

# Globalization and financial crisis : a dynamic approach

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# **Globalization and Financial Crisis: A Dynamic Approach**

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in partial fulfillment of the requirement for the degree of  
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*I dedicate this thesis to my beloved Mom,*

*and to the loving memory of my Dad...*



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# TABLE OF CONTENTS

<b>Acknowledgements</b> .....	1
<b>Table of Contents</b> .....	3
<b>List of Figures</b> .....	7
<b>List of Tables</b> .....	9
<b>Abstract</b> .....	11
 <b>Chapter 1</b> .....	 13
<b>Introduction</b> .....	
1.1 Globalization, Offshoring, Volatility .....	13
1.1.1 Globalization .....	13
1.1.2 Macroeconomic Volatility .....	15
1.1.3 Outsourcing and Offshoring .....	17
1.2 Globalization, Aid and Financial Crisis .....	23
1.3 The Contributions .....	24
 <b>Chapter 2</b> .....	 31
<b>Globalization and Volatility: A DSGE Model with Offshoring</b> .....	
2.1 Introduction .....	31
2.1.1 Offshoring and Volatility .....	32
2.1.2 DSGE Models .....	34
2.1.3 Offshoring and Volatility in a DSGE Model: my Approach .....	35
2.2 Theoretical Model .....	37
2.2.1 Assumptions .....	38
2.2.2 Offshoring Sector .....	39



2.2.3 Households .....	43
2.2.4 Firms.....	49
2.2.5 Government .....	50
2.2.6 Market Clearing.....	52
2.2.7 Exogenous Processes.....	53
2.2.8 Model Simulation.....	54
2.3 Model Parameterization .....	55
2.4 Steady State Equilibrium .....	57
2.4.1 Finding the Steady State .....	59
2.5 Stochastic Simulation Results .....	65
2.5.1 Impulse Response Functions to Productivity Shocks.....	66
2.5.2 Impulse Response Functions to Demand Shocks.....	75
2.5.3 Other Results .....	82
2.5.4 Volatilities.....	85
2.5.5 Sensitivity Analysis .....	90
2.6 Conclusions.....	93

97

## Appendix A.....

1 Mathematical Derivation of the Model .....	97
1.1 Offshoring Sector.....	97
1.2 Households.....	103
1.3 Firms .....	107
2 Collecting First Order and Other Conditions .....	108
3 Mathematical Derivation of the Necessary Conditions .....	113
4 Solving the Model .....	116
4.1 Choice of Autocorrelation and Standard Deviation Parameters .....	116
4.2 Resolution Method Concepts in <i>Dynare</i> .....	117
5 Collecting Steady State Equations .....	120

6 <i>Dynare</i> Implementation of the Model .....	122
7 Other Results.....	125

## Chapter 3

<b>Globalization, Offshoring and Volatility: European Perspective.....</b>	<b>127</b>
3.1 Introduction .....	127
3.2 Empirical Motivation .....	129
3.2.1 Offshoring in Central Europe – Stylized Facts.....	130
3.2.2 Employment Evidence .....	137
3.2.3 Export Evidence.....	143
3.2.4 Import Evidence.....	146
3.2.5 Summary of the Motivation Exercise.....	150
3.3 Theoretical Model.....	151
3.3.1 Offshoring Sector.....	152
3.3.2 Households.....	153
3.3.3 Firms .....	155
3.3.4 Government .....	156
3.3.5 Market Clearing Conditions.....	156
3.3.6 Exogenous Processes .....	157
3.4 Parameters Calibration and Steady State.....	158
3.5 Stochastic Simulation Results.....	162
3.5.1 Benchmark Results .....	162
3.5.2 Sensitivity Analysis.....	169
3.6 Conclusions .....	173

## Chapter 4

### How Aid Supply Responds to Economic Crises:

<b>A Panel VAR Approach .....</b>	<b>175</b>
4.1 Introduction.....	175
4.1.1 Aid .....	179
4.1.2 Financial Crisis and Aid .....	181
4.2 Model Discussion.....	190
4.2.1 Channels of Impact of the Crisis on ODA Provision .....	190
4.2.2 Banking Crises and Aid .....	193
4.3 Data.....	194
4.3.1 Adjustment of ODA for Debt Relief.....	196
4.4 A Theoretical Framework.....	198
4.5 Empirical Strategy.....	201
4.5.1 Data Preparation.....	205
4.6 Results .....	207
4.6.1 The Simple Three-Variable PVAR Model.....	209
4.6.2 Results - the Extended Model .....	225
4.7 Conclusions.....	230

## Chapter 5

<b>Conclusions .....</b>	<b>233</b>
5.1 Summary of Results.....	233
5.2 Further Research.....	237
<b>References.....</b>	<b>239</b>

# LIST OF FIGURES

Figure 1.1 General structure of the model developed in Chapter 2 .....	28
Figure 1.2 Strategies of firms in Chapter 2 and 3 .....	29
Figure 1.3 Structure of the model developed in Chapter 4.....	30
Figure 2.1 Imports in billions of constant (2000) US dollars .....	33
Figure 2.2 Offshoring cutoff of activities $z$ and downward sloping relative unit labor requirement $A(z_t)$ .....	40
Figure 2.3 Graph of $z_t'$ in function of $W_t$ and $W_t^*$ .....	64
Figure 2.4 The increase in offshoring margin due to a negative foreign productivity shock. ....	67
Figure 2.5 Impulse response functions to the foreign unit labor cost $a_{Ft}^*$ shock, $\bar{z}' = 0.06$ . ....	69
Figure 2.6 The decrease in offshoring margin due to a negative domestic productivity shock. ....	71
Figure 2.7 Impulse response functions to the domestic unit labor cost $a_{Ht}$ shock, $\bar{z}' = .06$ . ....	72
Figure 2.8 The increase in offshoring margin due to domestic demand shock.....	76
Figure 2.9 Impulse response functions to domestic demand $G_t$ shock, $\bar{z}' = .06$ .....	77
Figure 2.10 The decrease in offshoring margin due to foreign domestic demand shock.....	79
Figure 2.11 Impulse response functions to foreign demand $G_t^*$ shock, $\bar{z}' = .06$ .....	80
Figure 2.12 Volatility in a model with practically no offshoring margin ( $\bar{z}' = 0.0001$ ) .....	88
Figure 2.13 Volatility in the benchmark model with offshoring margin $\bar{z}' = 0.06$ .....	89
Figure A1. Movements in the offshoring cutoff due to changes in the relative wages .....	99
Figure 3.1 Number of employees in foreign affiliates and number of foreign owned enterprises established in Poland.....	131
Figure 3.2 Offshoring sector activity in Czech Republic (log values) .....	135
Figure 3.3 Share of employment in German-owned manufacturing companies abroad .....	137
Figure 3.4 Size of Aggregated Offshoring Sector in 4 CE countries.....	137
Figure 3.5 Employment in offshoring manufacturing sector in 4 CE countries (in logs) .....	138
Figure 3.6 Number of enterprises or establishments in Manufacturing: 1993 - 2007.....	139
Figure 3.7 Employment in offshoring sectors of German and CEC industries (log values) .....	140

Figure 3.8 Export in manufactures (constant USD) in the offshoring industry in CE countries.....	143
Figure 3.9 Export share (in percentage) of production in manufacturing in CECs sector.....	144
Figure 3.10 Intermediate input ratio in manufactures in CEC countries .....	147
Figure 3.11 Percentage change in imported intermediates ratio between 1995 and 2005.....	147
Figure 3.12 Imported intermediates ratio in manufacturing.....	148
Figure 3.13 Impulse response functions to the negative foreign productivity $a_{Ft}^*$ shock .....	165
Figure 3.14 Impulse response functions to the negative domestic productivity $a_{Ht}$ shock .....	166
Figure 3.15 Impulse response functions to domestic demand $G_t$ shock.....	167
Figure 3.16 Impulse response functions to foreign demand $G_t^*$ shock.....	168
Figure 3.17 The optimal level of offshoring in the European market .....	171
Figure 4.1 Net ODA disbursements .....	180
Figure 4.2 ODA to Africa by sector.....	181
Figure 4.3 Real GDP growth in the world (1980-2016) .....	182
Figure 4.4 Financial crises and pro-cyclical ODA outflows trend following ups and downs of donors' economies .....	184
Figure 4.5 First differences in net ODA and GDP.....	186
Figure 4.6 Aid for selected DAC donors.....	188
Figure 4.7 Total ODA net disbursements versus total ODA net disbursements net of debt relief.....	197
Figure 4.8 Estimation (1p): Impulse response functions of the GDP, fiscal balance and ODA to a positive standard deviation shock in 1-lag PVAR analysis .....	211
Figure 4.9 Estimation (2p): Impulse response functions of the GDP, fiscal balance and ODA to a positive standard deviation shock in 2-lag PVAR analysis .....	212
Figure 4.10 1 and 2-lag VAR response of ODA to negative shocks to GDP and fiscal balance for the full sample, crises or expansion.....	215
Figure 4.11 1 and 2-lag VAR response of ODA to negative shocks to GDP and fiscal balance for before and after the crisis.....	220
Figure 4.12 1-lag VAR impulse response functions of ODA to negative shocks to GDP and fiscal balance under different political orientations of the ruling party .....	223
Figure 4.13 Impulse response functions of aid to shocks in selected variables of the extended model.....	228

# LIST OF TABLES

Table 2.1 Calibration of the parameters .....	56
Table 2.2 Qualitative effects of productivity and demand shocks .....	81
Table 2.3 Selected correlations for different types of shocks for the benchmark model.....	82
Table 2.4 Selected standard deviations for different shocks for the benchmark model $\bar{z}' = 0.06$ .....	84
Table 2.5 Standard deviations for different levels of offshoring for the benchmark model .....	87
Table 2.6 Sensitivity analysis: selected correlations.....	91
Table 2.7 Sensitivity analysis: selected standard deviations .....	92
Table A1. Variables description.....	112
Table A2. Selected policy and transition functions for the benchmark model (first order).....	125
Table 3.1 Annual shares of EU15 enterprises to World enterprises in Poland and respective shares of Polish employees.....	130
Table 3.2 Imported intermediates ratio measured as imported intermediates to all intermediates.....	133
Table 3.3 Percentage change in intermediate import ratio between 1995 and 2005 for Central Europe.....	134
Table 3.4. Turnover and employment shares in German foreign affiliates .....	136
Table 3.5 Adjustment in the offshoring industry in CE countries. Extensive margin (employment) .....	142
Table 3.6 Adjustment in the offshoring industry in CE countries Extensive margin (export) .....	146
Table 3.7 Adjustment in the offshoring industry in CE countries. Intensive margin (import) .....	149
Table 3.8 Calibration of the parameters for the EU-CECs model .....	159
Table 3.9 Sensitivity analysis: selected correlations for the EU-CECs model .....	170
Table 3.10 Sensitivity analysis: selected standard deviations for the EU-CECs model .....	172

Table 4.1 Percentage changes in ODA and GDP for selected DAC donors .....	189
Table 4.2 Variables description .....	191
Table 4.3 Panel unit root tests.....	207
Table 4.4 Main results for the three-variable PVAR model of recessions and expansions .....	213
Table 4.5 Forecast Error Variance Decomposition for recessions and expansions analysis .....	217
Table 4.6 Main results for the 3-variable PVAR model of before and after the crisis analysis.....	218
Table 4.7 Forecast Error Variance Decomposition for before and after the crisis analysis.....	219
Table 4.8 Main results for the three-variable PVAR model of political influences.....	222
Table 4.9 Forecast Error Variance Decomposition for ODA: Party influence analysis.....	224
Table 4.10 Main results for the extended model.....	227
Table 4.11 Variance decomposition for the extended model .....	229

# ABSTRACT

This dissertation investigates some of the outcomes of globalization, exploring the effects and transmission of shocks between countries. It consists of three essays interconnected by the topic of globalization and economic crises.

The first essay studies one of the most prominent outcomes of globalization, global production markets, and their roles in transmitting shocks. A two-country, three-sector Dynamic Stochastic General Equilibrium (DSGE) model with offshoring is proposed and simulated for an open economy, inspired by the paper of Bergin P. & Feenstra R. & Hanson G., (2011) ‘Volatility due to offshoring: Theory and evidence’, *Journal of International Economics*, vol. 85, no 2, 163-173. The model implements two country-specific sectors and a common multinational sector with home and foreign producers where domestic multinational producers can reallocate production abroad. It is found that offshoring has generally positive effects for the home country, raising output and mitigating inflation, and these favorable effects are amplified by the ‘export’ of volatility that comes along. However, there exists a threshold beyond which the effects of offshoring become negative for the domestic economy. The study also establishes an interest rates channel of offshoring.

The second essay aims at showing that production reallocation is a substantial phenomenon within the European Union and studies its dynamics. The extensive and intensive margins on import, export and labor are estimated, revealing that offshoring is a channel of adjustment to shocks in Europe. The DSGE model is calibrated to fit Western and Central European data. Simulations confirm most of the qualitative and behavioral findings from the first essay; globally, offshoring amplifies the transmission of economic shocks across borders. The results reveal the existence in the European context of an optimal level of offshoring for which volatility is minimal. Offshoring is also found important for the labor market, as it contributes to job creation at home and abroad, but also to maintaining the cross-country wage gap.

The third essay tackles the issue of the effects of globalization spillovers from the developed world to developing countries, by addressing the challenges of international aid in times of financial crisis. In the presence of crisis, developing countries rely more crucially on aid, whereas developed countries reduce aid volumes. This study designs a theoretical framework of international aid provision based on a consumption model where donors consume international aid indirectly. The panel vector autoregression (PVAR) analysis is conducted from the yet unexplored standpoint of Official Development Assistance donors, and exposes the financial sources of aid volatility in the context of crisis. The main finding is that crises affect aid budgets and their trends. Financial volatility is found to decrease aid and to introduce some uncertainty to aid through fluctuations of its budget. The analysis establishes evidence that aid decisions are not purely economic, but also determined by internal political factors of donor countries: center parties appear more driven by economic determinants, while left and right-wing parties act in accordance with their ideological views.





# CHAPTER 1

## Introduction

### 1.1 GLOBALIZATION, OFFSHORING, VOLATILITY

#### 1.1.1 Globalization

The study of globalization is a dive into the complexity underlying the changes and exchanges – voluntary and involuntary – that, regardless of their initial scale, have a much more extensive influence than a naïve observer would foresee, in his obliviousness of the profound impact that technology has had on the modern world. The financial crisis has spectacularly illustrated the need to further our comprehension of these interconnected processes. Yet, when one starts pulling some insights out of the tangle of economic relations that characterizes globalization, an inextricable, global, and dynamic network follows. In this light, a multifaceted approach to the analysis of globalization comes forth as a necessity. This work studies relevant issues in the aftermath of the financial crisis from several angles, each angle highlighting globalization in its dynamism from a complementary viewpoint.

