labor, and Investment eco-systems, the objective functions are more related to economic performance, while that for the Natural Resource eco-system is more related to global sustainability. Case studies of data collection and factor analyses on selected group of nations including Singapore have been done.
4. A pilot implementation and validation of the EGOIN Composite Indices for 108 nations has been done. Each nation has its own EGOIN Composite Index.

1.4 Organization of the Thesis

Chapter One provides the background and motivation behind this research project, the overall research objective and specific objectives put forth by the author and the main contributions accomplished by the author. An extensive review on issues in economic and global ecological sustainability and their measurements is presented in Chapter Two. An introduction to the Trinity Development Theory originating from the lifetime work of the author's supervisor (Emeritus Professor Lim Chong Yah) is also given in this chapter. The review in this chapter is important in setting the undertones for the rest of the thesis.

Chapter Three describes the framework proposed by the author for the development of the EGOIN Composite Index as an indicator of economic sustainability of nations. The empirical methodology behind the composite index and the concept of balance development of production eco-systems is described here. The composite index comprises the component indices of the five production eco-systems: Entrepreneurship, Government, Ordinary Labor, Investment and Natural Resource. This chapter documents the innovative essence of the author's research.

Chapter Four presents an extensive discussion on the identification and analysis of the dominant factors for the indices of the production eco-systems. Data sources and data synthesis for the twenty identified factors and their variables are also described. Issues in economic sustainability of Singapore in are discussed here.

The validity and applications of the EGOIN Composite Index and its component indices are presented in Chapter Five. A summary of conclusions from this project is given in Chapter Six together with a list of recommendations on possible future research work to enhance the original contributions achieved so far. The EGOIN Composite Index and the five component indices computed for each of 108 nations are provided in the Appendices for reference.

Chapter Two

Literature Review

2.1 Introduction

Literature review is necessary in any research project to help in the understanding of the issues involved in the research topic. It provides the background knowledge to formulate the research questions and objectives, and guides the research methodology for the project. It focuses the research direction towards a realistic solution to the project objectives.

This literature review on issues of sustainable economic development is presented in three main sections. The first section examines the history and rationale behind the concerns on sustainable development of economies and therefore of mankind's existence. The second section presents the review on C.Y. Lim's 'Trinity' Development Theory, which is a cornerstone of theories on sustainable economic growth. The third section presents the review on definitions, models and indicators of sustainability. The literature review has helped to define what is meant by economic sustainability, to explain why it is so important to understand economic sustainability amid concerns over environmental issues, and why it is necessary to develop an implementable indicator for economic sustainability.

2.2 Concerns on Sustainable Development

There have always been concerns on sustainable development in the history of mankind, but the review here starts from the influential work of Thomas Robert Malthus (1766-1834). With a wealth of literature on this topic, we have arranged them into three sub-sections: the classical and early concerns on economic sustainability, the revival and renewed interest in ecological and economic sustainability sparked off by environmental concerns since the 1970's, and the current directions and actions taken on the need for a comprehensive suite of solutions to save the planet.

2.2.1 The Classical Debate

The original concept of sustainability refers to an equilibrium relation between human activities and their physical surroundings. It has a long tradition going back to the nineteenth century. Malthus (1798) asserted that the global population would be growing at an explosive or exponential rate relative to the food supply which would be growing at the slower arithmetic rate. He arrived at a frightening conclusion: *“Whereas each person had one basket of food at the beginning, two hundred years later, 256 people would have to share nine baskets. Only one hundred years after that, 4,096 people would have to share 13 baskets!”* Malthus suggested that only natural causes, misery, vice and moral restraint could check excessive population growth. However Malthus’ so-called ‘doomsday’ did not happen in the subsequent centuries. His theory has since been largely dismissed because of the prevailing evidence in the power of science and technology to overcome the demands imposed by population growth.

David Ricardo (1817) further opined that continuously increasing output would eventually bring resources of lower-grade into production. With the concomitant threatening population increases, the classical economists pointed out that these resources limits would

lead to the consequent diminishing returns to capital and labor employed in agriculture and lead to long-run economic stagnation. John Stuart Mill (1848) presented a differentiated view by examining beyond the limited availability of agricultural land in search of the value of amenities of nature. He was influential in developing the early form of Green Economics with his concern with the encroachment of the natural world and the destruction of ‘solitude’ from overcrowding.

William Stanley Jevons (1865) shifted focus from food shortage to energy and in particular coal, the main non-renewable energy resource used in production in his days. Jevons proclaimed that ultimately the increased scarcity and cost of coal would lead to economic stagnation in Britain. However again, there were no significant empirical evidence for the dismal conclusion pointing towards imminent population increases and economic stagnation during the later part of the 19th century and the first half of the 20th century. During this period, there was little evidence of natural resources or environmental destruction as limits to growth and so it appeared then that the limits debate was itself not sustainable.

2.2.2 Renewed Interest in Sustainability Issues

The oil crisis of the 1970’s and the simultaneous accelerated population growth in the developing countries saw a revival of interest in Malthus’ theory with the growing consensus that natural resource could limit economic growth, and the need to delve deeper into issues of sustainable development, increasing waste output, and detrimental effects of pollution on the environment. Erik Eckholm (1976) provided concrete examples of serious ecological deterioration that were taking place through deforestation, overgrazing by livestock, soil erosion and abandonment, desertification, silting of irrigation systems and reservoirs. Eckholm conveyed the increased intensity of humanity’s pressure on the limited land and the short-sighted practices like the ever shorter fallow periods for traditional agriculture, and the

use of dung for cooking and not as fertilizer for crops. These were in turn aggravated by the high prices of commercialized fossil fuels, and all of which tended to destroy land resources and decrease future world feeding capacity, increasing the threat of both malnutrition and mental deficiency, and compound poverty.

The limits debate also shifted focus from the economic development in the industrial countries to the developing countries. This contributed to the growing view that sustainable development is a widespread issue for the Third World as well. Many international discussions of sustainable development goes back to the United Nations Conference on the Human Environment, held in Stockholm in 1972, where the notion of sustainable development was put forward as a way of transforming conflicting objectives into complementary aspects of a common goal. Arising from this conference was the Stockholm Declaration (1972), a set of principles that represented the beginning of international dialogue between rich and poor countries regarding the links among economic growth, declines in global common-pool resource systems such as air, water and oceans, and the well-being of people around the world. This is the first document in international environmental law to recognize the right to a healthy environment.

In 1987, the World Commission on Environment and Development published ‘Our Common Future’, more commonly known as the ‘Brundtland Report’ (WCED, 1987). It called upon nations of the world to adopt the objective of sustainable development as the overriding goal and test of national policy and international cooperation. The Brundtland Commission framed the imperatives of sustainable development and focused on the environmental limits as implied by the fundamental changes through which the planet is experiencing. Since the Brundtland Commission report, it has become prevalent to include the concept of ‘interlocking crises’, for example, the notion that the growth of production as measured in national income should also include some social measures.

More than 80 percent of population growth is forecasted to occur in the urban areas of the world's poorest countries. As these people strive for the same standard of living enjoyed by people in rich countries, there is now concern that their industrialization may strain the productive capacity of the world's eco-systems. The Brundtland Commission defined sustainable development as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*". It emphasized that top priority should be given to the essential needs of the world's poorest population and at the same time that there ought to be limits in the exploitation of scarce natural resources and amenities so that the ability of the environment to meet present and future needs is sustainable. Aggravated by poverty and rising population, unsustainable economic development will lead to constrained economic growth and eventually a fall in economic welfare. Sufficient protection of the scarce natural resource base is thus seen as the necessary condition for sustainable growth and development.

Another example of one of the more pessimistic predictions on the world's future comes from the *Club of Rome* - a non-profit, non-governmental organization (NGO) and global think tank. The Club of Rome extrapolated trends and predicted disaster within one hundred years unless preventatives more severe than what Malthus had suggested were taken up. Its study shows that if the present growth trends in world population, industrialization, pollution, food production, and resource depletion continue unchanged, the limits to growth on this planet will be reached sometime within the next hundred years. The most likely outcome may be a rather sudden and uncontrolled decline in both population and industrial capacity. The Club of Rome recommended immediate action to avert a global crisis. Its first major report entitled 'The Limits to Growth' by Meadows (1972) observed that technological progress cannot be expected to ensure sustainable development, including safeguarding resources and protecting the environment without some massive global initiatives that are not

in the horizon. Up to relatively recent times, technology was seen as the solution to transform humanity and nature for the better, to free man from the limitations on his powers that were once accepted as inevitable. If technology is unable to ensure sustainable development, it is questioned in the Meadows Report on how mankind can continue rely on technology when the forces of population growth/demographics and environmental/climate change issues add their demand to the industry.

An updated report by Meadows (1992) entitled “*Beyond the Limits: The 30-Year Update*” revisits the argument that unabated population growth and consumption might outstrip the Earth’s natural capacities. The authors used updated figures and information to restate the original case presented 20 years before. Although *Beyond the Limits* is not hostile to technological solutions, it does argue that technology will not replace the capacities of nature. Using extensive computer models based on population, food production, pollution and other data, the authors demonstrated why the world is in a potentially dangerous ‘overshoot’ situation. Here, the overshoot means people have been steadily using up more of the Earth’s resources without replenishing its supplies. The consequences, according to the authors, may be catastrophic in that a worldwide economic collapse may occur if a severe correction is not made soon. The authors also discussed about measures to avoid overshooting.

The Gaia Movement is an international network of individuals and groups that share a concern for living more sustainably on Earth. The term “Gaia” is derived from Greek mythology which refers to the name of the Goddess of the Earth. Since the 1960s, James Lovelock, an independent ecologist and environmentalist, has used Gaia in his hypothesis that Earth is a super-organism. In his book, *The Revenge of Gaia*, Lovelock (2007) criticized the lack of respect which humans have for Gaia, through the rapacious damage done to rainforests and the reduction in planetary biodiversity. By the middle of the next century, according to Lovelock, most of the earth will be uninhabitable for humans and other beings,

with a massive extension of tropical deserts, as far as into middle Europe. Consequently, Lovelock is neither hopeful about earth's conditions, likely to be wrought with global warming, nor sanguine about human's capability to repair the damage. Evidence on the poor state of health of earth's eco-systems is provided by the Millennium Eco-system Assessment reports contributed by over 1300 experts from over 95 countries (UNEP, 2005). It concluded that 60 per-cent of the eco-system services that support life on Earth – such as fresh water, capture fisheries, air and water regulation, and the regulation of regional climate, natural hazards and pests – are being degraded or used unsustainably.

In the late 1970s, the concept of human needs was popularized as the principal development objective with the re-emergence of a social equity element, under the rubric of sustainable development. Streeten and Burki (1981) noted that the World Bank embraced the concept of basic human needs in 1978 with the aim to achieve it by greatly increasing investment in health, education, nutrition, sanitation, and water supplies. The premise was that the provision of basic human needs and the economic growth are complementary. Just as the protection of natural and environmental resources is a necessary condition for sustained economic growth, especially in poor countries directly reliant on their natural resource base, so is the investment in human resources a necessary condition for strong economic growth.

In the context of environmental decisions, distributive issue clearly does matter. Environmental goods and harms are distributed unevenly across class, ethnicity and gender, within and across national boundaries, within and between generations, and between species. This issue has been addressed within the environmental literature primarily in terms of the concepts of 'sustainable development'. Environmental harms often fall most heavily on the poor (Martinez-Alier, 2002). For example, the construction of dams such as Narmada Dam and the Three Gorges Dam can lead to the impoverishment and social dislocation of communities displaced by flooding. Geoffrey Heal (1998), in his dynamic and practical

economic analysis of the sustainability of the earth's future, viewed the environment as an economic eco-system that should be understood as a part of a nation's wealth and explained how this approach can lead to more conservative patterns of resource use. Heal focused mainly on the inter-temporal resource allocation and equity perspective. His analysis has a different emphasis from the Brundtland report, and his focus widens the subject of sustainable development from merely an issue for poor countries. Bryan Norton (1982) discussed the anthropocentric dimension underpinning sustainable development. He addressed the ethical dimension of sustainable development from the angle of human well-being and how to sustain this well-being over time. Tension occurs when there is competition between the well-being of, or opportunities faced by, current and future people. Recognition of the responsibility that present generations have over the impacts in far-off distant future is seen as the fundamental tenet of sustainable development. On the other hand, Ng Y.K. (2004) argued that the threat to sustainable development comes mainly from current generation's excessive environmental disruption, rather from disregard of the future generation.

Indeed, beyond a mere aggregate supply question, the renewed interest in sustainable development reflects the growing public awareness of the global environmental threats, and of the current era of high cost of fuel, food and raw materials. The message that is being spread is to live within the limits of planet Earth, to reduce conspicuous resource consumption, and to have a gentler ecological footprint per se. Food staples are not the only commodities that have risen sharply in price in recent years. Crude oil prices have increased from under USD25 a barrel in 2002 to over USD147 in July 2008. The world is exposed to more vulnerability which stimulated the limits debate to focus on another emerging global crisis: the rising global food and water shortage, rising energy costs, and battling spiraling inflation especially in the Asian region, amidst the background of a global slowdown.

2.2.3 Current Actions on Sustainability for the Anthropocene

The *Anthropocene* is a geologic chronological term like Jurassic or Cambrian; it was first used quite recently to mark the evidence and extent of human activities that have had a significant global impact on the Earth's eco-systems. However it has yet to be officially accepted by the scientific community and hence it is still regarded as an informal term. It was coined by ecologist Stoermer and then later popularized by Nobel Prize-winner in atmospheric chemistry Crutzen, based on the reasons that the influence of human behavior on the Earth's atmosphere in recent centuries is so significant that it is scientifically necessary to define a new geological era for the earth's crust.

With the gradual recognition that mankind's economic progress has led to a gradually unsustainable earth if the current economic directions persist, there have been actions taken towards a more anthropocentric form of economic management. Back in the 1870s, Jevons argued without much success that decennial variation in the intensity of solar radiation had a major impact on agricultural harvests and the durations of the business cycles. Although Jevons' evidence was weak, Maddison (2007) acknowledged that Jevons provided an interesting precursor of the recent debate on global warming. From such debates and growing awareness of environmental sustainability issues, there have been localized and global actions taken to reduce or even reverse the damage done to the environment. The 1987 Montreal Protocol has been successful in bringing a substantial reduction in chlorofluorocarbons (CFC) which depleted the ozone layer in the stratosphere (Stern, 2006). The environmental consequence of stratospheric ozone depletion would have led to an increase in ultra-violet radiation at the earth's surface, resulting in an increase in skin cancer and other impacts such as damage to crops and to marine plankton eco-system. Tax incentives to reduce use of leaded gasoline have also had a large degree of success internationally. Lead pollution from engine exhaust dispersed into the air and into the vicinity of roads would have led to medical

conditions such as low IQ and antisocial behavior in human beings. The apparent success in countering ozone depletion and lead pollution can be partly attributed to strong governmental support and action in many nations, although credit should also be given to the public opinion and awareness generated by scientific and academic communities and non-governmental organizations.

In 1992, a document entitled “*World Scientists’ Warning to Humanity*” (UCSUSA, 1992) was signed by about 1,700 of the world’s leading scientists from more than 70 countries, including the majority of Nobel laureates in the sciences. Basically, the document states that human beings and the natural world are on a collision course. Human activities have been inflicting harsh and often irreversible damage on the environment and on critical resources. If nothing is done about this, whole human society and the plant and animal ecosystems may eventually be so altered that it may be unable to sustain life in the manner that we are now accustomed to. Fundamental changes are urgently needed to avoid the collision course and some of their specific recommendations include moving away from fossil fuels to more benign and renewable energy sources to cut greenhouse gas emissions, and reducing the pollution of the water and the atmosphere. Stabilizing the population size is also essential. However it is also important that these measures are well thought through and backed by scientific data and analyses. We should guard against irrational hysteria and fears generated by pseudo-scientific arguments or false and non-relevant data. The latter is the essence of another appeal by again another large group of prominent scientists, known as the Heidelberg Appeal, also in 1992. This appeal states that while the signatories fully subscribe to the objectives of a scientific ecology for a universe whose resources must be taken stock of, monitored and preserved, the true culprits are ignorance and oppression, and not science, technology and industry.

The Intergovernmental Panel on Climate Change (IPCC) is a scientific intergovernmental body tasked with reviewing and assessing the most recent scientific, technical and socio-economic information produced worldwide relevant to the understanding of climate change. It provides the world with a clear scientific view on the current state of climate change and its potential environmental and socio-economic consequences, notably the risk of climate change caused by human activity. The panel was first established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP), two organizations of the United Nations. A main activity of the IPCC is publishing special reports on topics relevant to the implementation of the UN Framework Convention on Climate Change (UNFCCC), an international treaty that acknowledges the possibility of harmful climate change. Implementation of the UNFCCC led eventually to the Kyoto Protocol, which came into force in 2005, aiming at coordinating global action to deal with global warming arising from greenhouse gases emission. The Kyoto Protocol has been ratified by more than 190 countries which fall into two groups. The first group of mainly advanced capitalist countries of the OECD (except the US) and the former communist countries of the Soviet bloc made a collective commitment to cut their emissions of six key greenhouse gases (GHG) by about 5.2 per cent of their 1990 levels by 2012. The benchmark 1990 emission levels adopted by UNFCCC were the values deemed to have global warming potential calculated for the IPCC Second Assessment Report. The second group comprises the lower income countries, including China and India, which have no commitment of this kind. The intention is to reduce the Kyoto commitments at unspecified intervals in the future. An emissions trading scheme established by the EU countries permits participants to buy and sell emission reduction credits; a Clean Development Mechanism (CDM) enables the advanced countries to finance emissions reduction projects in developing countries and

receive credit for doing so. However it is unclear at this stage if the implementation of Kyoto protocol has significantly helped to reduce global GHG emissions.

The IPCC produced a detailed examination of the driving forces likely to induce global warming in its *Special Report on Emissions Scenarios* (IPCC, 2000). It examines the prospects over successive decades from 1990-2100 and presented 40 assessments or ‘storylines and scenarios’ after considering influences such as the population growth, per capita GDP and GDP growth, changes in the intensity of energy consumption per head of population and GDP, changes in the composition of energy used, emissions of ten types of greenhouse gases, and the cumulative increase of carbon dioxide, which by far is the most important. The IPCC foresees two types of impact from global warming: changes which are considered more or less certain and predictable within their 110-year time frame and potential impacts over a longer period which are less certain and could trigger irreversible disruptions in the world climate system (IPCC, 2000, 2001a and 2001b). In this regard, the world will not succeed in its efforts to mitigate global warming if the bigger, faster-growing economies do not take part. As a result, China, India, and their peers are under pressure to commit to cut emissions by a given percentage by 2050. The then Indian Prime Minister Dr. Manmohan Singh has stated that India would be willing to undertake to keep its per capita emissions below those of industrialized countries thus giving the latter a strong incentive to reduce their emissions as quickly as possible. (Commission on Growth and Development, 2008)

On a broader scale, there is the Earth Charter initiative which was created by the Earth Council and Green Cross International in 1994, and an Earth Charter Commission was formed in 1997 to oversee the drafting of a revised Earth Charter. The 2000 Earth Charter has 16 main principles, various supporting principles, and a conclusion. The principles are divided into four parts: (1) respect and care for the community of life; (2) ecological integrity; (3) social and economic justice; and (4) democracy, nonviolence, and peace. The

Charter has been formally endorsed by organizations representing millions of people, including the UNESCO, over 250 universities around the world, the International Union for Conservation of Nature and Natural Resources (IUCN), the Indian National Capital Territory of Delhi, the 2001 U.S. Conference of Mayors, and dozens of youth organizations. Such initiatives clearly lack concrete affirmative action, especially on the part of the governments. However they do help to focus attention on sustainability issues and galvanize personnel in both governmental and non-governmental organizations to consider sustainability issues in any future decisions and policies.

In a similar vein as the Earth Charter initiative, the World Summit for Social Development in 1995 produced a declaration and program of action that addressed defining and articulating a vision of sustainable development. It articulated a deep conviction that economic development, social development, and environmental protection are interdependent and mutually reinforcing components of sustainable development, which is the framework for efforts to achieve a higher quality of life for all people. It argued that equitable social development recognizes that empowering the poor to utilize environmental resources sustainably is a necessary foundation for sustainable development. Broad-based and sustained economic growth in the context of sustainable development is necessary to sustain social development and social justice.

In May 2008, the Commission on Growth and Development releases *The Growth Report: Strategies for Sustained Growth and Inclusive Development*. According to the Commission, fast sustained growth is not a miracle. Nobel economist Michael Spence, who chairs the Commission, explained how developing countries can attain fast sustained and equitable growth with the ‘right mix of ingredients’. For example, the report noted that successful cases are characterized by an ‘increasingly capable, credible, and committed government’ and ‘strong political leadership’. To sum up, the report asserted that countries

need leaders who are committed to achieving growth and who can take advantage of opportunities from the global economy. These leaders also need to know about the levels of incentives and public investments that are necessary for private investment to take off and ensure the long-term diversification of the economy and its integration in the global economy. Furthermore, in citing from Angus Maddison (2003) century-millennium data as reproduced in Figure 2.1, Spence presented the ‘renaissance of the world economy’ by explaining the uptick in world growth since the latter half of the 20th century as appearing quite sustainable. In other words, economic sustainability and global physical sustainability need not be mutually exclusive. This vision of sustainable growth resonates with the theory of development and underdevelopment economics of Singapore’s economist Lim Chong Yah, who is of the view that the solutions to sustainable development are often country-specific and economy-specific. In general, for slow growth economies to evolve into fast growth economies the following conditions are often necessary and which will be elaborated in details in Section 2.3:

- (1) Good knowledge transfer system;
- (2) Outward-looking, market-oriented economic policy and practice;
- (3) Development-oriented government and bureaucracy;
- (4) Sustained and sustainable family planning system;
- (5) Sound savings and investment system; and
- (6) Proper and fuller utilization of natural resources.

An example of a sustainable growth approach to solving natural resource sustainability is Singapore’s journey for its own water sufficiency. Water is one of the most precious natural resources as human life depends on it. Unfortunately, water-related diseases are a growing human tragedy, killing more than 5 million people each year - 10 times the number killed in wars. About 2.3 billion people suffer from diseases linked to dirty water (UNESCO, 2003). In Singapore, efforts into sustainable water development have been taken very seriously in a holistic manner, which has the challenging environment of a densely

populated island. This has since paid off tremendously, as the water supply and sanitation in Singapore is characterized by a number of achievements. Its access to water is now universal, affordable, efficient and of high quality. Using breakthroughs in membrane technology, and the work of Water Prize winner Andrew Benedek, Singapore was able to make use of technology like Newater (a water recycling process) and desalination to diversify its water sources. Innovative integrated water management approaches such as the reuse of reclaimed water, the establishment of protected areas in urban rainwater catchments and the use of estuaries as freshwater reservoirs have been introduced along with seawater desalination in order to reduce the country's dependence on imported water. In 2007, Singapore's water and sanitation utility, the Public Utilities Board, received the Stockholm Industry Water Award for its holistic approach to water resources management. This new found capability in sustainable water management has also become an export industry for Singapore as well as an inspiration to other nations.

Source: Angus Maddison (2003) *The World Economy*

Figure 2.1: Evolution of Global and Per Capita GDP in the Last 2000 Years

2.3 The ‘Trinity’ Development Model

The ‘Trinity’ Development Model was originally formulated to explain why in spite of the impressive and unprecedented economic progress in the twentieth century, the world is

still characterized by a wide disparity between the developed and underdeveloped nations (Lim C.Y., 2009). Three questions on sustainability, and development and underdevelopment have persistently challenged the minds of the growth and development economists. The first question is on why there are still so many poor countries which do not seem to get out of their poverty traps. The second question focuses on why there are some countries which are able to successfully break away from the extreme poverty circles and then went on to enjoy superlative economic growth rates. The third question is on why the economic growth rates of some affluent and matured nations gradually become slower. In other words, are high growth rates sustainable in the long run? Is it inevitable that once-affluent nations will eventually slow down or even become lower in economic ranking relative to newly affluent nations? The ‘Trinity’ Development Model basically has three parts: the EGOIN Theory, the Triple-C Theory and the S-Curve Theory. The subsequent sections will introduce each of the component theories in details.

2.3.1 The *EGOIN* Theory

The acronym *EGOIN* comes from the first letters of the five domestic co-determinants of economic development: **E**ntrepreneurship, **G**overnment, **O**rdinary labour, **I**nterest and **N**atural resources. This theory approaches the analysis of economic development of any nation largely from the human perspective. It emphasises the hypothesis that the economic development of a nation is a phenomenon largely determined by human aptitude, attitude and activities. Any differences in the quality and orientation of their human resources form the basis for the differences in the rate and level of economic development among nations. It will also be helpful to explain the local economic sustainability of a nation.

Entrepreneurship, Government and Ordinary labour (the *E*, *G* and *O*) are considered as active agents of growth. *EGO* is also the social capacity of an economy to accumulate and

utilize the available man-built physical and natural resources (i.e. the *I* and *N*). The theory puts human factors on the centre-stage and the aptitude and attitude of the government and its accompanying bureaucracy as the most important co-determinant of development. Two key features differentiate the *EGOIN* Theory from many other development theories. Firstly, the *EGOIN* Theory is multi-faceted. Secondly, it emphasizes on the human determinants of development, in particular the quality of the government and its bureaucracy. The multi-causality of the *EGOIN* and its focus on government provide a higher degree of realism to the theory.

2.3.1.1 The *EGO*, the *I* and the *N*

To explain the *EGOIN* model, we begin by making the distinction between income-producing wealth and non-income-producing wealth. These together refer to the potential wealth and hence provide an indication of the income that may be created. Income-producing wealth, denoted by the letter *W*, may also be called income-generating assets or capital at a point in time, and it is the stock of these assets that determines the level of income generated which we shall denote with the letter *Y*. This relationship may be stated in equation form as:

$$Y = f(W) \quad \text{where } f'(W) > 0 \quad (2.1)$$

Whilst the objective of development is to increase *Y*, the strategy of economic development would be to enlarge *W*, the income-producing wealth. It is the differences in *W* that largely explain the differences in *Y* temporally within a nation and internationally between nations. *W* can be subdivided into three parts:

$$W = W_H + W_I + W_N \quad (2.2)$$

where W_H refers to the income-producing human wealth, W_I is the income-producing physical infrastructure, and W_N is the income-producing natural resource. This approach may thus also be referred to as man-and-his-environment approach: W_H refers to man, W_I refers

to his built-up physical environment and W_N his utilized natural environment. ΔW_I in this theory is approximately the savings (S) in the Harrod-Domar model, but it is different from S in that it deals with investment and the consequent need for the other concomitant determinants, particularly W_H . Actual foreign investment and aid are included in W_I . The role of technology is embodied in all three components.

The three component parts of income-producing wealth are however not independent of one another. The stock of human wealth W_H is intrinsically dependent on the stock of physical infrastructure W_I and on the income-producing nature resource W_N . Likewise, W_I depends intrinsically on W_H and W_N just as W_N is intrinsically tied to W_H and W_I . Careful consideration of the nature of the relationship between the three constituent parts however suggests the relationship to be an asymmetric one. The stock of human wealth depends on the other two components only to the extent that the productivity of man is affected by his environment. The stock of income-producing physical infrastructure W_I on the other hand is the creation of human beings and is the embodiment of past human effort. It is produced by means of production with the level of technology frozen or embedded in it. Similarly, W_N refers to utilization of nature by man. Even W_N has technology embedded in it, e.g. genetically modified crops and new ways of mining shale oil.

2.3.1.2 The Components of W_H - *EGO*

To emphasize the crucial role played by the human agents, W_H is further subdivided into three integral parts, namely W_{HO} referring to ordinary labour, W_{HE} referring to special labour or entrepreneurship, and W_{HG} symbolizing another category of special labour: the government. They constitute the deciding trinity: three in one and one in three. Their

relationship is symbiotic: the tripartite symbiotism. W_{HO} includes management and co-ordination. W_{HE} refers to the economic leadership and W_{HG} the political leadership. The distinction between the two is between economics and politics. The separation is mainly for emphasis. Both W_{HE} and W_{HG} are characterised by leadership, forging new paths and leading the society, whereas W_{HO} handles the essential routine functioning of the economic system.

The word government is used here in a wide sense to refer to all persons who play an important role in shaping the public opinion and public policy of the country, not just to members of a political party or Government, which is undoubtedly by far the most important component, but not the only component in this category. W_{HG} in fact refers to all having influence in public opinion, including media and religious leaders. W_{HE} refers not just to private entrepreneurship as in the Schumpeterian theory of development but also to public entrepreneurship. Unlike the functions of Government, which are political in nature, politics here being defined in a wider sense, the functions of the entrepreneurs are economic in nature, be they in the public or private sector.

The entrepreneurial functions are adaptations and innovations in the economic sphere. These adaptations and innovations include the introduction and spread of new and better method of production, the finding of a new market, the discovery of new sources of material supply, new methods of organisation and mobilisation of resources and the introduction and spread of new products. Basically, these are also the functions of the Schumpeterian entrepreneurs. The main difference is that the EGOIN theory has extended the Schumpeterian entrepreneurship to the public sector. It has also included agricultural and other entrepreneurs, not just industrial and commercial as Schumpeter did.

The income-producing human wealth W_H can thus be written as:

$$W_H = W_{HE} + W_{HG} + W_{HO} \quad (2.3)$$

Together, W_{HE} , W_{HG} and W_{HO} constitute the national human *EGO* of the society. This national *EGO* is a product not just of the type and quality of education, but also that of history, culture and geographical environment. Together, they reflect and decide the value system and achievement orientation. *E* and *O* are the economic variables and *G* the non-economic, which is the political entity from which the economic entity is derived. *G* is also the policy options of the Government and the economic and political system. Policy options would include the monetary policy and system, the wage policy and system, savings policy, exchange rate policy, the extent of reliance on market forces, the degree of export-orientation and reliance on foreign entrepreneurship and foreign aid and all other important policies which are normally decided by a Government from time to time. Of supreme importance in the orientation of *G* in economic development is to have a competitive economy for goods and factors and due respect for the laws of supply and demand.

2.3.1.3 The Complete *EGOIN* Theory

If we now relate Equation (2.3) to Equations (2.1) and (2.2), we arrive at the relationship:

$$Y = f(W_{HE}, W_{HG}, W_{HO}, W_I, W_N) \quad (2.4)$$

The challenge in developing equation (2.4) into a model would be to find the measures and indicators for the three human determinants W_{HE} , W_{HG} , W_{HO} , and two non-human or physical environment determinants W_I and W_N . Each determinant may be further broken down into several quantifiable variables. Determining the weights for the variables would be another challenge.

If one wants to know the difference in the volume of income between country A and country B, or between two periods in the same country A, one needs to look at the differences in the five development determinants, W_{HE} , W_{HG} , W_{HO} , W_I and W_N . The first three human determinants are relatively more active than the last two passive physical determinants. Indeed, E , G and O are proactive, while I and N are reactive determinants. If EGO is passive and reactive, the result is likely to be economic stagnation. At any given point of time, if the two physical determinants W_I and W_N are given, then the level of development by the active determinants W_{HE} , W_{HG} , W_{HO} determine the level of development of the country, and at the same time they are constrained by W_I and W_N .

2.3.2 The Triple-C Theory

Although not clearly stated, the EGOIN Theory does not highlight the international dimension in the development process. The Triple-C Theory, as part of the ‘Trinity’ Development Model, brings forth the regional and global dimensions to the centre stage. Growth, according to the Triple-C Theory, is propelled by three engines: the domestic engine, the regional engine and the global engine. No nation in the modern world is an island unto itself. Even the biggest nation in the world, China (by population size) has to trade with the outside world and would like to benefit from the discoveries, inventions, innovations, technologies, and investments from the outside world. The **circular and cumulative causation** theory, which forms the basis of the Triple-C Theory, postulates that wealth tends to create wealth and poverty tends to accentuate poverty. The causation is circular, because investment creates income, the extent of which depends on the marginal propensity to consume, but the rise of income and expenditure itself will generate more investment. In other words, the multiplier and accelerator interact on each other in the development process,

and this process can be upward or downward. The process is not uni-directional, and the cause and effect are mutually interactive.

Besides, as pointed out earlier, the cumulative causation theory has its regional and global aspects. Wealth in a centre can spread to other growth centres within a country. The spread can also be across borders. When demand from Japan or US increases, the exporters to these countries enjoy the spill of wealth from these developed countries. Similarly, recession can spread from country to country and from region to region. An illustration of circular cumulative causation is that the economic ascendancy of China has clearly benefited Southeast Asia in one way or the other. Similarly, the development of Cambodia and Laos may be given a boost by the rapidly growing Vietnam and Thailand through economic linkages. When there are barriers to trade, to the flow of information and knowledge and when there are barriers to the flow of investment (or capital), wealth from one centre cannot flow to another centre easily. In other words, a purely autarkic country is also immune to the spread of recession as well as affluence. This explains the economic backwardness of North Korea, despite the affluence of South Korea. The 38th parallel is not just a demarcation line, but also an impenetrable barrier for factor flow and the flow of goods and services. Studies have also shown that the openness of an economy is closely correlated with the per capita income of the country.

Figure 2.2 shows the concept of Triple-C applied in this economic development process. The abilities to tap into the domestic, regional and international engines of growth are depicted as circular steady-state trajectories. To benefit from a larger engine of growth (e.g, regional) while the nation is still largely confined to the orbit of a smaller engine (e.g, domestic), the nation has to move into a transitional trajectory shown as an elliptical orbit. In this way, it can tap into the strength of the larger engine to eventually grow to orbit the regional trajectory circularly in the steady-state. This process may take ten years or more.

Similarly a nation which has matured to be able to harness the power of both the domestic and regional engines, can now start to go into a transitional trajectory to tap the international engine.

Hence of the three engines of growth, the domestic engine is still the most important. If the domestic engine dysfunctions, the country remains poor, as wealth or affluence cannot be spread from the region or the world, and the domestic engine is a function of its EGOIN. One cannot depend solely and mainly on external forces, including external aid, to initiate and sustain the growth and development process. Trading an economy out of poverty is by no means without merit as an advocacy, especially when trade is defined to include trade in services, such as international tourism.

Figure 2.2: The Triple-C Theory Applied to Economic Development

2.3.3 The S-Curve Theory

Figure 2.3: Illustration of the S-Curve Theory of Economic Development of Nations

The S-Curve theory basically classifies the world's economies into three broad groups: one, the low-income with low growth rate group; two, the middle income with high growth rate; and three, the high income but low growth rate group. These three groups are also figuratively termed respectively as the 'turtle', the 'horse' and the 'elephant' economies (Lim C Y, 2004). The main criterion of classification is the growth rate. The growth rate trend considered should be consistent and long term in nature, at least over a decade. A nation may undergo economic transition through all three groups; and if it does so, its three stages of growth and development roughly correspond to pre-industrial, industrializing and post-industrial economies or societies respectively. Figure 2.3 illustrates the per capita income of Singapore through the decades which seemingly traces out the S-shape profile. Table 2.1 (Lim C.Y., 2009) categorizes selected economies in the world into the three broad groups: turtles, horses and elephants. It shows the income level, the 10-year average growth rate before and after Asian Financial Crisis of these economies, and the gross fixed capital formation.

Nations in the first group suffer from both low income and low growth rates. They are in a low-*EGOIN* equilibrium trap. They are poor nations to start off with. They have thus not much to spare to invest in economic infrastructure, or in social infrastructure. Neither have

they achieved and accumulated much in capital stock (W_I) and human capital (W_O) to begin with. More often than not, they also do not have good, able and development-oriented Government (G). If they also do not pursue a market-oriented economy (poor E), and do not utilize their natural resources or have no natural resources (N), they continue to be poor economically. The odds are very much against them. Some of them may succeed in eventually having a higher per capita income growth rate but when this is not complemented with proper family planning, the only tangible success they have may be higher population growth rate and more people. The quality of life of their citizens may thus remain low.

For countries in the second group, their speed of growth is much faster in terms of per capita income. They have high savings and high investment rates, often supplemented by more investment from abroad. They are also most likely to practice family planning. China, for example, goes as far as to implement a one-child family system for the majority of its population. This reflects the high priority they place on economic welfare and economic well-being. China is prepared to discard or drastically modify their command economy for a market-oriented, forward-looking economy. Entrepreneurship (E) in China was not there under the erstwhile communist dictatorship. It has however since 1979 emerged and is still emerging after the Chinese Government adopted a “perestroika” open door policy. When they have a market-oriented policy, they are also likely to develop a high degree of international trade orientation, and the transfer of knowledge and technology from the developed countries. Vietnam too has emerged on this growth and development path since the opening up of the country in 1986. The Vietnamese calls their perestroika “Doi Moi”.

In the third group, the economies suffer from high-level equilibrium trap. The basic difference between the first and third groups lies in their per capita *EGOIN* or its resultant income. Their similarity lies in their low rates of per capita income growth. These mature economies tend to have high levels of consumption. Their saving rates and investment rates

are low and hence their growth rates are expected to be low. Their birth rates are low, because the opportunity costs of raising a family become much higher. Family formation is thus less emphasized than the quality of life of the present generation. They have an increasing proportion of their people belonging to the old-age groups. Their government development expenditure is also low in relation to their GDP. This, in a way, reflects the already higher state of capital formation and infrastructure development in these economies. With their physical infrastructure already built up and capital stock accumulated, the developed economies would find it more difficult to achieve further impressive physical capital development. Diminishing returns can set in easily. In addition, the rising labour cost and land cost in the mature economies also work in favour of the flow of investment to the developing countries that are capable of absorbing the investment inflow.

The horse economies, having a lower per capita income, can benefit enormously from the transfer of technology, organizations and the production processes from the developed economies. The transfer is a quantum leap. The scope for such quantum-leap transfers is much less among elephant economies. However, elephant economies do not stagnate or decline as prognosticated by Adam Smith, Karl Marx, Joseph Schumpeter and John Maynard Keynes. Because of new technological inventions and institutional development, they only display slower but not zero growth. The one-time widely held stagnation thesis does not hold water. The dismal science is not that dismal after all. Whether in the very long-run there will be growth in the present elephants depends very much on their future *EGOIN* and the inter-connectivity factor, particularly in the rate of advance in technological knowledge in the world and in their will for more economic affluence. The distant horizons appear unlimited. The spread of prosperity too appears unlimited, and in Southeast Asia in recent decades, certainly accelerated.

Table 2.1: Income, Growth Rates and Gross Fixed Capital Formation of Selected Nations

Countries	GNI per capita (2007)		ΔGDP per capita (%) (Growth Rate)			Gross Fixed Capital Formation (% of GDP)		
	Atlas (US\$)	PPP (Int \$)	1988-1997	1998-2007	1988-2007	1988-1997	1998-2007	1988-2007
Low income, low growth rate group (the ‘turtles’)								
Bangladesh	470	1,340	2.0	3.7	2.8	18	23	21
Haiti	560	1,310	-3.4	-0.9	-2.1	14	27	20
Madagascar	320	920	-1.4	0.9	-0.3	12	20	16
Malawi	250	750	1.2	0.1	0.7	17	17	17
Rwanda	320	860	1.2	2.4	1.8	14	19	17
Sierra Leone	260	660	-5.1	4.3	-0.4	8	11	9
Zambia	800	1,220	-1.8	1.9	0.1	11	20	15
Low income, high growth rate group (the ‘horses’)								
Cambodia	540	1,690	3.7	7.3	6.3	11	17	14
China	2,360	5,370	8.6	8.8	8.7	32	37	35
India	950	2,740	3.8	5.5	4.7	23	27	25
Indonesia	1,650	3,580	5.9	1.5	3.7	27	22	25
Malaysia	6,540	13,570	6.4	2.0	4.2	37	23	30
Thailand	3,400	7,880	7.2	2.6	4.9	38	25	32
Vietnam	790	2,550	5.5	5.9	5.7	23	31	28
High income, low growth rate group (the ‘elephants’)								
Canada	39,420	35,310	1.0	2.3	1.7	20	20	20
Denmark	54,910	36,300	1.7	1.7	1.7	19	20	19
France	38,500	33,600	1.6	1.7	1.7	20	19	19
Germany	38,860	33,530	2.1	1.5	1.8	22	19	21
Japan	37,670	34,600	2.6	1.0	1.8	30	24	27
New Zealand	28,780	26,340	0.8	1.9	1.3	20	22	21
Singapore	32,470	48,520	5.8	3.4	4.6	35	27	31

Source: Lim C.Y., 2009

2.4 Definitions, Models and Indicators of Sustainability

The review so far has pointed to the need to understand the complex issues behind the sustainability of economic development of individual nations and of the global world. It is thus important to have clarity on the definitions, models and indicators of sustainability.

2.4.1 Strong and Weak Sustainability

This section reviews an important issue in the current perspective on sustainability: what does any particular organization really mean when it states a stand to support sustainability? Generally, there is a current consensus to classify sustainability into two broad categories: strong sustainability and weak sustainability. Daly and Cobb (1989), using Aristotle's (384BC-322BC) distinction between *chrematistics* and *oikonomia*, explained this difference. *Chrematistics* can be thought of as the process of managing economic affairs in such a way as to maximize the monetary value of the decision maker's financial wealth. *Oikonomia* refers to household management, which in Greek times included a broad array of activities, a relatively larger number of people than we associate with modern *oikonomia* households, and elements of a multigenerational perspective. Daly and Cobb argued that *oikonomia* differs from *chrematistics* in that: (1) it takes a longer-term view; (2) it focuses attention on the well-being of the household community as opposed to a more individualistic perspective on financial wealth accumulation; and (3) it places a larger emphasis on use value, whereas *chrematistics* is more narrowly focused on money exchange values. While the prevailing economic focus on financial wealth is embodied in *chrematistics*, which is more to do with weak and local sustainability, the concept of *oikonomia* emphasizes the broader focus and longer time horizon that is more consistent with the sustainable development perspective, which has elements of global and strong ecological sustainability.

With the multiple (often ambiguous) definitions of sustainable development, it will be difficult to pinpoint a specific definition that can simultaneously satisfy economists, sociologists, ecologists, philosophers and policy makers. Hence analysts generally agree that the problem is in deciding: what is it that ought to be sustained? Ecologists and natural scientists will respond that it is the capacity of the eco-system that needs to be sustained. Natural resource that is critical for survival, for example, the ozone layer, is considered irreplaceable (strong sustainability). A world economy that depletes the ozone layer cannot be regarded as sustainable development. In his 1939 definition of income, Sir John Richard Hicks (1904-1989) commented: “the practical purpose of income is to serve as a guide for prudent conduct” and this comment has particular relevance for today’s concern with ecological sustainability (Hicks, 1946).

An economic definition of national income is the maximum amount that a person or a nation could consume over some time period and still be as well off at the end of the period as at the beginning. Thus income is maximum sustainable consumption. Sustaining consumption over a given period depends on maintaining the productive potential of the capital stocks that are needed to generate the flow of goods and services that are consumed. This gives rise to ‘Hicksian sustainability’, or non-decreasing consumption which is equivalent to ‘Hartwick-Solow sustainability’ (John Hartwick, 1977) defined in terms of maintaining the total capital stock or wealth of society. Economists are concerned with ‘Hicksian welfare’, the maximum amount of welfare or well-being that a nation can enjoy over some time period and still be as well off at the end of the period as at the beginning.

Hence there is a conceptual link between sustainability, wealth or capital and well-being. Following the lead of the Brundtland Commission report, the issue was put forth by economists such as David Pearce who argued that sustainable well-being is possible if the next generation inherits “*a stock of wealth...no less than the stock inherited by the previous*

generation”. If sustainability means leaving future generations with at least as many opportunities as we have today, then the economists’ suggestion to achieve this is by passing on to future generations a level of capital assets or wealth or social welfare that is at least as high as ours today (Pearce, 1989).

2.4.2 The Need for Sustainability Indicators

How do policy makers know if the country is on a sustainable economic development path? If the eloquence of policy speakers committed to the goal of sustainable development is to be judged based on real performance, then there must be indicators or some quantitative measures that we can use to monitor and interpret sustainable development. Without indicators, the rhetoric of achieving sustainable development risk withering into empty promises. In this regard, substantial literature which documents the progress in measuring sustainable development has been generated. Broadly speaking, they fall into two categories. First, there is the ‘green national accounting’ approaches which seek to adjust the existing economic or national accounts to better reflect resource depletion and environmental degradation. These are generally aligned with the weak sustainability rule. Second, there are approaches that have sought to construct physical environmental indicators of sustainable development, sometimes highly aggregated indicators, and these tend to fall within the strong sustainability rule (Neumayer, 2003).

Historically the main purpose for the system of national income accounting (SNA) is for short- and medium-terms macroeconomic policy and aggregate demand management. Traditional accounts are well suited for measuring macroeconomic activity defined as the market value of all the goods and services bought by consumers, firms, or government agencies, those invested to enhance production by firms and other enterprises, and those involved in net exports (export minus import expenditures) each year in a particular domestic

economy (UN, 1993). The gross domestic product (GDP), which is the central element of the SNA, can grow over time owing to a general increase in prices (inflation) or to an increase in the productive capacity of labor and capital in the economy, or a combination of both. When one removes the component of GDP increase that is due to inflation, one is left with *real* GDP growth, or GDP growth attributable only to increases in the quantity and quality of goods and services produced. *Economic growth* is growth in real GDP. Real GDP divided by population is per capita real GDP, or the average person's share of real GDP in the economy. To policymakers, the key macroeconomic policy goal is to promote the highest growth rate for real per capita GDP that is consistent with a low inflation. GDP has been very satisfactory for short- and medium-terms macroeconomic policy (fiscal and monetary policies), hence the positive experience with traditional SNAs.

Recent debates on environment and sustainability have highlighted two main criticisms on traditional national income (and product) accounts. The first criticism is that traditional accounts include certain expenditure which mitigates environmental impacts occurring during production that do not contribute directly to income and welfare. Such mitigating expenditures should be treated as expenditures on intermediate (not final) goods and services. This inclusion of intermediate expenditures in national accounts gives rise to inaccurate over-assessment of true income and welfare. The second criticism is the questionable exclusion of natural and environmental resources depletion in traditional accounts.

There has also been the recognition that above a threshold, GDP growth does not correlate well with changes in national well-being. In general, the concern for human well-being, environment, and macroeconomic sustainability has raised strong objections to traditional national accounting as a measure of changes in national well-being. There are other criticisms apart from the two abovementioned criticisms: for example, GDP fails to

account for how increases in output are distributed within the community and also fails to account for the contribution of social capital. Hence, the need to find a way to adjust GDP to provide more accurately the measure of human well-being over time and space has been highlighted in recent years.

2.4.3 System of Integrated Environmental and Economic Accounting

A more consistent and accurate treatment of environmental defensive expenditures and of depletion of natural capital is required which led the United Nations Statistical Office to publish in 1993 the revised SNA guidelines for integrating environmental and economic accounts. The new guidelines, known as the United Nations System of (integrated) Environmental and Economic Accounts (SEEA), are not meant to replace SNA but as an augmentation to ‘green’ the accounts (UN, 2003).

Although, there is general consensus that development cannot be sustainable if policy makers continue to rely on the narrow concept of GDP, the positive and very practical experience with traditional SNAs however suggests that we should not be over zealous in adopting a complete replacement for GDP. So the quest to measure sustainable development has still focused largely on SNA. Hence in line with the more conservative view, the SEEA uses satellite accounts for environmental entries in order that core accounts can maintain their integrity and their traditional role in macroeconomic management. The accounting framework includes asset accounts (natural resources balances), flow accounts for materials, energy and pollution, environmental protection expenditures and green alternatives to GDP.

In terms of uptake across countries, the SEEA appears to have been a qualified success. A number of countries has experimented and implemented a wide range of accounting activities based on SEEA framework (Glen-Marie Lang, 2007). This is a welcome development when compared to past experiences, where many end-users were not consulted

back then, hence green accounting activities were viewed with suspicion (Hamilton, 1994). However, the SEEA framework provides little leadership on the major debates about competing methods, particularly with regard to the ambiguous valuation of resource stocks and their depletion and degradation which could well limit the uptake of these frameworks. Despite covering a very wide range of relevant conceptual and empirical issues, the SEEA is by design not meant to provide clear guidelines for the purpose of measuring sustainability in either its weak or strong version (Dietz, 2007).

2.4.4 Green Gross Domestic Product

One method of GDP augmentation uses the ‘Hartwick’ rule to derive a measure of environmentally adjusted or green GDP. Green GDP can be derived as follows:

$$\begin{aligned} \text{Green GDP} = & \text{GDP} - \text{Hotelling Rent for Non - Renewables} \\ & - \text{Total Expenditure on Pollution Control} \\ & - \text{Other Direct Costs due to Environmental Degradation} \end{aligned} \quad (2.5)$$

Hotelling's theory defines that the net price path is a function of time while maximizing economic rent when fully extracting a non-renewable natural resource. The maximum rent that could be obtained while depleting the stock resource is known as Hotelling rent or scarcity rent. For an efficient exploitation of the resource, the percentage change in net-price per unit of time should equal the discount rate in order to maximize the current value of the resource capital over the extraction period (Hotelling, 1931). Hotelling rent reflects the excess of (price – marginal cost) from resource extraction, and also the opportunity cost of current resource consumption. Scarce resources consumed today are not available in the future, and so Hotelling rent reflects forgone future consumption value. Hartwick and other growth theories have shown that steady-state consumption can be maintained if Hotelling rent from consumption of nonrenewable resources is reinvested in some form of wealth or capital stock (natural, social, human, or human-made) to provide for future consumption. Thus, as

nonrenewable resources are exhausted, the Hotelling rents generated by dynamically efficient consumption of these resources create a revenue source that can be invested to develop substitutes for the time when the resource is exhausted. The ‘Hartwick-Solow’ rule suggests that sustainable development could be achieved by ‘covering off’ the liquidation of a non-renewable resource with investment in other forms of wealth. This rule however cannot be easily extended across all natural wealth.

2.4.5 Genuine/Adjusted Net Savings

Hamilton (1997) has developed a single indicator for weak-form sustainability known as genuine savings. The idea behind genuine savings is to determine whether total human-made, natural, and other capital stocks are growing, remaining constant, or declining. Sustainability can be equated to non-declining values of all assets, including natural resource and allows us to determine whether we are on a weak sustainable development path. Algebraically,

$$\text{Genuine Savings} = I - r(R - g) - p(e - d) \quad (2.6)$$

where I stands for aggregate investment in human and human-made capital of various kinds. The term $(R - g)$ is a measure of the extent to which renewable natural resource stocks (natural capital) have diminished from harvest rates R exceeding regeneration rates g . The term r is the per unit value of natural capital. Consequently, $r(R - g)$ is the amount that society must set aside each year as savings to offset reductions in the productive capacity of natural capital. For example, these savings could be used to invest in rehabilitation of natural capital, or for further investment in substitutes such as human or human-made capital. The $(e - d)$ reflects the excess of emissions of human wastes (e) relative to the assimilative capacity of the environment (d). Pollution occurs when $(e - d) > 0$, and the term p refers to the marginal social cost per unit of pollution. Thus, $p(e - d)$ is the amount that society must set

aside each year as savings to mitigate pollution-induced impairments in natural capital. In the present situation in which there are positive levels of pollution deposition $[(e - d) > 0]$ and resource stocks are being depleted $[r(R - g) > 0]$, genuine savings are less than investment I in human and human-made capital. The implication is that we must make further investments to maintain a constant sum of human, human-made, and natural capital.

The theoretical foundation for the genuine saving concept was laid by Pearce and Atkinson (1993) who also presented some of the first empirical estimates using results from the green national accounting literature. However genuine saving is more than a theoretical construct. In addition to the empirical results in Pearce and Atkinson (1993) and Hamilton and Clemens (1999), the World Bank has been publishing estimates of ‘adjusted net’ saving (the formal name for genuine saving at the Bank) for 140 countries since 1999 in the *World Development Indicators* (World Bank, 2005). The following summarizes how the saving estimates are constructed:

$$\begin{aligned} \text{Genuine saving} &= \text{Gross national saving} \\ &+ \text{Education expenditure} \\ &- \text{Consumption of fixed capital} \\ &- \text{Depletion of energy resources} \\ &- \text{Depletion of minerals} \\ &- \text{Net depletion of forests} \\ &- \text{CO}_2 \text{ damages} \\ &- \text{Particulate pollution damages} \end{aligned}$$

(2.7)

Postponing consumption (for example by saving out of income or through increasing human capital investments) will boost a country’s genuine saving rate while net depletion of natural assets (such as mining or harvesting commercial natural resources) and pollution emissions (such as carbon dioxide and particulate matter) shrink it. Genuine/adjusted net saving does not identify for us who is ultimately responsible for the change in natural capital due to resource extraction or pollution generation in any one country. Rather, as pointed out by Neumayer (2001), it merely shows that genuine saving is changing and tries to capture the

amount of change. The policy challenges involved in increasing genuine savings are thus closely linked to the components of savings. Genuine saving will be affected by aggregate demand management policies that influence gross saving effort. Increasing human capital investments and making them more effective will boost genuine savings. Achieving efficient levels of resource extraction and pollution emissions will also increase genuine saving, but it does not imply resource extraction or pollution emissions must be reduced to zero.

Are countries saving enough for the future? Sustainability requires that countries avoid negative genuine saving rates at the very least. The saving rates (and changes in wealth per capita in the presence of population growth) is one important piece of the puzzle for measuring sustainable development that has survived rigorous scrutiny by economic growth theorists (Hamilton and Bolt, 2007). Scrutiny outside the economic sphere has identified genuine saving's commitment to weak sustainability may be lacking rigor where critical natural assets are concerned. Even if the analysis is confined to weak sustainability, empirical findings to date are dismal - many countries find it hard to achieve positive genuine saving. With regard to empirical issue, Neumayer (2003) put forward a series of problems for practical measurements of genuine saving which arise from his critical assessment of World Bank (2002)'s estimates of 'adjusted net' savings.

The relationship between saving and sustainability has a growth theoretic basis and many analysts have established this link, for example, Hamilton and Clemens (1999), Dasgupta and Mäler (2000), and Asheim and Weitzman (2001). Intuitively, if we think of wealth – the value of all assets in an economy – as the basis of future wealth, then current changes in wealth must have future welfare consequences. It is at least conceivable that a decline in wealth now will lead to falls in future levels of welfare – such an economy would not be sustainable by Pezzy's (1989) definition. If genuine savings is negative and constant then the economy is on an unsustainable path. The general rule, specifically the minimum

target for sustainability, is to maintain positive genuine saving and ensure that it does not grow faster than the interest rate. These saving rules for competitive economies offer scope for actually using the concept of genuine saving in designing policies for weak sustainability.

Pezzey (2004) however makes the point that genuine saving provides a one-sided sustainability test: if saving is negative, then there must be future declines in utility, unless technical advances are high enough to offset the effect. He argues that the opposite is not true in general – positive saving at a point in time does not indicate that future utility is everywhere non-declining. Nevertheless, making positive genuine saving an element of a policy rule can yield sustainability (Hamilton and Hartwick, 2005). Despite some seeming deficiencies, empirical evidence suggests that genuine saving is a reasonably strong predictor of future consumption (Hamilton and Bolt, 2007). In other words, this indicator can provide important signals for policy. According to estimates by David Pearce and Giles Atkinson (1995), they established that there is an unsustainable pattern in Papua New Guinea. Of the 22 countries examined, they found 8 exhibited depreciation of man-made and natural capital in excess of savings, indicating unsustainability. All 8 were developing countries. In addition, 3 of the 22 (Mexico, Philippines, United Kingdom) were on the edge, with savings equal to depreciation. Thus the focus on genuine saving can yield valuable predictions about development prospects, especially for developing countries that are highly dependent on non-renewable resources. Hamilton and Bolt also rationalized, had countries such as Venezuela and Nigeria followed the standard Hartwick rule or maintained genuine saving at some modest and constant rate, they would be considerably better off than is actually the case.

2.4.6 Index of Sustainable Economic Welfare and Related Indicators

Beyond the sphere of green national accounting, there are other more ambitious indicators of weak sustainability which aims to provide better measures of current and future well-being than GDP. A well-known earlier idea called the Measure of Economic Welfare was proposed by Nordhaus and Tobin (1972). This was later expanded by Daly and Cobb into the Index of Sustainable Economic Welfare (ISEW) in the appendix to their book, *For the Common Good* (1989). Computation of the composite indicator ISEW begins with per capita real consumption spending (a major element of GDP), followed by the introduction of various adjustments to take into account a variety of environmental factors as well as socio-economic indicators that focus on the quality of life or welfare. The following are examples of the large number of adjustment factors that Daly et al. have included in their index:

- Deduction of an estimate of the amount that society would need to set aside in a perpetual income stream to compensate future generations for the loss of services from non-renewable energy resources such as oil and natural gas.
- Deduction for estimates of pollution and other environmental damages, including noise pollution, and what has been regarded as rather speculative estimate of damage from global warming.
- Deduction for income inequality.
- Addition of the non-marketed value of household production.
- Addition of the value of government expenditures for education, health, roads and highways.
- Deduction for the higher cost of urbanized living.

The ISEW (now also known as the Daly and Cobb Index) stimulated lively debates on a series of methodological and measurement issues much of which was presented in Cobb et al (1994), as well as the construction of similar indices for other countries like UK, Canada, Germany, Sweden and Australia. The initial Daly and Cobb index for the USA has since been refined and renamed the Genuine Progress Indicator (GPI). The GPI is very similar to the ISEW. To compute the GPI, one starts with real personal consumption spending which is then adjusted for income distribution (which is weighted with an index of income inequality),

before adjusting with a number of “welfare-relevant” elements to reflect social benefits or costs and environmental issues as well. Adjustment factors added to traditional consumption spending to arrive at the GPI include:

- The value of household work and parenting, based on the cost of hiring these services (predicated on the work of economist Robert Eisner).
- The value of volunteer work, using Census Bureau data and taking the opportunity cost of time at \$8 per hour.
- Services from government capital such as highways, streets, and other infrastructure, as a percentage of the total value of the stock of these assets.

Factors subtracted from traditional consumption spending (that is, defensive expenditures) to arrive at GPI include:

- Cost of crime
- Cost of family breakdown, based on added expenditures
- Loss of leisure time
- Cost of underemployment, at opportunity cost
- Cost of consumer durables
- Cost of commuting (a defensive expenditure)
- Cost of household pollution abatement
- Cost of automobile accidents
- Cost of water, air, and noise pollution
- Loss of wetlands
- Loss of farmlands
- Depletion of nonrenewable energy resources
- Other long-term environmental damage
- Cost of ozone depletion
- Loss of old-growth forests

It is notable that Genuine Saving approaches have been concerned as much with fleshing out the theoretical link between saving and sustainability as with practical issues about measurement. Neumayer (2001) has opined that Genuine Savings is probably the more theoretically correct measure of weak sustainability. By contrast, the ISEW/GPI has been criticized as measurement-driven and lacking in theoretical foundations (Neumayer, 1999).

Clearly, measurement is a pressing aim given the current systems of economic indicators does not clearly signal that an economy is on or off an unsustainable path. Yet, there is a critical role for conceptual work which formally examines the properties of indicators and their measurement, not just on optimal development paths but also for ‘real world’ economies which diverge substantially from optimality.

Generally, in the literature on ISEW/GPI, there are mostly critiques that ISEW/GPI tend to focus on the specific methodology adopted in different studies in identifying and incorporating components in the index with little reference to theory, except for Phillip Lawn (2003) who adopts the view that by adopting a concept of income and capital outlined by Irving Fisher (1867-1947) in 1906, these alternative indices are theoretically sound but in order to be broadly accepted, require the continuous development of more robust valuation methods. In this connection, the New Economic Foundation (NEF) tries to improve on ISEW/GPI composite indicator and their approach is to develop their Measure of Domestic Progress (MDP). The ISEW/GPI provided the basis for the NEF’s work on developing a MDP for the UK (Jackson, 1997). The MDP can be regarded as an ‘adjusted’ economic indicator which aimed to provide a single performance index by adapting conventional economic measures such as GDP or consumer expenditure to include social and environmental costs and benefits that normally lie outside the accounting framework (Jackson, 2004). In affirming that ISEW/GPI is one of the main attempts at constructing such an indicator, Jackson established that the MDP is basically a ‘re-labeled’ ISEW/GPI that incorporates focus on several additional developments. However, as far as interpretation is concerned in contrast to ISEW/GPI, a rising MDP does not guarantee sustainability or ensure ‘genuine’ progress. Furthermore, as reviewed by Clive Hamilton (1999), despite the substantial suspicions that the dismal findings of the ISEW/GPI studies could be largely an artifact of the particular methods used by practitioner, which Neumayer (2003) refers to as

artifact of highly contestable methodological assumptions, it is however interesting to note the burgeoning “mainstream” respectability of the notion that people living in modern advanced economies are no more happy despite evidence of economic progress (Layard, 2005).

Although the Green GDP, Genuine Savings, ISEW/GPI, and similar related weak-form sustainability measures (like MDP) are clearly controversial and somewhat subjective, it is also clear that current GDP accounting offers too narrow and highly incomplete view of economic well-being and macroeconomic sustainability. It is well-known to us that the national productivity depends not just on the environment, but also on non-market elements as exemplified by health care, schooling and social capital. Providing a precise definition of social capital is already uphill task, and finding quantitative indicators of social capital makes it even more difficult, and it is for that reason that social capital is excluded from the GPI. Nevertheless, it is increasingly important to capture all these important facets of modern society in the nation’s accounts. With time, a set of ‘best methods’ may develop that will lend more precision and acceptance to measures of weak-form sustainability.

2.4.7 Indicators of Strong Sustainability

What does it take for strong sustainability indicators to be implementable? Firstly, there is a need to make different types of natural capital measures commensurate; Here, the word ‘commensurate’ is referring to the need to equate the vastly different measures used for various factors of strong sustainability, e.g. how much does one unit of water quality and one unit of soil quality compare in their effects on strong sustainability. It is not referring to commensurability to enforce strong sustainability. Due to valuation problems, physical as well as monetary indicators of natural capital stock may be needed. Secondly, there is need to determine the appropriate spatial unit (geographic and political) within which the stock of

natural capital (or critical natural capital) is to be maintained. However by preserving natural capital at the global level while permitting depletion in some regions and augmentation in others may in the extreme lead to regional impoverishment and compromise the equity aspects of sustainable development (Daly, 1995; Holland, 1997).

Preserving natural capital in value terms does not preclude the possibility that certain forms of natural capital that provide basic life support functions can still be endangered or become irreversibly lost. Hence most indicators of strong sustainability are either physical indicators or hybrid indicators which combine the setting of environmental standards in physical terms with monetary valuation. Sustainable development occurs by conserving key elements of the natural capital stock that preserve ecological integrity (Pearce, 1996). The concept of material flows analysis and that of ecological footprints are two of the major important and popular categories of environmental sustainability composite indicators. However there is an alternative view (Ng & Wills) that if the correct shadow prices is used such that the prices of scarcer, more essential and critical resources are very high, then using aggregate values may suffice as indicators of strong sustainability.

Materials Flow Accounting (MFA)

Material flow accounting (MFA) was first developed to give expression to the objective of a steady-state economy, in which the scale or material throughput of the economy should be held constant. The purpose of MFA is to quantify the flow of materials including energy (or resource flows) in a defined area over a set time period. Any economy would take in raw materials from the environment including imports from foreign nations, for further processing, manufacturing, production and consumption. Then some materials such as the construction of buildings and infrastructure are added to the stock of human-made capital. Eventually, the products become waste and may be recycled, but finally have to be disposed

via landfill or incineration. Figure 2.4 illustrates the principle and concept underlying the MFA as a simple model of interrelation between the economy and the environment, in which the economy is an embedded subsystem of the environment. Similar to living beings, this subsystem is dependent on a constant throughput of materials and energy. Raw materials, water and air are extracted from the natural system as inputs, transformed into products and finally re-transferred to the natural system as outputs (waste and emissions).

Regarded as an extension of the SEEA-2003 (United Nations, 2003), Simon Dietz and Eric Neumayer (2007) affirmed that MFA are very similar to the physical flow accounts in the SEEA-2003 in which all the materials drawn into the economy as resource inputs and sooner or later all the residuals produced as waste (output) are properly accounted for, sector-by-sector. However MFA construction has two departures from the SEEA-2003. Firstly, MFA tends to aggregate all annual material inputs and outputs by weight in order to derive across-the-board indicators such as Total Material Requirement (TMR) and Total Domestic Output (TDO). Secondly, MFA require the ‘hidden’ flows of materials to be accounted for, e.g. mining overburden or mining wastes which are moved during extraction but are not used directly in the economy.