*Globalization* is the process of international integration and increase in worldwide exchange of various resources. It is not a new phenomenon, but has accelerated in recent history, mostly due to advances in transportation and telecommunication, among which the ease of global travel by air, the standardization of freight containers, and the access to information

through television and Internet played major roles. Globalization has numerous aspects, including global business (international trade, tourism, and offshoring), economic globalization (cross-border financial movements and crises), sociocultural globalization (culture and knowledge), and the globalization of labour (Featherstone 1990, Sassen 1999, IMF 2000).

The globalization of production and of financial markets, as well as the recent economic crisis, raised a discussion on the macroeconomic volatility transmission channels derived directly from the trade to macroeconomic variables volatility link. Greater trade openness affects aggregate and firm-level volatility by changing the exposure to macroeconomic shocks. In an open economy, shocks and volatility can be amplified across borders. Globalization has facilitated the transmission of international economic shocks through a variety of channels, among which the well-established financial channels. Global trade, through globalized production, is a less well explored channel. However, taking into consideration the interconnection of international trade and finance, and because trade openness itself is found to increase output instability, it is reasonable to expect some other aspects of trade to cause economic volatility. Therefore, the question arises as to whether trade in intermediates, or offshoring<sup>1</sup>, is any different.

*Trade in intermediates*, as opposed to trade in final goods, is the trade of parts and components or other items used as an input in the production of manufactured goods. Trends in trade in intermediate goods are indicative of the formation of *global value chains* (GVC)<sup>2</sup> because fragmented production processes require that components and partially assembled parts cross borders, sometimes many times, before final goods are produced and shipped to final markets (Feenstra, 1998; Arndt and Kierzkowski, 2001).

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<sup>1</sup> Practice of firms to relocate some business processes abroad.

<sup>2</sup> *Value chains* are activities that a firm performs in order to deliver a valuable product or service to the market. *Global value chains* are divided among multiple firms and spread globally, across a variety of geographic areas (Nadvi 2004). As production processes in many industries have been fragmented and moved around on a global scale, global value chains have become the foundations of the world economy (Gereffi and Korzeniewicz 1994; Gereffi, Humphrey, and Sturgeon 2005).

In the next section, I briefly review existing literature on macroeconomic volatility. In the subsequent section, I examine past studies on offshoring and explain how my work fits in this context.

### 1.1.2 Macroeconomic Volatility

In the thesis, offshoring is considered as a channel of shock transmission for macroeconomic volatility between the host country and the offshoring destination. The topic of volatility originates from the real business cycle literature<sup>3</sup>. The term arose to describe unstable markets, unpredictable capital flows or even unexpected changes of political climate (Aizenman and Pinto 2005). More formally, *volatility* is a measure of the potential variability in an economic variable or its function. *Macroeconomic volatility* concerns macroeconomic aggregates such as output, prices or employment<sup>4</sup>.

One of the most pronounced global economic trends of the last 30 years is the substantial decrease in macroeconomic volatility starting in the early 1980s, and its subsequent rise during and after the 2008-2009 crisis. At first, both *output volatility*, reflecting changes in GDP growth rates, and inflation volatility moderated in industrial nations, a phenomenon often called the *Great Moderation* (Blanchard and Simon 2001, Stock and Watson 2003). It is believed to have been caused by institutional and structural changes, the improved performance

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<sup>3</sup> Business cycle studies are more focused on cycles and trends related issues than on volatility itself. Business cycle synchronization and co-movement literature includes Yun (1996) on inflation co-movement, Kose et al. (2003) on globalization and business cycle volatility, and other works establishing a positive link between bilateral trade and business cycle synchronization in industrialized economies, for example, Frankel and Rose (1998), Clark and van Wincoop (2001), Baxter and Kouparitsas (2005) or Kose and Yi (2006).

<sup>4</sup> Measures of volatility are based on the realizations of a random variable, and include the standard deviation and coefficient of variation of a variable.

of macroeconomic policies, and serendipitous events in the developed world<sup>5</sup>. It brought several benefits, including the improvement of markets functioning, reduced inflation risks and economic uncertainty, stable employment and fewer recessions (Bernake 2004).

The greater predictability associated with the Great Moderation influenced the behaviour of firms, which started holding less capital and became less concerned about liquidity. In turn, this may have given rise to excessive risk taking, and contributed to the build-up of the recent crisis (Bean 2010). In other words, the Great Moderation enabled a classic period of financial instability, with stable growth encouraging greater financial risks. Since the global financial crisis in 2008, macroeconomic volatility is high again, and has arguably brought the period of the Great Moderation to its end (Clark 2009).

Thanks to the Great Moderation, macroeconomic volatility received considerable scientific attention. There is a large body of literature on the relation between volatility and finance<sup>6</sup> or volatility and growth<sup>7</sup>.

Volatility was extensively discussed in the field of international trade. The idea is that in an open economy, shocks and volatility can be amplified across borders. It is established that macroeconomic volatility can be influenced by cross-border transactions. Easterly et al. (2001), and Kose et al. (2003) expose the positive and significant contribution of *trade openness* to aggregated output volatility at the macro, cross-country level. Giovanni and Levchenko (2009) show how more open sectors of the economy are more volatile, but Buch et al. (2009) find that

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<sup>5</sup> Several studies using different empirical approaches have provided support for the good-luck hypothesis, see for example Ahmed et al. (2004) or Stock and Watson (2003).

<sup>6</sup> The relation between finance and volatility seems of a great importance, but suffers from an overabundance of potential channels of influence. Financial linkages allow economies to diversify their production structures by employing external funding, thus reducing potential sectoral shocks. But it is also generally agreed that the greater financial integration of the markets is likely to be an important channel for the transmission of shocks and to magnify their effects (Buch et al. 2005, Buch and Pierdzioch 2005). Both phenomena have to be integrated, as the net effect is what matters.

<sup>7</sup> Ramey and Ramey (1995) found that volatility has a negative impact on long-run growth. In growth theory, the inclusion of volatility and determinants such as trade, preferences or technology has been regarded as the follow-up of endogenous growth. More recently, Acemonglu et al. (2004, 2003) showed that institutions affect not only growth but also economic instability, and can amplify its negative effects.

export decreases firm-level volatility. The link between trade and volatility is apparently complex. Greater trade openness allows for better protection against domestic demand shocks and enhances the role of exchange rate, which in turn may lower or increase volatility. To add to this, greater specialization leads to increased exposure to external shocks. Yi (2003) argues that *vertical specialization*<sup>8</sup> makes a cut in tariffs, even small, foster world trade. This raises the question whether trade in intermediates is an important channel in amplifying or mitigating volatility. Due to globalization, value chains have spread worldwide and become sufficiently flexible that traded goods are not only final goods, but may also be parts or components. This outcome of globalization and its contribution to macroeconomic volatility have caught the attention of some leading researchers. Bergin, Feenstra and Hanson (2007, 2009, 2011) model and test volatility due to production offshoring, taking the example of USA and Mexico, while Tesar (2008) studies it for Western and Eastern Europe.

### 1.1.3 Outsourcing and Offshoring

Although they are often used interchangeably, the terms ‘outsourcing’ and ‘offshoring’ are to be distinguished.

*Outsourcing* is the contracting out of an internal firm process to a third-party organization, with the intention of reducing the cost. Outsourcing can involve transfers of labour and assets from one firm to another, or to so called ‘captive centres’ – smaller branch-companies owned by the parent firm<sup>9</sup>. The definition of outsourcing includes both foreign and domestic contracting, so it can include offshoring, which is a narrower term describing the relocation a

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<sup>8</sup> In international trade, using imported intermediate components and creating export goods.

<sup>9</sup> They are either acquired or newly created, often for that purpose.

business function from one country to another. The thesis focuses on offshoring, the movement of resources between countries.

*Offshoring* is the practice of outsourcing operations overseas, usually by companies from industrialized countries to less developed countries. It is part of a larger phenomenon of global distribution of work (global value chains). Lower labour costs, less strict environmental regulations and labour regulations, favourable tax conditions, and proximity to raw materials are among the reasons for relocating operations outside the firm's home country<sup>10</sup>.

In recent years, a great part of the growing international trade was in intermediate products (Hummels et.al 2001), so interest in offshoring is on the rise (Blinder 2006). Offshoring is called “the next industrial revolution” by Blinder (2006), and is changing the nature of international trade according to Hummels et al. (2001). This ‘back-and-forth’ trade might explain the puzzling observation that manufacturing exports have been rising, while manufacturing output has been falling (Bergoeing et al. 2004). The increasing importance of trade in intermediate products makes differentiating between the ‘gross’ trade and the traditional value added trade more essential. This phenomenon, together with the increasing export of manufacturing and intermediate goods from developing countries, underlie “the great transformation in the nature of world trade” described by Krugman (2008).

Offshoring can be divided into *offshoring of production* and *offshoring of services* as it typically concerns either an operational process, such as manufacturing, or supporting processes, such as services. The commonly known examples of production offshoring are the textile and electronics factories in China, and of services offshoring, the call or financial centers and IT offices in India. Offshoring of production focuses on the manufacturing sector (Houseman 2007, Harrison and McMillan 2011). Global sharing is dominated by production goods, and while offshoring of services (Amiti and Wei 2009, Bunyaratavej et al. 2007) is growing rapidly, it

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<sup>10</sup> See Carmel and Tija (2005) or Olsen (2006) for more discussion about offshoring and outsourcing.

remains secondary to offshoring of production. The offshoring of services is often confusingly called ‘outsourcing’. The literature on global offshoring includes research on the specification of firms which choose to offshore (Antras and Helpman 2004), studies of the effects of production sharing on the relative demand for skilled and unskilled labor (Feenstra and Hanson 1999, Ebenstein et al. 2009), works on the factors of productivity (Grossman and Rossi-Hansberg 2008), and on vertical linkages between countries (Giovanni and Levchenko 2009).

Offshoring is often undertaken with a view to reduce cost and increase corporate profits. It is widely understood that high-income countries, where labour costs are higher, are sources of offshoring, while developing economies with low labour costs are its destinations. However, Molnar et al. (2007) show that offshoring takes place between OECD countries, as one third of intermediates imported by high-income countries originate in other high-income countries.

It is also commonly known that China, Bangladesh, Mexico, Brazil and Vietnam are the main destinations for production offshoring, with the prototypical examples of textiles or electronics, while India is a favourite destination for most services offshoring – IT support and call centres. It is much less common knowledge that in reality, Western European companies tend to offshore the biggest share of their production to Central and Eastern Europe (Zorell 2009), and Mexico happens to be the main recipient of American production (Bergin et al. 2007, 2009).

Offshoring remains a controversial issue. On one hand, the origin and destination countries both appear to benefit through free trade, offshoring providing jobs on the destination side and cheaper goods and services to the origin. On the other hand, it spurs disputes about job losses and wage erosion in the source country (Krugman 2007). In general, offshoring to low-wage countries often substitutes for domestic employment; however, for firms that differentiate tasks at home and abroad, foreign and domestic employment are complements (see for example Harrison and MacMillan 2011). Originally, researchers interested in globalization and offshoring



were mostly concerned about *wages*, the influence of offshoring on unemployment and on the microeconomic structure, rather than on the macroeconomic perspective (Bhagwati 2004, Grossman and Rossi-Hansberg 2008). Offshoring was rather seen as damaging, as it was believed to be the cause of job loss in the home country (Hine and Wright 1998, Kletzer 2001). However, while current research either finds a very small effect of offshorable jobs on unemployment (Egger et al. 2007) or concludes that offshoring creates jobs (Mitra and Ranjan 2010). It also contributes to the cross-country wage gap (Criscuolo and Garicano 2010). It is also notable that the wealth creation effect of offshoring does not transmit from firms to employees (Farell 2005, Levy 2005), an important concern that is often absent from the public debate.

Offshoring yields three types of macroeconomic implications: macroeconomic volatility, price changes and inflation<sup>11</sup>, and effects on labor market, productivity<sup>12</sup> and wages. The view of offshoring as a channel for international shock transmission is based on the observation that it allows the home country to export its fluctuations abroad, so that volatility is magnified in the offshoring destination country. It is based on the business cycle co-movement literature and on the presence of vertical specialization in the world trade. The corpus of studies on offshoring with intermediate input and business cycle synchronization includes Burstein et al. (2008), Ambler et al. (2002) and on vertical specialization, includes Hummels et al. (2001) and Kose and Yi (2001, 2006). The importance of offshoring for macroeconomic volatility is evident; shifting production across borders amplifies cross-border fluctuations. Nevertheless, the nature and direction of these transmissions are yet to be determined.

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<sup>11</sup> Globalized offshoring may influence prices and inflation. It is particularly visible in the China-US trade pattern. China, as the largest exporter, contributes to the lowering of import prices and consumer prices (Mishkin 2009). Increasing globalization has moderated inflation in many countries (Feenstra 2010).

<sup>12</sup> As production now happens in many stages in various countries (Yi 2003), globalization and offshoring also have a more general impact on productivity. Amiti and Wei (2009) report evidence of a strong link between services offshoring and manufacturing productivity growth. Melitz (2003) also finds that reallocation towards more efficient firms explains why trade in parts may generate productivity gains without improving the actual overall efficiency.

Bergin et al. (2007, 2009, 2011) were first to shift from the business cycle with intermediate trade and implemented the trade model with offshoring allowing for some frictions. Their model explains the stylized fact that the offshoring industries in Mexico are twice as volatile as those in USA. Fluctuations adjust in the extensive margin (firm entry and exit) as plants are being created and closed. The extensive margin responds to demand shocks that are being transmitted across the border.

Most studies explore offshoring from a static and deterministic perspective, for instance Grossman and Rossi-Hansberg (2008), Yi (2003) or Burstein et al. (2008). Only recently have researchers started taking a dynamic approach. Zorell (2009) develops a Dynamic Stochastic General Equilibrium (DSGE) model for Europe and focuses on the effects of falling offshoring costs related to transportation and communication on volatility. He finds that lower offshoring costs increase volatility in high-wage countries, but that a U-shaped relationship is present in low-wage economies. Other studies include Manning et al. (2008) where the dynamics of firm-level and macroeconomic forces driving offshoring are examined. Zlate (2010) develops a dynamic model of offshoring with heterogeneous firms and two stages of production.

The recent crisis clearly reflects the pervasive globalization of production, in all its sophistication (Cattaneo et. al 2010) with offshoring as a channel of shocks contagion. Offshoring and outsourcing are now considered core factors in debates over the causes and consequences of the 2009 collapse of global trade (Baldwin 2009). The world economies are increasingly integrated, interdependent, and specialized. Sudden and severe declines in sales for large companies often trigger the closure of factories of foreign suppliers, and these shocks are transmitted not only through countries, but also in entire regions, from the developed to the developing world. For instance, the low demand for cars in the US affected not only the American car industry, but also the whole network of producers through the global automotive intermediates supply chain (Jansen and von Uexkull 2010). Another example from the

electronics industry shows an even deeper interdependence of trading countries. Ferrantino and Larsen (2009) find that a decrease in US imports for consumers electronics leads to a drop in US exports of electronic components. This apparently paradoxical relationship stems from the fact that assembly plants in the developing world often depend on parts manufactured in industrialized countries. In consequence, shocks to demand originating in industrialized countries transit to their offshoring destinations, and come back as a supply shock.