Figure 2.4: Material Flow Accounting Process

The use of TMR and TDO as sustainability criteria has been subject to criticism. Take the case of ‘material flows’: highly aggregated indicators of the mass of material dragged through the economic system and the residuals that are the by-products of this activity. It is hard to take anything positive from an indicator that simply adds, say, tons of residuals together regardless of the harm those materials cause in the receptor in environment. The MFA has been severely criticized as a blunt measurement which simply adds up ‘very different’ materials flows by weight to form a total mass without accounting for their respective environmental impacts. The impact of a ton of arsenic on a receiving environment such as a river system would be more lethal than a ton of sewage, yet MFA does not state the differential environmental impact.

Nevertheless, the determination of material flows in an economy represents a good first step towards monitoring the links between the economy and the ecology. MFA is based on sound concepts of the conservation matter and laws of thermodynamics. MFA does allow policy makers to study scenarios to assist in choosing the best options to encourage reductions in both resource consumption and waste generation and to consider suitable technological changes to contribute to sustainable development at different geographical scales including natural and man-made ecosystems (such as factories and businesses), cities, regional and national economies. Once one starts distinguishing between more and less harmful materials, in a meaningful way, then material flow analysis could represent a more useful measurement tool.

Ecological Footprint

Ecological footprint (EF) builds on the concept of measuring natural capital requirement of human society using the net primary product (NPP) indicator, which is derived from the amount of vegetation produced annually over the land area of the country

for which NPP is calculated. The purpose of EF is to quantify the total area of ecologically productive land and water per capita (or natural capital stock) that is needed to indefinitely sustain a given population at the current standard of living and at an average per capita consumption rate, and also to absorb all waste produced. It is also referred to as appropriated human-carrying capacity. The EF, a composite indicator, is regarded as an ambitious attempt to bring a number of environmental factors into one index.

The EF idea was conceived by William Rees (1992) in a study of cities which consume vast amounts of resources, and was further developed by Rees (1994) and Wackernagel (1996; 1997), stimulating a growing interest in the EF in the ensuing decade. The unit of measurement is the biologically productive area, termed the global hectare (gha), which represents an equal amount of biological productivity. The gha is normalized so that the number of actual hectares of bio-productive land and sea on the earth is equal to the number of global hectares on this planet. To calculate the bio-capacity of a nation, each of the six different types of bio-productive areas within a nation is multiplied by both an equivalence factor and a yield factor for that land type. The six bio-productive areas are:

1. Crop land for food and animal feed, fibre oil crops and rubber;
2. Grazing land for animals for meat, hides, wool and milk;
3. Forest area for harvesting timber or wood fibre for paper;
4. Fishing grounds for catching fish;
5. Built-up areas for accommodating infrastructure for housing, transport and industrial production; and
6. Land for sequestering the excess CO₂ from burning fossil fuels to replace it with biomass, for harvesting fuel-wood, for nuclear energy and for hydropower (Wackernagel et al. 1999).

By comparing the demand with the available supply it is possible to estimate the ecological sustainability of territories or countries. A nation's ecological footprint correspond to the aggregate land and water area in various ecosystem categories to produce all the resources it consumes, and to absorb all the waste it generates on a continuous basis, using

prevailing technology. In this regard, a footprint greater than total bio-capacity indicates that demands exceed the regenerative capacity of existing natural capital. For example, the products from a forest harvested at twice its natural regeneration rate have a footprint twice the size of the forest. The amount of overuse is termed as “ecological deficit”. Ecological deficits are compensated in two ways: (a) either the deficit is balanced through imports, resulting in “ecological trade deficit” or, (b) the deficit is met through the overuse of domestic resources, leading to natural capital depletion.

The EF concept has become the focus of both academic scrutiny and governments/businesses examination as a sustainability indicator (Chambers and Lewis, 2001), and the subject of much well-intentioned criticisms (Ecological Economics, 2000, Volume 32). Arising from the latter, there has been a significant change from the original static review of the EF concept in the recent ecological studies. Researchers have explored scenarios of different development paths in a dynamic context, for example, the study of North America using the ecological footprint scenario model (EFSM). Senbel et al (2003) assert that if North Americans were to maintain their lifestyles and their corresponding levels of consumption while avoiding ecological deficits, then they are required to increase (double) resource productivity of all ecosystems, and to reduce economic growth or consumption spending. The EF indicator, as a rhetorical device, sends a clear notion of limits: given that natural ecosystems cannot continue to double their productivity, the future looks dismal.

The EF concept has developed a large and rapidly growing amount of literature. It has also been argued that by committing to alternative energy supplies it is possible to reduce the ecological footprint substantially. Furthermore recent work on integrating ecological footprinting with material flow analysis and input-output analysis shows that the allocation of resource use sector by sector can be achieved. Despite this progress it should be noted that the problem of linking masses with monetary measures still remains – although some

attempts to bridge this gap are being made but a firmer theoretical basis for combining mass and monetary measures is required. At present the integration of MFA with ecological footprinting via input-output analysis is a step along the way to a more formal solution to this ecological-economic problem. Current work permits the examination of scenarios and allows policies to be targeted at different sectors of the economy as a contribution to do more with less. It should also assist in promoting sustainable consumption.

Van den Bergh and Verbruggen (1999) identify a number of problems with ecological footprint calculations that fall into the two categories identified above, such as the appropriateness of focusing on land-use required to support consumption, the lack of distinction between alternative (sustainable and unsustainable) land-uses and the neglect of multiple land-uses. Specific applications are also subject to criticism due to what seem to be arbitrary assumptions in terms of what types of consumption are included and how they are measured and weighted. In terms of the choices of components, problems inevitably arise due to inadequate data, a problem that is common to many environmental indicators. However, it would seem that in the case of ecological footprints, where international comparisons of results are made, differences in methodology due to data problems across applications are crucially important. It should be noted, though, that recent developments in the literature concerning the use of input-output tables and methodology in calculating ecological footprints are likely to mitigate the component problem in more recent and future applications (Wiedmann et al, 2006).

However, Van den Bergh & Verbruggen (1999) also express concern over the other key problem identified above: how components are weighted. They question the fact that physical consumption-land-use conversion factors are used in the ecological footprint calculation function as implicit weights in both conversion and aggregation. They then pointed out that while the physical weights used may be consistent with ecological principles

and thermodynamic laws, they do not necessarily correspond to social weights. This means that changes in relative scarcity over time and variation over space are not reflected in the ecological footprint measure. This problem is being magnified by a fixed weighting scheme, which means that a fixed rate of substitution is assumed between different categories of environmental pressure. They further argue that some categories receive identical weights even though they have distinctly different environmental impacts. They conclude that all these problems compound to render the ecological footprint a questionable tool for social decision making, such as ranking policy options. Furthermore, the use of the EF indicator shows that strong sustainability fails to be detected if the necessary land area for absorbing CO₂ emissions is counted in terms of land area for renewable energy resources rather than forestry. Since the current rate of CO₂ emissions is clearly in violation of strong sustainability, however, this puts doubt on whether EF can really provide an indicator of strong sustainability.

2.4.8 Measuring Sustainable Development: Challenge for the Future

Numerous indicators to quantify various concepts of sustainability now exist. This is in marked contrast to the early 1990s, when there was growing recognition of the need to monitor progress towards sustainability goals, but few practical indicators existed. Considerable progress has been made in constructing practical indicators over the last decade or so. However, there is no shortage of empirical questions/challenges when it comes to measuring sustainable development. These challenges can be summarized as:

- Which out of the many indicators to choose?
- What does the chosen indicator actually measure?
- How to implement the accounting for the chosen indicator?
- What are the political implications of poor sustainability performance?

Countries trying to implement the SEEA-type of indicators face both conceptual and empirical problems as there is no clear consensus on all issues. There are several alternative approaches to measuring the value of assets and depletion/degradation (user cost method or the net-price methods of adjusting national income accounts for depletion of natural capital). SEEA does not provide clear guidelines to countries as to whether they should monitor stocks (wealth and changes in wealth or savings) or flows (national income). This poses a challenge for the future of environmental accounting: to propose clearly which approach to use (as different approaches can give widely differing results) so as to be useful to countries wanting to implement the asset accounts.

In many cases, the very negative figures obtained for early versions of some of these sustainability indicators led to fears and concerns from governments of developing nations that they will be forced to forgo economic growth targets in order to fulfill environmental sustainability. An example is that of China's brief experiment with Green GDP. In 2004, the then Chinese premier Wen Jiabao announced that the Green GDP index would replace the Chinese GDP index itself as a performance measure for government and party officials at the highest levels. The first green GDP accounting report published in September 2006 showed that the financial loss caused by pollution was 3.05 percent of the nation's economy. As an experiment in national accounting, the Chinese Green GDP effort collapsed in failure in 2007, when it became clear that the adjustment for environmental damage had reduced the green growth rate to politically unacceptable levels, nearly zero in some provinces. In the face of mounting evidence that environmental damage and resource depletion was far more costly than anticipated, the Chinese government withdrew its support for the Green GDP methodology and abandoned the experiment, even though the concept is actually good. The Green GDP concept is fine on its own, but using it to replace conventional GDP can be political suicide. There is a need to develop an indicator of economic sustainability rather

than of economic output, so that politicians may find it less of a lightning rod in inviting unwanted political backlash.

In developing countries, Poverty Reduction Strategy Programs (PRSPs) have been adopted as a planning technique to alleviate poverty and promote sustainable economic growth. However, PRSPs use GDP in their monitoring framework. Consequently policy makers get information on short-term economic growth but not long term sustainable growth. As the long term cost of soil erosion is humongous in many developing countries, it may undermine any short term gains in GDP eventually. The urgent challenge is to augment GDP with a complementary indicator of sustainable development that can be used in PRSPs. Another challenge is estimating the elasticities of substitution for resources. The availability of databases of natural resource stocks and flows, in quantity and value terms, means that there is more scope for exploring this important question. Another issue is that increasing saving, for the poorest economies, could be taken to imply reducing their consumption and this is not a palatable policy option in such countries where the consumption is already at subsistence levels. For these ‘turtle’ countries which are in the neo-Malthusian trap (Lim Chong Yah, 2006), a better option would be to focus on boosting the efficiency of the economy through economic reforms, raising growth which potentially leads to a virtuous cycle of increasing saving and consumption.

Although some critics (like Neumayer) argue that ISEW/GPI lacks theoretical foundation, and as a result the inclusion of various components is arbitrary, Hamilton (2007) counter argues that the GPI builds a framework for measuring sustainable consumption: for each case there is a measure of well-being identified within GDP, and GPI tries to fix the known problem so far as it is able to do so with available data. GPI can be further refined to include the impacts of environmental/resource use through a more comprehensive natural resource accounting framework. The GPI can add value if the indicator is able to look at

better measurement of inter-temporal income distribution which should include more robust estimates of social preference for equality. Indeed, no one single measure of sustainability is likely to be sufficient. Different indicators provide different insights for policy making. Despite the complexity of measures such as the ISEW/GPI, they also exclude important factors such as risk and uncertainty. Should the path to sustainability be risk free, or is society willing to accept policies or technologies that offer a good chance of a major improvement, but at the cost of a small chance of a loss in sustainability? There are also calls for nations to be environmentally responsible and happy, requiring some re-orientation of both the market and national governments towards something more fundamentally valuable (Ng Y.K., 2008). To sum up, the various sustainability indicators are not ‘window of the future’. They are means to an end (tool) to assist in evaluating current reality and to construct scenarios in the search for sustainable development (ultimate goal).

2.5 Concluding Remarks

The extensive literature review documented in this chapter on the issues of sustainable development can be summarized as follows. Concerns on economic sustainability started in the early 1800’s with the Malthusian theory on mankind’s possible collapse back to subsistence-level conditions due to population growth outpacing agricultural production. Though subsequent technological progresses have largely debunked this ‘doomsday’ scenario, the spectra of unsustainable development of modern economy has gradually been revived in the last few decades; but this time is due to scientifically verified realization that planet Earth is unlikely to be ecologically sustainable in face of the massive depletion of natural resources and the environmental damage brought about by ‘rampant’ and short-sighted economic development. Various piecemeal actions are being undertaken by various nations and international organizations to bring about a more responsible and greener form of

sustainable development, with varying degrees of successes. There is also a growing realization that a holistic approach to sustainable economic development by each nation is necessary to bring underdeveloped nations out of poverty, to achieve sustainable economic growths in developed nations, and at the same time to ensure the global physical sustainability of the Earth (Ng Y.K., 2004). Such a holistic approach may be guided by C.Y. Lim's 'Trinity' Development Theory, whose EGOIN concept already has environmental economics embedded in its view of the Natural Resources (N) eco-system of any generic economy.

There is also a need to define clearly the notion of sustainable economic development and to measure the degree of such sustainability. Various indicators of sustainability have been proposed in the past, but none can adequately capture the essence of holistic and anthropocentric notion of economic sustainability now being considered. There is thus a need to develop a holistic model and index of economic sustainability of each nation which also reflects its contribution to global physical sustainability. Such an index will help us to assess the relative economic sustainability of each nation and to help each nation to develop policies to enhance its economic sustainability and the global sustainability of the Earth. Developing such a comprehensive indicator which has to be applicable to all nations on Earth is therefore the main focus of this thesis. Chapter 3 presents the framework to develop the new indicator of economic sustainability, while Chapter 4 describes the factors and databases required to implement the proposed indicator. Chapters 3 and 4 form the core of the thesis, containing the original intellectual properties created by the author. Chapter 5 presents the trial-run results of the computation of the new economic sustainability indicator for each of a total of 108 nations.

Chapter Three

Proposed Framework for EGOIN Composite Index as Indicator of Economic Sustainability

3.1 Introduction

The sustainability of economic growth in the developing economies, in the light of growing environmental concerns, has become a much discussed topic in recent years. An economic system is sustainable in the long term only if it accommodates the production eco-systems of the economy: workforce, entrepreneurs, management, capital, natural resources, etc. In this thesis, the term ‘eco-system’ is used to refer to an entire set of economic or ecological resources. The economic system is very complex and it is not easy to forecast the long-term sustainability and balance of the eco-systems. Over expansion and pre-mature growth of the economy can lead to bottlenecks and unbalance, ultimately decreasing the net happiness of the people. In the extreme, the eco-systems of production may be irreparably damaged, leading to economic collapse. Large nations like USA and China have large economic momentum and resilience, and are able to recover from any economic setbacks in due course. For small nations such as some of the ASEAN nations, any economic

deterioration arising from unforeseen destruction of its production eco-systems may result in long-term damage. Hence it is important to study the issues behind the economic sustainability of nations, particularly small and developing nations. This Chapter put forth the original ideas and framework to develop a composite index to measure and compare the economic sustainability of nations.

3.2 Motivations for Development of EGOIN Composite Index

There are many ways to categorize and classify the production eco-systems of an economy. One of the more intuitive ways is based on the '*EGOIN*' theory, which comes from the first letters of the five domestic co-determinants of economic development: **E**ntrepreneurship, **G**overnment, **O**rdinary labour, **I**nterest and **N**atural resources (Lim C.Y., 1991). This theory approaches the analysis of economic development of any nation largely from the human perspective. It emphasises the hypothesis that the economic development of a nation is a phenomenon largely determined by human aptitude, attitude and activities. Any differences in the quality and orientation of their human resources form the basis for the differences in the rate and level of economic development among nations. It is thus also possible to use this theory to study the sustainability of economic development.

Entrepreneurship, Government and Ordinary labour (the *E*, *G* and *O*) are considered as active agents of growth or production eco-systems. *E*, *G* and *O* together reflect the social capacity of an economy to accumulate and utilize the available physical and natural resources (i.e. the *I* and *N* production eco-systems). The theory puts human factors on the centre-stage and the aptitude and attitude of the government and its accompanying bureaucracy as a very important co-determinant of development. It should be pointed out here that the Ordinary Labour eco-system is taken to include all human-centric contributions other than those of entrepreneurship and governance nature. Although it is possible to replace 'Ordinary Labour'

with simply ‘Labour’, we would like to retain the acronym *EGOIN* which already has a well-known branding. Two key features differentiate the *EGOIN* Theory from many other development theories. Firstly, the *EGOIN* Theory is multi-faceted. And secondly, it emphasizes on the human determinants of development, in particular the quality of the government and its bureaucracy. The multi-causality of the *EGOIN* and its focus on government and even non-governmental organizations provide a higher degree of realism to the theory (Lim C.Y., 2009). In addition, as has been reflected in the literature review in Chapter Two, elements of weak and strong sustainability present in the inclusion of man-made physical capital (*I*) and natural capital (*N*) in the complete set of five eco-systems of *EGOIN* are important for the assessment of economic sustainability.

Technological progress (embedded in *E*) has enabled humanity to manipulate the Earth to meet their enormous demands on it, with any environmental problems that arise are to be solved through further technological development, e.g. capital substitution. This may not satisfy green advocates of strong sustainability which does not make allowances for the substitution of human and human-made capital for natural capital. However we must acknowledge that the current course of humanity has been falling far short of even weak sustainability for most nations. It would be far more realistic and pragmatic to achieve some degree of weak sustainability within each nation, particularly developing nations. With increasing globalization, the economic sustainability of individual nations will work collectively to a stronger global sustainability of the Earth. Most of the published arguments on weak versus strong sustainability do not give sufficient emphasis on the dimension of time. While the economic sustainability of developing nations may focus on weaker ecological sustainability in the early years, there would be impetus to shift to stronger ecological sustainability in later years when the nations mature to developed economy status. An index of economic sustainability based on the *EGOIN* theory can be more encompassing

on relevant dimensions of sustainable development such as health, security or distributional (national, international and intergenerational) equity. The index would be a useful and important tool for policy makers and economists to assess and track the economic sustainability of various nations over a period.

3.3 Model Structure of Proposed Composite Index

The model structure of the proposed EGOIN Composite Index is based on the philosophy that the economy of each nation is a delicate balance of five production eco-systems and that the economic sustainability of each nation shall contribute to the overall global ecological sustainability of entire world (e.g. CO₂ emission). This is illustrated in Figure 3.1. The economy of each nation is modeled as five eco-systems of Entrepreneurship, Government, Ordinary Labor, Investment and Natural Resource. When these eco-systems are in balance and harmony with each other, they collectively lead to economic sustainability of that nation in the long-run. The aggregate effects of the economic sustainability of all nations will impact on the global sustainability of the planet. The latter is closely linked to the Natural Resource eco-system of each nation.

Figure 3.1: EGOIN Composite Index as Indicator of Economic Sustainability of Individual Nation

3.3.1 Model Core: EGOIN Composite Index

It is proposed here that the EGOIN composite index at period t for nation i is given by

$$EGOIN_i = \frac{r_{Ei}E_i + r_{Gi}G_i + r_{Oi}O_i + r_{Ii}I_i + r_{Ni}N_i}{r_{Ei} + r_{Gi} + r_{Oi} + r_{Ii} + r_{Ni}}$$

where

E_i = Entrepreneurship Index;

G_i = Government Index;

(3.1)

O_i = Ordinary Labor Index;

I_i = Investment Index;

N_i = Natural Resource Index;

and $r_{Ei}, r_{Gi}, r_{Oi}, r_{Ii}, r_{Ni}$ are their respective weights

The composite index has a value in the range (0 to 100). Each of the 5 component indices E_i , G_i , O_i , I_i and N_i also has a value in the range (0 to 100). The composite index is thus a weighted summation of five component indices, as illustrated in Figure 3.2. The formulation of these five component indices and their respective dynamically modulated weights are crucial to the characteristics of the model and the objectives of the composite index as an indicator of economic sustainability.

Figure 3.2: Computation of EGOIN Composite Index

3.3.2 RMSD-modulated Weights of the Component Indices

If the formulation and calibration of the equations for each of the five component indices E , G , O , I and N (to be discussed in Section 3.3.3) are reasonably executed, then the indices will have equitable contributions to the composite index. For example if both E and I have the same value of 75, then they are both having equal impact on the economic sustainability which the EGOIN Composite Index is supposed to measure. If any of the component indices is significantly higher than the rest, the additional overall contribution to economic sustainability would be less effective than a case where all five component indices are advanced equally but with smaller amount for each. To capture this essence of sustainable development in the EGOIN Composite Index, the weights r_E , r_G , r_O , r_I and r_N here have to play an additional role compared with those used in other global indicators which is only to ascribe different degrees of significance to the component indices. Each of the component indices by itself also serves as a useful indicator of the ‘state of health’ of the respective ecosystem. Hence the weights of the EGOIN component indices of each nation shall not be equal and nor are they the same for all nations. Instead they shall be computed individually for each nation using the equations described below. It is proposed in this thesis that the degree of balanced economic development can be modeled by the Root-Mean-Square Deviation (RMSD) of the component indices. The RMSD or root-mean-square error (RMSE) is frequently used as an aggregate measure of the differences between pair of values (θ_1, θ_2) for an entire system of N pairs, as defined by equations (3.2) and (3.3). The individual differences are called residuals, and the RMSD serves to aggregate them into a single measure of deviation power. This mathematical technique has been applied successfully in many scientific and engineering applications, such as bioinformatics (Coutsias, 2004).

$$RMSD = \sqrt{\frac{1}{N} \sum_{i=1}^{i=N} \delta_i^2} \quad (3.2)$$

$$\text{Residual} = \delta_i = (\theta_{1i} - \theta_{2i}) \quad (3.3)$$

In the most general form of this concept of RMSD-based weights, it is proposed that if there are q number of component indices X , i.e. $\{X_1, X_2, \dots, X_q\}$, then the weight of the m^{th} component index of nation i is given by:

$$r_{mi} = r_{m0} \left[1 - 0.01\beta \sqrt{\frac{\sum_{p=1}^q (X_{mi} - X_{pi})^2}{(q-1)}} \right] \quad (3.4)$$

Where r_{m0} is the unmodulated weight of the m^{th} index X_m and is common for all nations; and β is the eco-systems balance factor to be applied to all weights. For the proposed EGOIN model, q has a value of 5. More specifically, from Equation (3.4), the expressions of the weights for the five component indices in the EGOIN model can be written as follow.

$$r_{Ei} = r_{E0} \left[1 - 0.01\beta \sqrt{\frac{((E_i - G_i)^2 + (E_i - O_i)^2 + (E_i - I_i)^2 + (E_i - N_i)^2)}{4}} \right] \quad (3.5)$$

$$r_{Gi} = r_{G0} \left[1 - 0.01\beta \sqrt{\frac{((G_i - E_i)^2 + (G_i - O_i)^2 + (G_i - I_i)^2 + (G_i - N_i)^2)}{4}} \right] \quad (3.6)$$

$$r_{Oi} = r_{O0} \left[1 - 0.01\beta \sqrt{\frac{((O_i - E_i)^2 + (O_i - G_i)^2 + (O_i - I_i)^2 + (O_i - N_i)^2)}{4}} \right] \quad (3.7)$$

$$r_{Ii} = r_{I0} \left[1 - 0.01\beta \sqrt{\frac{((I_i - E_i)^2 + (I_i - G_i)^2 + (I_i - O_i)^2 + (I_i - N_i)^2)}{4}} \right] \quad (3.8)$$

$$r_{Ni} = r_{N0} \left[1 - 0.01\beta \sqrt{\frac{((N_i - E_i)^2 + (N_i - G_i)^2 + (N_i - O_i)^2 + (N_i - I_i)^2)}{4}} \right] \quad (3.9)$$

To illustrate the workings of the RMSD-modulated weights, Equations (3.1) and (3.5 to 3.9) have been computed for an arbitrary Nation A. Figure 3.3(a) shows the radar plots of the EGOIN component indices and their RMSD-modulated weights at the current situation. The component indices are $E = 60$, $G = 70$, $O = 70$, $I = 70$ and $N = 20$. The eco-systems balance factor β was set to 1.0 for a default modulation. The EGOIN Composite Index was found to be 51.54. Suppose five years later, the N Index of Nation A has improved from 20 to 70 with no change in the other four indices, as shown in Figure 3.3(b). All the RMSD-modulated weights have also increased significantly. The EGOIN Composite Index has now improved to 64.00, an increase of 24.18%.

In contrast, Figure 3.4 shows the case for the Nation A with β was set to 0.0 for nil modulation. The component indices have the same initial values as in the case in Figure 3.3(a). As the weights are no longer RMSD-modulated, the initial EGOIN Composite Index is now 62. With same change in N Index from 20 to 70 after five years, the un-modulated weights stay unchanged. The EGOIN Composite Index has therefore only improved from 62.00 to 68.00, an increase of only 6.45%.

The examples of Figures 3.3 and 3.4 illustrate the following traits of the proposed model when depicted as radar plots:

1. The five component indices by themselves are already useful and informative indicators of the ‘state of health’ of the E, G, O, I and N eco-systems;
2. The use of RMSD-modulated weights allows the *EGOIN* Composite Index to capture the degree of balanced development of a nation, which is crucial to guide the path to stronger ecological sustainability.

(a) Nation A at present, with EGOIN = 51.54

(b) Nation A after 5 years, with EGOIN = 64.00; Δ EGOIN = 24.18%

Figure 3.3: Effects of RMSD-based Weights of the EGOIN Model

(a) Nation A at present, with EGOIN = 62.00

(b) Nation A after 5 years, with EGOIN = 68.00; Δ EGOIN = 6.45%

Figure 3.4: Effects of Using Un-modulated Weights

3.3.3 Component Indices

Each component index should be built upon characteristics that analyses (to be discussed in Chapter Four) have found to be essential to promoting economic sustainability. These characteristics for each index can be measured by a number of factors that are in turn characterized by a combination of objective data and/or subjective responses to surveys. It is important to note that these fundamental characteristics are not to be arbitrarily chosen, but should be drawn from established theoretical and empirical research on the significant drivers of economic growth and physical sustainability. The importance of each of these factors to long-term sustainable economic growth without compromising global sustainability can be determined statistically by using correlation analyses and regressions.

For each nation i in the set of n nations, its EGOIN component indices in general can be given by:

$$X_i = \frac{\sum_{j=1}^m w_j x_{ji}}{\sum_{j=1}^m w_j} \quad (3.10)$$

Where $X_i \in \{E_i, G_i, O_i, I_i, N_i\}$, x_{ji} is a member of set of factor sub-indices, i.e. $x_{ji} \in \{x_{1i}, x_{2i}, \dots, x_{mi}\}$, and w_j is a member of set of weights, i.e. $w_j \in \{w_1, w_2, \dots, w_m\}$. The set of weights is common and static for the entire set of n nations, whereas each nation has its own set of sub-indices of factors. The number of sub-indices is m for each X_i , which is typically 3 to 5 for practical considerations. Figure 3.5 illustrates the relationship between the EGOIN Composite Index, its component indices and its factor sub-indices in a tree relationship structure. As each component index has a value in the range (0-100), each of the factor sub-indices x_{ji} should also has a value in the range (0-100) for consistency, while the

weights w_j have values in the range (0-1). These weights represent the factors' relative importance as factors of sustainability.

Figure 3.5: EGOIN Composite Index Represented as a Tree Structure

While each country's path to economic development is varied and diverse, decades of established theoretical and empirical research on economic growth and development have identified some common themes. Using this research which is discussed in Chapter Four, it is proposed in the EGOIN Composite Index framework that factors x_{ji} that lead to higher levels of both 'state of health' and performance of the respective eco-system can be identified. In order to determine the weights for these factors leading to greater economic sustainability, regression analysis using econometric methods such as General Methods of Moments (GMM) can be applied. For E, G, O and I Eco-Systems, it is proposed in this framework that economic performance drivers such as GDP can be used as the dependent

variable in these GMM panel regressions. The regressions estimate a “weight” for each variable – or a “coefficient” in econometric terminology. For the N Eco-System, the goal of global sustainability can be used as the driver.

Figure 3.6: The Drivers for the Five Production Eco-Systems

The E Index: Entrepreneurship Eco-System

Entrepreneurship has been regarded as a very special sector of the human capital which brings together the other production eco-systems to generate wealth. Conventionally, entrepreneurs are seen as exploiters of factors of production without little regard to sustainability. Indeed they have been caricatured as some of the worst culprits responsible for current destruction of the environment. However they should be seen as one of the most important production eco-systems of any sustainable economy and the greening of entrepreneurship has also been receiving increasing attention.

Self-employment and small business start-ups have always been seen as a means of creating employment. An individual who chooses to become self-employed reduces the unemployment rate not only by gaining employment for himself/herself but also by hiring any additional workers for his/her business. To this end, nations have been channeling

resources into entrepreneurial training, research and development, and as incentives to encourage new business start-ups. Frequently, it is also the ability to organize new technology and intellectual properties into new product lines and businesses which characterizes entrepreneurship. A new term, ‘technopreneurship’, has thus been coined to connect entrepreneurship with technology. Both the business management aspects and the R&D of new technology can be groomed and nurtured in universities, specialized institutes and in existing companies. Hence the entrepreneurship eco-system can be broadened to include all these activities. With the increasing concern on economic sustainability, other new concepts and interpretations of entrepreneurship have arisen, with new terms such as social entrepreneurship, eco-entrepreneurship and sustainopreneurship coming into the literature. Generally, they refer to using creative business organizing to solve problems related to the sustainability agenda to create social and environmental sustainability as a strategic objective and purpose, while at the same time respecting the boundaries set in order to maintain the production eco-systems of the economy. Specifically, the E Index of each nation i can be written as, assuming four significant factors, i.e. $m = 4$:

$$E_i = \frac{\sum_{j=1}^m w_{Ej} x_{Eji}}{\sum_{j=1}^m w_{Ej}} = \frac{w_{E1} x_{E1i} + w_{E2} x_{E2i} + w_{E3} x_{E3i} + w_{E4} x_{E4i}}{w_{E1} + w_{E2} + w_{E3} + w_{E4}} \quad (3.11)$$

The G Index: Government

The word Government is generally used in a wide sense to refer to all persons who play an important role in shaping the public opinion and public policy of the country, not just to members of the ruling political party or the governmental civil service, which is undoubtedly by far the most important component, but not the only component in this category. The Government as a production eco-system consists of all persons and

organizations which influence economic activities including media bosses, religious leaders, public societies, political opposition parties and grass-root committees. Academic research has found that in general, political freedom, strength of institutions, and regulatory quality are significant contributors to economic growth. Effective, fair, and accountable governments also increase public confidence, leading to higher levels of life satisfaction among citizens. Likewise, the opportunity to have a voice in their government is correlated with more responsible citizens. A good and green Government should also take a longer term view in managing the economy, with clear direction on economic sustainability rather than simply short term goals to win votes. The G Index can be given by,

$$G_i = \frac{\sum_{j=1}^m w_{Gj} x_{Gji}}{\sum_{j=1}^m w_{Gj}} = \frac{w_{G1} x_{G1i} + w_{G2} x_{G2i} + w_{G3} x_{G3i} + w_{G4} x_{G4i}}{w_{G1} + w_{G2} + w_{G3} + w_{G4}} \quad (3.12)$$

The O Index: Ordinary Labour

The Ordinary Labour production eco-system consists of all the labour that is not included under the Entrepreneurship and the Government eco-systems. It generally expected that wages would increase over the years. For long term sustainability, this should be off-set by increasing labour productivity. Besides rising costs of labour, other factors which affect the sustainability of this eco-system are to be considered when analyzing its contribution to the overall economic sustainability of the nation. The major issues include productivity, education, work experience and re-training, health level and health-care costs, aging population and immigration, social capital. Of late, the happiness of the general population is being viewed as very important to the sustainability of this eco-system and to the entire economy. The happiness characteristics may be embedded in the social capital and the mental health of the population. The O Index can be given by,

$$O_i = \frac{\sum_{j=1}^m w_{Oj} x_{Oji}}{\sum_{j=1}^m w_{Oj}} = \frac{w_{O1} x_{O1i} + w_{O2} x_{O2i} + w_{O3} x_{O3i} + w_{O4} x_{O4i}}{w_{O1} + w_{O2} + w_{O3} + w_{O4}} \quad (3.13)$$

The I Index: Investment

Without investment, a modern economy as we know it would not have existed. The degree of investment activities is an important indicator of economic sustainability. The following factors are significant components of the investment eco-system.