While the thesis focuses on offshoring as a mechanism for transmitting shocks abroad, the reverse effect – the impact of global shocks on offshoring – is similarly important. Major global shocks undoubtedly influence offshoring activities, as they share the same channels of transmission. This is well illustrated by the impact of the global 2008-2009 crisis on global value chains. Finance and trade, the two main channels of offshoring, were also the two main channels of transmission of the contraction, reflecting a drop in demand.

The crisis had an impact on *offshoring incentives*. The immediate and expected response to the crisis was a reduction of outsourcing activities, particularly in offshore employment (Vickery et al. 2009). Gerrefi and Fernandez-Stark (2010) conclude that the crisis has had two opposing effects: a general contraction of demand due to the recession; and, at the same time, a substitution effect by which tasks are being moved from developed countries to emerging economies by the companies seeking to reduce cost.

The recent crisis has not reversed globalization, but accelerated two long-term trends in the global economy: *the consolidation of global production chains* and *the growing importance of markets in the South*<sup>13</sup>. The trend on the demand side is toward diversification. While the demand in the North has collapsed, South-South trade has increased together with the raising interest of Northern exporters in Southern emerging markets. Indeed, those markets have become more attractive to domestic and foreign producers, both from the North and the South

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<sup>13</sup> A book by Cattaneo et. al (2010) discusses both phenomena extensively.

(Kaplinsky and Farooki 2010, Milberg and Winkler 2010). On the supply side, there is a trend towards the consolidation of global production chains at the country and firm levels (Sturgeon et al. 2008, Sturgeon and Kawakami 2010). An increasing preference for larger, well-established, and global suppliers, leads to the gradual disappearance of marginal suppliers. During the recovery, this could exacerbate asymmetries in the market, as large companies have advantages in credit markets that would ease their expansion and further consolidation.

Global production markets not only have proven resilient but they also have become a crucial structural feature of the world economy.

## 1.2 GLOBALIZATION, AID AND FINANCIAL CRISES

Another dimension of globalization lies in the interconnection of the developed and developing countries. Indubitably, the strong interdependence between the developed and developing worlds surfaced with the recent economic downturn. As per the global character of the economy, it affected not only the North, but also the South. Alongside, the *Official Development Assistance (ODA)*<sup>14</sup> is subject to a pro-cyclical trend, as aid falls when the donors encounter a recession (Arellano et al. 2009). However, ODA, despite being criticized as ineffective, remains a major element in the budget of many developing countries, and has been such since the 1960s (World Bank 2001a; te Velde et al. 2002; Samuelson 2000), and is found to have a positive effect on growth (Arndt et al. 2010, 2011). This situation leads to a conflict: in the presence of crises, developing countries rely even more on aid (Brautigam 2000), while developed countries reduce aid volumes (Addison et al. 2010). This vicious circle is not

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<sup>14</sup> Official Development Assistance (ODA) is a term denoting international aid flow. It was introduced by the Development Assistance Committee (DAC) of the OECD.

theoretical, but is at the heart of the late 2000s' crisis, and has given rise to a discussion on the under-provision of aid by donors. In a recent brief, Hallet (2009) justifies these concerns by looking at past and current trends in aid provision in relation with economic cycles, a concern shared by other researchers who looked at historic evidence from past crises (Roodman 2008, Dang et al. 2009).

While the decline of aid flows during recession may somehow intuitively be expected, economists are not unanimous. Some find that crises may not always lead to a reduction of the aid to GDP ratio, arguably a good measure of the real effect of crisis on the willingness to provide aid (Pallage and Robe 2001); others, including Mold et al. (2010) find that aid provision is in fact insensitive to recessions. This apparent inconsistency of the literature and the overall lack of donors-centered studies leave important questions unanswered. Will the North manage to respond to the growing need for aid? Will donors decrease their aid disbursements? How does the financial crisis affect aid supply?

## 1.3 THE CONTRIBUTIONS

This thesis consists of two major parts. In the first part (Chapters 2 and 3) I develop a Dynamic Stochastic General Equilibrium (DSGE) model<sup>15</sup> of offshoring for an open economy extending Bergin et al. (2011). Then, after finding evidence of offshoring in the European context using panel data methods, I calibrate the DSGE model for the regional core-periphery distribution of the European Monetary Union (EMU) with regard to the Central European Countries (CECs).

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<sup>15</sup> The DSGE models attempt to explain aggregate economic phenomena and are derived from microeconomic principles, i.e. are based on the preferences of the decision-making agents and they are not vulnerable to the Lucas critique.

The objective of Chapters 2 and 3 is to contribute to the research on one of the outcomes of globalization, global production markets, and on their role in transmitting shocks that often lead to crises. I seek the answer to the question: to what extent does offshoring, consisting in reallocating parts of production and services abroad, contribute to macroeconomic volatility? Although the topic is still unexplored, this problem is well grounded in the literature. In particular, the financial causes of macroeconomic volatility are well studied, but not those related to trade. Taking the interconnection of international trade and finance into consideration, it is reasonable to expect some aspects of trade to cause economic volatility. Indeed, trade openness itself is found to increase output instability. Therefore I am interested in answering the question of whether trade in intermediates is any different. Offshoring is found to influence macroeconomic volatility of the US and of Mexico (Bergin et al. 2007, 2009, 2011) and is hypothesized to be a factor of the economic volatility of the new and old member-states of the EU (Feenstra 2010; Burstein et al. 2008; Tesar et al. 2008).

To address these issues, I build a DSGE model with endogenous offshoring based on Bergin et al. (2011). I implement offshoring into an open economy model and rigorously analyze the dynamics of global production. The model of Bergin et al. (2011) is a General Equilibrium model with micro-foundation. While they compare the moments of the model with the data for Mexico and the US, I follow Campbell's (1994) suggestion of looking at deviations after the shocks from the steady state through Impulse Response Functions. To perform stochastic simulations, I use *Dynare*, an open source software platform for DSGE modeling (Adjemian et al. 2011). My results benefit from many of the latest developments in computational economics, as *Dynare* is at the forefront of DSGE research.

The main objective of the model is to study the relationship between offshoring and the second moment properties of macroeconomic variables, and to verify the hypothesis of offshoring being a channel of international shocks transmission. Specifically, I explore how offshoring

influences wage gap, output, labor, consumption, prices, interest rates and inflation, and whether an increase in offshoring raises volatility in those variables.

Figure 1.1 gives an overview of the general structure of the model developed in Chapter 2. There are two countries (dashed boxes), two country-specific sectors, home and foreign, and one common multinational sector, which corresponds to offshoring sector. The home country can offshore production to the foreign country. Each economy is populated by households, firms and a government.

Figure 1.2 illustrates the strategies of the firms in the model. There are country-specific and multinational firms in both countries. The multinational sector firms are able to choose to offshore production abroad, while homogenous sector firms are limited to the domestic production market.

In the second part of my thesis (in Chapter 4), I concentrate on the dynamics of the relationship between developed and developing countries, another manifestation of globalization that surfaced with the recent economic crisis. I build a theoretical consumption model of aid and use *panel vector autoregression (PVAR)*<sup>16</sup> to evaluate it empirically.

This fourth chapter tackles the issue of the effects of globalization spillovers from the developed world to developing countries, by addressing the challenges of international aid provision in times of financial crisis. Globalization is examined under the light of Official Development Assistance (ODA). I attempt to answer the question of whether and how donors adjust aid budgets in response to various macroeconomic shocks. The main objective of the study is to explore the channels and behavioural consequences of unexpected financial shocks on aid budget adjustments in the short run. I address the issue of aid provision from the relatively

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<sup>16</sup> PVAR is an extended vector autoregressive (VAR) analysis (Sims 1980) allowing the use of panel data. This class of models is particularly suited for policy analysis as they attempt to capture both static and dynamic interdependencies between variables, allow for unrestricted links across units, incorporate time variations in the coefficients and in the variance of the shocks, and take cross sectional dynamic heterogeneities into account. See Canova and Ciccarelli (2013) for a detailed discussion about panel VAR models.

unexplored perspective of aid supply from the donor countries, rather than from the more commonly studied point of view of the recipient countries. Figure 1.3 gives an overview of the model developed in Chapter 4: a developing country demands aid and a developed country allocates aid supply. The developed country follows an adjustable aid target and is prone to exogenous shocks related to financial crises.

In the last chapter I conclude the thesis and propose some further research directions.



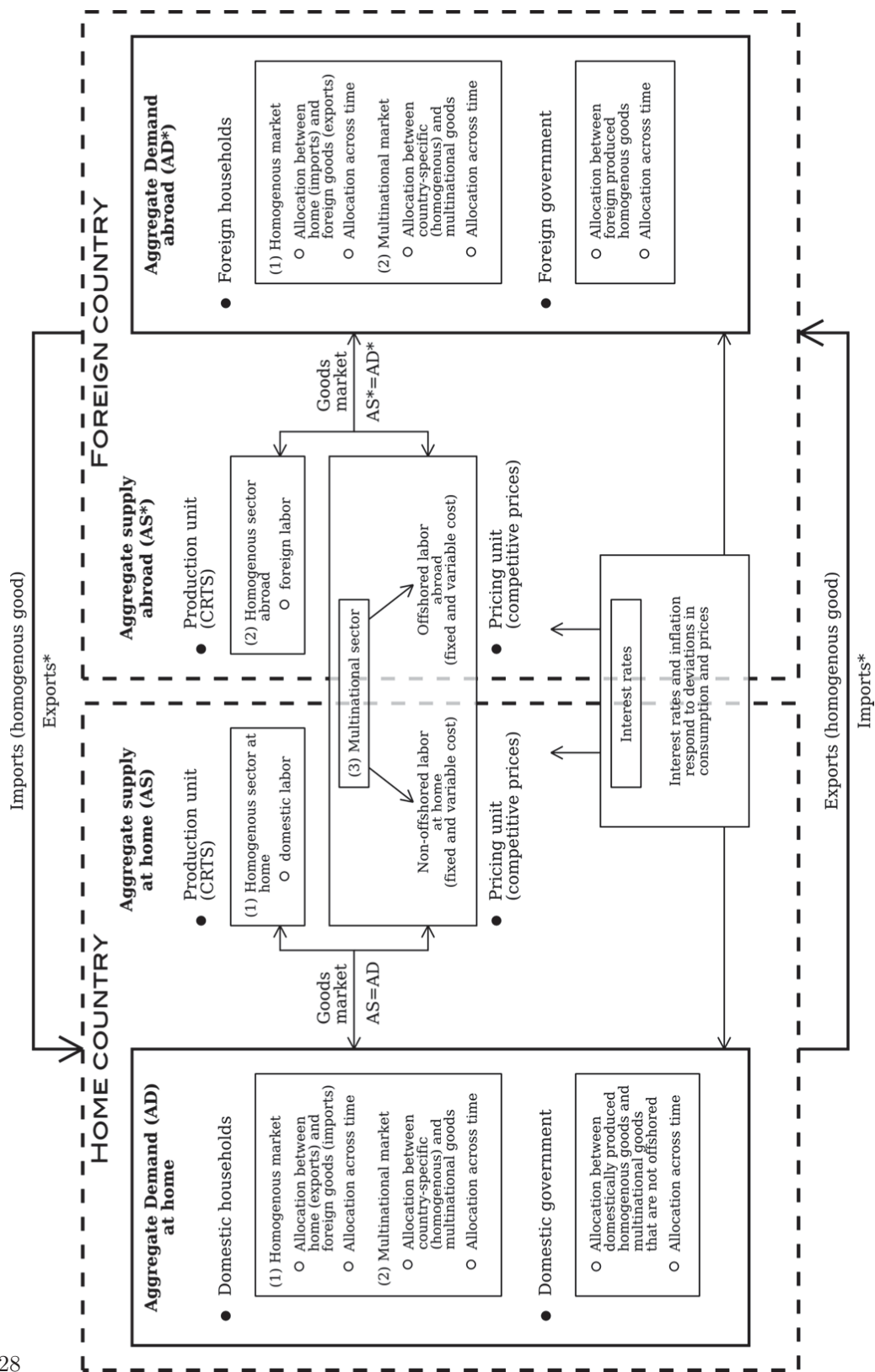


Figure 1.1 General structure of the model developed in Chapter 2.

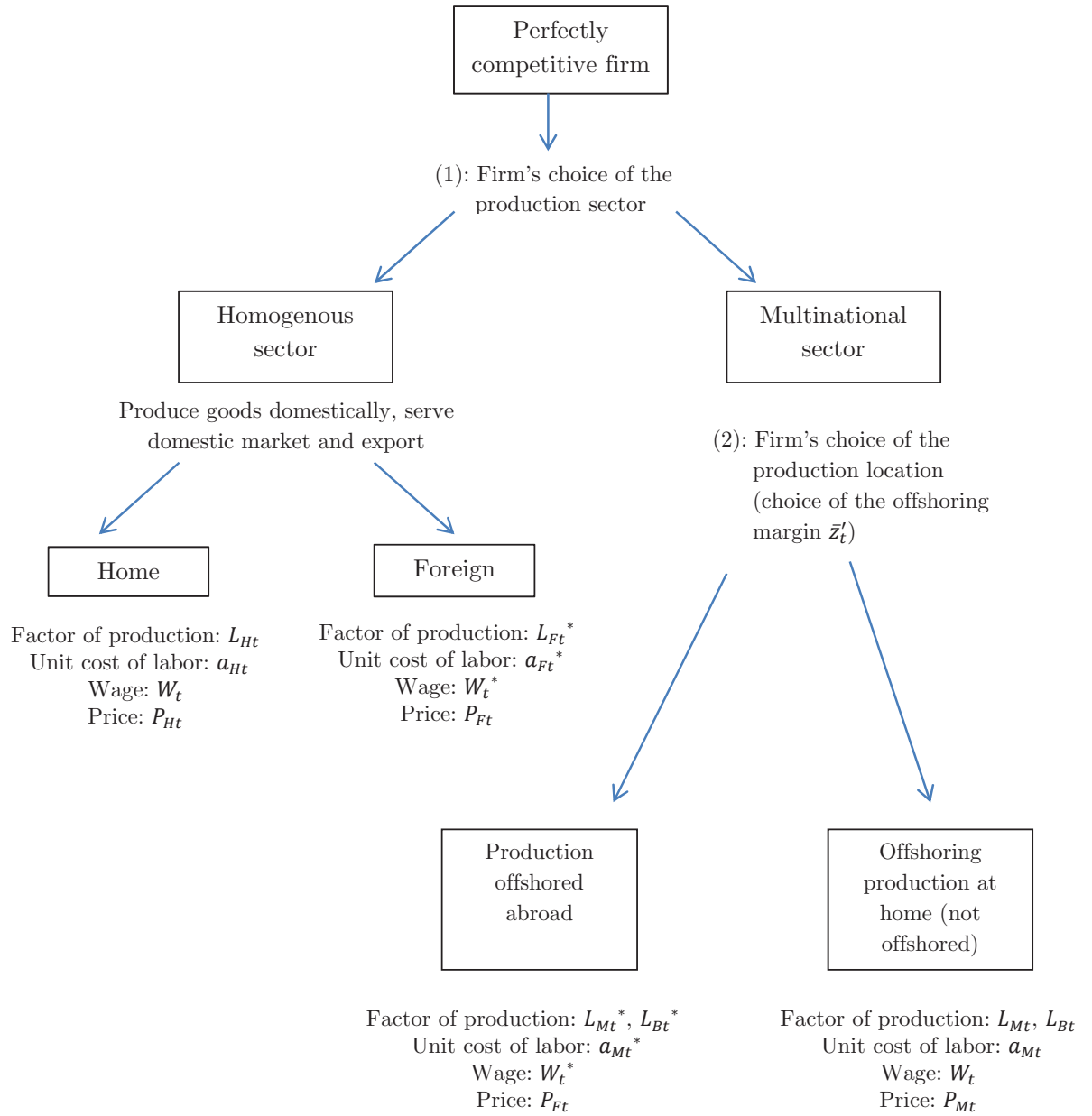


Figure 1.2 Strategies of firms in Chapter 2 and 3.

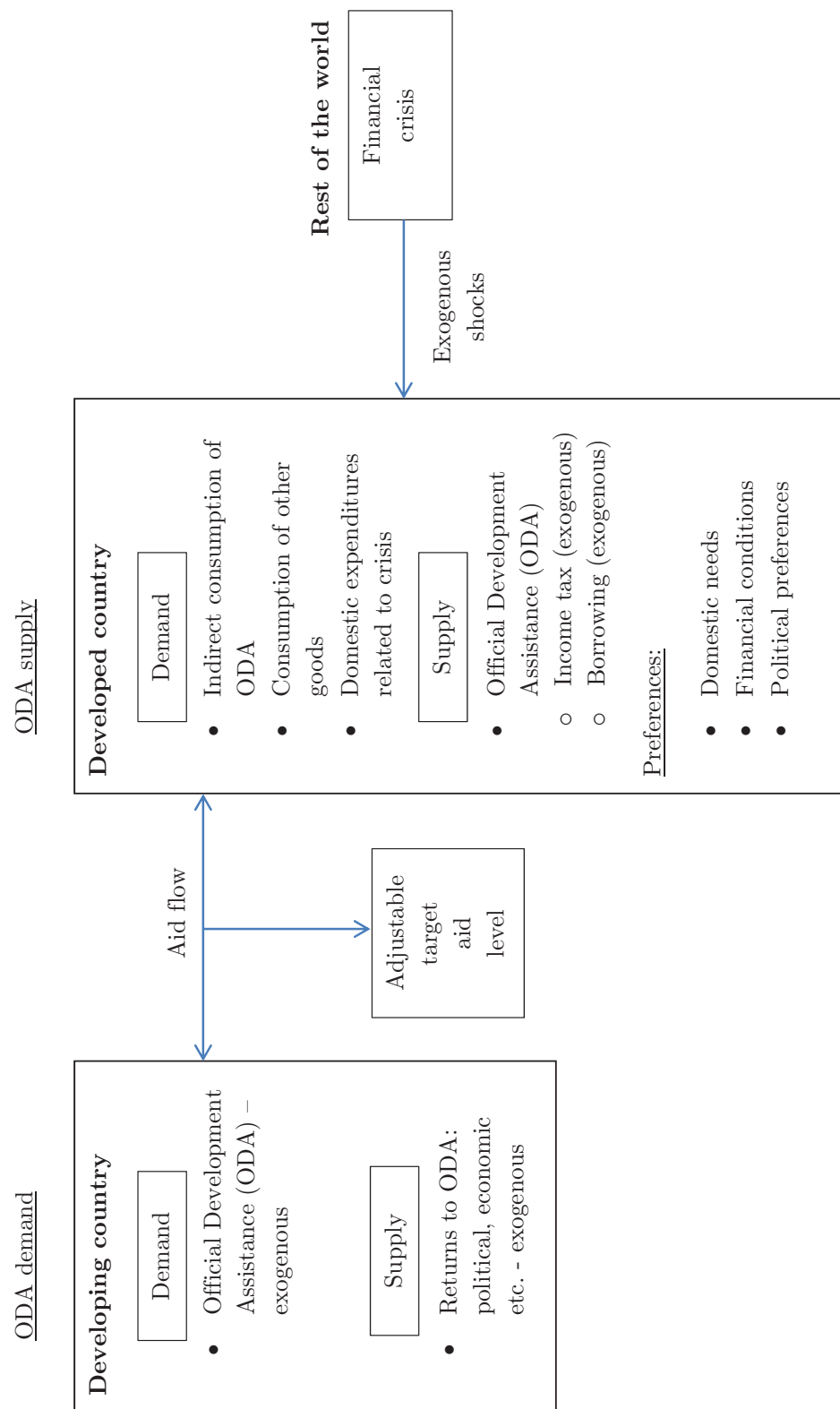


Figure 1.3 Structure of the model developed in Chapter 4.

## CHAPTER 2

# Globalization and Volatility: A DSGE Model with Offshoring

### 2.1 INTRODUCTION

Offshoring is responsible for the fast growing global trade in intermediate products, which contributes to the increase in global linkages and creates global production markets. As discussed in Chapter 1, insights from two separate research directions hint that these global markets form a volatility transmission channel. First, the trade literature suggests that openness and specialization increase volatility. I extend this reasoning to trade in intermediates. Second, the business cycle literature suggests that an “export” of fluctuations takes place between countries engaged in offshoring.

These findings are not just theoretical, but have their sources in the real world. Offshoring is raising and changing global trade. American, European and Japanese firms reallocate part of their production and services to Latin America, Central Europe, China and other Asian countries. These decisions have several consequences. One effect is that the corresponding industries in offshoring countries are more correlated with each other. This strengthening of ties is well illustrated by the offshoring from the U.S. to Mexico (Bergin et al. 2009, BHF (2009) thereafter) and from Western to Central Europe (Burstein et al. 2008). Another outcome is the increased volatility in the offshoring destination country, in particular in

employment (BHF 2009). Bergin et al. (2011) – BHF (2011) thereafter – explain higher volatility in the offshoring destination country by the generally higher volatility in the lower-wage economy and the differences between labor market institutions in both countries.

To understand how offshoring affects volatility, this chapter develops a model of global offshoring based on BHF (2011) and studies its second moment properties. Offshoring industries in the foreign country (offshoring destination) are more volatile than corresponding industries at home, a stylized fact observed both in the US with regard to Mexico, and in Western and Central Europe. To explain this phenomenon, the model uses the extensive margin of offshoring which responds to demand and productivity shocks, transmitting them abroad.

### 2.1.1 Offshoring and Volatility

As shocks and volatility can be amplified across open borders, globalization has emerged as a new factor in the transmission of economic shocks, which happen through a variety of channels. The recent crisis illustrated the importance of re-examining those channels. Globalized production is a less well explored channel despite its growing importance in global trade and its implications for the economy. Indeed, as was shown in Chapter 1, offshoring has influence on labor markets, prices and inflation, productivity, wages, and output. From the macroeconomic point of view, global production and trade in intermediates contribute to the volatility of the whole economy.

Figure 2.1 (Sturgeon and Memedovic 2010) shows the world's imports of final and intermediate goods and illustrates how they differ in volatility. In response to crises, trade in intermediate goods appears much more volatile than trade in either type of final goods, capital

or consumption goods. Additionally, the aggregate trends in final and intermediate goods imports have become increasingly similar over time, especially since the mid-1980s.

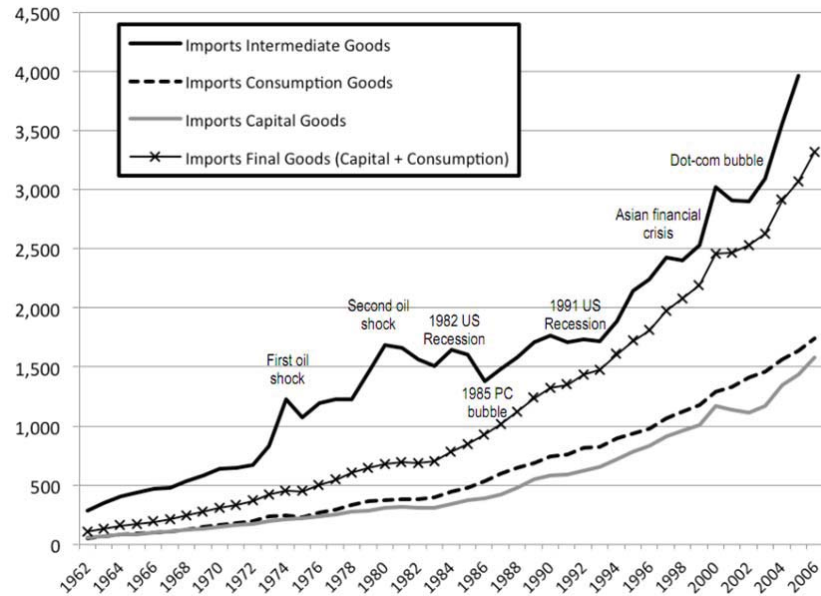


Figure 2.1 Imports in billions of constant (2000) US dollars.  
Source: Sturgeon and Memedovic (2010).

There are only a few theoretical papers devoted to the relationship between offshoring and macroeconomic volatility. The most relevant literature is related to offshoring and business cycle. Burstein, Kurz and Tesar (2008) propose a real business cycle model with global production sharing that leads engaged economies to an increased synchronization of their business cycles; Zlate (2010) studies the effects of offshoring on the dynamics of international business cycle and real exchange rates; Kose and Yi (2001, 2006) and Ambler et al. (2002) examine intermediate inputs and business cycle synchronization. BHF (2009) study employment volatility in relation to offshoring.

The existing studies model offshoring in various ways. BHF (2011) focus on the traditional concept of Ricardian comparative advantage while the idea developed by Grossman and Rossi-Hansberg (2006, 2008) is centered on a trade-off between offshoring costs and lower wages abroad. Yi (2003) employs three sequential production stages for which Ricardian comparative advantage determines the location of production, but does not model any shocks. What is more, different models define the nature of offshoring differently. Bergin et al. (2007, 2011) regard offshoring as an industry-specific phenomenon, while Grossman and Rossi-Hansberg (2008) or Zorell (2009), as an input-specific issue.

This research concentrates on the one of the most prominent outcomes of globalization, global production markets, and on their role in transmitting shocks. Past studies have shown that offshoring is found to influence the macroeconomic volatility of the US and of Mexico, and is suspected to be a factor of the economic volatility of the new and old EU member-states (BHF 2011, Burstein et al. 2008, Tesar et al. 2006, and Marin 2006).

### 2.1.2 DSGE Models

Advances in economic modeling have resulted in models that can generate results often closely matching real world dynamics. Dynamic stochastic general equilibrium (DSGE) models can be used to analyze historical economic events, current economic conditions, and hypothetical changes in policy. They bring together advances in computational economics and time series econometrics to produce estimates of structural parameters, latent variables, and economic shocks that generate economic fluctuations.

An advantage of DSGE models is that they can be adapted to suit a wide variety of applications. This class of models is based on micro foundations: DSGE models are

macroeconomic models derived from microeconomic principles. Because all agents in a DSGE model make decisions, the model can capture the endogenous effects of changes in policy. Another advantage of DSGE models is their transparency. A DSGE model can provide a more precise insight about the nature of the shocks that drive observed economic variations than alternative modeling strategies.

### 2.1.3 Offshoring and Volatility in a DSGE Model: my Approach

I propose a two-country, three-sector Dynamic Stochastic General Equilibrium (DSGE) model with offshoring based on BHF (2011) with stochastic simulation. I add intertemporal optimization, endogenous prices in the multinational sector, interest rates, inflation, and managerial labor. The model aims to explain how global production sharing may affect macroeconomic volatility. It is a Ricardian two-country and three sector model of trade with a continuum of goods, and with home, foreign and multinational (offshoring) sectors. The home economy engages in offshoring to the foreign country. The countries differ by wage rate, but unlike BHF (2011) we do not focus on the US and Mexico, but consider a more general case. The model targets employment fluctuations in offshoring industries in a low wage country, which tend to be higher than in a high wage country.

I decide to extend the model and go beyond calibration, so as to extract more complete information about the underlying mechanisms. I add stochastic processes to simulate model-extrinsic variations, and analyze the transmission of productivity and demand shocks. The model is simulated with MATLAB and *Dynare*<sup>17</sup> for an open economy.

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<sup>17</sup> *Dynare* is a software platform for handling a wide class of economic models, in particular dynamic stochastic general equilibrium (DSGE) and overlapping generations (OLG) models. It is available for free at [www.dynare.org](http://www.dynare.org).



The main finding drawn from the analysis of the impulse response functions and second moment properties of the model is that global production sharing contributes significantly to the cross-border transmission of volatility. Cost-saving is the primary reason driving production offshoring. Consistently, it is found that both productivity and demand shocks influence offshoring decisions through the extensive margin. Volatility is amplified by the scale of outsourcing; hence international production becomes a channel that ‘exports volatility’ from home to the foreign country.

Offshoring is found to have a positive effect on the home country, raising output and employment in the domestic managerial offshoring sector and mitigating inflation. It also fosters employment in the multinational sector abroad, but at the cost of increasing the wage gap. The analysis reveals the synchronization of employment between home and foreign countries. The simulation shows that increasing the extensive margin of offshoring ‘creates’ volatility in both countries. Employment in the offshoring sector is significantly more volatile abroad than at home.

## 2.2 THEORETICAL MODEL

To analyze the way in which exogenous shocks affect an economy engaged in offshoring activities, I build a DSGE model of an open economy<sup>18</sup> based on BHF (2011). The economy is populated by households, firms, and government authorities.

The model exhibits many characteristics of the Real Business Cycle literature. It is driven by real shocks, including productivity and demand shocks. It focuses on the real side of the economy: quantities of aggregate production, consumption, and employment, relative prices including real wages, and real interest rate. Nominal variables do not affect real variables. There is no role for stabilizing policies, and in particular the Central Bank is not an agent and monetary policy does not play any role in the model.

Firms have no market power and markets are perfectly competitive. All prices adjust instantaneously, and all prices and wages are flexible without nominal rigidities. The competitive equilibrium is Pareto optimal. Firms in the homogenous sector are identical price takers, and households are infinitely lived identical price-takers.

Even though I do not focus on the nominal side of the economy, the model also incorporates some elements of the New Keynesian paradigm. As in BHF (2011) thereafter, multinational firms produce a continuum of products indexed from 0 to 1 and there is free entry of firms in each industry. The model assumes rational expectations.

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<sup>18</sup> The derivation of the model is shown in part 1 of Appendix A. All variables of the model are listed and described in Table A1 on page 112 in Appendix A.