- Domestic savings - saving is closely related to investment. By not using income to buy consumer goods and services, it is possible for resources to instead be invested by being used to produce fixed capital, such as factories and machinery. Saving can therefore be vital to increase the amount of fixed capital available, which contributes to economic growth.
- Domestic investments - it provides an indicator of the future productive capacity of the economy. It includes replacement purchases plus net additions to capital assets plus investments in inventories. Non residential investments are expenditures by firms for machines, tools and other equipment. Residential investment includes expenditures by households and firms on apartments, buildings, and new factories, while changes in inventories in a given period are goods that are produced by firms but kept to be sold later.
- Foreign direct investments (FDI) - amount of investment by foreign investors in an economy where they own at least 10 per cent of the paid up aggregate of equity capital, reinvestment of earnings, and other long-term and short-term capital. There are two types of FDI: inward foreign direct investment and outward foreign direct

investment, resulting in a *net FDI inflow* (positive or negative) and "stock of foreign direct investment", which is the cumulative number for a given period.

- Confidence in financial institutions – the perception from investors as to whether the nation's financial institutions can offer good returns on their investments.

The I Index can be given by,

$$I_i = \frac{\sum_{j=1}^m w_{Ij} x_{Iji}}{\sum_{j=1}^m w_{Ij}} = \frac{w_{I1} x_{I1i} + w_{I2} x_{I2i} + w_{I3} x_{I3i} + w_{I4} x_{I4i}}{w_{I1} + w_{I2} + w_{I3} + w_{I4}} \quad (3.14)$$

The N Index: Natural Resource

By definition, natural resources are what occur naturally within a nation's environments that exist relatively undisturbed by mankind, and in a natural form. It is often characterized by the degree of biodiversity and geo-diversity existing in the natural resource eco-system. In traditional economics, nature resource as a production eco-system is very well studied and documented, particularly in the form of coal, oil, gas, minerals, agricultural land, soil, rivers, lakes, rain-forests, fish-stocks and other marine life. Being very visible and tangible, the concern on their sustainability has greatly captured the attention of the general public. Besides natural resources residing within a nation's boundaries, the sustainability of imports of natural resources should also be factored into the computation of N_i . The N Index can be given by,

$$N_i = \frac{\sum_{j=1}^m w_{Nj} x_{Nji}}{\sum_{j=1}^m w_{Nj}} = \frac{w_{N1} x_{N1i} + w_{N2} x_{N2i} + w_{N3} x_{N3i} + w_{N4} x_{N4i}}{w_{N1} + w_{N2} + w_{N3} + w_{N4}} \quad (3.15)$$

3.4 Implementation and Applications Issues

The issues in the applications and implementation framework of the proposed EGOIN Composite Index are discussed here.

1. The EGOIN Composite Index is not meant to replace the GDP, unlike, say the Green GDP. Difficulties in measuring capital depreciation have made GDP the standard for measuring overall economic performance and growth. GDP will likely remain as a very important indicator of any nations' current economic performance, which is not directly measured by the EGOIN Composite Index. Instead the latter is an indicator of a nation's performance in its path towards long-term economic sustainability, as a responsible component nation of the global community. Hence the EGOIN Composite Index is meant to complement the GDP, not to replace it.
2. Unlike Green GDP and other green accounting systems, the EGOIN Composite Index does not seek to monetarize the physical side of sustainability in its implementation. It thus avoids the complexities of dealing with the physical-monetary dichotomy within its data and accounting framework. The EGOIN framework has the accounting advantages of the hybrid physical-monetary approach, even though it is based on a different concept. It is able to tap into a wide variety of international data sources and frameworks, both physical and monetary.
3. The EGOIN Composite Index avoids the stigma attached to strong ecological sustainability indicators, such as the Environmental Sustainability Index, which is sometimes seen as green activists' tool to force certain nations to implement environmentally friendly policies at the expense of national economic growth.
4. Well-known attempts at data aggregation for composite indices are the Human Development Index (HDI), the Environmental Sustainability Index (ESI), the Genuine Progress Indicator (GPI) and the Ecological Footprint (EP). All these measures are

known to suffer from a more or less judgmental selection of partially correlated indicators, a questionable mix of weighting and valuation techniques, and/or inconsistency with standard accounting concepts and conventions. The EGOIN Composite Index framework has proposed systematic methods to select factors and to assign weights to these factors in the computation of the five component indices, based on econometric analyses. Admittedly, this will require much research and pilot implementations for it to mature into a rigorously validated system.

5. The five component indices of the EGOIN Composite Index can be depicted by a variety of ways, but it is best to illustrate them using a radar plot as shown in Figure 3.7. It allows easy visual evaluation as well as quick assessment on the relative balance of the five eco-systems for each individual nation and for comparison among nations. The composite index of each nation allows nations to be ranked and compared for further analyses into issues of economic sustainability. This is illustrated in Table 3.1.
6. During pilot implementations, correlation analyses of EGOIN Composite Index and its component indices against other measures of economic and sustainability performances such as GDP and ESI can further strengthen the framework and the understanding of issues in measuring of economic sustainability.

Figure 3.7: Visual Evaluation of Economic Sustainability using EGOIN Radar Plots

Table 3.1: Application of EGOIN Component Indices in Ranking of Nations

Country	Rank	EGOIN Index	E Index	G Index	O Index	I Index	N Index
Nation 1	1	67.14	89	76.0	79.0	67.0	70.0
Nation 2	2	51.54	60	70.0	70.0	70.0	40.0
.....	3						
.....							

3.5 Concluding Remarks

In this Chapter, the framework for the development of the EGOIN Composite Index to measure the economic sustainability of nations has been proposed. The index would be a useful and important tool for policy makers and economists to assess the economic sustainability of various nations. The framework covers the theory, core model, equations, implementation methodologies and application guidelines. The motivation behind this approach arises from the literature review presented in Chapter 2. The proposed core model which takes into account the complex inter-relationships of the production eco-systems is based on the *EGOIN* theory, which comes from the first letters of the five main domestic co-determinants of economic development: **E**ntrepreneurship, **G**overnment, **O**rdinary labour, **I**nterest and **N**atural resources. The composite index and its component indices are not meant to replace the venerable GDP, unlike what some weak sustainability indicators and green accounting measures are meant to do so. Nor do the EGOIN indices focus too much on strong sustainability issues at the expense of economic growth and human happiness. Instead, the EGOIN indices are meant to complement the GDP measure by monitoring on the ‘**state of health**’ of the nation’s production eco-systems and overall balance of its economic development for long-term economic sustainability. The identification of factors for each EGOIN component index and their data sources are discussed in the next Chapter 4. The computation of real-world EGOIN indices for 108 nations is given in Chapter 5.

Chapter Four

Identification and Analysis of Factors of Economic Sustainability

4.1 Introduction

In Chapter Three, the framework for developing the EGOIN Composite Index has been introduced. One crucial requirement of the framework is to identify the significant factors for each of the five component indices (E, G, O, I and N). In this Chapter, detailed documentation on how the factors for the five production eco-systems can be identified, analyzed and selected is presented. A large number of data sources have also been searched and data-sets extracted to support the analysis and illustrate this important aspect of the proposed framework. For each of the component indices, it has been realized for practicality that it should not comprise of more than four or five dominant factors or sub-indices (x). Otherwise it would be difficult to obtain the weights (w) from econometric analysis with accuracy and convergence. Also, it does not make logical sense to have large number of dominant factors, as the very essence of dominance implies only a few significant ones. However each of the sub-index x may itself be comprised of a number of other variables.

The starting point in the consideration of factors to be short-listed for each index should be rooted in the fundamentals of economic analysis. The total factor productivity

concept is implicit in many of the analyses and is therefore briefly discussed in the beginning of this chapter. The rest of the chapter is sectioned and arranged according to the discussion on the five component indices of EGOIN:

- E Index for Entrepreneurship;
- G Index for Government;
- O Index for Ordinary Labor;
- I Index for Investment;
- N Index for Natural Resource.

As one of the objectives of this research is to examine the sustainability issues for Singapore, data for factors and variables relevant to economic sustainability of Singapore is presented throughout this Chapter for discussion. For the purpose of comparison, data for nine other nations are also presented. The general information for the ten nations is given in Table 4.1 below. They are chosen based on having diversity in terms of developing statuses and geographical locations. Five of the ten nations are from ASEAN including Singapore.

Table 4.1: General Information on Ten Nations Selected for Case Studies

Country	Average GDP Growth (2005-2009) (% per annum)	Per Capita GDP 2009 (US\$)	Remarks
Colombia	4.11	5,165	Developing nation, South America
Denmark	1.46	55,870	Mature economy, Europe
Indonesia	4.42	2,345	Developing nation, ASEAN
Israel	3.13	26,256	Newly mature economy, Middle-East
Japan	1.70	39,455	Mature economy, East Asia
Malaysia	3.94	7,029	Developing nation, ASEAN
Philippines	3.58	1,830	Developing nation, ASEAN
Singapore	3.46	36,757	Newly mature economy, ASEAN
Thailand	3.83	3,891	Developing nation, ASEAN
Turkey	5.25	8,214	Developing nation, Central Asia

4.1.1 Total Factor Productivity

In Solow's Model, a basic form of neo-classical aggregate production function is assumed. Economists have been relating on how inputs are transformed into outputs in an economy by an aggregate production function which in the most basic form is,

$$Y(t) = A(t) \bullet f(K(t), L(t)) \quad (4.1)$$

Where: $Y(t)$ represents the real output in an economy at time t ,

$A(t)$ represents a multi-factor index, (role of E, G and N are implicit in this index)

$K(t)$ is the real capital input, and

$L(t)$ is the real labor input.

There are many possible forms of function f , but the Cobb-Douglas function is used more often than any other output relationship because of its amenability to analytical manipulation, and because in the long-run, the precise relationship between capital and labor in the production function is not required because regression analysis is usually subsequently applied to estimate the weights or coefficients. Then equation (4.1) becomes,

$$Y(t) = A(t)[K(t)]^\alpha [L(t)]^\beta \quad (4.2)$$

Where α and β are the respective elasticity of output to inputs of capital and labor. In general it can be further assumed with constant returns to K and L , thus $\beta = (1 - \alpha)$. $A(t)$ is now interpreted as the productivity.

$$Y(t) = A(t)[K(t)]^\alpha [L(t)]^{1-\alpha} \quad (4.3)$$

Equation (4.3) is differentiated in time (t) to give a formula in partial derivatives of the respective relationships of labor, capital and productivity to output.

$$\frac{dY}{dt} = \frac{\partial Y}{\partial K} \frac{dK}{dt} + \frac{\partial Y}{\partial L} \frac{dL}{dt} + \frac{\partial Y}{\partial A} \frac{dA}{dt} \quad (4.4)$$

Where,

$$\begin{aligned}
\frac{\partial Y}{\partial K} &= \alpha [K(t)]^{\alpha-1} A(t) [L(t)]^{1-\alpha} = \frac{\alpha Y}{[K(t)]} \\
\frac{\partial Y}{\partial L} &= \frac{(1-\alpha)Y}{[L(t)]} \\
\frac{\partial Y}{\partial A} &= \frac{Y}{[A(t)]}
\end{aligned} \tag{4.5}$$

Therefore,

$$\frac{dY}{dt} = \frac{\alpha Y}{[K(t)]} \frac{dK}{dt} + \frac{(1-\alpha)Y}{[L(t)]} \frac{dL}{dt} + \frac{Y}{[A(t)]} \frac{dA}{dt} \tag{4.6}$$

The growth factor of the output is defined as its change as a proportion of the output of previous year. Dividing by Y gives,

$$\frac{\frac{dY}{dt}}{Y} = \frac{\alpha}{[K(t)]} \frac{dK}{dt} + \frac{(1-\alpha)}{[L(t)]} \frac{dL}{dt} + \frac{1}{[A(t)]} \frac{dA}{dt} \tag{4.7}$$

The term on the left hand side is the output growth (GDP growth) while the first two terms on the right hand side are proportional changes in capital and labor year-on-year, weighted by their respective elasticities on output. The remaining term on the right hand side is known as the Solow residual and it represents that part of the GDP growth which is not explicable by measurable changes in capital or labor. It has been commonly regarded that this residual is a measure of the level of technology or Total Factor Productivity (TFP). More recently, it has been used to study effects of entrepreneurship activities, innovation, education and any other traits thought not to be related to capital or labor. A simple linear regression form of the Equation (4.7) is given by,

$$\ln(Y(t)) = \alpha \ln(K(t)) + (1-\alpha) \ln(L(t)) + \ln(A(t)) + \varepsilon \tag{4.8}$$

Many econometric studies based on Equation (4.8) or its variants have been done, with somewhat controversial conclusions. Equation (4.8) can be written in the growth rate form,

$$TFPG = \hat{Y} - \varepsilon_K \hat{K} - \varepsilon_L \hat{L} \tag{4.9}$$

where ε_K is the output elasticity of capital and ε_L is the output elasticity of labor.

Under assumptions of profit maximization, competitive factor markets and constant returns to scale, the factor elasticities shall equal the factor shares in the national accounts. Then,

$$TFPG = \hat{Y} - \alpha \hat{K} - (1 - \alpha) \hat{L} \quad (4.10)$$

Where α is the factor share of capital.

4.1.2 Issues with TFP Estimation

The crux of the TFP problem is that since TFP is computed as the residual of a regression analysis, it is very susceptible to inconsistencies in the way time series data has been calculated or defined over the years. The computational methodology behind regression analysis is basically to seek the weights of main variables, labor and capital. Whatever not attributed to labor and capital is then regarded as contribution to TFP. There is thus an inherent tendency to under-estimate TFP; it is almost like trying to measure background noise. Also, the effects of technical progress cannot be entirely excluded from the factor shares data of capital and labor. That is, it is quite impossible to have a Hicks-neutral situation. Unless one can multiply the growth rate of the capital stock by the capital share after eliminating the effect of technical progress, it is not likely to achieve an analysis where all technical progress is captured and reflected in the TFP growth. There are generally two methods to estimate the factor shares: the regression and the national accounts methods.

The regression approach has three major disadvantages. First, it is based on the assumption that the growth rate of each input is exogenous, while the growth rate of output is endogenous. However, this is far from true even in the most ideal situations. For example, an economy that has a faster rate of output growth due to rapid TFP growth would also invest more and have a higher rate of capital growth. Therefore, the regression approach will overestimate the capital coefficient. Second, the factor shares are usually estimated to be similar across countries (in cross-country regression) or over time (in a time-series

regression). However, there are no special reasons to assume that these shares are constant. Third, the estimation of the factor shares is not done independently, but needs to rely on the growth rates of the factors of production. These rates are also not directly measured and are sometimes subject to significant errors.

The national accounts method uses data derived from the national accounts statistics to estimate factor shares by measuring the share of income that is distributed to each factor of production. This method too has its drawbacks. Firstly, using income shares to estimate the technological factor shares, this approach assumes, sometimes implicitly, that capital and labor markets are perfectly competitive and that the income of each factor of production is equal to the value of its marginal product. This ignores the possibility of market imperfections. Secondly, this method ignores the effects of government policies and regulations, including tax policy. Thirdly, the national accounts approach ignores the problems related to the classification of workers who are not employees. Lastly, the formal classification of workers is not an exogenous variable, but is itself affected by country-specific considerations, such as the tax and social security systems.

The proposed framework described in Chapter Three to compute the EGOIN Composite Index as an indicator of economic sustainability does not have the disadvantages of estimating TFP described above as it does not rely on regression analysis or on national accounts method directly or entirely. Moreover the classical TFP theory does not directly include factors such as technical advance, higher entrepreneurial inputs, better governance, etc. In EGOIN, Entrepreneurship, Government and Ordinary labour (the *E*, *G* and *O*) are considered as active agents of growth or production eco-systems. *E*, *G* and *O* together reflect the social capacity of an economy to accumulate and utilize the available physical and natural resources (i.e. the *I* and *N* production eco-systems). The theory puts human factors on the centre-stage and the aptitude and attitude of the government and its accompanying

bureaucracy as a very important co-determinant of development. It should be pointed out here that the Ordinary Labour eco-system is taken to include all human-centric contributions other than those of entrepreneurship and governance nature. Two key features differentiate the *EGOIN* Theory from many other development theories. Firstly, the *EGOIN* Theory is multi-faceted. And secondly, it emphasizes on the human determinants of development, in particular the quality of the government and its bureaucracy. The multi-causality of the *EGOIN* and its focus on government and even non-governmental organizations provide a higher degree of realism to the theory (Lim C.Y., 2009). In addition, elements of weak and strong sustainability present in the inclusion of man-made physical capital (*I*) and natural capital (*N*) in the complete set of five eco-systems of *EGOIN* are important for the assessment of economic sustainability.

4.1.3. Economic Sustainability and TFP

Assuming that TFP growth rates can be estimated realistically and they are sustainable, it is possible in principle to estimate long-run GDP growth rates. To calculate long-run growth rates, it is assumed that the rate of capital accumulation is endogenously determined as in the standard classical growth model, subject to consumption and saving choices, that effective labor per person and factor shares stay constant, and that TFP continues to grow at the same rate as during the final years in the period under study. The long-run per capital GDP growth rate according to the steady-state solution of the neoclassical growth model is equal to the TFP growth rate divided by the share of labor in the production function. The estimated long-run per capita growth rates estimated by Sarel (1997) are reproduced in Figure 4.1. The results indicate interesting growth rate dynamics, both across time and across the five ASEAN countries and US. However, such estimation is very sensitive to the underlying assumptions made in TFP estimation, as discussed in the last

section. Hence it cannot be regarded as a reliable forecasting tool and the results of Figure 4.1 may not be used with confidence. Instead of using the aggregate production function concept to directly estimate long term sustainable GDP growth rates, we relied on models based on the function to help identify the significant factors and variables for each EGOIN component index. The computed EGOIN Composite Index and its component indices then provide the indications of degree of economic sustainability, without seeking to forecast long-term GDP growth rates.

Source: Sarel (1997)

Figure 4.1: Simulated Long-Term Sustainable GDP Growth of ASEAN Nations

4.2 The Entrepreneurship Eco-System

Quantitative studies into the entrepreneurship aspects of the economy have been relatively recent, compared to say, labor or capital. There is no global consensus yet on what should go into an indicator to measure the characteristics of entrepreneurship. Nor do any of the existing indicators have been explicitly developed to account for the contributions of an entrepreneurship eco-system towards economic sustainability.

4.2.1 Major Factors

Analysis into factors of entrepreneurship eco-system can start by extending the total factor productivity approach of Equation (4.8) with successively additional variables, for example by incorporating innovation as a separate aspect of entrepreneurship and determinant of economic growth rates and evaluating its significance (Ho Y.P., 2009):

$$\ln(Y(t)) = \ln(B) + \alpha \ln(K(t)) + \beta \ln(L(t)) + \gamma \ln(S(t)) + \phi \ln(Z(t)) + \varepsilon \quad (4.11)$$

Where the multi-factor index $A(t)$ of Equation (4.8) has now been decomposed into:

$S(t)$ = stock of knowledge capital, as an indicator for innovation;

$Z(t)$ = other factors affecting measured productivity (e.g. business environment, education attainment of workforce), and

B = a proportionality constant.

The challenge here would be: how do we know if innovation should be analyzed, out of the many possible variables? We can look to the major reports in entrepreneurship. The annual GEM reports have been grouping its participating economies into three levels: factor-driven, efficiency-driven, and innovation-driven. This concept is in turn, based on the World Economic Forum's (WEF) *Global Competitiveness Report*, which identifies three phases of economic development based on GDP per capita and the share of exports comprising primary goods. According to the WEF classification, the factor-driven phase is dominated by subsistence agriculture and extraction businesses, with a heavy reliance on labor and natural resources. In the efficiency-driven phase, further development is accompanied by industrialization and an increased reliance on economies of scale, with capital-intensive large organizations more dominant. As development advances into the innovation-driven phase, businesses are more knowledge intensive, and the service sector expands. In the 2009 report by Danish Enterprise and Construction Authority, six overarching factors have been

identified to be affecting a country's entrepreneurial performance; up from the five factors used in its 2006 report:

1. regulation (including incentive structure);
2. market conditions (market access);
3. access to financing (supply of capital);
4. creation and diffusion of knowledge (new in 2009 report);
5. entrepreneurial skills (supply of skills); and
6. entrepreneurial culture.

Based on the studies by GEM and WEF, it is proposed here that the variables determining the nature, level and sustainability of national entrepreneurial activity may be classified into three groups:

1. the basic requirements for production factor-driven activities,
2. the efficiency enhancers for efficiency-driven activities, and
3. the knowledge capital factors for innovation-driven activities.

The first group consists of mainly basic business environment factors, including the institutions, infrastructure and costs of doing business, the financing and regulations on businesses, and the necessary macro-economic stability to enable business start-ups. The second group comprises primarily the efficiencies and sizes of the markets, the access to regional and international markets (Triple-C effect), and increasingly the technological readiness such as internet bandwidth. The last group includes R&D expenditure and activities, diffusion and transfer of knowledge capital, legal infrastructure of protection and exploitation of intellectual properties. However it does not mean that nations which have progressed to innovation-based activities do not rely so much on the first two groups of factors; on contrary the latter are the foundations of the pyramid upon which the knowledge capital factors are the apex of. Above all, there has also to be positive entrepreneurial attitudes, actual entrepreneurial activities and aspirations to bind the factors of entrepreneurship eco-system together for sustainable development of the economy.

Business Environment and New Business Creation

New business creation has been the most conventional role of entrepreneurship, and the latter flourishes in an environment which is conducive to doing business. Such environment is more than just good macro-economic conditions. It requires that attention be paid to the laws, regulations and institutional arrangements that shape daily economic activities. The recent series of global financial crises has renewed interest in good rules and regulation for more resilience in entrepreneurship eco-system. In times of recession, effective business regulation and institutions can ease economic adjustment. Easy entry and exit of firms, and flexibility in redeploying resources, make it easier for entrepreneurs to scale back businesses for which demand has weakened and to start doing new ventures. Clarification of property rights and strengthening of market infrastructure such as credit information and collateral systems can contribute to confidence as investors and entrepreneurs look to adapt the economy to rapid changing global forces (Audretsch, 2007).

Market Access, Efficiency, and Size

The efficiency, size and access of goods markets are factors which can affect the intensity and aspirations of entrepreneurial efforts. The size of the market affects productivity since large markets allow firms to exploit economies of scale, which in turn encourages more positive entrepreneurial outlook. Under imperfect competition, an increase in the home market size has two opposing effects on firms' profits. Both positive and negative effects would affect the decision of potential entrepreneurs on whether or not to start a new business. Positive effects come from density economies (Ciccone and Hall, 1996; Ciccone, 2002), and market expansion (Krugman, 1980). On the other hand, a negative effect results from competition among firms. If the positive effects dominate over the negative effects, entrepreneurs are more likely to establish new firms or expand their existing businesses.

Traditionally, the markets available to firms have been constrained by national borders. In the era of globalization, international markets have become a substitute for domestic markets, especially for small countries. There is vast empirical evidence showing that trade openness is positively associated with growth. Even if some recent research casts doubts on the robustness of this relationship, the general sense is that trade has a positive effect on growth, especially for countries with small domestic markets. Examples of studies on relationships between trade and entrepreneurship is the network intermediation by Rauch and Watson (2002) which hypothesizes that the agents who become international trade intermediaries first accumulate networks of foreign contacts while working as employees in production or sales, then become entrepreneurs who sell access to and use of the networks they accumulated. Together with large-scale trading companies along the lines of the Japanese ‘sogo shosha’, they facilitate exports which can be regarded as a substitute for domestic demand in determining the size of the market for the firms of a country. This is consistent with the Triple-C Theory described in Section 2.3.2. By including both domestic and foreign market sizes as factors on economic sustainability, this gives credit to export-driven economies and geographic trade areas such as the ASEAN region that comprises many countries but have synergetic regional common market.

The impact of market size on entrepreneurship has been investigated by Sato (2009) using data on Japanese prefectures. The results show that a larger market size leads to higher incentive of the inhabitants to become entrepreneurs. In their study, they employed two indices of entrepreneurship: the share of potential entrepreneurs and the share of self-employment. Using maximization of utility function with budget constraint of individuals and price function of firms, they arrived at the following econometric equation which relates the share of entrepreneurs (e) in a goods sector to the population density (D).

$$\ln(e_{it}) = a_0 - \ln(D_{it}) - \frac{1}{2} \ln(h_{it}) + \ln(-2h_{it}^{-1/2} + a_1 D_{it}^{1/2} + a_2 D_{it}^{3/2}) + b_1 \ln(G_{pit}) + b_2 \ln(g_{pit}) + b_3 \ln(M_{it}) + b_4 \ln(S_{hait}) + b_5 \ln(S_{hmit}) + b_6 \ln(S_{hpit}) + b_7 \ln(V_{it}) + b_8 \ln(G_{dt}) + u_{it} \quad (4.12)$$

where

e_{it} = share of entrepreneurs in differentiated good sector

h_{it} = area of inhabitable land

G_d = per capita gross domestic product

G_{pit} = provincial per capita gross domestic product

g_{pit} = year on year ratio of provincial per capita gross domestic product = G_{it} / G_{it-1}

D_{it} = population density

M_{it} = price - cost margin

= $(G_{it} - \text{intermediate output} - \text{indirect tax less subsidies} - \text{compensation of employees}) / G_{it}$

S_{hait} = share of agriculture sector in G_{it}

S_{hmit} = share of manufacturing sector in G_{it}

S_{hpit} = share of public sector in G_{it}

V_{it} = effective job opening to job applicant ratio

u_{it} = standard error term

Here, the population density D_{it} is used as a proxy for the domestic market size which has both positive and negative effects on entrepreneurship. The per capita prefecture gross domestic product G_p represents the current condition, the year to year comparison of G_p indicates the future prospect, and the price-cost margin M which describes the overall economic conditions of the corresponding region is a proxy for profitability of business in the region. In order to account for the differences in industry structures, the shares of agriculture, manufacturing, and public sectors in the GDP of the prefecture (S_{ha} , S_{hm} , and S_{hp}) have been added to the equation. This study has also shown that employment density and population density are similarly significant as proxies for market size. The positive effects dominated over negative effects and were largely due to density economies for larger regions and market expansion for smaller regions.

Nations with efficient goods markets are well positioned to produce the right mix of products and services given their particular supply-and-demand conditions, as well as to

ensure that these goods can be traded in the most effective way. Healthy market competition, both domestic, regional and international, is important in driving market efficiency and thus business productivity, by ensuring that the most efficient firms, producing goods demanded by the market, are those that thrive. This helps ensure long-term sustainability in the entrepreneurship eco-system of the nation. The best possible environment for the exchange of goods requires a minimum of impediments to business activity through government intervention. For example, competitiveness is hindered by distortionary or burdensome taxes and by restrictive and discriminatory rules on international trade. The recent series of economic crises has highlighted the degree of interdependence of economies worldwide and the degree to which growth depends on open markets. Protectionist measures are counterproductive as they reduce aggregate economic activity by introducing distortion effects. Market efficiency and hence ease of entrepreneurship also depends on demand conditions such as customer orientation and buyer sophistication.

Innovation, Knowledge Capital, Research & Development

It is well-known from both the neo-classical and endogenous growth models of economic growth that technological innovations are important in stimulating growth through generating technological progress and raising productivity. It is also important that latest knowledge of strong technological and scientific developments is readily available to many enterprises. For entrepreneurs, it is crucial that the knowledge available is efficiently disseminated throughout society, as this lays the groundwork for developing innovative new solutions. Countries with higher levels of technological innovation will have faster growth rates.

The Schumpeterian tradition has coupled the concepts of entrepreneurship and innovation such that in much of the work linking technological innovation to economic

growth, the role of entrepreneurship is implicit as an underlying cause and beneficiary of innovation. However, innovation is not solely carried out by the entrepreneurs themselves. The evolution of modern markets has seen the emergence and proliferation of professional innovators and innovation facilities managed by private large companies, academic institutions or public sector. Similarly, the definition of the entrepreneur has also expanded beyond its role as an innovator to embrace, among others, risk taking and managerial responsibilities. Given the nature of contemporary markets, it can be argued that when business creation activities and innovation activities are aggregated to the national level, there is not likely to be substantive overlap between the two constructs. Hence, in a macroeconomic formulation of the determinants of national economic growth, business creation and innovation can be treated as two distinct and separate factors that manifest different facets of the entrepreneurship phenomenon. This approach is also in line with current view of entrepreneurship as embodying both new business creation, and imitative and innovative entries by established firms (Wong P.K., 2005).

Figure 4.2: Major Factors of Entrepreneurship Eco-System for Economic Sustainability

In summary, the major factors of the Entrepreneurship Eco-System can be categorized under Business Environment, Market Access, and Knowledge Capital. They roughly correspond to the three stages of entrepreneurial development. In addition, there is the necessary Entrepreneurship Culture to bind all the other factors into a healthy and sustaining eco-system. This is the entrepreneurship attitude and aspiration which the GEM has been aiming to measure. Figure 4.2 illustrates the major factor groups of the entrepreneurship eco-system.

4.2.2 Data Synthesis and Case Studies

In this section, sources and types of data relevant to various factors of the entrepreneurship eco-system are reviewed, discussed and summarized. Case studies on sub-indices of factors computed are discussed.

Business Environment Sub-Index

One possible source of data on business environment is the ‘Doing Business’ project by The World Bank which has been collecting data to gauge the health of business environment of more than 180 nations since 2001. Empirical research funded by the World Bank has shown that the effect of the laws, regulations and institutional arrangements that shape daily economic activities is closely correlated to economic growth. Since 2001, more than 800 academic papers have used one or more data-sets constructed in ‘Doing Business’ reports and in the related background papers. It provides a quantitative measure of regulations in 9 areas which roughly correspond to the 9 stages of the life of a typical business. The data apply to domestic small and medium-size enterprises. In future, it will also look at regulations on employing workers as well as other measures such as availability of electricity. An index for business environment can either be directly constructed from these data-sets, or the

methodologies employed in the data-sets can be adapted to construct the index. Tables 4.2(a), (b) and (c) list the data from ‘Doing Business’ for the group of 10 selected nations for case study. The 9 data-sets are:

1. **Starting a business:** It looks at the number of procedures, the number of days, the cost and the minimum paid-in capital to start a business.
2. **Dealing with licenses:** It tracks the number of procedures, the number of days, and the cost involved to obtain the necessary business licenses.
3. **Registering property:** It tracks the number of procedures, the number of days and the cost involved to register a property.
4. **Getting credit:** This is based on the depth of credit information index, the strength of legal rights index, the public credit registry coverage, and the private credit registry coverage.
5. **Protecting investors:** This is based on four sub-indices – the extent of disclosure index, the extent of director liability index, the ease of shareholder suit index, and the strength of investor protection index.
6. **Paying taxes:** This tracks the number of tax payments, the time to prepare, file and pay the taxes, and the total tax rate.
7. **Trading across borders:** This includes the number of documents to prepare for export and import, the time for exports and imports to be completed, and the cost of fees levied on the exports and imports.
8. **Enforcing contracts:** It tracks the number of procedures, the number of days, and the cost involved to enforce contracts.
9. **Closing a business:** It tracks the time and the cost involved to close down a business, and the recovery rate.