### 2.2.1 Assumptions

The baseline model is a Dynamic Stochastic General Equilibrium (DSGE) model with continuum of goods, two countries and three sectors extending the specification of BHF (2011). It models global production sharing by combining Ricardian trade with relative unit labor cost (Dornbush, Firscher and Samuelson, 1977), a continuum of goods  $z$  in the multinational sector (Romalis, 2004), and the distribution of relative unit-labor requirement function between countries defined by Eaton and Kortum (2002), in a standard open macroeconomic specification. In contrast to BHF (2011), I add dynamics by implementing intertemporal optimization, endogenous prices in the multinational sector, interest rates and inflation, managerial labor  $L_{Bt}$ , and  $L_{Bt}^*$ , and formulate a complete DSGE model.

There are two countries: home and foreign. Each country has two sectors: a homogenous, country-specific sector denoted by  $H$  for the home country, and  $F$  for the foreign country, and a differentiated multinational products sector  $M$  with continuum of goods and free entry and exit of firms. The offshoring sector  $M$  is common for both countries. The foreign country is denoted by an asterisk. Each country produces two types of goods, a homogenous country-specific good  $j$  and a continuum of differentiated multinational goods  $z$ . The multinational goods can either be produced at home or offshored. There is an offshoring relationship between the two countries, described in section 2.2.2 below, such that the home country offshores to the foreign country.

Production in the offshoring sector in each country incorporates two activities: a managerial component  $L_{Bt}$  which involves a fixed cost, and an assembly component  $L_{Mt}$  representing variable cost.

The offshoring decisions of firms are driven by cost saving and are taken in response to macroeconomic shocks. Along the continuum of goods, there exists a threshold  $z'_t$ , at which firms

in the home country start to offshore tasks abroad. It is endogenously determined and central to the model.

### 2.2.2 Offshoring Sector

#### Offshoring cut-off

The model assumes that the home country is engaged in offshoring driven by the cost saving incentive. There exists a cutoff defined by the relative wage between the home and the foreign countries, below which production of good  $z$  is offshored abroad.

Let good  $z \in [0, 1]$  be a good produced in the multinational sector  $M$ . A different unit labour input requirement is involved in the production in each sector. The unit labor requirements in the multinational sector  $M$  for tasks performed to produce good  $z$  at home and abroad are  $a_{Mt}(z)$  and  $a_{Mt}^*(z)$ , respectively. They are specified by  $a_{Mt}(z) = \frac{T}{(z_t)^{\frac{1}{\theta}}}$  and  $a_{Mt}^*(z) = \frac{T^*}{(1-z_t)^{\frac{1}{\theta}}}$ , where  $T$  and  $T^*$  are used to scale the unit labor requirements levels of the home and foreign country. The parameter  $\theta$  defines the curvature of the distribution of productivities (Eaton and Kortum 2002).

The relative unit labor requirement is equal to<sup>19</sup>:

$$A(z) = \frac{a_{Mt}(z)}{a_{Mt}^*(z)} = \frac{T}{T^*} \left( \frac{1-z_t}{z_t} \right)^{\frac{1}{\theta}} \quad (2.1)$$

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<sup>19</sup> I follow BHF (2011) with this specification. Eaton and Kortum (2002) derive a similar relationship in a footnote on page 1747. I use exactly the same heterogeneity parameter  $\theta$ . The unit labour cost constants  $T = \left(\frac{1}{t_1}\right)^{\frac{1}{\theta}}$  and  $T^* = \left(\frac{1}{t_2}\right)^{\frac{1}{\theta}}$  replace the efficiency constants.

Let us order the goods  $z$  so that  $A'(z) < 0$ ; i.e. the comparative advantage of country  $F$  decreases as  $z$  increases. This implies  $a_{Ht} - a_{Ft}^* < 0$ , where the unit labor requirements in the two countries are  $a_{Ht}(z)$  and  $a_{Ft}^*(z)$ . Let  $W_t$  and  $W_t^*$  the wages in each country.

I define the wages ratio  $\tilde{\omega} = \frac{W_t^*}{W_t}$  as the *offshoring cutoff* at:

$$A(z_t') = \frac{W_t^*}{W_t} \quad (2.2)$$

The offshoring condition defining  $z_t'$  requires  $A(z_t) = A(z_t')$  and is defined as:

$$\frac{W_t^*}{W_t} = \frac{T}{T^*} \left( \frac{1 - z_t}{z_t} \right)^{\frac{1}{\theta}} \quad (2.3)$$

Figure 2.2 presents this relationship graphically.

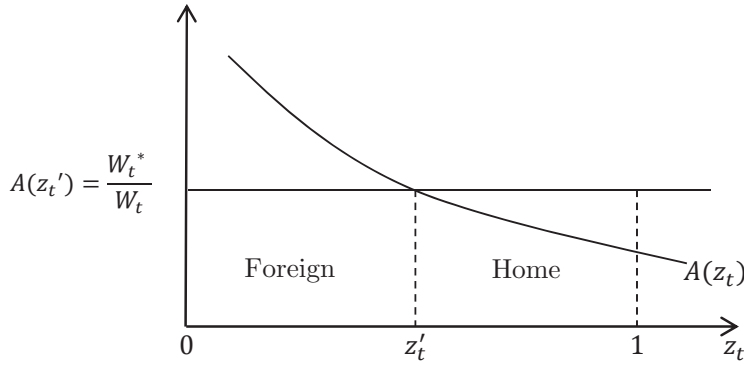


Figure 2.2 Offshoring cutoff of activities  $z$  and downward sloping relative unit labor requirement  $A(z_t)$ .

$A(z_t)$  is decreasing in  $z$ , so the products are arranged by increasing order of home comparative advantage. The model implies that the offshored activities (performed abroad) are  $z_t < z_t'$ , and those not offshored and done in the home country are  $z_t > z_t'$ .

## Prices

The price index of multinational goods  $P_{Mt}$  is calculated by integrating the relative unit cost at home and abroad over the offshoring cutoff range:

$$P_{Mt} = \int_0^{z'_t} W_t^* a_{Mt}^*(z_t) dz + \int_{z'_t}^1 W_t a_{Mt}(z_t) dz \quad (2.4)$$

which implies

$$P_{Mt} = T^* W_t^* \frac{\theta}{\theta - 1} \left[ 1 - (1 - z'_t)^{\frac{\theta-1}{\theta}} \right] + T W_t \frac{\theta}{\theta - 1} \left[ 1 - (z'_t)^{\frac{\theta-1}{\theta}} \right] \quad (2.5)$$

## Demand

Denote the quantity of the variety  $i$  of product  $z$  demanded in multinational sector  $M$  as  $d_{Mt}(z, i)$ . The demand may then be specified as the constant elasticity of substitution (CES) function aggregated for all firms  $N(z)$  over individual varieties  $i$ ,

$$d_{Mt}(z) = \int_0^{N(z)} [d_{Mt}(z, i)^\sigma di]^{\frac{1}{\sigma}}, \quad \sigma \in (0, 1) \quad (2.6)$$

I adopt a simpler, perfect competition approach by setting the elasticity of substitution between varieties  $\sigma$  equal to unity. The overall demand in the multinational sector in the home country  $D_{Mt}$  is specified as the aggregate of the demands for all products  $z$ .

$$D_{Mt} = \int_0^1 d_{Mt}(z) dz \quad (2.7)$$

where  $d_{Mt}(z)$  denotes the demand for product  $z$ . The market for  $z$  is *perfectly competitive* with low entry and exit barriers, continuity of products  $z$ , and with no single buyer or seller large enough to influence the market price  $P_{Mt}$ .

## Labor

The total labor demand in the multinational sector at home  $\tilde{L}_{Mt}$  consists of the labor demand for the variable cost (assembly or manufacturing) activities  $L_{Mt}$  for home country activities  $z_t > z'_t$ , i.e. that are not offshored, and the labor demand for the fixed cost (managerial) activities  $L_{Bt}$ , which depend on the fixed cost  $B_t$  and only change with the level of offshoring. Similarly, the total labor demand in the offshoring sector abroad  $\tilde{L}_{Mt}^*$  is equal to the labor demand for the variable cost activities  $L_{Mt}^*$  for activities offshored to the foreign country  $z_t < z'_t$ , and the labor demand for the fixed cost activities  $L_{Bt}^*$  performed abroad.

I assume that the fixed cost at home consists of  $L_{Bt}$  units of labor, and  $L_{Bt}^*$  units of labor abroad. Those are the managerial costs of offshoring incurred at home and abroad. Informally, we can think of  $L_{Mt}$  and  $L_{Mt}^*$  as “less skilled labor” and of  $L_{Bt}$  and  $L_{Bt}^*$  as “more skilled” labor. I assume that setting up a plant abroad is costless.

There is labor mobility between sectors within a country, and between fixed and variable cost activities within the home or foreign outsourcing sector, but there is no labor mobility between countries. Each country has a unique equilibrium wage rate.

I obtain the total labor demand at home  $\tilde{L}_{Mt}$  by integrating the fixed cost  $B_t$  and the variable labor input requirement over  $z \in [z'_t, 1]$ :

$$\tilde{L}_{Mt} = \int_{z'_t}^1 B_t dz + \int_{z'_t}^1 a_{Mt}(z) y_t(z) dz \quad (2.8)$$

where  $\tilde{L}_{Mt}$  is the total labor demand in the domestic offshoring sector,  $a_{Mt}$  is the unit labor requirement to produce  $z$ , and  $y_t(z)$  represents the output of good  $z$  per firm.

Integrating yields the demand for labor in the multinational sector in the domestic market:

$$L_{Mt} = \frac{D_{Mt} + D_{Mt}^* \left( \frac{1-n}{n} \right)}{W_t} (1 - z'_t) \quad (2.9)$$

where the share of the total population residing at home is denoted by  $n$ . Hence,  $(1 - n)$  resides abroad, and like in BHF (2011), foreign quantities are scaled by  $\frac{1-n}{n}$  to allow for different sizes of countries.

The fixed cost labor demand is:

$$L_{B_t} = B(1 - z'_t) \quad (2.10)$$

where  $D_{M_t}$  and  $D_{M_t}^*$  are the home and foreign demands for multinational goods, and  $B$  is the fixed cost incurred at home.

Equivalently, the total foreign country labor demand in the multinational sector  $\tilde{L}_{M_t}^*$  is:

$$\tilde{L}_{M_t}^* = \int_0^{z'_t} B^* dz + \int_0^{z'_t} a_{M_t}^*(z) y_t^*(z) dz \quad (2.11)$$

Integrating yields the demand for labor in the multinational sector in the foreign market:

$$\left(\frac{1-n}{n}\right)L_{M_t}^* = \frac{D_{M_t} + D_{M_t}^* \left(\frac{1-n}{n}\right)}{W_t^*} z'_t \quad (2.12)$$

and

$$L_{B_t}^* = B^* z'_t \quad (2.13)$$

where  $B^*$  is the fixed cost in the offshoring sector incurred abroad.

### 2.2.3 Households

The economy is populated by infinitely lived households, indexed by  $h \in [0, 1]$ . Households are identical in terms of preferences.

The households consume baskets of homogenous (domestic and foreign) goods and differentiated (multinational) goods indexed by  $z$ . County-specific goods  $j$  are tradable, while



offshoring goods  $j$  are produced at home or abroad and then traded in the multinational sector  $M$ . I index home and foreign goods by  $j$ .

Define  $P_{Ht} = \left( \int_0^1 P_{Ht}(j)^{1-\vartheta} dj \right)^{1/(1-\vartheta)}$  and  $P_{Ft} = \left( \int_0^1 P_{Ft}(j)^{1-\vartheta} dj \right)^{1/(1-\vartheta)}$  as the utility-based price indices associated to the baskets of domestic and foreign varieties of goods, respectively.  $P_{Ht}(j)$  and  $P_{Ft}(j)$  are the prices of the individual good  $j$ , and  $\vartheta > 1$  is the elasticity of substitution between varieties within each category.

Let  $P_{Mt} = \left( \int_0^1 P_{Mt}(z)^{1-\sigma} dz \right)^{1/(1-\sigma)}$  be the utility-based price index associated to the baskets of multinational varieties of goods, with  $P_{Mt}(z)$  the price of an individual good  $z$ , and  $\sigma > 1$  the elasticity of substitution between varieties within each category.

In each period, the households optimally allocate their expenditure on differentiated goods within each category. The demand functions for a specific product are:

$$C_{Ht}(j) = \left( \frac{P_{Ht}(j)}{P_{Ht}} \right)^{-\vartheta} C_{Ht}, \quad C_{Ft}(j) = \left( \frac{P_{Ft}(j)}{P_{Ft}} \right)^{-\vartheta} C_{Ft}, \quad \text{and} \quad C_{Mt}(z) = \left( \frac{P_{Mt}(z)}{P_{Mt}} \right)^{-\sigma} C_{Mt} \quad (2.14)$$

For all  $j \in [0, 1]$ , good  $j$  is produced by a continuum of firms (owned by domestic or foreign households), where  $C_{Ht} = \left( \int_0^1 C_{Ht}(j)^{\vartheta-1/\vartheta} dj \right)^{\vartheta/(\vartheta-1)}$  and  $C_{Ft} = \left( \int_0^1 C_{Ft}(j)^{\vartheta-1/\vartheta} dj \right)^{\vartheta/(\vartheta-1)}$  are composite indices of domestic and foreign (imported) goods, respectively.

Similarly, for all  $z \in [0, 1]$ , good  $z$  is produced by a continuum of firms (owned by domestic households), where  $C_{Mt} = \left( \int_0^1 C_{Mt}(z)^{\sigma-1/\sigma} dz \right)^{\sigma/(\sigma-1)}$  is the composite index of multinational goods  $z$  consumed at home.

The households consume a CES composite of all three home products ( $C_{Ht}$ ), foreign products ( $C_{Ft}$ ), and multinational products ( $C_{Mt}$ ):

$$C_t = \left[ \omega^{\frac{1}{\chi}} \left( \left( \alpha^{\frac{1}{\eta}} C_{M_t}^{\frac{\eta-1}{\eta}} + (1-\alpha)^{\frac{1}{\eta}} (C_{H_t})^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}} \right)^{\frac{\chi-1}{\chi}} + (1-\omega)^{\frac{1}{\chi}} (C_{F_t})^{\frac{\chi-1}{\chi}} \right]^{\frac{\chi}{\chi-1}} \quad (2.15)$$

where  $\alpha \in [0, 1]$ .  $\alpha$  is the share of home-produced multinational goods  $z$  in total consumption,  $(1-\alpha)$  represents the share of domestic-produced goods  $j$ ,  $\omega$  is the share of home produced goods and  $(1-\omega)$  stands for the share of foreign-produced goods  $j$ . I assume the law of one price as binding constraint, so the size of  $(1-\omega)$  does not indicate the openness of the economy, but the home or foreign bias in consumption. If  $\omega$  is large, households prefer domestic goods (from country-specific or multinational sectors), and if  $\omega$  is small, household consume lots of imported goods while domestic production is exported. Woodford (2007) uses  $\omega$  to distinguish a large open economy ( $\omega = 1$ ) from a small open economy ( $\omega = 0$ ). The elasticity  $\chi > 1$  is the elasticity of substitution between home-produced and foreign, imported goods, while  $\eta > 1$  is the elasticity of substitution between home and offshorable goods.

The consumption-based price index can be written as:

$$P_t = \left[ \omega \left( \left( \alpha P_{M_t}^{1-\eta} + (1-\alpha) (P_{H_t})^{1-\eta} \right)^{\frac{1}{1-\eta}} \right)^{1-\chi} + (1-\omega) (P_{F_t})^{1-\chi} \right]^{\frac{1}{1-\chi}} \quad (2.16)$$

Households face two allocation decisions. The first decision is to allocate the expenditure across country-specific (home or foreign) and multinational goods. The first order conditions derived from the maximization of equation (2.15) subject to the fixed expenditure constraint between home, foreign and multinational goods specify the following optimal isoelastic demand schedules of consumption:

$$C_{Ht} = (1 - \alpha)\omega \left(\frac{P_{Ht}}{P_t}\right)^{-\eta} C_t \quad (2.17)$$

$$C_{Ft} = (1 - \omega) \left(\frac{P_{Ft}}{P_t}\right)^{-\chi} C_t \quad (2.18)$$

$$C_{Mt} = \alpha\omega \left(\frac{P_{Mt}}{P_t}\right)^{-\eta} C_t \quad (2.19)$$

The second decision of the households is to seek an optimal intertemporal allocation across different states of the economy.

Across time, the representative domestic household maximizes the utility function given by:

$$U_t = U(C_t) - U(L_t) \quad (2.20)$$

$$U_t = \frac{1}{1 - \emptyset} C_t^{1 - \emptyset} - \frac{1}{1 + \mu} L_t^{1 + \mu} \quad (2.21)$$

where  $(C_t) = \frac{1}{1 - \emptyset} C_t^{1 - \emptyset}$ ,  $\emptyset > 0$  and  $U(L_t) = \frac{1}{1 + \mu} L_t^{1 + \mu}$ ,  $\mu > 0$ .

The expected utility in the home country takes the form of:

$$E_0 \sum_{t=0}^{\infty} \beta^t [U(C_t) - U(L_t)] \quad (2.22)$$

where  $t$  denotes the period. Future utility is valued less, so the discount factor  $\beta$  satisfies  $0 < \beta < 1$ . Additionally,  $u'_t > 0$  and  $u''_t \leq 0$ .

Define the value function at time  $t$  as:

$$\max_{\{C_t, L_t\}} V_t = \sum_{t=0}^{\infty} \beta^t U_t = \sum_{t=0}^{\infty} \beta^t \left[ \frac{1}{1 - \emptyset} C_t^{1 - \emptyset} - \frac{1}{1 + \mu} L_t^{1 + \mu} \right] \quad (2.23)$$

$$U_t = U(C_t, L_t), \quad 0 < \beta < 1, \quad u'_t > 0 \quad \text{and} \quad u''_t \leq 0$$

where  $\emptyset > 0$  and  $\mu > 0$  denote respectively the inverse of the intertemporal elasticity of substitution between future and current consumptions, and the wage elasticity of labor supply.

$E$  is the expectation operator.  $C_t$  is the consumption and  $L_t$  is the labor supply of a representative household at time  $t$ . The first term in the objective utility function represents the utility of goods consumption and the second term captures the disutility of work effort. Like in BHF (2011), uncertainty in the model is dealt with by assuming complete asset markets, as often in international macroeconomics. In each period, the representative household holds only bonds denominated in domestic currency as its assets. The household derives income from working and makes consumption decisions.

There is no capital in this model. The household is subject to the following sequence of budget constraints (Chari et al. 2002) at period  $t$ :

$$P_t C_t + \sum_{s^{t+1}} Q(s^{t+1}|s^t) b(s^{t+1}) = W_t L_t + b_t - Tax_t \quad (2.24)$$

where  $P_t$  is the composite price of home, foreign and multinational goods,  $b$  is the quantity of state-contingent assets (identical across countries) expressed as numeraire good, purchased at period  $t$  and expiring at time  $t + 1$ .  $s^t$  is the series of events occurring until period  $t$ . The asset  $b$  brings return of one numeraire good if state  $s^{t+1}$  occurs.  $Q$  denotes the price of one numeraire good in units of  $s^t$  state.  $W_t$  is the nominal wage, and  $Tax_t$  is a lump-sum tax paid by consumers.

The first order conditions (FOC) derived from the maximization of equation (2.23) subject to the budget constraint, equation (2.24), with respect to  $C_t$ ,  $L_t$  and  $b_{t+1}$  generate the following relationships:

$$\frac{P_t C_t^\emptyset}{P_t^* C_t^{*\emptyset}} = \xi \quad (2.25)$$

$$L_t^\mu = \frac{W_t}{P_t} (C_t)^{-\emptyset} \quad (2.26)$$

$$\beta E_t \left( \frac{C_{t+1}}{C_t} \right)^{-\theta} = \frac{1}{1 + i_{t+1}} E_t \left( \frac{P_{t+1}}{P_t} \right) \quad (2.27)$$

Equation (2.25) defines the risk-sharing condition between home and the foreign country, where  $\xi$  is a constant indicating the relative per-capita wealth of the home country in the initial assets allocation. Equation (2.26) states the relationship between the utility from consumption and disutility from labor. The wage is given, and workers do not have any market power.  $1/\mu$  is the Frisch elasticity of labor supply to the wage rate, given a constant marginal utility of consumption. Equation (2.27) is the Euler equation governing the dynamic evolution of consumption. Given the nominal interest rate  $i_t$ , if the current price level is low relative to the future price level, current consumption is encouraged over future consumption.

The real interest rate  $r_t$  is defined as

$$r_t = i_t - \pi_t \quad (2.28)$$

and inflation as:

$$\pi_t = \frac{P_{t+1}}{P_t} \quad (2.29)$$

Conditions corresponding to equations (2.14) - (2.19), and (2.23) - (2.26) apply symmetrically to the foreign country.

For simplification, in this open economy, there are only three price levels: of home country-specific goods  $P_{Ht}$ , of foreign country-specific goods  $P_{Ft}$ , and of multinational products  $P_{Mt}$ . This implies that  $P_{Ht} = P_{Ht}^*$ ,  $P_{Ft} = P_{Ft}^*$ , and  $P_{Mt} = P_{Mt}^*$ . I am also assuming that foreign households have similar preferences as those of domestic households.

### 2.2.4 Firms

There are two types of firms. The first type is the multinational firm producing differentiated intermediate good indexed by  $z \in [0,1]$ . Each of these goods  $z$  is perfectly competitive, so there is free entry and exit of firms. These goods are both tradable and offshorable. The second type of firm is the perfectly competitive firm producing domestic or foreign homogenous goods  $j$  which are tradable but not offshorable. Markets are complete.

#### Country-specific firms

The representative home country firm is a perfectly competitive firm that produces a single homogenous good  $j$ . I employ a simple linear production function. The firm uses labor as sole input, according to the following specification:

$$Y_{Ht} = \frac{L_{Ht}}{a_{Ht}} \quad (2.30)$$

where  $Y_{Ht}$  represents output,  $L_{Ht}$ , labor, and  $a_{Ht}$  is the country-specific unit labor cost.

The first order condition (FOC) derived from the profit maximization condition specifies wages and relative prices:

$$W_t = \frac{P_{Ht}}{P_{Mt} a_{Ht}} \quad (2.31)$$

The unit labor requirement is driven by a simple AR(1) process:

$$A_{Ht} = A \exp(a_{Ht}) \quad (2.32)$$

$$a_{Ht} = \bar{a}_H + \rho_a a_{Ht-1} + \epsilon_t^{a_{Ht}} \quad (2.33)$$

where  $\rho_a \in (0,1)$  is the serial correlation parameter for domestic productivity,  $\bar{a}_H$  is the steady state unit labor cost, and errors are normally distributed with  $\epsilon_t^{a_{Ht}} \sim iid N(0, \sigma_{a_{Ht}}^2)$ , where  $\sigma_{a_{Ht}}$  is the standard deviation. This exogenous shock to unit labor requirement captures shocks to productivity. An increase in  $a_{Ht}$  is an adverse productivity shock as it leads to a decrease in the marginal product of labor. Analogous conditions apply to the homogenous sector in the foreign country.

### Multinational firms

The multinational firm uses labor alone as an input, except that the labor employed comes from both home and the foreign country. The production function is described by the following equation:

$$Y_{Mt} = \frac{L_{Mt}}{a_{Mt}} + \left( \frac{1-n}{n} \right) \frac{L_{Mt}^*}{a_{Mt}^*} \quad (2.34)$$

where  $Y_{Mt}$  represents output,  $L_{Mt}$  and  $L_{Mt}^*$ , labor,  $n$  is a scaling factor between home and foreign country, and  $a_{Mt}$  is the home component of the unit labor requirement in the multinational sector, while  $a_{Mt}^*$  is the foreign component of the unit labor requirement in the multinational sector. There is no specific wage in the multinational sector; home and foreign wages apply.

### 2.2.5 Government

The government uses lump-sum taxes  $Tax_t$  to finance its expenditures. To simplify the analysis, I assume that the government budget is balanced at each period. Additionally, I

assume that the government consumes a fraction  $\tau_t$  of the output of good  $j$ , and  $\tau_t'$  of good  $z$ .

In aggregate terms:

$$G_t(j, z) = \tau_t Y_{Ht}(j) + \tau_t' Y_{Mt}(z) \quad (2.35)$$

The simple balanced-budget rule states:

$$Tax_t = P_t G_t = P_{Ht} G_{Ht} + P_{Mt} G_{Mt} \quad (2.36)$$

where  $P_t G_t$  denotes total government expenditure,  $P_{Ht} G_{Ht}$  is the fraction of government expenditure spent on the home country specific good  $j$  and  $P_{Mt} G_{Mt}$ , on the multinational good  $z$ .

Government expenditure is driven by the following simple AR(1) process:

$$G_t = G \exp(g_t) \quad (2.37)$$

$$g_t = \bar{g} + \rho_G g_{t-1} + \epsilon_t^g \quad (2.38)$$

where  $\rho_G$  is the serial correlation parameter for government demand,  $\bar{g}$  is the steady state government expenditure, and errors are normally distributed with  $\epsilon_t^g \sim iid N(0, \sigma_g^2)$ , where  $\sigma_g$  is the standard deviation. This exogenous shock to government consumption captures shocks to demand. Government allocates demand between country-specific and multinational goods in the same way as consumers<sup>20</sup>. This implies  $G_{Ht}^* = G_{Mt}^* = G_{Ft} = 0$  and the following government demands:

$$G_{Ht} = (1 - \alpha) \omega_G \left( \frac{P_t}{P_{Ht}} \right) G_t \quad (2.39)$$

$$G_{Mt} = \alpha \omega_G \left( \frac{P_t}{P_{Mt}} \right) G_t \quad (2.40)$$

$$G_{Ft}^* = \omega_G^* \left( \frac{P_t^*}{P_{Ft}^*} \right) G_t^* \quad (2.41)$$

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<sup>20</sup> For simplicity, government of a specific country consumes only good specific to that country. Additionally, only home country government consumes both home country and multinational good. Foreign country government consumes only foreign country-specific good.



Following BHF (2011), the government has higher preferences for home goods as compared to foreign goods, so  $\omega_G > \omega$ .

### 2.2.6 Market Clearing

Following BHF (2011), I close the model by defining equilibrium market clearing conditions for output and labor. The market clearing condition in the home country-specific goods market is given by:

$$D_{Ht} + \left(\frac{1-n}{n}\right) D_{Ht}^* = Y_{Ht} \quad (2.42)$$

where  $D_{Ht}$  and  $D_{Ht}^*$  are domestic and foreign demands for home country specific goods. At home, the sources of demand are private consumption and government spending  $D_{Ht} = C_{Ht} + G_{Ht}$ , and abroad, private consumption only  $D_{Ht}^* = C_{Ht}^*$ . Analogous conditions apply to the foreign country.

Similarly, market clearing in the offshoring goods market requires:

$$D_{Mt} + \left(\frac{1-n}{n}\right) D_{Mt}^* = Y_{Mt} \quad (2.43)$$

where  $D_{Mt}$  and  $D_{Mt}^*$  are domestic and foreign demands for the multinational good. At home, the demand in the multinational sector is divided between private consumption and government spending  $D_{Mt} = C_{Mt} + G_{Mt}$ , while abroad the demand equals private consumption  $D_{Mt}^* = C_{Mt}^*$ .

The market clearing condition in the domestic labor market is:

$$L_t = L_{Ht} + \tilde{L}_{Mt} = L_{Ht} + L_{Mt} + L_{Bt} \quad (2.44)$$

The total labor supply  $L_t$  at home equals the sum of labor demand in country specific sector,  $L_{Ht}$ , and in the multinational sector,  $\tilde{L}_{Mt}$ . The corresponding condition applies to the foreign labor market.

The general equilibrium model consists of 30 endogenous variables  $\{L_t, L_t^*, L_{Ht}, L_{Ht}^*, L_{Mt}, L_{Mt}^*, W_t, W_t^*, C_{Ht}, C_{Ht}^*, C_{Ft}, C_{Ft}^*, C_{Mt}, C_{Mt}^*, P_{Ht}, P_{Ht}^*, P_{Ft}, P_{Ft}^*, P_{Mt}, P_{Mt}^*, z_t', i_t, P_t, P_t^*, C_t, C_t^*, r_t, \pi_t, Y_{Ht}, Y_{Ht}^*, Y_{Mt}, Y_{Mt}^*, L_{Bt}, L_{Bt}^*\}$  and 4 exogenous variables  $\{G_t, G_t^*, a_{Ht}, a_{Ft}^*\}$ <sup>21</sup>.

## 2.2.7 Exogenous Processes

The model includes structural shocks to demand and supply. Demand shocks enter through the terms  $G_t$  and  $G_t^*$ , while productivity supply shocks enter through the unit labor requirements  $a_{Ht}$  and  $a_{Ft}^*$ .

The stochastic processes for the home and foreign productivity shifter in a country-specific market, and domestic and foreign government consumptions can be modeled by:

$$a_{Ht} = \bar{a}_H + \rho_{a_H} a_{H,t-1} + \epsilon_t^{a_H} \quad (2.45)$$

$$a_{Ft}^* = \bar{a}_F^* + \rho_{a_F^*} a_{F,t-1}^* + \epsilon_t^{a_F^*} \quad (2.46)$$

$$G_t = \bar{G} + \rho_G G_{t-1} + \epsilon_t^G \quad (2.47)$$

$$G_t^* = \bar{G}^* + \rho_{G^*} G_{t-1}^* + \epsilon_t^{G^*} \quad (2.48)$$

Shocks are in log-linear terms and follow an AR(1) process. Shocks are uncorrelated. I assume orthogonal shocks across the countries.

As in BHF (2011), Burstein et al. (2008) and Berman et al. (1998), I assume that productivity shocks in one country's multinational sector are perfectly transmitted to the other country's multinational sector because technology spreads quickly. It implies that the relative cost schedule  $A(z)$  does not respond to productivity shocks and the main mechanism of the model is through the shifts in relative wage.