Table 4.2(a): Data on Business Environment

Nation	Ease of Doing Business Rank (out of 183 countries)	(1) Starting a Business				(2) Dealing with Licenses			(3) Registering Property		
		Procedures (number)	Time (days)	Cost (% of income per capita)	Min. capital (% of income per capita)	Procedures (number)	Time (days)	Cost (% of income per capita)	Procedures (number)	Time (days)	Cost (% of property value)
Colombia	39	9	20	13	0	11	51	403	7	20	2
Denmark	6	4	6	0	39	6	69	59	6	42	1
Indonesia	121	9	60	26	60	14	160	195	6	22	11
Israel	29	5	34	4	0	20	235	107	7	144	5
Japan	18	8	23	7	0	15	187	19	6	14	5
Malaysia	21	10	18	16	0	25	261	7	5	144	3
Philippines	148	16	53	29	5	26	204	93	8	33	4
Singapore	1	3	3	1	0	11	25	20	3	5	3
Thailand	19	7	32	6	0	11	156	12	2	2	1
Turkey	65	6	6	14	10	25	188	219	6	6	3

Source: Doing Business 2011, *The World Bank and the International Finance Corporation***Table 4.2(b): Data on Business Environment (con't)**

Nation	(4) Getting Credit				(5) Protecting Investors				(6) Paying Taxes		
	Credit Information Index	Private bureau coverage (% of adults)	Public bureau coverage (% of adults)	Legal Rights Index	Disclosure Index	Director Liability Index	Shareholder Suits Index	Investor Protection Index	Payments (number)	Time (hours)	Total tax rate (% profit)
Colombia	5	61	0	5	8	8	9	8	20	208	79
Denmark	4	5	0	9	7	5	7	6	9	135	29
Indonesia	4	0	22	3	10	5	3	6	51	266	38
Israel	5	90	0	9	7	9	9	8	33	230	33
Japan	6	76	0	7	7	6	8	7	13	355	56
Malaysia	6	82	49	10	10	9	7	9	12	145	34
Philippines	3	6	0	3	2	2	8	4	47	195	49
Singapore	4	40	0	10	10	9	9	9	5	84	28
Thailand	5	33	0	4	10	7	6	8	23	264	37
Turkey	5	43	16	4	9	4	4	6	15	223	44

Source: Doing Business 2011, *The World Bank and the International Finance Corporation*

Table 4.2(c): Data on Business Environment (con't)

	(7) Trading Across Borders						(8) Enforcing Contracts			(9) Closing a Business		
Nation	Documents for export (number)	Time for export (days)	Cost to export (US\$ per container)	Documents for import (number)	Time for import (days)	Cost to import (US\$ per container)	Procedures (number)	Time (days)	Cost (% of debt)	Time (years)	Cost (% of estate)	Recovery rate (cents on the dollar)
Colombia	6	14	1770	8	14	1750	34	1346	48	3	1	53
Denmark	4	5	744	3	5	744	35	380	23	1	4	86
Indonesia	5	21	704	6	27	660	40	570	123	6	18	14
Israel	5	12	665	4	12	605	35	890	25	4	23	45
Japan	4	10	989	5	11	1047	30	360	23	1	4	93
Malaysia	7	18	450	7	14	450	30	585	28	2	15	39
Philippines	8	16	816	8	16	819	37	842	26	6	38	4
Singapore	4	5	456	4	4	439	21	150	26	1	1	91
Thailand	4	14	625	3	13	795	36	479	12	3	36	42
Turkey	7	14	990	8	15	1063	35	420	19	3	15	20

Source: Doing Business 2011, *The World Bank and the International Finance Corporation*

It is clear that the data-sets do not measure all aspects of the business environment that matter to entrepreneurship, but it serves as a proxy for the broader business environment like a cholesterol test for human health. Another data set that is close to the ‘Doing Business’ data-set is the OECD indicators of product market regulation; they have a correlation index of 0.72 and can also be used to synthesize the Business Environment Sub-Index .

Singapore in 2011 is ranked number one out of 183 nations in the ‘Doing Business’ ranking which is based on simple averaging of its data-sets. This indicates that it is easy and low-cost to start, maintain and wind-down businesses in Singapore (it takes only 20 minutes to register a new company on-line). Denmark and Japan are ranked 6 and 18 respectively. Thailand and Malaysia are not far behind at 19 and 21 respectively. The other two major ASEAN nations, Indonesia and Philippines, are ranked at 121 and 148 respectively.

Market Access Sub-Index

The Market Access factor is mainly characterized by the domestic and foreign market sizes and the freedom from market barriers. The size of the domestic market can be estimated

from the gross domestic product plus the total value of imports of goods and services, minus the total value of exports of goods and services, all valued at purchasing power parity (PPP). The size of the foreign market can be estimated by the exports of goods and services. The major market barriers are the trade barriers and the tax burden.

International trade freedom can be measured as a composite index of the absence of tariff and non-tariff barriers that affect imports and exports of goods and services, e.g. using the methodology adopted by the Heritage Foundation. It is based on two inputs: the trade-weighted average tariff rate and the non-tariff barriers (NTBs). Different imports entering a country can, and often do, face different tariffs. The weighted average tariff uses weights for each tariff based on the share of imports for each good. Weighted average tariffs are a purely quantitative measure and account for the basic calculation of the score using the following equation:

$$TF_i = \left[\frac{Tariff_{max} - Tariff_i}{Tariff_{max} - Tariff_{min}} \times 100 \right] - NTB_i \quad (4.15)$$

where TF_i represents the trade freedom in country i , $Tariff_{max}$ and $Tariff_{min}$ are the upper and lower bounds for tariff rates, and $Tariff_i$ is the weighted average tariff rate in country i . The minimum tariff is usually zero percent, and the upper bound can be set as 50 percent. An NTB penalty is then subtracted from the base score. A penalty of 5, 10, 15, or 20 points can be assigned according to the following scale:

- **20** - NTBs are used extensively across many goods and services and/or act to effectively impede a significant amount of international trade.
- **15** - NTBs are widespread across many goods and services and/or act to impede a majority of potential international trade.
- **10** - NTBs are used to protect certain goods and services and impede some international trade.
- **5** - NTBs are uncommon, protecting few goods and services, and/or have very limited impact on international trade.

- **0** - NTBs are not used to limit international trade.

Determining the extent of NTBs in any country's trade policy regime is difficult but may be done using both qualitative and quantitative information. Restrictive rules that hinder trade vary widely, and their overlapping and shifting nature makes their complexity difficult to gauge. The categories of NTBs suggested by Heritage Foundation to be considered include:

- **Quantity restrictions**—import quotas; export limitations; voluntary export restraints; import–export embargoes and bans; and countertrade.
- **Price restrictions**—antidumping duties; countervailing duties; border tax adjustments; variable levies/tariff rate quotas.
- **Regulatory restrictions**—licensing; domestic content and mixing requirements; sanitary and phytosanitary standards (SPSs); safety and industrial standards regulations; packaging, labeling, and trademark regulations; advertising and media regulations.
- **Investment restrictions**—exchange and other financial controls.
- **Customs restrictions**—advance deposit requirements; customs valuation procedures; customs classification procedures; customs clearance procedures.
- **Direct government intervention**—subsidies and other aid; government industrial policy and regional development measures; government-financed research and other technology policies; national taxes and social insurance; competition policies; immigration policies; government procurement policies; state trading, government monopolies, and exclusive franchises.

Fiscal freedom of a country is the measure of the tax burden imposed by its government. It includes both the direct tax burden in terms of the top tax rates on individual and corporate incomes and the overall amount of tax revenue as a percentage of GDP. It can be composed of three quantitative variables (Beach, 2008):

1. The top tax rate on individual income,
2. The top tax rate on corporate income, and
3. Total tax revenue as a percentage of GDP.

In Heritage Foundation's current methodology, each of these numerical variables is weighted equally as one-third. This equal weighting allows a country to achieve a score as high as 67 based on two of the factors even if it receives a score of 0 on the third. However it is more appropriate here to reduce the weight for individual income tax. In addition, the index is calculated with a quadratic cost function to reflect the diminishing revenue returns from very high rates of taxation. The data for each variable are converted to a 100-point scale using the following equation:

$$FF_{ij} = 100 - \alpha(Variable_{ij})^2 \quad (4.16)$$

where FF_{ij} represents the Fiscal Freedom in country i for variable j ; $Variable_{ij}$ is the value (based on a scale of 0 to 100) in country i for variable j ; and α is a coefficient set to 0.03.

Table 4.3 lists the indices for trade freedom, fiscal freedom, domestic market and foreign market. Most of the ten nations studied have relatively low barriers towards international trade. Denmark has relatively high tax burden. Singapore has very low trade and tax barriers. However its domestic market is quite limited due to its city state nature. An overall Market Access Sub-Index computed from these four variables with equal weightage yield an index of 81.0 for Singapore.

Table 4.3: Data for Market Access

Country	Trade Freedom Variable ¹ (0-100)	Fiscal Freedom Variable ¹ (0-100)	Domestic Market Variable ² (0-100)	Foreign Market Variable ² (0-100)	Market Access Sub-Index (0-100)
Colombia	73.2	74.5	65.71	67.14	70.1
Denmark	87.6	43.2	57.14	70.00	64.5
Indonesia	73.8	83.0	72.86	78.57	77.1
Israel	87.8	62.3	58.57	68.57	69.3
Japan	82.6	67.0	87.14	85.71	80.6
Malaysia	78.7	84.6	61.43	82.86	76.9
Philippines	77.8	78.8	62.86	71.43	72.7
Singapore	90.0	91.1	57.14	85.71	81.0
Thailand	75.9	74.8	67.14	82.86	75.2
Turkey	85.4	78.2	72.86	77.14	78.4

Sources: ¹ 2011 Index of Economic Freedom, *The Heritage Foundation*;

² The Global Competitiveness Report 2010-2011, *World Economic Forum*

Knowledge Capital Sub-Index

The difficulty with establishing an indicator for innovation variables in entrepreneurship is the determination and definition of knowledge capital. It is a concept which is based on assuming that the know-how from the experience, information, learning, and skills of the residents of the economy have intrinsic value which can be shared and leveraged, and can be regarded as one of the factors of production. It may consist mainly of technical information (as in chemical and electronics industries) or may reside in the actual experience or skills acquired by the individuals (as in construction and service industries). Hence it is much more than simply intellectual properties, such as patents. If we take the view that the stock of knowledge capital is mainly produced by R&D activities, then the knowledge capital stock in any period may be expressed as:

$$S_{it} = (1 - \delta)S_{i(t-1)} + R_{it} \quad (4.13)$$

Where

S_{it} = Stock of knowledge capital at time t (in constant prices)

R_{it} = Expenditure on R&D and innovation during period (in constant prices)

δ = Depreciation rate of knowledge.

There are now three issues with Equation (4.13): 1) how do we determine the depreciation rate of knowledge; 2) what is the initial stock in the initial period, i.e. at $t=0$; and 3) we have neglected the fact that not all expenditure on R&D will result in creation of new knowledge.

A pragmatic solution to the initial stock problem would be to assume the initial period to be when data collection on R&D expenditure was first started. In the case of Singapore, data on R&D expenditure was first published in 1978 by the then National Science and Technology Board (NSTB) and subsequently its successor organization, the Agency for Science, Technology and Research (A*STAR). In this so-called perpetual inventory method, the initial stock of R&D capital may be calculated according to the following procedure:

$$S_{i0} = \frac{R_{i0}}{g + \delta} \quad (4.14)$$

Where

S_{i0} = stock of R&D capital at the beginning of the first year for which R&D expenditure data (in constant prices) is available.

R_{i0} = expenditure on R&D (in constant prices) during the first year for which it is available.

g = the average annual logarithmic growth of R&D expenditure over the period for which published R&D data were available. From here we can see that the initial stock problem is also the problem of determining the depreciation rate of knowledge.

Among other more comprehensive sources of data in the innovation factor is the Global Innovation Index (GII) that is created by INSEAD and its partners to put into perspective the new trends and practices in innovation across the world. The basic framework of the GII is to calculate the index as a simple average of an innovation input sub-index and an innovation output sub-index, which capture the enabling environment for innovation, and the results of innovation respectively. There are five input pillars (Institutions, Human capital and research, Infrastructure, Market sophistication, and Business sophistication) and two output pillars (Scientific outputs, and Creative outputs). Each pillar is divided into sub-pillars and each sub-pillar is composed of individual indicators. Sub-pillar scores are calculated as the weighted average of individual indicators; pillar scores are calculated as the simple average of the sub-pillar scores. Four measures are then calculated:

- The Innovation Input Sub-Index is the simple average of the first five pillar scores.
- The Innovation Output Sub- Index is the simple average of the last two pillar scores.
- The Global Innovation Index is the simple average of the Input and Output Sub-Indices.
- The Innovation Efficiency Index is the ratio of the Output Sub-Index over the Input Sub-Index.

The innovation input sub-index is very broad since it includes many factors in our E, G, O, and I indices. Hence the GII cannot be directly used for our Innovation sub-index which has

a much narrower definition. However some of the data-sets particularly those in the scientific outputs and creative outputs are deemed to be important indicators of knowledge capital and R&D and can be adapted for the computation of a Capital Knowledge sub-index for our E Index.

Nine variables have been selected and their data-sets for the case study set of nations are tabulated in Table 4.4. The 9 variables are:

1. **Research & Development:** This variable tracks the researchers' headcount per unit population, the gross expenditure on R&D as percentage of GDP, and the number of quality research institutions.
2. **Knowledge Workers:** This variable includes knowledge-intensive employment as percentage of total employment, the percentage of firms engaging in research training, the amount of R&D performed by private sector, and the amount R&D funding by private sector.
3. **Innovation Linkages:** This variable tracks the number of joint academic-industry research collaboration, the state of research cluster development, the percentage of R&D financed from abroad, the number of joint ventures and strategic alliance initiated, and the number of pan-national patent filings.
4. **Knowledge Absorption:** This variable includes royalties and license fees payment, high-technology imports excluding re-imports, computer and communication service imports, and the net foreign direct investment inflow, all as percentage of GDP.
5. **Knowledge Creation:** This measures the value of domestic resident patents, of international patents filed locally, of the domestic resident utility models filed, and of the scientific & technical articles published.

6. **Knowledge impact:** This measures the growth rate of GDP per worker, the new businesses per unit adult population, and the amount of computer software spending as % GDP.
7. **Knowledge diffusion:** This variable tracks the amount of royalty & license fees receipts as % GDP, the amount of high-tech exports less re-exports, the amount of computer & communication service exports, and the FDI net outflows as % GDP.
8. **Creative intangibles:** This includes the value of domestic resident trademark applications, Madrid system resident trademark applications, and the information-communication technology models in organizations and businesses.
9. **Creative goods & services:** This includes the amount of recreation & culture consumption, the national feature films per unit population, the daily newspapers per unit population, the creative goods exports, and the creative services exports.

Table 4.4: Data-Sets Extracted from INSEAD's Global Innovation Index 2011 Database

Nations	Research & Development	Knowledge workers	Innovation linkages	Knowledge absorption	Knowledge creation	Knowledge impact	Knowledge diffusion	Creative intangibles	Creative goods & services
Colombia	14.6	37.4	30.2	38.5	2.3	18.6	21.4	49.8	25.6
Denmark	63.6	82.6	53.3	38.2	58.3	35.7	44.8	50.7	54.1
Indonesia	18.1	7.0	40.8	36.7	1.0	23.2	30.5	48.6	2.8
Israel	93.7	86.6	37.2	46.7	77.4	33.1	62.0	51.8	28.9
Japan	65.1	82.3	41.2	44.3	69.4	21.5	58.5	42.3	23.3
Malaysia	26.4	69.0	44.9	61.6	8.8	30.4	52.1	55.2	24.7
Philippines	11.5	46.7	30.9	32.4	3.3	19.6	43.8	41.1	10.2
Singapore	60.2	87.3	68.3	81.7	32.0	36.8	78.0	41.4	32.4
Thailand	18.5	52.7	41.8	56.1	8.6	27.0	36.2	50.7	29.1
Turkey	20.9	41.1	21.8	25.1	17.9	17.7	21.0	50.7	32.5

All variables measured by indices in range 0 to 100, with 100 as indicating best performance

From the above table, it can be seen that Singapore is relatively weak in domestic creation of knowledge and creative intangibles. Its innovation factor is very much dependent on foreign imports. Many innovation linkages failed to translate to productivity and new businesses. For long term sustainability, there is need for Singapore to improve on its

translational research to bridge the gap between academic research and business-ready products and services.

Entrepreneurial Culture Sub-Index

The entrepreneurial culture factor measures entrepreneurial mindset and the societal and individual attitude to entrepreneurship and to the possibilities of each of these individuals becoming an entrepreneur. This factor may be regarded as having symbiotic relationship with the other factors, because if the latter are seen as positive, this is expected to improve the chances of entrepreneurial successes, which in turn will have a cumulative effect. In other words, improving the nation's business environment, innovation outputs and market access will help to create a more positive entrepreneurial outlook. However it also involves a great deal of societal attitude and acceptance of risk taking.

The societal attitude to entrepreneurship is a key element affecting whether newly founded enterprises will be successful. For instance, it is decisive whether starting and growing an enterprise is associated with high or low social status. If the population takes a favorable view of entrepreneurship, this will probably lead to a natural growth in entrepreneurial activity. A positive entrepreneurial culture is more likely to motivate individual entrepreneurs to start their own business. An entrepreneurial mindset is characterized by focusing on opportunities, innovative problem-solving and an optimistic approach to trial-and-error and risk-taking. This type of mindset is useful for large enterprises and public-sector positions and for people who wish to start their own businesses.

Measuring variables of entrepreneurial culture is very difficult. Instead, it is more common to use an indicator which for example, measures the preference for becoming self-employed. This is not a perfect substitute, but provides a good idea of how attractive self-employment is considered to be, thus measuring the part of the entrepreneurial culture which deals with starting an enterprise. There is little objective data available; instead one has to

rely on subjective responses to survey questions. The Global Entrepreneurship and Development Index project has computed its Entrepreneurial Attitude index which is one of the closest indicators in terms of definition to our Entrepreneurial Culture (Acs, 2010). This index is based on the following survey responses:

1. The percentage of the 18-64 aged population recognizing that conditions are good for starting businesses in the next 6 months in their area of residence;
2. The percentage of the 18-64 aged population claiming to possess the required knowledge and skills to start businesses;
3. The percentage of the 18-64 aged population stating that the fear of failure would not prevent them from starting new businesses;
4. The percentage of the 18-64 aged population knowing someone who started a business in the previous 2 years;
5. The percentage of the 18-64 aged population who thinks that starting business is a good career choice;
6. The percentage of the 18-64 aged population who thinks that fellow citizens attach high status to successful entrepreneurs.

Table 4.5: Data from Global Entrepreneurship and Development Index (2010)

Country	Entrepreneurial Attitude Index	Entrepreneurial Activity Index	Entrepreneurial Aspiration Index	GED Index
Colombia	0.383	0.280	0.174	0.279
Denmark	0.754	0.966	0.569	0.763
Indonesia	0.172	0.460	0.137	0.256
Israel	0.365	0.473	0.580	0.472
Japan	0.305	0.468	0.417	0.397
Malaysia	0.485	0.447	0.160	0.364
Philippines	0.271	0.047	0.058	0.125
Singapore	0.378	0.711	0.583	0.558
Thailand	0.206	0.328	0.128	0.221
Turkey	0.306	0.278	0.233	0.272

Each index ranges from 0 to 1, with 1 indicating best performance

The Entrepreneurship Attitude index from GEDI is tabulated in Table 4.5 along with their Activity index and Aspiration index for comparison. The latter two indices included factors not exclusive to the Entrepreneurship Eco-System. It can be seen that Singapore is not strong in its Entrepreneurial Attitude or Culture.

4.3 Government Eco-System

Of the five eco-systems considered in the EGOIN Composite Index, the Government Eco-system is probably the hardest to define and to measure. There is no consensus on what exactly constitute a healthy Government eco-system that will ensure economic sustainability and promote global sustainability. In general, it has been observed that owners of land, corporate shares, or intellectual property will be unwilling to invest in the improvement and upkeep of their property if their rights as owners are not protected. In addition, proper management of public finances is also critical to ensuring trust in the national business environment. Government attitudes toward businesses and economic freedoms, and the efficiency of its institutions are also very important; too much bureaucracy and red tape, overregulation, corruption, lack of honesty in dealing with public contracts, lack of transparency and trustworthiness, and the political dependence of the judicial system, will all impose significant economic costs on businesses and degrade the sustainability of economic development.

4.3.1 Major Factors

According to United Nations Economic and Social Commission for Asia and Pacific (UNESCAP, 2007), good governance has 8 major characteristics. It should be participatory, consensus oriented, accountable, transparent, responsive, effective and efficient, equitable and inclusive, and following the rule of law. This is illustrated in Figure 4.3. These eight characteristics are to a certain extent rather subjective to be measured. They are also by no means constitute the only or absolutely correct way to define what can be regarded as good governance. In addition, good governance assures that the views of minorities are taken into account and that the voices of the most vulnerable in society are heard in decision-making. It should also be responsive to the present and future needs of society. Thus economic growth

(as measured by growth in per capita GDP) may not be the best yardstick to judge the performance of the Government Eco-system. Indicators capturing the quality of governmental management of public finances are thus necessary.

Figure 4.3: The Eight Major Characteristics of Good Governance

By drawing on existing notions of governance, and seeking to navigate between various broad and narrow definitions, we can define governance for economic sustainability as the traditions and institutions by which authority in a particular nation is exercised with the following objectives:

1. Having the capacity to effectively formulate and implement sound policies for sustainable economic development;
2. Having the respect of the people and the state for the institutions that govern economic, social and environmental interactions; and
3. Having proper process and environment by which the government is selected, participated, monitored and renewed.

Each of the objectives is further analyzed and discussed in terms of characteristics and measurable traits in this section.

The first objective on the list is very fundamental of the Government Eco-system – the **effectiveness of its public and private institutions**. The quality of these institutions has a strong bearing on investment decisions and organization of production, and plays a key role in the ways in which societies distribute the benefits and bear the costs of development strategies and policies. It is thus required to capture the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Although main-stream economic literature has focused mainly on public institutions, private institutions are also an important element in the process of sustainable economic growth. The **regulatory quality** of the private sector has to be measured.

The second objective on the list is embodied in the **rule of law**, property rights and freedom of contract, and characterized by external and internal openness of the markets, the protection of property rights and freedom of economic initiative. It is also characterized by a **corruption-free** society. Corruption comes in many forms and good governance and economic freedoms do not automatically guarantee that the nation is free of corruption. Global corruption resulting from bribery, price-fixing cartels and undue influence on public policy is causing distorted money flows and obstructing the path towards sustainable economic growth. Political corruption is the abuse of public power, office, or resources by elected government officials for personal gain, e.g. by extortion, soliciting or offering bribes. Corruption can also take place in the private sector which can be in the form of various corporate crimes. Systemic corruption is the complete subversion of a political or economic system. Corruption can be checked by the will and attitude of the people and its government. An economy is well served by businesses that are run honestly, where managers abide by strong ethical practices in their dealings with the government, other firms, and the public at large. Private-sector transparency is indispensable to business, and can be brought about

through the use of standards as well as auditing and accounting practices that ensure responsible management.

The third objective on the list is characterized by two main factors: (i) **governmental system and accountability**, and (ii) **safety and security**. The factor of governmental system and accountability is concerned with the extent to which a society is autocratic or democratic. This factor depends on the competitiveness of executive recruitment; constraints on chief executives; regulation of political participation; and competitiveness of political participation. The perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression and association do also matter.

The factor of safety and security is important as societies that are plagued by internal and external threats to national security and personal safety cannot foster growth in average levels of income or in stable renewal of government. Stable economic environments are necessary for attracting investment and sustaining economic growth. In addition, when citizens worry about their personal safety, they are unlikely to be concern about the sustainability of their environment. When society and basic institutions are unsafe and unstable, then capital, investment, and people may begin to outflow. Studies have shown that organized political violence such as riots, coups, and civil war, as well as general crime and mistrust stemming from a lack of social cohesion can impede economic growth and weaken support for long-term sustainability (Khan, 2009).

4.3.2 Data Synthesis and Case Studies

Data for various factors of Government Eco-System are available from many sources. However they all have the following issues:

- Many of them do not have objective measurements and are based on subjective surveys, or a mixture of objective and subjective data;

- Many of them are aggregates of other indicators drawn from a variety of other third-party sources at different time points;
- Some of the indicators are in evolving states and therefore their definitions, sampling and computational methodology have been changing every year;

For example, the Legatum Institute has compiled a governance index which measures countries' performances in three areas: effective and accountable government; fair elections and political participation; and rule of law. Each area is further based on a number of characteristics, a total of 16 which are tabulated in Table 4.6. Some of these characteristics are measured by objective data, while others are based on survey responses. The relative weights of the factors are obtained by regressions on two outcomes: income and on well-being, and are shown as bar chart in Figure 4.4. This composite indicator does not include much data on safety and security, except for a single indicator on responses to a survey question on whether the subject has confidence in the country's military. However Legatum has a separate aggregate index on Safety and Security.

Source: Legatum Institute, 2011

Figure 4.4: Variables and Weights Used by Legatum Institute for its Governance Index

The Worldwide Governance Indicators (WGI) project is funded and undertaken by World Bank and Brookings Institute to compile and report aggregate and individual

governance indicators for 213 economies over the period 1996–2010, for six indicators of governance. These are:

1. Government Effectiveness;
2. Regulatory Quality;
3. Rule of Law;
4. Control of Corruption;
5. Political Stability and Absence of Violence.
6. Voice and Accountability

These aggregate indicators combine the views of a large number of enterprise, citizen and expert survey respondents in industrial and developing countries. The individual data sources underlying the aggregate indicators are drawn from a diverse variety of survey institutes, think tanks, non-governmental organizations, and international organizations. However the WGI project does not compute an aggregate score out of its six indicators of governance.

The World Economic Forum (WEF) publishes an annual report entitled Global Competitive Report. It evaluates the economic competitiveness of more than 130 nations in 12 areas. One of the areas is the Institutional Environment of each nation which is basically the governance effectiveness of its public and private institutions. This area assesses the legal and administrative framework within which individuals, firms, and governments interact to generate income and wealth in the economy. Table 4.7 lists the characteristics used by WEF in its computation of its Institutions Environment index. It can be seen that this index basically encompasses the essential characteristics of good governance depicted in Figure 4.3. However it does not include factors such as safety and security, and corruption.

Since 1995, Transparency International (TI) has published an annual Corruption Perceptions Index (CPI), ordering the countries of the world according to the degree to which corruption is perceived to exist among public officials and politicians. The organization defines corruption as the abuse of entrusted power for private gain.

Table 4.6: Factors Used by Legatum Institute in its Governance Index

	Characteristics	Description
1	Government Type	The extent to which a society is autocratic or democratic. This measure depends on the competitiveness of executive recruitment; constraints on chief executives; regulation of political participation; and competitiveness of political participation.
2	Government Effectiveness	This variable captures the efficiency and quality of bureaucracy; level of government stability and effectiveness with respect to the implementation of policies.
3	Regime Stability	The number of years since the most recent regime change.
4	Political Constraints	The extent to which a change in the preference of a political actor may lead to policy change. This is an indicator of the existence of checks and balances in a political system.
5	Separation of Powers	Composite variable including five components that are highly correlated: <ul style="list-style-type: none"> • Competitiveness in Executive Branch - The extent of competition in the participation of various political fractions in the executive branch. • Competitiveness in Legislative Branch - The extent of competition in the participation of various political fractions in the legislative branch. • Judiciary Independence - The extent to which the judiciary system is independent in its actions from the preferences of the executive authorities. • Regulation of Executive Election - Regulation refers to the extent to which a polity has institutionalized procedures for transferring executive power. • Political participation - This variable indicates to what extent citizens enjoy freedom of political choice and the legal right and ability in practice to change the laws and officials that govern them through free and fair elections.
6	Government Approval	Survey: do you have confidence in the National Government?
7	Efforts to Address Poverty	Survey: In the country where you live; are you satisfied with the efforts to deal with the poor?
8	Environmental Preservation	Survey: In the country where you live; are you satisfied or dissatisfied with efforts to preserve the environment?
9	Business and Government Corruption	Survey: Is corruption widespread in businesses and throughout the government?
10	Rule of Law	The extent to which individuals within a society respect property rights; the police and the judiciary system; as well the quality of police and legal safeguards.
11	Regulation	Measures the extent of regulation within the business sector. It captures general regulation with respect to investment and competition.
12	Confidence in Military	Survey: Do you have confidence in each of the following or not? How about the military?
13	Confidence in the Judicial System	Survey: Do you have confidence in each of the following or not? How about the judicial system?
14	Political Rights	Ability to participate in political processes such as voting in legitimate elections; joining parties; running for office; etc. This variable captures elements relating to the electoral process; political pluralism and participation as well as the functionality of the government and additional discretionary political rights.
15	Voiced Concern	Survey: Have you voiced concern to a public official in the past year?
16	Confidence in the Honesty of Elections	Survey: Do you have confidence in each of the following or not? How about the honesty of elections?

Table 4.7: Characteristics Used in Institutional Environment Index by WEF

Public institutions (75%)	1. Property rights (20%)	Property rights
		Intellectual property protection
	2. Ethics and corruption (20%)	Diversion of public funds
		Public trust of politicians
		Irregular payments and bribes
	3. Undue influence (20%)	Judicial independence
		Favoritism in decisions of government officials
	4. Government inefficiency (20%)	Wastefulness of government spending
		Burden of government regulation
		Efficiency of legal framework in settling disputes
		Efficiency of legal framework in challenging regulations
		Transparency of government policymaking
	5. Security (20%)	Business costs of terrorism
		Business costs of crime and violence
		Organized crime
		Reliability of police services
Private institutions (25%)	1. Corporate ethics (50%)	Ethical behavior of firms
	2. Accountability (50%)	Strength of auditing and reporting standards
		Efficacy of corporate boards
		Protection of minority shareholders' interests
		Strength of investor protection

Table 4.8 tabulates the six good governance indicators of WGI for the case study set of ten nations. Denmark scored high in all six indicators. Singapore has high percentiles in 5 out of the 6 indicators, the exception being the ‘Accountability and Voice’ indicator. This may be due to the perceived lack of press freedom in Singapore, an issue which has been mentioned in international media every now and then. Indonesia has among the lowest scores in many of the indicators. Israel has low score in the ‘Political Security and No Violence’ indicator, probably due to the frequent outbreaks of violence in its occupied territories and the possibility of war breaking out between Israel and its Arab neighbors.

In Table 4.9, governance-related indicators from the Heritage Foundation, the Transparency International, the Legatum Institute, and the World Economic Forum are listed for comparison. It can be seen that the Legatum Institute's Governance Index and the WEF's Institution Environment Index are quite closely correlated. They generally correspond well with three of the WGI indicators: 'Government Effectiveness', 'Regulatory Quality' and 'Rule of Law' in Table 4.8. The WGI indicator for 'Accountability and Voice' shows less correspondence compared to other indicators, perhaps due to the perceived lack of freedom of information in some countries. This anomaly is particularly striking for Singapore, which has one of the lowest scores among the ten nations for this indicator, while garnering almost perfect scores in the other WGI indicators and fairly high scores in the wider aggregate indices from Legatum and WEF.

In the 2011 General Election of Singapore, the percentage popular vote of the ruling People's Action Party went down by over 6%, with the opposition party winning many more parliamentary seats. Political analysts have opined that the change in voting patterns is partly due to unhappiness towards the ruling party's economic policies in recent years which resulted in infrastructural and social strains. In other words, the democratic institution of Singapore has been effective in bringing diverse and alternative views of its citizens to the attention of its Government. This important aspect of good governance is likely to be reflected in a higher score of the 'Accountability and Voice' indicator for Singapore in future. Overall, Singapore has ranked high in its Government Eco-System Index.

In general, indices computed from wider inclusion of relevant characteristics are likely to be more consistent and robust. Hence an acceptable index for good governance may be taken from either the Legatum index or the WEF index, or by averaging the six WGI indicators.

Table 4.8: Worldwide Governance Indicators for 2009

Country	Worldwide Governance Indicators Project (Percentile)					
	Accountability and Voice	Governmental Effectiveness	Regulatory Quality	Rule of Law	Political Stability & No Violence	Control of Corruption
Colombia	42.7	56.2	57.1	39.6	7.1	48.1
Denmark	99.5	99.5	99.0	98.1	85.8	100
Indonesia	48.3	46.7	42.9	34.4	24.1	28.1
Israel	67.3	82.4	81.4	74.5	9.40	74.8
Japan	81.0	86.7	81.0	88.2	83.5	87.1
Malaysia	31.8	79.5	60.0	65.1	46.7	58.1
Philippines	45.5	50.0	52.4	35.4	10.8	27.1
Singapore	34.1	100.0	100.0	92.5	90.1	99.0
Thailand	34.6	59.5	61.9	50.9	14.6	51.0
Turkey	45.0	63.8	58.6	58	18.9	60.0

Source: Worldwide Governance Indicators 2009, *World Bank Institute***Table 4.9: Comparison of Various Governance-Related Indicators**

Country	Heritage Foundation		Transparency International	Legatum Institute		World Economic Forum
	Properties Rights	Freedom from Corruption	Corruption Perception Index	Safety & Security Index	Governance Index	Institution Environment Index
Colombia	50.0	37.0	35.0	39.4	60.5	48.6
Denmark	90.0	93.0	93.0	87.1	91.8	82.9
Indonesia	30.0	28.0	28.0	62.9	56.1	57.1
Israel	70.0	61.0	61.0	51.2	73.3	68.6
Japan	80.0	77.0	78.0	85.2	79.9	72.9
Malaysia	50.0	45.0	44.0	64.6	70.6	65.7
Philippines	N.A.	N.A.	24.0	52.2	61.8	44.3
Singapore	90.0	92.0	93.0	88.9	87.6	87.1
Thailand	45.0	34.0	35.0	56.7	62.7	57.1
Turkey	50.0	44.0	44.0	52.9	64.1	51.4

Note: all figures in percentile.