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<sup>21</sup> For convenience, Table A1 on page 112 in the Appendix A lists and describes all variables of the model.

### 2.2.8 Model Simulation

To simulate the model, I first find the necessary conditions characterizing the equilibrium<sup>22</sup>. The next step is to solve for a deterministic steady state of the non-linear model. This step is done by combining both analytical and numerical methods. For the latter, I use *Mathematica 8*. I calibrate the parameter values that determine the numerical values of variables at steady state.

The model is highly non-linear and finding a purely analytical solution is very difficult. Solving the model using computational methods requires linearization of the intra and intratemporal optimality conditions around the steady state. I use methods based on first and second-order Taylor expansion.

The final step is to perform the stochastic simulation, compute the policy functions, and analyze the model by plotting impulse responses, and computing theoretical moments.

The stochastic simulation is run in *Dynare*, a program which uses a collection of MATLAB routines to log-linearize (through first order Taylor approximation) and simulate the model. Dynare uses perturbation methods<sup>23</sup> to solve non-linear models with forward looking variables. The fundamental idea of perturbation methods is to use the deterministic steady state as a starting point for computing approximate solutions to the nearby problems relying on Taylor series expansions (Judd 1998, Schmitt-Grohé and Uribe 2004).

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<sup>22</sup> The necessary conditions and their mathematical derivation can be found in parts 2 and 3 of Appendix A.

<sup>23</sup> For details see [www.dynare.org](http://www.dynare.org) and Collard and Juillard (2001a, 2001b).

## 2.3 MODEL PARAMETERIZATION

The model is solved numerically with the parameter values summarized in Table 2.1<sup>24</sup>. Following the business cycle literature, the annual discount rate  $\beta$  is set to 0.96, the labor supply elasticity  $\mu = 1$ , and the inverse of the elasticity of intertemporal substitution  $\phi$  is set to 2.

The benchmark model follows closely the calibration of BHF (2011). The home bias parameter for the home country  $\omega$  is set to 0.88, while for the foreign country,  $\omega^* = 0.71$ . I assume that the government has complete bias towards domestic goods, so the parameters  $\omega_G$  and  $\omega_G^*$  are equal to 1. I address the stylized fact that the private consumers bias is smaller than the government bias in both countries by ensuring  $\omega < \omega_G$  and  $\omega^* < \omega_G^*$ . The parameter  $n$  is calibrated to reflect the approximate 3/4 share of the home country in the combined population of the two countries. The offshoring share parameter  $\alpha$  is calibrated at 0.24.

Calibrating the relative unit labor requirement distribution  $A(z)$  involves choosing  $\theta$ ,  $T$ , and  $T^*$  so that the steady state offshoring margin  $\bar{z}' = 0.06$  as in BHF (2011). The curvature parameter  $\theta$  is calibrated at 8.28 based on the estimation by Eaton and Kortum (2002). The technology parameter for the domestic offshoring sector,  $T$ , is calibrated to satisfy the equation  $a_{Mt}(\bar{z}') = \frac{T}{(\bar{z}')^{\frac{1}{\theta}}} = 1$ , so  $T = (\bar{z}')^{\frac{1}{\theta}} = 0.712$ . The foreign technology parameter  $T^*$  is calibrated to equalize the relative labor unit requirement from condition (2.1) to the relative wage condition (2.2). As I assume the relative wage  $\frac{\bar{w}^*}{\bar{w}} = 1/8$ ,  $T^*$  is equal to 7.94. The relative wealth parameter  $\xi$  is chosen to allow the relative wage ratio of 1/8. The fixed cost labor parameters  $B$  and  $B^*$  are multiplicative coefficients tied to the offshoring margin  $\bar{z}'$ .

The serial correlation parameters  $\rho_{a_H}$ ,  $\rho_{a_F^*}$ ,  $\rho_G$  and  $\rho_{G^*}$  describe how fast the shocks

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<sup>24</sup> For the numerical solution of the model, I write a *Dynare* program. It can be found in part 6 of Appendix A.

disappear, and are all set to 0.9 as a common measure<sup>25</sup>. The standard deviations of all shocks  $\sigma_{\epsilon}^{aH}$ ,  $\sigma_{\epsilon}^{aF}$ ,  $\sigma_{\epsilon}^G$ , and  $\sigma_{\epsilon}^{G*}$  are equal 0.01<sup>26</sup>, therefore shocks have a 1% standard deviation, which is a common practice in macroeconomic literature. Table 2.1 summarizes the parameters of the model.

Table 2.1 Calibration of the parameters

Parameters		BHF (2011)	Benchmark $\bar{z}' = 0.06$
$\omega$	Home bias in home country	0.88	0.88
$\omega^*$	Home bias abroad	0.71	0.71
$\alpha$	Offshoring expenditure share	0.24	0.24
$\beta$	Discount factor	-	0.96
$\mu$	Labor supply elasticity	1	1
$\phi$	Risk aversion	2	2
$n$	Relative size of home country	0.74	0.74
$\xi$	Relative wealth of home country	4.3	1.97
$\theta$	Curvature of distribution	8.28	8.28
$T$	Home country technology	0.712	0.712
$T^*$	Foreign country technology	7.94	7.94
$\omega_G$	Home country government preferences	1	1
$\omega_G^*$	Foreign country government preferences	1	1
$B$	Fixed cost incurred at home	-	0.27493
$B^*$	Fixed cost incurred abroad	-	10.04177
$\frac{\bar{W}^*}{\bar{W}}$	Wage ratio	$\frac{1}{8}$	$\frac{1}{8}$
$\bar{z}'$	Offshoring margin	0.06	0.06
$\rho_{aH}$	Serial correlation parameter for domestic productivity	-	0.9
$\rho_{aF^*}$	Serial correlation parameter for foreign productivity	-	0.9
$\rho_G$	Serial correlation parameter for domestic government demand	-	0.9
$\rho_{G^*}$	Serial correlation parameter for foreign government demand	-	0.9
$\sigma_{\epsilon}^{aH}$	Standard deviation of home productivity	-	0.01
$\sigma_{\epsilon}^{aF}$	Standard deviation of foreign productivity	-	0.01
$\sigma_{\epsilon}^G$	Standard deviation of domestic government demand	-	0.01
$\sigma_{\epsilon}^{G^*}$	Standard deviation of foreign government demand	-	0.01

Note: See Table A1 on page 112 of Appendix A for variables description.

<sup>25</sup> In the standard real business cycle models productivity shocks are large and persistent due to innovation and learning effects, and are commonly assumed equal to 0.9 (see for instance Tesar 1991). Government expenditure might be less persistent due to limited resources, political variability, or preference for consumption rather than investment. I follow Gali et al. (2007) and set the persistence parameter of government spending to 0.9 which is consistent with the US evidence and guarantees an average government size, while an alternative calibration of lower persistence would imply a large government. See part 4.1 in Appendix A for further discussion.

<sup>26</sup> I normalize all shocks in the model to have the same persistence parameters value of 0.9 and standard deviations of 0.1. This choice helps to avoid overcomplicating the analysis and allows easily comparing the responses to productivity shocks with government spending shocks. It is straightforward to see the effects of offshoring and compare with different model specifications. See part 4.1 in Appendix A for further discussion.

## 2.4 STEADY STATE EQUILIBRIUM

The model solving strategy does not fundamentally differ from the standard procedure found in earlier DSGE literature (Uhlig 1995, 1997). However the advancement of computational methods has made it possible to solve models larger in scale and to do analysis more efficiently than before.

After finding the first order and other necessary conditions and calibrating the parameters, I calculate the steady state. This process is done both analytically and computationally, using the *Mathematica* program. Afterwards, I use the *Dynare* program in MATLAB to log-linearize the model around the steady state, solve for the recursive law of motion, and calculate the impulse response functions and HP-filtered moments.

Below, I discuss some important concepts and address preliminary issues<sup>27</sup>. Then I proceed to derive the steady state in the following section.

### Stationarizing a non-linear model

Models analyzed in *Dynare* must be *stationary*<sup>28</sup>: a local approximation of the system around the steady state must behave such that the model variables fluctuate in the neighborhood of the steady state, and return to steady state after shock. It is therefore necessary to “stationarize” a non-stationary model before linearizing and computing the local approximation of the solution. However, as my model is not a growth model, I do not have stationarity problems.

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<sup>27</sup> I discuss those concepts more extensively in part 4.2 of Appendix A.

<sup>28</sup> The stationarity of a time series is determined by its statistical properties. In particular, mean, variance, and autocorrelation should be constant over time. Most statistical methods are based on the assumption that the time series can be approximately stationary, or “stationarized” through the use of mathematical transformations.

## Log-linearization of the model

To understand the behavior of the system in presence of perturbations (shocks), it is necessary to have an expression of the transition functions. These functions determine the value of endogenous variables at the next period in function of their values at the current period and the current value of exogenous variables. In general, it is not possible to obtain the exact expression of the transition functions of a non-linear system. However, I am interested in the response of the system to shocks around a steady state (equilibrium), so asymptotically valid approximations of the transition functions around steady-state suffice. *Dynare* implements algorithms that approximate the transition functions with first, second or third order Taylor series expansions. These polynomials can be computed from a Taylor expansion of the original expression of the model. This approximation allows presenting the model as a set of polynomials and further allows solving it analytically.

My model is log-linearized around the steady state. Log-linearization is a popular method to approximate non-linear dynamic stochastic models. Certain models lend themselves to easy manual log-linearization, and benefit from being inputted in log-linear form in *Dynare*, as they avoid having to compute the steady-state or caring about initial conditions. However, if there are sums in the model equations, the log-linearized model becomes overly complex to compute and requires knowing the steady-state of the non-linear system, which voids the benefits of manual log-linearization. Because my model contains sums, it is more feasible to log-linearize using *Dynare*<sup>29</sup>. There is no particular drawback in automating the process, but manual log-linearization is far more laborious. For computational purposes, it is not necessary to log-linearize the equations when using *Dynare*. The benefit of manipulating the log of variables (where the steady-state value allows it) solely lies in the improved interpretability, as the value

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<sup>29</sup> The standard procedure in *Dynare* is to log-linearize variables with steady state different than zero and linearize those with the steady state equal to zero. All my variables have endogenous steady states greater than zero.

can be directly interpreted in percentage of change from the steady-state. Of course, the change in variable implies that their steady-state values are the logarithm of the steady-state values of the variables in the non-linear system.

### 2.4.1 Finding the Steady State

At the steady state, I assume that all variables are constant<sup>30</sup>. However, the non-linear system<sup>31</sup> of equations is too complex to be directly solved analytically, i.e. to obtain the expression of steady-state variables in function of parameters. It is also too highly dimensional and non-linear for numerical search based on specific parameter values to be effective. Numerical methods get trapped in local minima or into steady states with many null variables, which then appear at the denominator of Jacobian elements and prevent obtaining a solution. The variables that should not be equal to zero at the steady-state are:  $C_t$ ,  $C_{Ht}$ ,  $C_{Ht}^*$ ,  $C_{Ft}$ ,  $C_{Ft}^*$ ,  $C_{Mt}$ ,  $C_{Mt}^*$ ,  $P_{Ht}$ ,  $P_{Ft}$ ,  $P_{Mt}$ , and  $P_t$ .

As purely analytical or numerical solutions are not feasible, the idea is to solve the system analytically as a function of parameters and of a minimal number of a steady-state variables, and then use numerical methods to solve the simplified system of the equations that remain (defining the parameterized variables) for specific parameter values. Steady-state values are therefore obtained using combined analytical calculations and numerical optimization with *Mathematica 8*. The values of parameters for the benchmark model are based on BHF (2011).

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<sup>30</sup> Steady state variables are denoted by a bar accent.

<sup>31</sup> At the stage of finding the steady state values, the system is non-linear. The log-linearization is performed by Dynare when running the simulation, using the steady state values (true and endogenous), that are computed prior to the simulation. See section 2.2.8 for the solution steps.



I derive the steady state from the first order and other conditions. Following BHF (2011), I also impose that  $\bar{W} = 8\bar{W}^*$ . By definition, at steady-state, all lagged and forward-looking variables are equal to their non-lagged value. Taking the above considerations into account, I derive the steady-state values of all variables in function of the values of the parameters and of 3 basis steady-state variables ( $\bar{W}$ ,  $\bar{C}$  and  $\bar{P}_H$ ). The whole system can then be reduced to terms that are sole function of these 3 variables and of the parameters. It results in a drastic reduction of the dimensionality of the corresponding numerical problem, as I am left to solve a non-linear system of 3 independent equations with 3 degrees of freedom.

In the following, I detail the steps to derive the analytical expression of the steady-state values<sup>32</sup> of all non-parameterized variables in function of the values of the parameters and of the 3 basis steady-state variables ( $\bar{W}$ ,  $\bar{W}^*$ , and  $\bar{P}_H$ ).

The wage ratio at steady-state:

$$\bar{W} = 8\bar{W}^* \quad (2.49)$$

From (2.3) and (2.49), I obtain the expression of  $\bar{z}'$  in function of the basis variables:

$$\bar{z}' = \frac{T^\theta \bar{W}^\theta}{T^{*\theta} \bar{W}^{*\theta} + T^\theta \bar{W}^\theta} \quad (2.50)$$

From (2.5) and (2.50), I have:

$$\bar{P}_M = T^* \bar{W}^* \frac{\theta}{\theta-1} \left[ 1 - (1 - \bar{z}')^{\frac{\theta-1}{\theta}} \right] + T \bar{W} \frac{\theta}{\theta-1} \left[ 1 - (\bar{z}')^{\frac{\theta-1}{\theta}} \right] \quad (2.51)$$

With this expression of  $\bar{P}_M$ , I obtain  $\bar{P}_F$  using the foreign equivalent of (2.31):

$$\bar{P}_F = \bar{W}^* \bar{P}_M \bar{a}_F^* \quad (2.52)$$

I then can use (2.16) and the corresponding equivalent for the foreign country to derive  $\bar{P}$  and  $\bar{P}^*$  :

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<sup>32</sup> I list all steady state equations in part 5 of Appendix A.

$$\bar{P} = \bar{P}_F^{(1-\omega)} \left( \bar{P}_H^{(1-\alpha)} \bar{P}_M^\alpha \right)^\omega \quad (2.53)$$

$$\bar{P}^* = \bar{P}_F^{(1-\omega^*)} \left( \bar{P}_H^{(1-\alpha)} \bar{P}_M^\alpha \right)^{\omega^*} \quad (2.54)$$

Using (2.53) and (2.54) in (2.25), the total consumption abroad is:

$$\bar{C}^* = \left( \frac{\bar{P}}{\xi \bar{P}^*} \right)^{\frac{1}{\theta}} \bar{C} \quad (2.55)$$

All consumptions follow, using equations (2.17) to (2.19) and their equivalents for the foreign country.