4.4 Ordinary Labor Eco-System

While in the short-term, we may measure the productivity of the ordinary workforce in terms of amount of goods and services that a worker produces in a given amount of time, here we are aiming to quantify the ‘state of health’ of the Ordinary Labor Eco-System, which would be affecting the long-term economic sustainability of the nation. The Ordinary Labor Eco-System basically consists of two main components: the labor market and the people in the workforce. The efficiency and flexibility of the labor market are critical for ensuring that workers are allocated to their most efficient use in the economy and provided with incentives to give their best effort in their jobs. The long-term quality of the workforce in general is affected by the health, the education and the social capital.

The main factors for the Ordinary Labor Eco-System are illustrated in Figure 4.5. An effective and sustainable healthcare system is required to ensure the population remains healthy for work and able to remain productive till old age (Riesman, 2009). A good education system is required to ensure a highly educated workforce and also to provide life-long education and re-training so the labor force is able to take full advantage of advancing technologies and changing labor market. Social capital helps to ensure healthy and cohesive social relations and therefore a happy population. Social capital is a very broad term and it is here used to refer to all aspects of social network and values which hold the society together directly or indirectly towards the objective of economic sustainability. Healthcare, education system and social capital together ensure a healthy, well-educated and environmentally responsible and happy workforce (Ng Y.K., 2008) which together with an efficient and flexible labor market, can sustain the long-term economic development for the nation.

Figure 4.5: Factors for Ordinary Labor Eco-System in Sustainable Economy

4.4.1 Major Factors

Education and Work Experience

If economic growth may be regarded as a crude short-term proxy indicator of Ordinary Labor Eco-System, then studies done on the contribution of education to economic growth can provide guidance to the understanding of educational factors for the computation of the O Index. Among the notable works, the standard Mincerian human capital earnings model developed by Jacob Mincer (1974) relates educational variables to returns to ordinary labor. The Mincerian equation estimates the changes in earnings using educational attainment and work experience as explanatory variables. In empirical modeling, a quadratic term in work experience is often added to the model to capture possible non-linear returns to work experience such as returns to on-the-job training. The standard Mincerian equation may thus be represented as follows:

$$\log(w_i) = \beta_0 + \beta_1 S_i + \beta_2 X_i + \beta_3 X_i^2 + \varepsilon_i \quad (4.17)$$

where $\log(w_i)$ is the natural log of the wage of individual i , S_i is the individual's years of schooling, X_i is the individual's years of working experience, and ε_i is a disturbance term. The coefficient β_1 is the Mincerian private rate of return to investment in schooling. This coefficient indicates that each additional year of schooling raises the wage by β_1 percent on average, all other things constant. It is likely to be positive as wages tend to increase with the number of years of schooling. The coefficient β_2 is also likely to be positive, as work experience adds value to the productivity of the worker and hence bring about higher wages. The coefficient β_3 may however be negative, as the return to work experience usually increases at a decreasing rate. It is even possible that after many years of work experience, its return becomes negative and then falls at an increasing rate.

Econometric studies on the Mincerian model with micro-economic data for developed and developing countries have shown that the average private return to schooling to be in the range of 6-10 percent, with the lower end as a representative estimate for an OECD average and the higher end as a representative estimate for a world average. While these micro-econometric studies mainly focus on the effects of schooling and/or work experience on individual wage income, they do not account for macroeconomic education externalities. However, the micro-economic relation between individual years of schooling and wages can be translated into a relation between average years of schooling and per capita income. The reason is that the share of total wages in GDP (labor share) does not follow a trend, neither over time nor across countries. Since labor shares are constant, wages are therefore proportional to per capita income. Hence the private return to schooling has to be multiplied by the labor share to derive a benchmark for the macro-economic return to schooling that would be expected in the absence of an education externality. In other words, any positive difference between an observed macro return to schooling and the proportionally adjusted

private return to schooling would be an indication of the significance of an education externality (Carstensen, 2008).

The production function framework of the augmented Solow Model may be combined with the Mincer model to provide a model to study the effects of education and work experience factors on the aggregate economy output. Adapting from Equation (4.3), we have

$$Y_j = B_j K_j^\alpha [h_j L_j]^{1-\alpha} \quad (4.18)$$

Where h_j is the average level of education in country j . Educational capital accumulation may generate an externality such that,

$$B_j = A_j h_j^\gamma \quad (4.19)$$

Where A_j is an index of country specific technology that grows over time at an exogenous rate and γ represents the education externality. The average level of education may be specified as a function of average schooling years and average experience, such that

$$h_j = \mu e^{\beta_1 S_j + \beta_2 X_j + \beta_3 X_j^2} \quad (4.20)$$

where μ is a constant, S_j is average years of schooling and X_j is average years of working experience in country j , and β_1 , β_2 and β_3 represent the *average* individual private returns to schooling and experience. Substituting (4.20) and (4.19) into (4.18), we get:

$$Y_j = B_j K_j^\alpha [\mu e^{\beta_1 S_j + \beta_2 X_j + \beta_3 X_j^2}]^{1-\alpha+\gamma} (L_j)^{1-\alpha} \quad (4.21)$$

Equation (4.21) can be used to derive a production function like Equation (4.8) to estimate the significance of education to economic growth.

Health and Healthcare Infrastructure

The impact of health issues on labor productivity can also be studied using similar approach as for education. For example, the link between nutrition, health and labor productivity can be studied by estimating wage equations for individuals. This is based on the

premise that wages is a proxy for marginal productivity of labor. Studies have indicated that wages are a function of various characteristics, height, household characteristics, total land owned by the household and the season:

$$\log(w_i) = \alpha_0 + \alpha_1 X_i + \alpha_2 \text{Height}_i + \alpha_3 Y_i + \varepsilon_i \quad (4.22)$$

Where X is a vector of individual characteristics, and Y is a vector of household characteristics such as land ownership. Height has been chosen as a variable to represent the stock of nutritional and health status, but other variables can also be used (Chansarn, 2010).

From another perspective, the issue of health as a driver of productivity has been studied directly. Productivity is defined as output per unit of input, and a society's productivity can be measured in several ways depending on what we choose to consider as inputs. In addition, a large number of proxy measures for health status may be used. Each health proxy may capture different aspects of a society's general health, and each may have a different relationship with the various productivity measures. In Figure 4.6, this relationship between health status and productivity measures is illustrated. The two conventional productivity measures are output per hour worked and output per person employed (or 'per worker'). Presenteeism (that is, workers going to work while sick) affects output per hour worked, while absenteeism (workers missing work due to sickness) reduces output per worker. 'Social' measures of productivity take a broader view of who is counted as an input; they include output per labor force participant and output per working age person. Unemployment and labor force nonparticipation due to illness or disability can affect these social productivity measures. Note that each of the health issues in Figure 4.6 can encompass any number of specific illnesses, disabilities, and physical, mental or social conditions (Sharpe, 2011).

Figure 4.6: Productivity Measures in View of Impacts of Health

Social Capital and Happiness

The third major factor in Ordinary Labor Eco-system, ***Social Capital***, is usually seen as more of a sociological concept, as the term social capital is frequently used by different social sciences. Generally, it refers to the social networks and the bonding that a society experiences when people trust one another. It highlights the value of social relations and the role of cooperation and confidence to get collective or economic results. It is a broad term, and can be defined accentuating different aspects depending on the perspective. In general terms, social capital is the outcome of social relations, and consists of the expected benefits derived from the preferential treatment and the cooperation between individuals and groups. Durlauf and Fafchamps (2004) presented three main underlying ideas that are now commonly found in almost all of the definitions of social capital:

1. Social capital generates (positive) externalities for members of a group.
2. These externalities are achieved through shared trust, norms, and values and their subsequent effects on expectations and behavior.
3. Shared trust, norms and values arise from informal forms of organization based on social networks and associations.

The metaphor of ‘capital’ here should be qualified, because unlike financial capital which is a resource that can be easily transferred by an individual or organization to another, the

benefits of various forms of social organization are the results of the participation of individuals in advantageously organized groups and these benefits are usually not transferrable.

Putnam (2000) distinguishes between two types of social capital, i.e. bonding and bridging social capital. The bridging type can be defined as bonds of connectedness that are formed across diverse social groups (open networks), whereas bonding social capital cement only homogenous groups (closed networks). Both networks provide opportunities for social interaction, for which individuals have a preference. Examples of bonding social capital are the ties and cohesiveness in families and in religious communities, while examples of bridging social capital are the levels of trust in a society and the manner in which citizens think they can rely on others. Individuals shall endogenously choose how much time resource they allocate on closed networks and on open networks, depending on their preferences and the opportunity costs. Each individual also optimally chooses time spent on rent-seeking activities, on work and on investment and learning.

Participation in open networks has the beneficial side-effect of protection against opportunistic behavior by others. At the aggregate level, participation in open networks translates into civic engagement (i.e. bridging capital). If the level of civic engagement is high in the society, opportunistic behavior becomes less attractive for individuals and a more efficient system of exchange stimulates the economy. While more bridging social capital may lead to faster economic growth in the long run, it may not necessarily be apparent in the short-term, as it may require the maintenance of networks, which is a time-consuming process and comes at the expense of working time. Another example is while marriages (bonding social capital) may lead to population growth necessary for economic sustainability in the very long term, it may lead to more working women dropping out of the workforce in the near term, leading to slower economic growth in the short term.

Labor Market Efficiency and Flexibility

Lastly, labor markets should have the flexibility to shift workers from one economic activity to another rapidly and at low cost, and to allow for wage fluctuations without much social disruption. The importance of the latter has been dramatically highlighted by the difficulties countries with particularly rigid labor markets—such as Spain—have encountered in recovering from the recent major economic downturn. Efficient labor markets must also ensure a clear relationship between worker incentives and their efforts, as well as equity in the business environment between women and men.

4.3.2 Data Synthesis and Case Studies

Education Sub-Index

This should measure countries' performance in three areas: access to education, quality of education, and human capital. Access to education allows citizens to develop their potential and contribute productively to their society. This can be measured by the ratio of total enrolment to the population of the age group that officially corresponds to the level of education considered. The levels of education to be considered are primary level, secondary level and tertiary level. Such data is available from World Development Indicators.

Global data on quality of education is however limited and therefore pupil to teacher ratio (source: World Development Indicators), as well as measures of citizens' perception of education may be used to assess quality. Because of the importance of citizen's own perceptions of the educational opportunity available to them, both objective and subjective variables may be utilized to assess the quality of education in a given country. These survey data is available from Gallup World Poll.

Human capital stock, which is measured by the average levels of education in the workforce, is essential for promoting private sector research and development as well as

producing useful knowledge for a society. It has been found to be an engine for growth, making a case for the non-diminishing effect of education on rising GDP levels. Data on the average number of years of secondary and of tertiary education completed in the workforce is available from the Legatum Institute.

Table 4.10 lists samples of raw data described above. The raw data can then be used to compute sub-indices for access to education, quality of education, human capital as well as an eventual Education Sub-Index as shown in Table 4.11. Singapore appears to be lacking in the area of tertiary level education attainment and can do with better pupil-to-teacher ratio.

Table 4.10: Data on Education-Related Variables

Country	Primary Level Enrolment (%) ¹	Secondary Level Enrolment (%) ¹	Tertiary Level Enrolment (%) ¹	Pupil to Teacher Ratio ¹	Satisfaction Educational Quality (%) ²	Children are Learning (%) ²	Secondary Education per Worker (years) ³	Tertiary Education per Worker (years) ³
Colombia	90.02	90.58	35.36	29.40	76.72	46.25	1.43	0.88
Denmark	95.62	119.21	80.30	9.93	84.18	92.47	3.24	1.30
Indonesia	94.83	75.77	18.00	18.82	79.83	94.19	1.84	0.37
Israel	97.13	91.50	60.41	13.41	59.98	67.75	3.25	1.43
Japan	100.00	100.66	57.87	18.49	60.99	87.87	2.92	1.23
Malaysia	97.49	69.08	29.75	15.75	94.60	98.19	1.81	0.80
Philippines	90.44	81.37	27.83	33.67	83.72	85.38	1.38	1.04
Singapore	96.58	97.78	33.70	19.30	95.26	98.58	2.71	1.02
Thailand	94.00	84.00	38.00	15.99	89.46	89.52	0.29	1.21
Turkey	93.86	82.12	37.10	16.10	60.03	47.16	1.34	0.70

Sources: ¹ World Development Indicators 2011; ² Gallup World Poll 2011; ³ Legatum Institute 2011

Table 4.11: Computation of an Education Index

Country	Access to Education	Quality of Education	Human Capital	Overall Education Index
Colombia	71.99	51.09	47.42	56.83
Denmark	98.38	87.52	89.03	91.64
Indonesia	62.87	78.18	35.23	58.76
Israel	83.01	67.90	93.82	81.58
Japan	86.18	70.11	81.83	79.37
Malaysia	65.44	87.36	50.15	67.65
Philippines	66.55	62.40	52.39	60.45
Singapore	76.02	84.33	71.24	77.20
Thailand	72.00	82.53	42.44	65.65
Turkey	71.03	58.49	39.66	56.39

Health Sub-Index

There are three groups of variables which contribute to an overall health indicator for sustainable development: basic health indicators, healthcare and infrastructure, and health satisfaction. Raw data for these three groups of variables are given in Tables 4.12 and 4.13 and Figure 4.7 respectively for the ten-nation case studies.

Basic Health Indicators – These include the infant mortality, life expectancy, cases of tuberculosis, and malnourishment. In view of the rapid industrialization and urbanization brought about by high economic growth, another indicator of growing importance is the mortality caused by respiratory diseases. Basic health indicators provide indications on the quality of basic human health services of the nation which are necessary for a healthy and sustainable workforce. Infant mortality rate is defined as number of infants dying before the age of one (or five depending on database used) per 1,000 live births in a given year. Life expectancy at birth indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life. By adding weights to the years in which a person is sick, we get the health-adjusted life expectancy. Most of these data are available from the World Development Indicators databank of World Bank. Data on malnourishment is not available for many countries and so is left out of this study. Death rate from respiratory diseases and infections is defined as death rate per 100,000 people. Incidence of tuberculosis cases per 100,000 people is also available.

Healthcare and Infrastructure - A strong healthcare infrastructure in which residents are able to enjoy good physical and mental health leads to higher levels of labor productivity, better performance in education, and longer years of employment. The indicators in this area include rates of immunization for the percentage of children aged 12-23 months against infectious diseases such as diphtheria, pertussis (or whooping cough), tetanus and measles. Further indications of good healthcare are medical expenditure per capita,

number of hospital beds per 1000 people from all public, private and specialized hospitals, and the percentage of population with access to proper sanitation. The quality of water supply for human consumption is also a very important factor in healthcare.

Degree of Health Satisfaction – Self-reported wellbeing and self-reported health are commonly found by researchers to be strongly and significantly correlated to a overall society's health, as this fosters strong human capital that leads to productive aggregate economic output. Mentally and physically healthy citizens are the bedrock of a productive workforce, which in turn leads to higher levels of income per capita. Information on this is available from Gallup World Poll which was obtained from surveys in the following areas:

- Satisfaction with health;
- Level of worrying;
- Well rested;
- Having health problems;
- Satisfaction with environmental beauty.

Indicators on degree of health satisfaction for the ten-nation case study are illustrated in Figure 4.7

Three indices for basic health, healthcare and infrastructure, and degree of health satisfaction have been computed from the indicators and are tabulated in Table 4.14. The overall health index is obtained from a simple average of these indices. It is interesting to note that Japanese are less satisfied with their health despite their country having one of the best healthcare and infrastructure. For Singapore, it can be seen that the death rate from respiratory diseases is relatively high.

Table 4.12: Basic Health Indicators

Country	Infant Mortality Rate ¹ (per 1000 live births)	Life Expectancy ¹ (years)	Health-Adjusted Life Expectancy ¹ (years)	Incidence of Tuberculosis Cases ¹ (per 100,000)	Death from Respiratory Diseases ² (per 100,000)
Colombia	16.99	72.83	62	35.39	46.37
Denmark	3.5	78.28	70	8.06	101.8
Indonesia	24.8	70.61	58	227.98	118.46
Israel	3.8	80.6	71	7.54	36.28
Japan	2.6	82.51	75	21.09	118.91
Malaysia	9.6	74.29	63	103.26	72.85
Philippines	22.79	71.94	59	290	100.57
Singapore	2.4	80.49	70	26.5	86.97
Thailand	6.44	68.99	60	142.26	79.27
Turkey	21.4	71.95	62	29.56	70.63

Sources: ¹ World Development Indicators, World Bank, 2011² World Health Organization, 2011**Table 4.13: Healthcare and Infrastructure Indicators**

Country	Rate of Immunization Against Infectious Disease ¹ (% of children population)	Rate of Immunization Against Measles ¹ (% of children population)	Health Expenditure per Person ² (international dollars PPP)	Hospital Beds ¹ (per 1,000 people)	Access to Proper Sanitation ¹ (% of population)	Water Quality ³ (positive % of total responses)
Colombia	93	95	626	1.2	74	73.15
Denmark	75	89	3349	3.82	100	96.35
Indonesia	75	80	89	0.6	52	82.31
Israel	96	97	2263	6.3	100	66.04
Japan	98	98	2514	14.1	100	82.58
Malaysia	96	90	500	1.8	94	86.77
Philippines	87	92	230	1.2	72	84.24
Singapore	96	95	1228	2.8	100	99.81
Thailand	98	96	347	2.23	93	84.98
Turkey	96	96	645	2.6	87	55.11

Sources: ¹ World Development Indicators, World Bank, 2011² World Health Organization, 2011³ Gallup World Poll, 2011

Sources: Gallup World Poll

Figure 4.7: Indicators on Degree of Health Satisfaction**Table 4.14: Computation of a Health Indicator**

Country	Basic Health Index	Healthcare & Infrastructure Index	Health Satisfaction Index	Overall Health Index
Colombia	53.21	59.40	60.61	57.74
Denmark	79.80	80.29	71.17	77.08
Indonesia	23.26	48.38	69.58	47.07
Israel	86.77	77.47	48.81	71.01
Japan	86.23	90.95	72.39	83.19
Malaysia	60.49	64.73	73.64	66.29
Philippines	27.08	57.43	59.83	48.11
Singapore	82.09	73.54	87.07	80.90
Thailand	58.81	65.33	72.10	65.41
Turkey	44.90	60.94	57.11	54.31

Social Capital Sub-Index

Social capital is usually regarded as difficult to measure in that it is neither an individual-level nor a group-level phenomenon, but one that cuts across levels of analysis as individuals participate in various groups. Seven variables have been identified (Legatum 2011) which can be measured from polls conducted by Gallup World Polls:

1. **Trust in Others:** An indicator to gauge the percentage of society who has trust in others. Measured by the percentage of survey respondents who were asked if they feel that there are others in their society who can be trusted.
2. **Donations:** An indicator to gauge the degree of philanthropy in the society. Donations are seen as a proxy for philanthropy attitude. Measured by the percentage of survey respondents who were asked if they have done any act of philanthropy such as donating money to a charity in the past month.
3. **Formal Volunteering:** An indicator to gauge the prevalence of volunteerism in the society. Measured by the percentage of survey respondents who were asked if they have done any volunteering of time to an organization in the past month.
4. **Helping Strangers:** An indicator to gauge the spirit of helping strangers in the society. Measured by the percentage of survey respondents who were asked if they would help a stranger or someone whom they do not know but needed help.
5. **Perceptions of Social Support:** An indicator to gauge the degree of perceived social support. Measured by the percentage of survey respondents who were asked if they have relatives or friends whom they can count on to help them when they need them.
6. **Marriage:** An indicator to gauge the degree of social network bonded by marriage. Measured by the percentage of survey respondents who claimed that they are married.

7. **Religious Attendance:** An indicator to gauge the degree of social bonding through religious activities. Measured by the percentage of survey respondents who claimed to have attended a place of worship or religious service within the last seven days.

These seven variables contributed to either bonding or bridging networks or an overlap of both as shown in Figure 4.8. Sample data of these variables are given in Table 4.15. A Social Capital Index measuring these countries' performances in social cohesion and engagement, as well as community and family networks can be thus computed.

Singapore's Social Capital Index of 63.5 is lower than those of Denmark, Indonesia, Israel, Japan, and Thailand. This may be a sign that stress in society is creating certain degree of social strain and general unhappiness in Singapore. For comparison, in the Happy Planet Index 2009, Singapore was ranked 49 out of 143 countries, while in the Satisfaction with Life Index 2006, Singapore was ranked 53 out of 178 countries.

Figure 4.8: Variables Classified Under Social Capital

Table 4.15: Data on Social Capital

Country	Trust in Others ¹	Donations ¹	Formal Volunteering ¹	Helping Strangers ¹	Perceptions of Social Support ¹	Marriage ¹	Religious Attendance ¹	Social Capital Index (0~100) ²
Colombia	12.58	24.10	19.93	62.83	88.59	28.92	61.88	61.57
Denmark	64.00	67.69	19.75	45.61	95.39	56.39	16.08	94.00
Indonesia	26.74	45.97	27.99	35.77	77.94	71.91	78.77	64.86
Israel	27.02	54.40	26.68	45.76	93.66	61.88	39.41	77.00
Japan	33.88	16.72	22.82	24.86	88.84	68.85	38.36	69.14
Malaysia	8.09	32.45	29.21	31.17	79.17	58.66	73.26	54.57
Philippines	13.42	24.81	36.40	47.73	77.52	52.13	63.87	57.00
Singapore	20.62	34.91	9.81	34.87	86.63	68.28	39.53	63.50
Thailand	19.82	83.19	16.19	52.53	89.32	67.61	80.78	74.57
Turkey	8.40	14.60	7.48	35.71	64.49	65.22	54.90	39.71

Sources: ¹ Gallup World Poll, 2010² Legatum Institute, 2011***Labor Market Efficiency Sub-Index***

An index for Labor Market Efficiency can be constructed from an aggregate of the following variables:

1. The degree of cooperation in labor-employer relationships in the country. This can be based on survey responses on how labor-employer relations may be characterized in the country, ranging from confrontational to generally cooperative.
2. Decision process on wages in the country. This can be based on survey responses ranging from wages being set by centralized bargaining process, to wages entirely up to each individual company.
3. The rigidity of employment in the country. This measures the difficulty of hiring, the rigidity of working hours, and the difficulty of firing. This can be based on data compiled by World Bank.

4. The characterization of the hiring and firing of workers in the country. This can be based on survey responses ranging from hiring and firing that is heavily impeded by regulations, to that which is very flexibly determined by employers.
5. Redundancy costs in change of employment. This variable estimates the cost of advance notice requirements, severance payments, and penalties due when terminating a redundant worker, expressed in weekly wages. In some countries, e.g. Bolivia and Venezuela it is not possible to terminate a worker for economic reasons.
6. The relationship between wages and productivity in the country. This can be based on correlation coefficient between average income and productivity, or on survey responses on perception of relationship between wages and productivity.
7. The degree of professionalism in senior management of companies in the country. This can be based on survey responses on the perception ranging from that of senior positions being filled usually with relatives or friends without regard to merit, to that of mostly professional managers chosen for merit and qualifications.
8. The barriers to net talent inflow and retention in the country. This can be measured by the annual inflow of foreign professionals into the country minus the outflow of local citizens to work abroad in professional areas. A survey on whether the country welcome, attract and retain talented people with responses ranging from that of the best and brightest normally leaving to pursue opportunities in other countries, to that of many opportunities for talented people within the country, is also applicable.
9. The barriers to greater contributions of the female gender to the Ordinary Labor Eco-System. The freedom from social and other barriers which restrict women participation in the workforce and which place glass ceilings on women in management positions is very important to the long-term economic sustainability.

Currently, this may be gauged by the female-to-male participation ratio in the labor force.

Sample data on the variables of Labor Market Efficiency is given in Table 4.16.

Table 4.16: Data on Variables of Labor Market Efficiency

Country	Co-operation in labor- employer relations ¹ (index 1 to 7, 7=most cooperative)	Flexibility of wage determination ¹ (index 1 to 7, 7=most individual)	Rigidity of employment ² (0 to 100, 100=worst)	Hiring and firing practices ¹ (index 1 to 7, 7=least regulated)	Redundancy costs ² (weeks of salary)	Reliance on professional management ¹ (index 1 to 7, 7=most reliant)	Brain drain ¹ (index 1 to 7, 7=most attractive to foreign talent)	Female participation in labor force ³ (female to male ratio)	Pay and Productivity relation ¹ (index 1 to 7, 7=most related)
Colombia	4.6	5.3	10	3.9	59	4.2	3.1	0.84	3.4
Denmark	5.7	4.5	7	5.8	0	5.8	4.8	0.92	4.5
Indonesia	4.6	5.3	40	4.4	108	4.5	4.6	0.58	4.6
Israel	5.1	5.6	17	4.2	91	5.3	4.4	0.89	4.6
Japan	5.7	5.8	16	3.0	4	5.6	4.7	0.73	4.8
Malaysia	5.3	5.4	10	4.2	75	5.3	4.6	0.58	5.1
Philippines	4.5	4.6	29	3.2	91	4.7	3.1	0.63	3.8
Singapore	6.2	6.1	0	5.9	4	5.9	5.8	0.73	5.6
Thailand	4.9	4.8	11	4.5	54	4.5	4.2	0.82	4.5
Turkey	3.8	4.6	35	4.0	95	4.1	3.0	0.35	3.9

Source: ¹ World Economic Forum, *Executive Opinion Survey*

² The World Bank, *Doing Business 2010*

³ International Labour Organization, *KIILM Net 2010*

Many nations are now facing the aging population issue, which will definitely impact on the labour sustainability and put strain on the healthcare system. Figure 4.9(a) shows the shift of Singapore's population to higher age groups in the last decade for both genders. Figure 4.9(b) shows the old age support ratios of Singapore changing over the years, which is defined as the number of residents aged 15-64 years per elderly resident (person aged 65 years and over). Singapore is particularly vulnerable to the aging population issue, as it lacks a vast hinterland to provide a younger working population and where retired elderly folks can move to. Immigration may be able to mitigate this aging population issue to some extent, but it can bring new problems in terms of worsening of social capital.

(a) Aging population profile in Singapore;

(b) Old age support ratio of Singapore

Source: Department of Statistics, Singapore

Figure 4.9: Threat of Aging Population to Labor Market and Healthcare of Singapore

4.5 Investment Eco-System

The Investment Eco-system of an economy is not just simply the amount of gross investments made in the nation over a period of time. It is the ability and effectiveness of the nation to attract investments both from within and without, to make good use of the investment funds, to replace depreciated capital at the right time with newer technology, and to provide the best returns to its investors. The index of the Investment Eco-system is thus not a measure of gross or net investments but an indicator of the nation's effectiveness in investing for a sustainable economic performance in the long term, in relation to all other nations considered in the computation of the index.

Before looking into the issue of identifying factors characterizing the Investment Eco-System, it is intuitive to re-visit the definition and components of investment. In macro-economics, investment is defined as the amount of goods purchased over a unit of time, which is not to be consumed but to be used for future production. In measures of national income and output, gross investment I appears as a component of gross domestic product Y :

$$Y = C + I + G + (X - M) \quad (4.23)$$

where C is consumption, G is government spending, and $(X-M)$ is net exports. Thus investment is what that remains of total expenditure after consumption, government spending, and net exports have been subtracted. Net investment is gross investment with depreciation deducted. As it occurs over a period of time, it is therefore a flow and not a stock. By contrast, capital is accumulated net investment up to a point in time, which is a stock. There are two sources of financing this domestic investment. One is domestic savings, defined as a part of the gross domestic product that is not consumed. Foreign savings (net imports) can serve as a complementary source of financing investment outlays.

$$I = sY + (M - X) \quad (4.24)$$

In Equation (4.24), s is the domestic saving rate. Under balance of payment equilibrium, net imports are equaled to real foreign capital inflows F including both official (F_{pu}) and private (F_{pr}) capital flows.

$$M - X = F \Rightarrow I = sY + F \quad (4.25)$$

$$F = F_{pu} + F_{pr} \quad (4.26)$$

Foreign private capital can be further decomposed into direct foreign investment FDI implying long-term investment and other foreign investment (OFI) which is mainly the short-term flows, as reflected through the size of the private sector credit market ($PSCM$), and the real exchange rate with respect to the US dollar (REX).

$$F_{pr} = FDI + OFI \quad (4.27)$$

$$OFI = \lambda PSCM + \mu REX \quad (4.28)$$

Here, λ and μ are coefficients. Hence investment is given by

$$I = sY + F_{pu} + FDI + \lambda PSCM + \mu REX \quad (4.29)$$

Equation (4.29) can serve as a starting point to identify major factors of Investment Eco-System in contributing to economic sustainability.

4.5.1 Major Factors

In Equation (4.24), the first term in the right hand side is an indicator of gross domestic saving. Hence to identify the major factors of the investment eco-system, it is important to examine the linkage between investments and savings. They have been regarded as both sides of the same coin. Indeed in a simple single-economy ideal world, whatever goods that are not consumed must have been saved, and whatever that has been saved, must have been invested. However in the real complex world with many nations, domestic savings do not equal to investments in each nation. In fact if we assume that investors are able to

easily invest anywhere in the world, they would logically invest in countries that offer the highest return per unit of investment. This would drive up the price until the return per unit of investment across different countries is similar. This would then imply that statistical data should show no relationship between savings and investment at all within a single country. However actual statistics have shown that this is far from being true in most countries. This is the well-known Feldstein-Horioka puzzle, one of the six major international economic puzzles. This issue also concerns the degree of contributions of savings and investments to long term economic sustainability. The original Feldstein-Horioka (FH) regression (1980) is written as:

$$\left(\frac{I}{Y}\right)_i = \alpha + \beta \left(\frac{S}{Y}\right)_i + \mu_i \quad i = 1, 2, 3, \dots, N \quad (4.30)$$

The relationship between national investment and saving shares of GDP is known as the FH regression. The FH coefficient, β measures the saving-investment association. The FH original estimates is based on annual data from 1960-74 for 16 Organisation of Economic Cooperation and Development (OECD) countries (Australia, Austria, Belgium, Canada, Belgium, Finland, Germany, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Sweden, UK and the US). They found that $\beta = 0.89$ with $R^2=0.91$. Feldstein and Horioka argue that β should be close to zero in a frictionless open economy world. Hence, they could not reject the null hypothesis of $\beta = 1$. This indicates the high saving-investment association (or high saving retention) and they interpret it as an indication that capital is highly immobile internationally. This empirical finding that savings and investment within a country are highly correlated with each other has been typically seen to run against the conventional hypothesis of perfect capital mobility. If the capital flows between the OECD countries are reasonably free, this should hold true for domestic saving and investment rates for those countries.

The contribution of foreign direct investment to the functions of Investment Ecosystem is not so clear-cut. This may be partly due to that FDI effectiveness is more dependent on characteristics of individual nations, such that the linear empirical growth model is unable to fully quantify. There have been contradicting conclusions drawn from various studies done on whether FDI influences economic growth. For example, some studies have found that FDI has a statistically significant impact on growth in all countries (Blomstrom, 1992) while some concluded that the direct effect is negative, and the net effect is positive only for developing countries with high initial levels of general education (Borensztein, 1998). However, a recent study of FDI in many countries found no such correlation. (Carkovic and Levine, 2005). Therefore FDI may need some complementary domestic institutions to be present in sufficient extent or depth before it can benefit macroeconomic growth. Countries may need to start out with a well-educated labor force or a sophisticated financial system (Alfaro, 2004).

A study done using a partially non-linear model has found that there may be an FDI threshold, above which FDI can significantly and substantially increase growth (Schmidt, 2008). This study concluded that a country must receive a minimum amount of FDI before its macroeconomic growth rate can show significant respond. This FDI threshold is not high, occurring at about 18 times per capita GDP of each country. When FDI is in sufficient quantity, it makes a substantial contribution to economic growth. It increases the growth rate of GDP per capita by between 0.83 and 1.57 percentage points each year, depending on the actual amount of FDI. In that study, the non-linear growth regression model that distinguishes the macroeconomic experience of each country i individually is given by,

$$\Delta Y_i = \beta_0 + \beta_1 I_{Di} + \beta_2 \Delta P_i + \beta_3 (LIFE)_i + \beta_4 (TRADE)_i + g(Y_{0i}, FDI_i) + \varepsilon \quad (4.31)$$

Where ΔY_i is the rate of economic growth,

I_{Di} is the per capita share of domestic investment in GDP,

P_i is the rate of growth of the population,

$LIFE_{0i}$ is the initial life expectancy at birth,

$TRADE_i$ is the share of exports plus imports in GDP per capita,

Y_{0i} is initial GDP per capita relative to that of the U.S.,

FDI_i is net inflows of FDI relative to GDP per capita,

$g()$ is a non-linear function of inter-acting variables, and

ε is the statistical error of the estimated model.

In summary, domestic savings and foreign direct investments are like the twin engines of a nation's Investment Eco-System. However an amenable macro-economic environment is necessary for the engines to be sustainable and effective. A minimum size of the capital stock depending on the maturity of the economy is also important for the Investment Eco-System to deliver contributions to the economic sustainability. This is summarized in Figure 4.10.

Figure 4.10: Major Factors of the Investment Eco-System

4.5.2 Data Synthesis and Case Studies

As investment has traditionally been a well-studied economic topic, data on gross domestic savings, foreign direct investments and capital per worker can be easily obtained from the national accounting systems of most nations. Capital per worker change is determined by three variables:

- Investment (saving) per worker.
- Population growth, increasing population decreases the level of capital per worker.
- Depreciation – capital stock declines as it depreciates.

An indicator for macro-economic environment is less easy to synthesize but may be aggregated from a basket of proxies comprising inflation rate, interest rate spread, national budget balance, national debt, and country credit rating.

Table 4.17: Major Investment-Related Factors for Economic Sustainability

Country	Domestic Savings (% GDP)	FDI Volatility (US\$/3-year volatility)	Capital per worker (US\$)	Macro-Economic Environment					
				Overall Rating (1-7)	Inflation (% Δ CPI)	National Budget Balance (% GDP)	Interest Rate Spread (%)	National Debt (%GDP)	Country Credit Rating (0-100)
Colombia	21.21	5.35	21993	4.8	7.00	-2.7	6.8	42.7	56.3
Denmark	24.55	0.60	121570	5.6	3.40	0.0	3.2	51.8	90.4
Indonesia	28.94	4.23	11351	5.2	10.10	-2.6	5.2	31.1	50.1
Israel	16.90	3.06	102940	4.7	4.60	-5.1	2.6	78.4	69.4
Japan	25.77	1.41	142923	4.1	1.38	-11.4	1.1	217.6	87.3
Malaysia	42.20	6.20	46675	5.0	5.44	-7.0	2.8	53.7	70.1
Philippines	13.41	1.60	8891	4.6	9.31	-3.9	5.8	57.3	48.5
Singapore	49.96	5.14	182595	5.2	6.49	-1.6	5.1	113.1	89.1
Thailand	31.65	10.5	27312	4.9	5.47	-4.4	4.9	49.0	58.5
Turkey	17.39	9.77	42211	4.5	10.44	-5.5	3.4	45.2	52.5

Sources: World Development Indicators (2009), Global Competitiveness Report (2010)

A few interesting points can be noted from Table 4.17. Singapore has one of the highest domestic savings rate, averaging around 50% for many years. This is partly due to its Central Provident Fund system, an excellent form of imposed saving scheme for all its working citizens and permanent residents, and also due to governmental, corporate and household savings. Much of the domestic savings have been invested in its infrastructural capital, resulting in a relatively high capital per worker. The overall macro-economic environment rating of Singapore is good, though not as high as that of Denmark.

4.6 Natural Resource Eco-System

The goal of sustainability – sustainable human well-being – is pinned for by all countries and future generations to come. Certainly the pursuit for sustainable earth will come at a financial cost (and a hefty one too as in the proposed Copenhagen accord) to tame global warming. However any rational human beings who cared enough for Gaia (Mother Earth) will also know that there is an even greater cost to inaction about the planet.

Figure 4.11: The Water-Energy-Food Nexus and Need for Environmental Preservation

So, what should the sustainability index of the natural resource eco-system be measuring? It should serve as an indicator of the nation's ability to obtain and utilize natural resources efficiently, whether these resources come from within the physical national boundaries of the nation, or imported from without. One should therefore consider how the index can capture the measurements of sustainable usage of water and energy, food production and consumption, supply and utilization of construction materials and of the preservation and restoration of the environment, as illustrated in Figure 4.11. The ill by-products of consumption of natural resources include pollution of air, water and land, and climate change arising from carbon emissions. Hence the end-goal of the Natural Resource Eco-System should be very much considered from the perspective of global sustainability besides national economic sustainability, and its index would be an aggregate of various environmental indicators.

4.6.1 Water Resource Sustainability

According to the Centre for Ecology and Hydrology (CEH), United Kingdom, the sustainable management of this very important natural resource can be quantified by considering the following key components:

1. **Resources** - The physical availability of surface and ground water, taking the account of the variability and quality of the resource as well as the total amount of water.
2. **Access** - The extent of access to water for human use, accounting for not only the distance to a safe source, but the time needed for domestic water collection, and other significant factors. Access means not simply safe water for drinking and cooking, but water for irrigating crops or for industrial use.
3. **Capacity** - The effectiveness of people's ability to manage water. Capacity is interpreted in the sense of income to allow purchase of improved water, and education and health which interact with income and indicate a capacity to lobby for and manage a water supply.
4. **Use** - The ways in which water is used for different purposes; it includes domestic, agricultural and industrial use.
5. **Environment** - An evaluation of environmental integrity related to water and of ecosystem goods and services from aquatic habitats in the area.

The CEH has proposed the Water Poverty Index (WPI) based on the above considerations.

Mathematically, it is calculated as,

$$WPI = \frac{\sum_{i=1}^N w_i X_i}{\sum_{i=1}^N w_i} \quad (4.32)$$

Where X_i and w_i are the i^{th} component of the WPI and its respective weight. Each component itself is composed from a number of sub-components and weights.

In the light of Singapore's experience in its water management, the WPI should also take into account the following additional three water resources:

- Water from desalination plants;

- Water from re-cycling plants;
- Water imported from sources outside of the nation.

Indeed the concept of WPI may also be applied to other natural resources such as energy, food and construction materials. The challenges of calculating such indices lie in data collection for the key components and in deciding the weights for these components.

Table 4.18: Data on Variables in Water Sustainability

Country	Drinking Water Access ¹	Sanitation Water Access ¹	Water Quality Index ²	Water Stress Index ³	Water Scarcity Index ⁴	Water Sustainability Index
Weights	20%	20%	20%	20%	20%	
Columbia	87	75	54.58	68.03	100	76.9
Denmark	100	100	74.87	71.74	100	89.3
Indonesia	65	46	62.20	95.26	100	73.7
Israel	100	100	57.68	N.A.	49	76.7
Japan	100	100	87.82	54.91	100	88.5
Malaysia	98	93	54.63	86.79	100	86.5
Philippines	87	75	89.32	66.99	100	83.7
Singapore	100	100	98.02	N.A.	100	99.5
Thailand	96	95	82.67	45.58	100	83.9
Turkey	94	86	57.87	35.56	100	74.7

Sources: ¹ World Development Indicators

² UNEP GEMS/Water

³ UNH Water Systems Analysis

⁴ FAO

4.6.2 Environmental Sustainability and Pollution

According to World Health Organization's *Air Quality Guidelines*, lower respiratory tract infections are the second most common disease which is due to environmental factors (WHO, 2005). Such infections are frequently caused by air pollution, which is estimated to cause approximately 2 million premature deaths worldwide per year. The effect of particulate air pollution is known to have significant negative impact on health (Quah Euston, 2003). There are at least six major forms of air pollution:

1. **Sulfur Dioxide Emissions (SO₂)** - Sulfur dioxide is the major cause of acid rain, which degrades trees, crops, water, and soil. It can also form hazardous aerosols under certain atmospheric conditions. A sulfur dioxide indicator based on estimates of

emissions compiled from several different sources to filter out errors can be formulated.

2. **Nitrogen Oxide Emission (NOX)** - Nitrogen oxides are a group of highly reactive gases. They contribute to the formation of ground-level ozone, fine particulates, and acid rain. The damages associated with NOX overlap heavily with those listed for SO₂ and acid rain. Additionally, nitrogen from NOX emissions can dissolve in water and lead to eutrophication: the increase in nitrates leading to increase in plankton population which ultimately leads to depletion of oxygen for other organisms.
3. **Non-Methane Volatile Organic Compound Emissions** - Non-methane volatile organic compounds, or NMVOCs, are a sub-category of volatile organic compounds, which contain carbon and are active in atmospheric reactions. Notably, they often react with NOX to form ozone, which can damage plant surfaces and irritate animal tissues.
4. **Regional Ozone** - In the troposphere, ozone shields the planet from dangerous ultraviolet radiation. At ground level, however, ozone is dangerous to living organisms. Ozone corrosively damages plant surfaces and irritates animal tissues. Plants can also directly absorb ozone through their pores, which can severely inhibit their functioning and growth. Ozone has the potential to degrade overall ecosystem health and productivity.
5. **Indoor air pollution** - It affects mainly the poorer developing countries, whose people have to rely on burning bio-fuels such as wood, charcoal or dung in their homes for cooking. The chemicals and particles released from burning can become lodged in the lungs when inhaled, leading to numerous respiratory problems, including acute lower respiratory tract infections. Hence indoor air pollution poses greater health risks in developing nations.

6. **Urban Particulates** - Outdoor air particulates associated with high degrees of industrialization and urbanization are more prevalent in fast developing and developed countries. Hence both distinct air pollution measures of indoor air pollution and urban particulates should be used in constructing an air quality index to account for environmental risks in nations at different development levels.

Table 4.19 shows the data for the above six types of pollution. The target for indoor air pollution is set at 100 for total absence of solid fuel used indoors. The target for urban particulates is set at 100 for 20 micrograms or less of particulates per cubic meter. The SO₂, NO_X and NMVOC targets are set at 100 for 0.01 Gg or less of emissions per square km of populated area. The regional ozone index target is set at 100 for not exceeding threshold of 40 ppb over a consecutive 3-month period. An aggregate Pollutant Emission Index computed by the author using weights given in the table is shown in the last column. The weights are assigned based on typical values used in other environmental indicators such as the ESI. Because of the heavy concentration of petro-chemical industries in the city state of Singapore and emissions coming from ships docked at its port which is one of the busiest in the world, the SO₂, NO_X and NMVOC emission indices are controversially provided as zero from many data sources. This situation may eventually improve when the International Maritime Organization gradually enforce stricter emission standards on its members in future.

Table 4.19: Data on Variables in Pollutant Emission Factor (2010)

Country	Sulfur Dioxide Emissions	Nitrogen Oxide Emissions	NMVOC Emissions	Regional Ozone	Indoor Air Pollution	Urban Particulates	Pollutant Emission Index
Weights	0.2	0.1	0.1	0.1	0.25	0.25	
Columbia	59.36	49.76	39.51	19.29	86.22	94.01	67.79
Denmark	58.36	37.07	39.35	38.30	94.74	100.00	71.83
Indonesia	51.94	46.74	31.71	15.09	38.57	25.06	35.65
Israel	27.52	27.64	22.90	100.00	94.74	76.11	63.27
Japan	44.17	33.81	32.66	9.35	94.74	79.27	59.92
Malaysia	51.85	44.98	32.59	35.21	94.74	92.89	68.55
Philippines	43.22	45.74	35.11	100.00	50.42	93.02	62.59
Singapore	0.00	0.00	0.00	64.34	94.74	62.33	45.70
Thailand	44.50	48.25	32.41	5.35	75.67	33.29	44.74
Turkey	49.34	46.78	43.73	38.74	88.42	63.84	60.86

Sources: WHO, World Bank, UNFCCC, Yale University for EPI

4.6.3 Energy Sustainability and Climate Change

Sustainable energy development is greatly promoted whenever there were sharp increases in energy prices. For example, the oil crisis during the early 1970s stimulated a significant interest in research into new energy sources and energy efficiency. This interest was sustained with the further increases in crude oil prices in the late 1970s and early 1980s. The interest however waned when the oil price hike collapsed in the mid-1980s. The current high oil prices appear to be causing a repeat of history in the interest in sustainable energy use. However there is an important difference this time, as Maddison (2007) reveals “*The major thrust of the modern debate on energy is assessment of the impact of human economic activity in raising the global temperature by causing a change in the net impact of solar radiation.*” The concern with sustainable development of economies and environment is motivating the research in energy economics. Higher energy use is already changing the world's climate in dangerous ways. The strain of rising populations, combined with income growth, is rapidly overexploiting the forests, fisheries, leading to land degradation, and the loss of habitat and extinction of a vast number of animal and plant species. So even if the oil

prices start dropping tomorrow, the issues of global warming, carbon emissions and long-term sustainable development of our planet (the Gaia issue) are unlikely to be forgotten.

Any analysis on energy sustainability will inevitably lead to the issue of climate change, which impacts on environmental sustainability itself. This is because consumption of energy particularly from fossil fuel sources produces vast amount of greenhouse gases (GHG). These differ from the air pollutants in that they are not toxic and do not directly bring harm to humans and environment. Instead they contribute to global warming and climate change because they can absorb from radiation from the sun and re-emit it in the form of heat. The most common greenhouse gases are water vapor and carbon dioxide. Water vapor however does not constitute a problem as it forms clouds and returns to earth as rain after an average of nine days. Carbon dioxide on the other hand stays in the atmosphere for many years and is therefore accumulative. It is therefore the main agent for global warming and climate change. The predicted impacts of climate change arising from global warming include sea-level rises, flooding of coastal areas, melting of glaciers, droughts, heat waves, and enlarging deserts. Some of these effects are already being observed globally and are projected to accelerate in severity. While much of the greenhouse gas emissions have been originating from developed nations, it is likely that the developing countries will be the ones most affected by the impacts of climate change (Stern 2006).

GHGs may be emitted from a number of human consumption activities such as in electricity generation, transportation, industries, agriculture, forestry, and waste management (IPCC 2007). However, it is the energy sector which produces the largest share of GHG emissions globally. The emissions patterns of individual countries tend to vary greatly. For example, many developing nations have very low emissions from the energy sector but high GHG emissions from deforestation and agriculture. Indonesia has one of the highest GHG emissions in the world due to its rapid and extensive land use change. On the other hand,

some developed countries have actually been able to reduce their energy sector emissions by investing in renewable energy technologies that can produce energy with low or no emissions. These renewable energy sources include solar photovoltaic panels, solar thermal collectors, wind turbines and micro-hydro turbines.

Measuring the severity of GHG emissions also provides an indicator of energy consumption. A climate change index may be computed from a weighted summation of the following sub-indices:

- *Greenhouse Gas Emissions per Capita (including land use emissions):* Countries with large populations tend to emit more GHGs (IPCC2007 WGIII). Therefore, simply measuring gross emissions is not a helpful way of comparing country performance. A more useful comparison of performance across countries is GHG emissions per capita. The GHGs in this calculation include CO₂ from fossil fuels, land use change emissions, and non-CO₂ gasses like methane and NO_x, and are measured in metric tons of carbon dioxide equivalents. The lower the per capita emissions, the less the average person in a given country contributes to climate change. Developing nations generally have the lowest per capita emissions due to their relatively small industrial sectors and lifestyles with lower commercial energy intensities; however, they often rank among the highest for land use change emissions.
- *CO₂ Emissions per Electricity Generation:* Emissions per capita are important but do not directly point to some of the most critical areas of the economy. The majority of global anthropogenic GHG emissions, about 65%, come from the energy sector. Within this sector, the largest contributor is electricity generation, which makes up 41% of energy-related GHG emissions. Therefore, the 2010 EPI uses the emissions intensity of the electricity sector to help measure countries performance on climate

change. IEA data for CO₂ emissions is divided by the total associated electricity output. This reflects the relative efficiency of electricity production.

- Industrial Greenhouse Gas Emissions Intensity:** Differences in per capita emissions often have more to do with history and circumstance than current performance. Industrial emissions intensity, on the other hand, captures a largely contemporaneous process. The measurement reflects the total CO₂ emitted by the industrial sector, divided by the total industrial GDP, measured in purchasing power parity (PPP). It is therefore a measure of emissions efficiency and offers insight into how a country's industrial economy is managed. Countries that perform best on this indicator are those that have invested in low-carbon growth in their industrial sectors through energy conservation, investment in clean technologies, or other changes that result in industrial processes with lower emissions. It is a fair measure because it does not reflect shifts from industrial to service-based economies, as an emissions-per-GDP measure may, which has more to do with a development path than climate policy. The target for emissions intensity of the industrial sector is 36.3 tons CO₂ per \$1,000,000 (USD, 2005, PPP). This value is a reduction that is proportionate to the target for GHG emissions per capita.

Table 4.20: Data on Variables in Climate Change Factor (2010)

Country	CO ₂ Emission per Capita	CO ₂ Emission per Unit of Electricity Generated	GHG Emission in Industry	Climate Change Index
Columbia	80.12	81.17	43.85	71.32
Denmark	44.88	71.16	23.67	46.15
Indonesia	55.71	79.11	6.41	49.24
Israel	44.44	36.34	4.23	32.37
Japan	52.50	72.22	15.90	48.28
Malaysia	41.92	76.60	8.87	42.33
Philippines	99.79	42.25	15.98	64.45
Singapore	50.74	80.70	12.12	48.57
Thailand	75.84	48.10	12.07	52.97
Turkey	74.58	50.75	14.58	53.62

4.6.4 Sustainable Consumption

There has been growing recognition that current patterns of consumption and production, particularly those in the developed and highly industrialized regions, are one of the major causes of concern for global sustainability. It is thus important that this is adequately captured in the proposed N Index for natural resource sustainability. While any excessive consumption of water and energy in industrial and transportation activities has been addressed in the Water Sustainability Index, the Environmental Pollution Index and the Climate Change Index, these indices have not included the effects on preservation of biodiversity, natural habitat, forest and agricultural lands, and marine life-stocks. This form of environmental degradation arises mainly from consumption of food, construction materials, industrial feed-stock, and the myriad of material goods in affluent lifestyle. The latter is a new global consumer culture which can be partly characterized by a growing emphasis on the individual, a search for wider opportunities and experiences (professional and leisure), a desire for comfort and autonomy, and personal material accumulation. The ultimate summation of such changes and convergence of behaviors is that the globe has witnessed an unprecedented explosion in the consumption of goods and services in the past twenty years.

Table 4.21 illustrates how an indicator for sustainable consumption may be aggregated from the following indices:

1. Household consumption per capita;
2. Biodiversity and habitat preservation index;
3. Forestry preservation index;
4. Fishery preservation index;
5. Agricultural land preservation index.

Table 4.21: Variables in Sustainable Consumption Factor

Country	Household Consumption per Capita Index	Biodiversity and Habitat Preservation Index	Forestry Preservation Index	Fishery Preservation Index	Agricultural Land Preservation Index	Sustainable Consumption Index
<i>Weights</i>	<i>0.5</i>	<i>0.1</i>	<i>0.1</i>	<i>0.1</i>	<i>0.1</i>	
Columbia	93.04	82.66	96.89	88.59	76.16	80.95
Denmark	32.80	52.71	100.00	36.50	87.45	44.07
Indonesia	99.36	63.19	18.90	70.41	86.70	73.60
Israel	48.89	72.76	100.00	91.64	36.80	54.57
Japan	03.68	63.16	100.00	87.63	67.99	33.72
Malaysia	90.35	74.07	89.11	52.83	94.75	76.25
Philippines	98.31	64.16	47.95	76.27	84.57	76.45
Singapore	52.15	44.24	100.00	50.00	97.73	55.27
Thailand	95.97	79.77	89.85	60.13	90.01	79.96
Turkey	86.72	17.14	100.00	55.63	64.13	67.05

Singapore has been frequently described as a nation with no natural resource. However it does have several important resources which may be regarded as natural or quasi-natural and they are very important to the economic sustainability of Singapore. One of these is its land surface area. Over the years, its land area has increased due to land reclamation. In land scarce Singapore, this is very significant as every unit area of land is very well utilized, with urban infrastructure growing ever higher above ground and also starting to extend deeper underground. The sustainability of this resource has given rise to a new term, urban sustainability. A potential threat to this sustainability is any rising sea level due to climate change. Here, a connection between the economic and urban sustainability of Singapore and the climate change aspect of the strong global environmental sustainability can be clearly seen. The Singapore Government has recently set up its National Climate Change Secretariat under its Prime Minister's Office, signaling the importance it places on climate change and global warming.

4.7 Concluding Remarks

In this chapter, the concept of five production eco-systems of a nation has been analyzed to identify the major factors affecting the contributions of each eco-system to the economic sustainability of the nation. Extensive searches for data-sets and their sources have been done to suggest appropriate sub-indices of factors for the computation of EGOIN component indices. Sample data-sets for case studies of ten nations including Singapore are presented in this chapter to discuss issues in the economic sustainability of nations, particularly that of Singapore. Table 4.22 summarizes the major factors identified for the computation of the E, G, O, I and N Indices. The major issues affecting the economic sustainability of Singapore appear to be the aging population for Labor Market and the rising costs of Healthcare for its Ordinary Labor Eco-System, and the Energy & Climate Change implications in its Natural Resource Eco-System.

Table 4.22: Major Factors for EGOIN Component Indices

Entrepreneurship (E Index)	Government (G Index)	Ordinary Labor (O Index)	Investment (I Index)	Natural Resources (N Index)
Business Environment	Governance Effectiveness & Regulatory Quality	Labor Market *	Domestic Savings	Water Sustainability
Market Access	Political Accountability & Rule of Law	Education	Foreign Direct Investments	Environmental Pollution
Capital Knowledge	Corruption Freedom	Healthcare *	Macro-economic environment	Energy & Climate Change *
Entrepreneurial Culture ⁺	Safety & Security	Social Capital	Infrastructure Capital	Sustainable Consumption

⁺ needs improvement in Singapore

* long term sustainability issues for Singapore

Chapter Five

Pilot Implementation of EGOIN Composite Index

5.1 Introduction

Using the proposed framework described in Chapter Three for developing the EGOIN Composite Index as an indicator of economic sustainability and the shortlisted 20 dominant factors of economic sustainability described in Chapter Four, the EGOIN Composite Index and its component indices (E Index, G Index, O Index, I Index and N Index) have been computed for 108 countries. The values of the computed indices are given in Appendix A while their rankings are given in Appendix B. The 108 nations are chosen due to the availability of data for all the 20 factors of the five component indices. The quantity of nations is sufficient to observe the general characteristics of the computed indices.

In this pilot implementation, the eco-system balance factor β was set to the default value of 1.0, enabling the full effect of RMSD modulation to be reflected in the computation. The effects of β have been described in p.67. The initial weights of component indices $\{r_{E0}, r_{G0}, r_{O0}, r_{I0}, r_{N0}\}$ were all set to unity, from which the actual weights for each nation were then computed as explained in Chapter 3. Analyses of the overall characteristics of the computed indices and assessments on the economic sustainability of selected nations using the indices are given in this chapter.

5.2 Overall Characteristics of EGOIN Composite Index and its Components

A measure that may have some relationship to the current state of economic sustainability is the average per capita GDP growth. A short-term five-year moving average growth rate would even out some of the fluctuations due to global financial booms and busts, while a longer term 50-year average would truly capture the direction of each nation's momentum of economic activity. The relationship between the short-term (2007-2011) and long-term (1961-2011) average per capita GDP growth rates and the current EGOIN Composite Index of each nation for 108 nations is plotted as scatter plots in Figure 5.1. Their Spearman Rank Correlations are -0.46 and 0.32 for short-term and long-term GDP growth rates respectively, showing a mild correlation. Hence the EGOIN Composite Index is not really duplicating the role of the GDP indicator. However a few other interesting observations can be made regarding their relationship:

- Nations with high EGOIN Composite Indices (70% or more) have low but respectable long-term average economic growth of around 2% per annum. One possible explanation for these characteristics is that nations with high EGOIN Composite Indices and are therefore economically more sustainable are mainly the economically developed and advanced nations with well developed production eco-systems. Their GDP growths have slowed to lower but more sustainable rates. These mature economies are also more likely to pay greater attention to environmental sustainability.
- Nations with high average economic growths of (greater than 3%) tend to have lower EGOIN Composite Indices. These are likely to be the developing nations as they play the catch-up game in the economic arena. However their production eco-systems are not fully developed or robust and they may also aim for high GDP growths at the expense of ecological sustainability, hence their lower EGOIN Composite Indices.

- There is also significant number of nations with low economic growths and low EGOIN Indices. Hence aiming for lower GDP growth does not automatically suggest being able to attain higher economic sustainability.

It is reasonable to assume that an economy which has been sustainable and therefore doing relatively well in the last few decades would have relatively high per capita GDP. By plotting the per capita GDP of each nation against its EGOIN index, a positive relationship is obtained in Figure 5.2. The Spearman Rank Correlation is 0.90. This shows that nations with high EGOIN indices are mainly those which can achieve high per capita GDP by 2009, perhaps contributed by their economic sustainability in the past decades.

Figure 5.1: Average Per Capita GDP Growth against EGOIN Indices of 108 Nations

Figure 5.2: Per Capita GDP in 2009 against EGOIN Indices of 108 Nations

(a) short-term growth (recent 5 years)

(b) long-term growth (recent 50 years)

Figure 5.3: Average Per Capita GDP Growth against E Index of 108 Nations

(a) short-term growth (recent 5 years)

(b) long-term growth (recent 50 years)

Figure 5.4: Average Per Capita GDP Growth against G Index of 108 Nations

Figure 5.5: Average Per Capita GDP Growth against O Index of 108 Nations

Figure 5.6: Average Per Capita GDP Growth against I Index of 108 Nations

Figure 5.7: Average Per Capita GDP Growth against N Index of 108 Nations

Having examined the overall characteristics of the EGOIN Composite Index, some analysis on its component indices would be helpful. Again the short and long term average GDP growth rates of each nation is plotted against its component indices, this time in five separate plots. Figures 5.3 to 5.7 show the results for the five indices respectively: E, G, O, I and N. All the five component indices exhibit similar characteristics as that of the overall EGOIN Composite Index. This indicates that all five component indices exhibit consistent sustainability trends of the five eco-systems. Their Spearman Rank Correlations are:

	Short-Term GDP Growth Rate	Long-Term GDP Growth Rate
E Index	-0.50	0.26
G Index	-0.44	0.30
O Index	-0.43	0.27
I Index	-0.36	0.32
N Index	-0.33	0.23

Does the EGOIN Composite Index capture traits of strong sustainability? It would be possible to gauge this by plotting the Index or its components against a strong ecological sustainability indicator. As the N Index is an aggregate of a number of strong sustainability indicators (water, pollution, climate change, habitat), it is reasonable to use N Index as the ecological indicator against the other four EGOIN component indices. Figures 5.8 to 5.11

show strong positive correlation between each of the (E, G, O, I) indices with the N index.

This shows element of strong sustainability in them. Their Spearman Rank Correlations are:

- N Index against E Index: 0.69
- N Index against G Index: 0.58
- N Index against O Index: 0.69
- N Index against I Index: 0.60

Figure 5.8: N Index against E Index of 108 Nations

Figure 5.9: N Index against G Index of 108 Nations

Figure 5.10: N Index against O Index of 108 Nations

Figure 5.11: N Index against I Index of 108 Nations

5.3 Case Studies on Selected Nations

In this section, we discuss the economic sustainability of the same group of selected nations as used in the discussions in Chapter Four. Table 5.1 lists the EGOIN Composite Index and component indices of the ten nations including Singapore. The corresponding rankings according to the indices are listed in Table 5.2. The EGOIN radar plots for the ten nations are given in Figure 5.12. The top three nations in terms of economic sustainability in this selected group are (in order) Japan, Denmark and Singapore. It is interesting to note that Denmark outperformed Japan in E, G, O and I indices but has a weaker N Index due to its heavier reliance on coal-fired electricity generation plants while Japan has been investing in cleaner nuclear energy. However Denmark has been rapidly working towards its CO₂ emissions reduction targets by investing heavily in wind energy systems, while it is unclear how the recent Fukushima nuclear disaster will impact on Japan's N Index in future.

For Singapore, its EGOIN Composite Index for 2011 is 70.8 and is ranked 19 out of 108. Its 2011 EGOIN component indices are (E=87.7, G=88.0, O=73.2, I=82.1, N=69.6) and the respective rankings are (E=9, G=9, O=28, I=6, N=23)/108. It is apparent from this set of statistics that Singapore's overall economic sustainability is currently relatively positive but has weaknesses in its O and N component indices. For its Entrepreneurship eco-system, Singapore scored high in the business environment factor and the market access factor, reflecting the ease of doing business and the very open economy of the nation. Its capital knowledge factor is also relatively high, as a result of government-led emphasis in R&D and innovation. The entrepreneurial culture is somewhat lacking in Singapore, but the weight for this factor is not high for all nations, so its negative effect on the E component index of Singapore is not significant. For its Government eco-system, Singapore has performed very well in all factors except the 'accountability & voice' factor. This factor is based on data from international sources which include items such as press freedom which is deemed to be

lacking in Singapore from their yardsticks. Overall, the G component index of Singapore is still one of the highest among the 108 nations studied.

Table 5.1: EGOIN Composite Index and Component Indices for Selected Nations

Country	E Index	G Index	O Index	I Index	N Index	EGOIN Composite Index
Columbia	63.79	54.18	63.91	64.64	76.77	57.60
Denmark	91.43	90.39	83.54	84.07	69.15	73.81
Indonesia	54.79	58.13	60.80	67.86	44.61	50.65
Israel	77.93	66.66	76.17	74.36	62.43	64.94
Japan	80.71	81.51	77.51	80.00	72.54	74.61
Malaysia	70.57	68.77	66.80	76.29	64.99	65.33
Philippines	58.86	58.91	61.11	65.21	65.68	59.07
Singapore	87.71	88.01	73.19	82.14	69.64	70.79
Thailand	64.50	60.91	68.60	75.64	62.15	60.87
Turkey	64.64	60.71	58.20	59.93	60.40	58.82

For its Ordinary Labour eco-system, Singapore has strength in its labour market factor and health factor. Its social capital factor is however not so high, reflecting the growing frustrations in its social fabric. Surprisingly, Singapore's education factor is lagging behind that of Japan, Israel and Denmark. Closer examination of the data sets in this factor reveal some potential issues arising from aging population, low productivity in blue collar workers and the need to expand further in tertiary education. In the health factor, the rising costs of healthcare and increasing demand on healthcare infrastructure is another potential issue which can weaken Singapore's O index in future. For its Investment eco-system, Singapore has one of the highest I component indices among the 108 nations. For its Natural Resources

eco-system, Singapore scored high its water sustainability factor, but fared relatively poor in the other factors of energy sustainability & climate change, sustainable consumption and environmental pollution. Clearly, more is needed to be done to improve Singapore's energy resilience, carbon footprint, waste re-cycling and pollution emissions in its petrochemical industries.

Among the ASEAN nations besides Singapore, Malaysia is also quite robust in its economic sustainability. It is fairly well-balanced in its entire economy with strong investment eco-system. Indonesia's long-term economic sustainability will depend on how it improves its management of its natural resources (its N index ranked 95/108). Thailand and Philippines are doing better than Indonesia in this aspect.

Table 5.2: Ranking of EGOIN Composite Index and Component Indices for Selected Nations

Nation	E Index Rank	G Index Rank	O Index Rank	I Index Rank	N Index Rank	EGOIN Rank
Columbia	55	83	59	53	8	56
Denmark	1	2	6	4	26	11
Indonesia	80	64	73	41	95	80
Israel	23	40	20	25	54	33
Japan	18	18	17	10	17	9
Malaysia	32	36	53	20	43	30
Philippines	66	61	71	50	39	49
Singapore	9	9	28	6	23	19
Thailand	52	54	40	22	55	42
Turkey	51	55	82	67	62	51

Figure 5.12: EGOIN Radar Plots for Selected Ten Nations Case Study

From the radar plots in Figure 5.12, it is obvious that Singapore is relatively weak in its N component index. It can also be seen that Japan is more well-balanced in its five EGOIN eco-systems compared with Denmark, and hence has a higher EGOIN Composite Index.

5.3 Economic Sustainability and the S-Curve

The top ten nations out of the 108 nations in the EGOIN Composite Index ranking are listed in Table 5.3 while the bottom ten nations are listed in Table 5.4. It can be observed that among the top ten nations, most have average GDP growth of around 2%. Their per capita GDP are also very high. In fact these are the so-called ‘elephant’ nations in the review on C.Y. Lim’s S-curve theory in Chapter Two. This is consistent as nations which have been economically sustainable are more likely to end up in this category.

Table 5.3: Top Ten Nations in EGOIN Index

Nation	Long-Term Average Per Capita GDP Growth %p.a.	Per Capita GDP in 2009 (US\$)	EGOIN Rank (/108)
Norway	2.64	78,436	1
Switzerland	0.95	63,628	2
Sweden	2.19	43,389	3
Austria	2.61	45,561	4
France	2.24	40,663	5
Finland	2.70	44,580	6
Germany	1.95	40,669	7
New Zealand	1.19	29,352	8
Japan	3.31	39,455	9
United Kingdom	2.02	35,142	10

Table 5.4: Bottom Ten Nations in EGOIN Index

Nation	Long-Term Average Per Capita GDP Growth %p.a.	Per Capita GDP in 2009 (US\$)	EGOIN Rank (/108)
Zambia	-0.32	1006	99
Senegal	-0.11	1020	100
Ghana	0.80	1097	101
Kenya	1.29	738	102
Uzbekistan	1.95	1181	103
Mali	1.28	601	104
Nigeria	1.61	1089	105
Ethiopia	1.88	385	106
Central African Republic	-0.68	447	107
Zimbabwe	-0.01	466	108

Figure 5.13: Relationship between EGOIN Composite Index and the S-Curve

The plot of long-term average GDP growth against EGOIN Composite Index of Figure 5.1 is reproduced in Figure 5.13 to illustrate the location of these ‘elephant’ nations in this diagram. From Table 5.4, it can be observed that the ten nations with the lowest EGOIN Composite Indices all have low per capita GDP and generally low average GDP growth. A few of them have average GDP growths of close to 2%, but because they are not very economically sustainable, their economic growths may not be sustained for long. These are in fact the ‘turtle’ nations. To break out of their poverty traps, they need to improve their economic sustainability which is indicated by their EGOIN Composite Indices. These ‘turtle’ nations lie on the left side of the plot in Figure 5.13. The rest of the nations which have relatively high GDP growths and mid-level EGOIN indices are the ‘horse’ nations.

From Figure 5.13, we can make an important hypothesis. If the ‘horse’ nations continue to maintain or improve their economic sustainability, they may eventually end up in

the ‘elephant’ category. This is sustainable development. However if they neglect their economic sustainability, they may risk sliding back into the ‘turtle’ category. This would be unsustainable development. Hence it would be prudent for ‘horse’ nations to track their EGOIN Composite Indices besides their GDP growth rate figures.

In a sense, the computation of the EGOIN Composite Index has now been related to the S-Curve through Figure 5.13. Also, in the computation of the EGOIN component indices, factors linking a nation to other nations in terms of trade, investment, migration of workforce and talent and natural resources have been included, so the Triple-C theory is already embedded in the EGOIN Composite Index. Hence the EGOIN Theory, the Triple-C Theory and the S-Curve Theory have now been linked together by the EGOIN Composite Index. These three theories have been termed as the ‘Trinity Development Theory’.

5.5 Concluding Remarks

From the collected data of the 108 nations, the sub-indices have been computed for the 20 major factors. The weights of the factors were then estimated by regression technique. The five EGOIN component indices were then computed and finally the EGOIN Composite Index was then obtained for each of the 108 nations. These composite and component indices computed for 2010 are listed in the Appendices. This chapter presents a brief discussion on the computed EGOIN indices. It was observed that nations with high values of EGOIN Composite Index generally have moderate average per capita GDP growth rates of around 2% per annum. There is also a significant positive correlation between EGOIN Composite Index and per capita GDP for all nations. On the other hand, nations with high per capita GDP growth rates are observed to have relatively lower EGOIN Composite Indices. These

observations seem to indicate that nations with high degree of economic sustainability are likely to have recent average per capita GDP growth rates of moderate values and also likely to have high per capita GDP. Similar characteristics are also observed for the correlation between per capita GDP growth and each of the five component indices E, G, O, I and N. One possible explanation for these characteristics is that nations with very high per capita GDP must have been economically sustainable (high EGOIN Composite Indices) in order to arrive at their current level of per capita GDP. These are the economically developed and advanced nations ('the Elephants') with well developed production eco-systems. Their GDP growths have slowed to lower but more sustainable rates. They are also more likely to pay greater attention to environmental sustainability. On the other hand, developing nations ('the Horses') have much higher GDP growth rates as they play the catch-up game in the economic arena. However their production eco-systems are not fully developed or robust and they may also aim for high GDP growths at the expense of ecological sustainability. Hence they have lower EGOIN Composite Indices. It should also be noted that having lower GDP growths do not automatically suggest attaining higher economic sustainability as there are nations with both low GDP growths and low EGOIN indices ('the Turtles'). More research in this area is therefore needed to understand the relationship between the change in EGOIN indices with time and the GDP growth rates.

From the computed EGOIN Composite Index and component indices, it was observed that the Ordinary Labor and Natural Resources eco-systems are crucial areas which may weaken Singapore's economic sustainability in future and which therefore should deserve careful attention from the policy makers.

Chapter Six

Conclusions and Recommendations

6.1 Conclusions

The focus of this thesis is on developing a measure of economic sustainability. A comprehensive indicator of economic sustainability based on the EGOIN concept has been developed in this thesis. The entire analytical framework is described in Chapter 3, covering the rationale of using the EGOIN concept as the basis for the framework, the original development of the model structure by the author, the details of the model equations and the econometric analysis procedure required to estimate the weights of the 20 major factors constituting the new indicator. The identification of the factors is presented in Chapter 4, which also discusses the sources of data sets required for the factors. The new indicator is termed by the author as the EGOIN Composite Index and it has five component indices (E, G, O, I and N). Chapters 3 and 4 are the core of the thesis, containing the original intellectual properties created by the author. Chapter 5 presents the trial-run results of the computation of the new economic sustainability indicator for each of a total of 108 nations.

The motivation behind the development of a new indicator for economic sustainability arises from the literature review presented in Chapter 2. The extensive literature

review on the issues of sustainable development can be summarized as follows. Concerns on economic sustainability started in the early 1800's with the Malthusian theory on mankind's seemingly destined collapse back to subsistence-level conditions due to population growth outpacing agricultural production. Though subsequent technological progresses have largely debunked this 'doomsday' scenario, the spectra of unsustainable development of modern economy has gradually been revived in the last few decades; but this time is due to scientifically verified realization that planet Earth is unlikely to be ecologically sustainable in the face of massive depletion of natural resources and the environmental damage brought about by rapid economic development without sufficient regard to ecological sustainability. Various piecemeal actions have been undertaken by various nations and international organizations to bring about a more responsible and greener form of sustainable development, with varying degrees of successes. There is also a growing realization that a holistic approach to sustainable economic development by each nation is necessary to bring underdeveloped nations out of poverty, to achieve sustainable economic growths in developed nations, and at the same time to ensure the global physical sustainability of the Earth. Such a holistic approach may be guided by C.Y. Lim's 'Trinity' Development Theory, whose EGOIN concept already has environmental economics embedded in its view of the Natural Resources (N) eco-system of any generic economy.

There is also a need to define clearly the notion of sustainable economic development and to measure the degree of such sustainability. Various indicators of sustainability have been proposed in the past, but none can adequately capture the essence of holistic and anthropocentric notion of economic sustainability now being considered. There is thus a need to develop a comprehensive model and indicator of the economic sustainability of each nation which also reflects its contribution to global physical sustainability. Such an indicator will help us to assess the relative economic sustainability of each nation and to help each

nation to develop policies to enhance its economic sustainability and the global sustainability of the Earth. Developing such a comprehensive indicator which has to be applicable to all nations on Earth is therefore the main focus of this thesis.

Chapter 3 presents the framework to develop the new indicator of economic sustainability. The author proposed that the new indicator shall reflect the complex inter-relationships of the production eco-systems of a nation. This shall be based on the ‘*EGOIN*’ idea proposed by C.Y. Lim way back in 1991, which comes from the first letters of the five main domestic co-determinants of economic development: **E**ntrepreneurship, **G**overnment, **O**rdinary labour, **I**ntervestment and **N**atural resources. This concept has largely been a qualitative treatment and no one has ever tried to quantify the EGOIN concept. The notion of an EGOIN Composite Index and the development of the framework to calculate this composite index and its five components are the author’s original ideas and contributions in this thesis. Hence the main outcome of this project is the proposed framework for the development of a novel EGOIN Composite Index as an indicator of economic sustainability of nations. The index would be a useful and important tool for economists to assess the economic sustainability of various nations. The core model of the index is an interdependently weighted summation of five component indices (E, G, O, I, N) for the five production eco-systems of an economy: the Entrepreneurship Eco-system, the Government Eco-system, the Ordinary Labor Eco-system, the Investment Eco-system and the Natural Resource Eco-system. The essential philosophy of the proposed EGOIN Composite Index has been illustrated in Figure 3.1 in Chapter 3, showing that the aggregate effects of the economic sustainability of all nations will impact on the global sustainability of the planet. The latter is closely linked to the Natural Resource eco-system of each nation, in the form of a feedback loop. Hence all nations are also interdependent on each other. This feedback weighting mechanism is achieved in the proposed model by root-mean-square deviation based equations

which allow the weights for the E, G, O, I and N component indices of each nation to be automatically adjusted to penalize any economy whose production eco-systems are not developing in balanced tandem, and is not putting enough emphasis on global ecological sustainability in its economic development.

Chapter 4 presents the detailed analysis on how each of the five component indices can be estimated. They are built upon characteristics that the analyses have found to be essential to promoting economic sustainability. The characteristics for each index are measured by a number of factors that are in turn characterized by a combination of objective data and/or subjective responses to surveys. These fundamental characteristics are drawn from established theoretical and empirical research on the significant drivers of economic growth and physical sustainability. The importance of each of these factors to long-term sustainable economic growth without compromising global sustainability has been determined statistically by using correlation analyses and regressions. While each country's path to economic development is varied and diverse, decades of established theoretical and empirical research on economic growth and development have identified some common themes. In order to determine the weights for these factors leading to greater economic sustainability, regression analysis using econometric methods such as General Methods of Moments (GMM) have been applied. For the E, G, O and I eco-systems, economic performance drivers such as per capita GDP have been used as the dependent variable in these GMM panel regressions. For the N eco-system, the goal of global ecological sustainability was used as the driver.

For each of the five EGOIN component indices, four major factors have been identified. For the Entrepreneurship E index, the major factors have been found to be: 1) business environment; 2) market access; 3) capital knowledge; and 4) entrepreneurial culture. For the Government G index, the major factors have been found to be: 1) governance

effectiveness & regulatory quality; 2) political accountability & rule of law; 3) freedom from corruption; and 4) safety & security. For the Ordinary Labour index, the major factors have been found to be: 1) labour market; 2) education; 3) healthcare; and 4) social capital. For the Investment I index, the major factors have been found to be: 1) domestic savings; 2) foreign direct investment; 3) macro-economic environment; and 4) infrastructure capital. For the Natural Resources N index, the major factors have been identified as: 1) water sustainability; 2) environmental pollution; 3) energy & climate change; and 4) sustainable consumption.

Extensive searches for data-sets and their sources have also been done to obtain significant and reliable data for the computation of the 20 major factors for the EGOIN component indices for a total of 108 nations. Sample data-sets for 10 of the 108 nations including Singapore have been extracted from the author's EGOIN project database and presented in Chapter 4 to highlight selected issues in the economic sustainability of nations, including that of Singapore. The choice behind the 10 highlighted nations is partly due to the relevance to Singapore of its major ASEAN neighbors (Malaysia, Indonesia, Thailand, Philippines), and partly to have representative nations from East Asia (Japan), Europe (Denmark), Central Asia (Turkey), South America (Colombia) and Middle-East (Israel).

From the collected data of the 108 nations, the sub-indices have been computed for the 20 major factors. The weights of the factors were then estimated by regression technique. The five EGOIN component indices were then computed and finally the EGOIN Composite Index was then obtained for each of the 108 nations. The composite and component indices of 2010 are listed in the Appendices. Chapter 5 presents a brief discussion on the computed EGOIN indices. It was observed that nations with high values of EGOIN Composite Index generally have moderate per capita GDP growth rates of around 2% per annum. There is also a significant positive correlation between EGOIN Composite Index and per capita GDP for all nations. On the other hand, nations with high per capita GDP growth rates are observed to

have relatively lower EGOIN Composite Indices. These observations seem to indicate that nations with high degree of economic sustainability are likely to have recent average per capita GDP growth rates of moderate values and also likely to have high per capita GDP. Similar characteristics are also observed for the correlation between per capita GDP growth and each of the five component indices E, G, O, I and N. One possible explanation for these characteristics is that nations with very high per capita GDP must have been economically sustainable (high EGOIN Composite Indices) in order to arrive at their current level of per capita GDP. These are the economically developed and advanced nations with well developed production eco-systems. Their GDP growths have slowed to lower but more sustainable rates. They are also more likely to pay greater attention to environmental sustainability. On the other hand, developing nations have much higher GDP growth rates as they play the catch-up game in the economic arena. However their production eco-systems are not fully developed or robust and they may also aim for high GDP growths at the expense of ecological sustainability. Hence they have lower EGOIN Composite Indices. It should also be noted that having lower GDP growths do not automatically suggest attaining higher economic sustainability as there are nations with both low GDP growths and low EGOIN indices. More research in this area is therefore needed to understand the relationship between the change in EGOIN indices with time and the GDP growth rates.

For Singapore, its EGOIN Composite Index for 2011 is 70.8 and is ranked 19 out of 108. Its 2011 EGOIN component indices are (E=87.7, G=88.0, O=73.2, I=82.1, N=69.6) and the respective rankings are (E=9, G=9, O=28, I=6, N=23)/108. It is apparent from this set of statistics that Singapore's overall economic sustainability is currently relatively positive but has weaknesses in its O and N component indices. For its Entrepreneurship eco-system, Singapore scored high in the business environment factor and the market access factor, reflecting the ease of doing business and the very open economy of the nation. Its capital

knowledge factor is also relatively high, as a result of government-led emphasis in R&D and innovation. The entrepreneurial culture is somewhat lacking in Singapore, but the weight for this factor is not high for all nations, so its negative effect on the E component index of Singapore is not significant. For its Government eco-system, Singapore has performed very well in all factors except the ‘accountability & voice’ factor. This factor is based on data from international sources which include items such as press freedom which is deemed to be lacking in Singapore from their yardsticks. Overall, the G component index of Singapore is still one of the highest among the 108 nations studied. For its Ordinary Labour eco-system, Singapore has strength in its labour market factor and health factor. Its social capital factor is however not so high, reflecting the growing frustrations in its society. Surprisingly, Singapore’s education factor is lagging behind that of Japan, Israel and Denmark. Closer examination of the data sets in this factor reveal some potential issues arising from aging population, low productivity in blue collar workers and the need to expand further in tertiary education. In the health factor, the rising costs of healthcare and increasing demand on healthcare infrastructure is another potential issue which can weaken Singapore’s O index in future. For its Investment eco-system, Singapore has one of the highest I component indices among the 108 nations. For its Natural Resources eco-system, Singapore scored high its water sustainability factor, but fared relatively poor in the other factors of energy sustainability & climate change, sustainable consumption and environmental pollution. Clearly, more is needed to be done to improve Singapore’s energy resilience, carbon footprint, waste re-cycling and pollution emissions in its petrochemical industries. In summary, the human (O) and natural resources (N) are areas which may weaken Singapore’s economic sustainability in future and which therefore should deserve careful attention from the policy makers.

The economic sustainability of individual nations collectively affects the global ecological sustainability of whole world. If the global ecology is becoming unsustainable, it would drag down the N (natural resources) indices of all nations, and thus lowering the EGOIN composite indices of most nations. Nations which are most responsible for the deterioration of global ecology would see a larger decrease in their EGOIN composite indices. The EGOIN Composite Index of economic sustainability can serve as a useful tool for policy makers to plan sustainable economic development which is holistic and inclusive of ecological (environmental) sustainability. Having said this, it should also be noted that even if every nation is improving its economic sustainability, it does not necessary imply the ecological sustainability of the entire planet is improving. A more sophisticated dynamic tracking of ecology with time and apportioning of global ‘diswelfare’ may need to be included in the computation of N indices of individual nations.

6.2 Recommendations

There are several possible areas to further the research documented in this thesis.

1. The EGOIN Composite Index and its component indices have so far been computed for 108 nations using data mainly in the period 2010-2011. It would be useful to continuously update the indices annually using new data and for a greater number of nations. Further analyses can then be done to track the sustainable development of nations into the future.
2. It would be interesting to compute EGOIN indices for various nations using past data to track how indices have been changing in history as far back as possible. This area of research is not easy as data-sets for many of the factors and variables may not be available or consistently compiled in the past. It would be intuitive if one or more nations can be identified as having high growth rates in the past but has now fallen

into unsustainable development with average of zero or negative growth rates. Their past EGOIN performances would be the key to helping to refine the framework for computing the EGOIN indices.

3. It is not uncommon for the computational methodologies and the data sourcing for global indicators to be refined periodically as new evidence and data sources become available. The EGOIN core model may be tweaked and the basket of factors and their weights can be fine-tuned if necessary so that the EGOIN Composite Index can better reflect the relative ranking of nations in terms of their economic sustainability.

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Appendix A – EGOIN Composite Index and Component Indices of 108 Nations
- Raw Values

Country	E Index	G Index	O Index	I Index	N Index	EGOIN Index
Algeria	55.57143	51.20714	62.78571	67.14286	67.41236	54.77837
Argentina	67	56.9	70.41429	68.07143	61.04677	59.73979
Australia	86.78571	88.16429	84.47143	81.57143	65.65562	71.59916
Austria	83.07143	85.92143	80.12857	79.85714	78.13439	77.95335
Bangladesh	49.71429	50.55714	45.5	61.14286	43.95245	45.48315
Belarus	59	51.85714	73.35714	58.78571	65.36919	54.77443
Belgium	79.64286	82.37143	78.21429	77.5	58.07016	65.66733
Belize	65.28571	57.04286	63.05714	62.35714	69.92811	59.49005
Bolivia	52.28571	50.87143	58.28571	62.21429	44.33745	48.5009
Botswana	59.85714	70.53571	53.67143	58.85714	41.31132	48.71881
Brazil	65.78571	58.76429	64.08571	72.07143	63.40547	60.56904
Bulgaria	64.5	63.65714	66.94286	58.57143	62.5323	60.61238
Cambodia	47.57143	56.68571	47.51429	51.21429	41.68936	45.24146
Cameroon	44.64286	46.42143	44.35714	54.21429	44.62298	44.14019
Canada	87.57143	88.42143	82.17143	82.5	66.43678	71.91754
Central African R.	44.78571	45.6	30.14286	43	33.34203	35.51454
Chile	70.64286	76.07857	67.05714	68.85714	73.34276	67.66003
China	62.07143	56.75714	66.1	75.35714	49.00473	53.45325
Colombia	63.78571	54.17857	63.91429	64.64286	76.77389	57.59995
Costa Rica	68.57143	71.70714	67.54286	69.92857	86.39663	65.02507
Croatia	70.07143	66.90714	69.87143	65.14286	68.65091	66.16127
Czech Republic	73.85714	73.67143	74.6	74.71429	71.62066	72.45527
Denmark	91.42857	90.39286	83.54286	84.07143	69.15383	73.80581
Dominican R.	60.35714	54.67857	60.31429	57.42857	68.44132	55.98497
Ecuador	57.5	50.25	60.65714	62.78571	69.34254	54.37821
Egypt	54.21429	54.69286	61.98571	59.14286	62.00398	55.30927
El Salvador	55.5	59.43571	58.48571	53.07143	69.07376	54.13232
Estonia	78.64286	74.77143	70.55714	63	63.80333	63.50196
Ethiopia	42.92857	47.57143	37.97143	42.21429	43.1	40.78749
Finland	89.35714	90.03571	84.42857	81.14286	74.74065	76.69032
France	80.28571	78.86429	77.45714	76.64286	78.21843	76.79956
Germany	85	82.34286	79.07143	79.5	73.22189	75.06323
Ghana	51.28571	62.46429	48.51429	36.5	51.33391	43.7996
Greece	70.42857	67.77143	71.74286	68.78571	60.86616	64.08313
Guatemala	58.21429	52	57.97143	61.28571	53.97228	53.79829
Honduras	55.5	54.85	59.78571	48.42857	49.87176	50.27924
Hungary	69.28571	72.57143	71.71429	66.07143	69.11395	67.31503
Iceland	87.71429	85.37857	82.97143	69.28571	93.48025	73.74621
India	50.07143	62.6	48.71429	67.5	48.34619	48.3802
Indonesia	54.78571	58.12857	60.8	67.85714	44.61432	50.65288
Iran	52.71429	47.26429	61.25714	58	59.96439	51.42412

Country	E Index	G Index	O Index	I Index	N Index	EGOIN Index
Ireland	87.85714	87.75	80.57143	75.78571	67.10605	70.27719
Israel	77.92857	66.66429	76.17143	74.35714	62.42746	64.94105
Italy	72.21429	71.93571	76.07143	73.35714	73.05396	71.68932
Jamaica	66.42857	59.87857	62.98571	57.85714	58.03791	57.93674
Japan	80.71429	81.51429	77.51429	80	72.54079	74.60631
Jordan	58.78571	63.9	66.72857	51.14286	56.11251	54.26418
Kazakhstan	58.14286	56.28571	68.31429	65.35714	57.30284	56.43324
Kenya	51.28571	45.43571	46.08571	38.64286	51.38757	43.26162
Kuwait	71.64286	71.21429	69.1	76.5	51.12549	59.2858
Latvia	71.14286	65.43571	68.32857	56.28571	72.51367	60.98284
Lebanon	54.28571	50.93571	61.62857	59.85714	57.91216	53.54097
Lithuania	69.85714	67.20714	70.41429	58.21429	68.32839	62.41487
Macedonia	60.64286	58.6	64.27143	48.21429	60.62617	53.77335
Malaysia	70.57143	68.77143	66.8	76.28571	64.98595	65.33496
Mali	43.71429	57.75714	41.2	55.21429	39.42563	41.78324
Mexico	62.85714	57.48571	65.67143	72.5	67.34157	60.24319
Moldova	59.92857	52.96429	62.92857	43.14286	58.82625	49.74688
Mongolia	63.21429	58.02857	63.41429	54.07143	42.79508	49.92519
Morocco	58.85714	59.42143	61.01429	70.64286	65.61265	58.7285
Mozambique	47.42857	54.23571	36.87143	55.92857	51.22467	44.19934
Namibia	56.07143	63.42143	53.54286	60.78571	59.27656	55.47584
Nepal	49.14286	51.07857	51.02857	46.71429	68.23603	46.84361
Netherlands	87	86.1	81.8	84.42857	66.35542	72.09704
New Zealand	85.85714	89.42143	84.18571	77.42857	73.35984	74.65734
Nicaragua	50.07143	54.18571	57.32857	45.78571	57.05339	49.31099
Nigeria	46.71429	44.80714	39.7	52.42857	40.19085	41.52002
Norway	88.14286	88.56429	86.35714	85.64286	81.13213	82.52855
Pakistan	51.71429	46.27143	40.08571	54.64286	47.9645	44.49695
Panama	69.28571	65.22143	66.81429	65.5	71.3665	65.15843
Paraguay	57.85714	54.64286	59.35714	64.71429	63.51158	56.58084
Peru	59.35714	56.45714	59.72857	64.14286	69.27689	57.50242
Philippines	58.85714	58.91429	61.11429	65.21429	65.68465	59.06745
Poland	70	72.73571	73.38571	69.78571	63.10986	65.99088
Portugal	74.42857	77.04286	73.31429	68.78571	72.9845	70.35127
Romania	65.78571	61.8	65.82857	61	67.00872	61.8671
Russia	64.28571	49.77857	69.08571	61.85714	61.21289	55.45428
Rwanda	48.64286	60.27143	40.92857	51.07143	44.60849	44.10474
Saudi Arabia	65.85714	62.15714	67.87143	73.92857	55.32032	58.91886
Senegal	48.14286	56.78571	44.47143	45.92857	42.27565	43.83059
Singapore	87.71429	88.00714	73.18571	82.14286	69.63635	70.79178
Slovakia	70.21429	69.48571	72.2	66.5	74.45563	67.68724
Slovenia	76.92857	76.98571	76.12857	71.57143	64.95095	68.1793
South Africa	68.64286	61.85714	56.72857	58.14286	50.78513	53.86833

Country	E Index	G Index	O Index	I Index	N Index	EGOIN Index
South Korea	81.57143	72.42143	74.58571	77.64286	57.04487	63.67063
Spain	75.64286	74.78571	76.58571	72.07143	70.6165	71.36577
Sri Lanka	57.14286	59.56429	65.91429	55.64286	63.71436	56.73445
Sudan	50.64286	42.17857	47.42857	55.92857	47.09437	45.2738
Sweden	90.71429	88.85	81.91429	81.71429	86.04813	81.00732
Switzerland	87.42857	91.85	81.45714	84.92857	89.09283	82.21374
Syria	50.14286	53.67143	63.52857	59.71429	64.58092	53.27391
Tanzania	45.5	53.74286	46.04286	49.71429	47.90339	46.34465
Thailand	64.5	60.91429	68.6	75.64286	62.15487	60.86988
Trinidad & Tobago	69.35714	63.17143	63.87143	63.92857	54.2471	58.34725
Tunisia	67.64286	65.25714	67.52857	65.92857	60.58068	62.86286
Turkey	64.64286	60.70714	58.2	59.92857	60.39754	58.8194
Uganda	48.57143	49.44286	45.17143	51.92857	49.77066	47.35356
Ukraine	58	52.88571	67.51429	49.5	58.21771	51.8417
United Arab E.	78.35714	71.32857	71.61429	73	40.67042	54.31433
United Kingdom	88.64286	85.98571	78.85714	76.71429	74.23773	73.90272
United States	89.64286	86.96429	83.91429	77.92857	63.47516	69.2502
Uruguay	64.85714	74.55	70.97143	67.14286	59.10517	61.88794
Uzbekistan	53.85714	54.92857	66.47143	36.57143	42.26878	42.60631
Venezuela	59.57143	49.95714	63.74286	64.14286	62.89989	55.35302
Vietnam	56.78571	61.99286	60.47143	62.21429	58.99939	58.2282
Yemen	44.78571	48.75714	45.45714	46.71429	48.31278	45.6748
Zambia	47.14286	55.95	42.55714	43.78571	47.00481	43.86206
Zimbabwe	37.78571	34.07143	40.72857	3.142857	47.81762	26.02149

Appendix B – EGOIN Composite Index and Component Indices of 108 Nations

- Rankings

Country	E Index	G Index	O Index	I Index	N Index	EGOIN Index
Algeria	77	90	67	44	33	66
Argentina	44	69	36	40	58	46
Australia	13	8	2	8	40	17
Austria	16	14	13	11	7	4
Bangladesh	93	94	95	64	98	92
Belarus	65	89	26	72	42	67
Belgium	20	16	16	15	69	29
Belize	49	68	64	59	22	47
Bolivia	85	93	81	61	97	86
Botswana	62	34	86	71	104	85
Brazil	48	62	58	31	50	44
Bulgaria	53	45	48	73	53	43
Cambodia	98	72	91	90	103	94
Cameroon	105	102	99	85	94	97
Canada	10	7	8	5	37	15
Central African R.	104	104	108	103	108	107
Chile	31	22	47	37	13	25
China	58	71	53	23	86	76
Colombia	55	83	59	53	8	56
Costa Rica	42	31	44	34	3	32
Croatia	35	39	37	51	29	27
Czech Republic	27	26	23	24	19	13
Denmark	1	2	6	4	26	11
Dominican R.	60	79	76	78	30	61
Ecuador	73	95	74	58	24	68
Egypt	82	78	68	70	56	65
El Salvador	78	59	80	87	28	71
Estonia	21	24	34	57	46	36
Ethiopia	107	100	106	104	99	106
Finland	4	3	3	9	9	6
France	19	19	18	18	6	5
Germany	15	17	14	12	14	7
Ghana	87	49	90	107	80	101
Greece	33	37	30	39	59	34
Guatemala	69	88	83	63	78	73
Honduras	79	77	77	95	84	81
Hungary	39	28	31	46	27	26
Iceland	8	15	7	36	1	12
India	92	48	89	42	87	87
Indonesia	80	64	73	41	95	80
Iran	84	101	70	76	63	79

Country	E Index	G Index	O Index	I Index	N Index	EGOIN Index
Ireland	7	10	12	21	35	21
Israel	23	40	20	25	54	33
Italy	28	30	22	27	15	16
Jamaica	45	57	65	77	70	55
Japan	18	18	17	10	17	9
Jordan	68	44	51	91	75	70
Kazakhstan	70	74	42	49	72	60
Kenya	88	105	93	105	79	102
Kuwait	29	33	38	19	82	48
Latvia	30	41	41	79	18	41
Lebanon	81	92	69	68	71	75
Lithuania	37	38	35	74	31	38
Macedonia	59	63	57	96	60	74
Malaysia	32	36	50	20	43	30
Mali	106	66	101	83	107	104
Mexico	57	67	56	29	34	45
Moldova	61	86	66	102	67	83
Mongolia	56	65	63	86	100	82
Morocco	67	60	72	33	41	52
Mozambique	99	81	107	81	81	96
Namibia	76	46	87	66	64	62
Nepal	94	91	88	97	32	89
Netherlands	12	12	10	3	38	14
New Zealand	14	4	4	16	12	8
Nicaragua	91	82	84	100	73	84
Nigeria	101	106	105	88	106	105
Norway	6	6	1	1	5	1
Pakistan	86	103	104	84	89	95
Panama	40	43	49	48	20	31
Paraguay	72	80	79	52	48	59
Peru	64	73	78	55	25	57
Philippines	66	61	71	50	39	49
Poland	36	27	25	35	51	28
Portugal	26	20	27	38	16	20
Romania	47	53	55	65	36	40
Russia	54	97	39	62	57	63
Rwanda	95	56	102	92	96	98
Saudi Arabia	46	50	43	26	76	50
Senegal	97	70	98	99	101	100
Singapore	9	9	28	6	23	19
Slovakia	34	35	29	45	10	24
Slovenia	24	21	21	32	44	23
South Africa	41	52	85	75	83	72

Country	E Index	G Index	O Index	I Index	N Index	EGOIN Index
South Korea	17	29	24	14	74	35
Spain	25	23	19	30	21	18
Sri Lanka	74	58	54	82	47	58
Sudan	89	107	92	80	92	93
Sweden	2	5	9	7	4	3
Switzerland	11	1	11	2	2	2
Syria	90	85	62	69	45	77
Tanzania	102	84	94	93	90	90
Thailand	52	54	40	22	55	42
Trinidad & Tobago	38	47	60	56	77	53
Tunisia	43	42	45	47	61	37
Turkey	51	55	82	67	62	51
Uganda	96	98	97	89	85	88
Ukraine	71	87	46	94	68	78
United Arab E.	22	32	32	28	105	69
United Kingdom	5	13	15	17	11	10
United States	3	11	5	13	49	22
Uruguay	50	25	33	43	65	39
Uzbekistan	83	76	52	106	102	103
Venezuela	63	96	61	54	52	64
Vietnam	75	51	75	60	66	54
Yemen	103	99	96	98	88	91
Zambia	100	75	100	101	93	99
Zimbabwe	108	108	103	108	91	108