$$\bar{C}_M = \alpha \omega \bar{P}_M^{\alpha \omega - 1} \bar{C} \quad (2.56)$$

$$\bar{C}_M^* = \alpha \omega^* \bar{P}_M^{\alpha \omega^* - 1} \bar{C}^* \quad (2.57)$$

$$\bar{C}_H = (1 - \alpha) \omega \bar{P}_M^{\alpha \omega} \bar{C} \quad (2.58)$$

$$\bar{C}_H^* = (1 - \alpha) \omega^* \bar{P}_M^{\alpha \omega^*} \bar{C}^* \quad (2.59)$$

$$\bar{C}_F = (1 - \omega) \bar{P}_M^{\alpha \omega} \bar{C} \quad (2.60)$$

$$\bar{C}_F^* = (1 - \omega^*) \bar{P}_M^{\alpha \omega^*} \bar{C}^* \quad (2.61)$$

Using (2.53) in (2.26),  $\bar{L}$  can be written in function of solved variables:

$$\bar{L} = \frac{\bar{W}}{\bar{P} \bar{C}^2} \quad (2.62)$$

The same goes for  $\bar{L}^*$  by using the foreign equivalent of (2.26), (2.54) and (2.55):

$$\bar{L}^* = \frac{\bar{W}^*}{\bar{P} \bar{C}^{*2}} \quad (2.63)$$

We have the following expressions of  $\bar{L}_M$  (2.9) and  $\bar{L}_M^*$  (2.12):

$$\bar{L}_M = \frac{(1 - \bar{z}')}{\bar{W}} \left( \frac{\alpha \omega_G \bar{G} \bar{P}}{\bar{P}_M} + \bar{C}_M + \bar{C}_M^* \left( \frac{1 - n}{n} \right) \right) \quad (2.64)$$

$$\bar{L}_M^* = \frac{\bar{z}'}{\bar{W}^*} \left( \frac{n}{1 - n} \right) \left( \frac{\alpha \omega_G \bar{G} \bar{P}}{\bar{P}_M} + \bar{C}_M + \bar{C}_M^* \left( \frac{1 - n}{n} \right) \right) \quad (2.65)$$

From Equation (2.30), (2.42), their foreign equivalents, and (2.39) and (2.41):

$$\frac{\bar{L}_H}{\bar{a}_H} = \left( \bar{C}_H + (1 - \alpha) \omega_G \left( \frac{\bar{P}}{\bar{P}_H} \right) \bar{G} + \left( \frac{1 - n}{n} \right) \bar{C}_H^* \right) \quad (2.66)$$

$$\frac{\bar{L}_F^*}{\bar{a}_F^*} = \left( \bar{C}_F + \left( \frac{1 - n}{n} \right) \left( \bar{C}_F^* + \omega_G^* \left( \frac{\bar{P}^*}{\bar{P}_F} \right) \bar{G}^* \right) \right) \quad (2.67)$$

With these results, I can use (2.44) and its foreign counterpart to obtain:

$$\bar{L} = \bar{L}_M + \bar{L}_H + \bar{L}_B \quad (2.68)$$

$$\bar{L}^* = \bar{L}_M^* + \bar{L}_F^* + \bar{L}_B^* \quad (2.69)$$

I also use the previously found expressions of steady-state consumptions and prices in home and foreign version of (2.42), and (2.43), substituted in (2.39)-(2.41) to get the outputs:

$$\bar{Y}_H = \bar{C}_H + \frac{1 - n}{n} \bar{C}_H^* + (1 - \alpha) \omega_G \bar{G} \frac{\bar{P}}{\bar{P}_H} \quad (2.70)$$

$$\bar{Y}_{Ft}^* = \bar{C}_{Ft} + \frac{1-n}{n} \left( \bar{C}_F^* + \omega_G^* \bar{G}^* \frac{\bar{P}^*}{\bar{P}_F^*} \right) \quad (2.71)$$

$$Y_M = C_M + \frac{1-n}{n} C_M^* + \alpha \omega_G \bar{G} \frac{\bar{P}}{\bar{P}_M} \quad (2.72)$$

The Euler equation (2.27) determines the interest rate at steady-state:

$$\bar{r} = \frac{1}{\beta} - 1 \quad (2.73)$$

And from (2.28) and (2.29):

$$\bar{r} = \bar{r} - 1 \quad (2.74)$$

$$\bar{\pi} = 1 \quad (2.75)$$

At this point, I have an expression of the steady-state in function of all parameters and of  $\bar{W}$ ,  $\bar{W}^*$ , and  $\bar{P}_H$ . In addition, I have yet to satisfy equations (2.31), (2.15) and its foreign equivalent, and (2.34). Hence, I am left to solve a non-linear system of 4 independent equations, but with only 3 degrees of freedom, due to the addition of the constraint on the wage ratio, which removes one degree of freedom. This is an issue as numerical methods generally require that the system is not overdetermined. The parameter  $\zeta$ , solely present in equation (2.25), is freed and becomes a variable for the purpose of the numerical search. The resulting system of 4 equations and 4 variables is manipulated in *Mathematica 8* in a guided search for a numerical solution based on the parameter values found in BHF (2011). The system is too highly non-linear to find a solution using automated routines alone, so visually plotting some of the functions in implicit form helps to manually provide the algorithm with better initial search values, and to understand the behavior of some of the variables. For instance, Figure 2.3 show a graph of  $z_t'$  in function of  $W_t$  and  $W_t^*$ . The red point locates the steady state of the benchmark

model. This figure reveals the high sensitivity of  $z_t'$  to  $W_t$  and  $W_t^*$  around steady state, and how a small change in one variable can rapidly vary others.

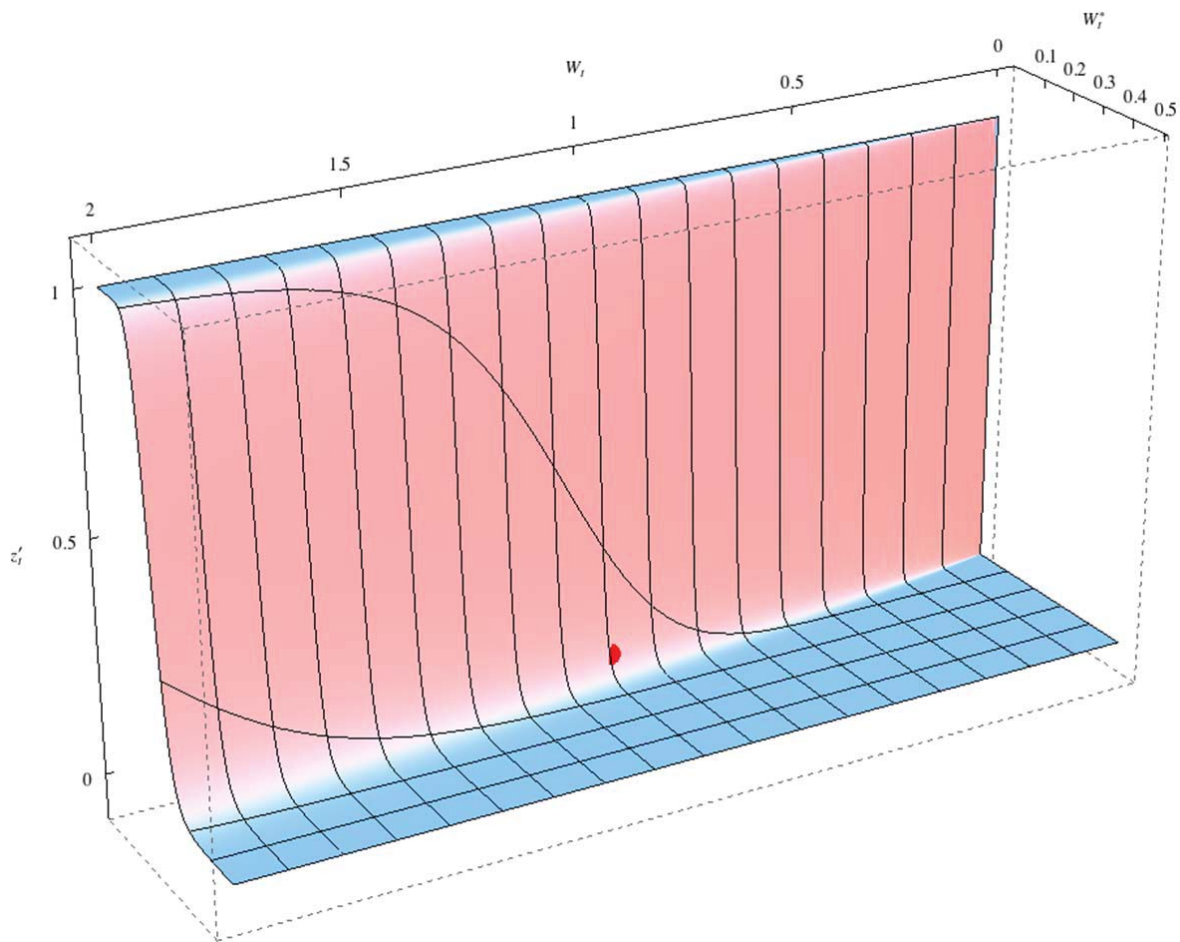


Figure 2.3 Graph of  $z_t'$  in function of  $W_t$  and  $W_t^*$ .

## 2.5 STOCHASTIC SIMULATION RESULTS

The study of the *impulse response functions* (IRFs) of an economic model helps to determine its dynamic properties. The IRFs show how a model responds to an impulse or shock applied to the error term of one of its exogenous variables. In stochastic simulations, shocks are temporary; they are typically only applied at the first period of the simulation. The economy begins at a steady state, with all shocks to stochastic processes equal to zero. After applying a small perturbation to one of the shocked variables, the economy follows a time path defined by the law of motion and returns to equilibrium<sup>33</sup>. The trajectories of impulse response functions describe these adjustments. They illustrate the expected future path of the endogenous variables as a dynamic response to an exogenous shock in the first period, equal to one standard deviation. Apart from IRFs, outputs of the simulation include the *decision and transition functions* of the model, and descriptive statistics such as the *moments of simulated variables*, and the *correlations* and *autocorrelation coefficients*.

In general, the simulated models are non-linear and need to be approximated. I use automated Taylor approximation in *Dynare*<sup>34</sup>. The first order Taylor approximation of the system around the steady state is used to compute IRFs. The first order approximation is a well-established technique to solve DSGE models (Campbell 1994, Uhlig 1995 and 1997, Blanchard and Kahn 1980, Sims 2002) as it is computationally more convenient. In addition Kim and Kim (2003) and Schmitt-Grohe and Uribe (2004) present second order approximation solving methods. Comparisons between first and second order approximations can be found in Collard and Julliard (2001a) and in Schmitt-Grohe and Uribe (2004).

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<sup>33</sup> The law of motion is equivalent to the linear policy functions (see Table A2 in Appendix A).

<sup>34</sup> For more details see part 4.2 of Appendix A.

First order approximation techniques are useful and more convenient when studying impulse response functions. However, in some cases first order approximation leads to spurious results. For example, in welfare analysis, non-linearity matters when comparing different policies and first order is not sufficient. See Woodford (2002) and Kim and Kim (2003) for a discussion.

Second order approximation allows departing from the certainty equivalence principle satisfied by first order approximations which neglect higher moments, so the variance of future shocks is taken into account. It improves the accuracy of the solution, especially for the second order terms, related to the variances of endogenous variables.

To empirically verify these considerations, I perform the simulation experiments with the first and second order recursive laws of motion and find that the difference is very small for impulse response functions. Therefore I only report impulse response functions for first order approximations. However, the calculated second moments tend to differ between first order and second order simulations for most parameters tested. To illustrate that, I report both results in selected tables.

### 2.5.1 Impulse Response Functions to Productivity Shocks

The model includes four structural shocks to supply and demand. Demand shocks are positive and enter through the terms  $G_t$  and  $G_t^*$ . Productivity supply shocks are negative and enter through the unit labor costs  $a_{Ht}$  and  $a_{Ft}^*$ . Table 2.2 on page 81 summarizes the qualitative effects of domestic and foreign productivity and demand shocks on selected variables.

Productivity shocks are transmitted through  $a_{Ht}$  and  $a_{Ft}^*$  which are not total factor productivities, but instead are unit labor costs. These are the inverse of the usual macroeconomics notation, but it is a standard definition in trade economics. It implies that a

rise in  $a_{Ht}$  or  $a_{Ft}^*$  is not a rise in productivity, but instead a rise in unit cost (fall in productivity). In particular, when the unit labor cost of the foreign homogenous good  $a_{Ft}^*$  increases, the foreign marginal product of labor denoted as the inverse of unit labor cost  $MPL_t^* = \frac{\Delta Y^*}{\Delta L^*} = \frac{1}{a_{Ft}^*}$  falls instead of rising. Therefore, a positive shock to  $a_{Ft}^*$  is an *adverse productivity shock*. The transmission mechanism is equivalent to a fall in offshoring costs: an adverse productivity shock results in foreign workforce being relatively cheaper as  $W_t^*$  falls, the relative home-to-foreign wage  $\frac{W_t}{W_t^*}$  increases and raises the offshoring margin  $z_t'$ , which results in the home country offshoring more to the foreign country. This is illustrated on Figure 2.4. Relative wages are the main driving force in the model.

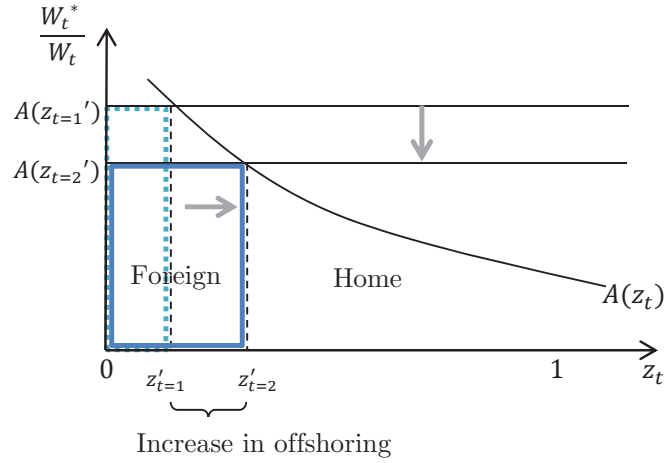


Figure 2.4 The increase in offshoring margin due to a negative foreign productivity shock.

Figure 2.5 illustrates the effects of a negative foreign productivity shock on key macroeconomic variables. The impulse response functions are significant and are in logs, therefore the vertical axes represent percentage changes. After the initial shock, the response of



variables is above or below their steady-state levels, and then adjusts gradually back to the steady state over time. The economy takes on average 40 periods to return to the stationary state.

My objective is to carefully study the effects of offshoring. I focus on the multinational sector. I present selected IRFs as a detailed discussion of all aspects of the model would be lengthy and beyond the scope of this thesis.

I find that a productivity shock has an effect on relative wages through the decrease in foreign wage premium that follows, and encourages offshoring. This result differs from BHF (2011) who reason that productivity shocks only have a minor impact on the relative wages<sup>35</sup>. In contrast, I find that productivity shocks alter offshoring decisions, a result consistent with Zlate (2010).

Without considering offshoring yet, Figure 2.5 show that the model exhibits a standard response to productivity shocks in the foreign homogenous goods sector. A decrease in productivity in the foreign country decreases the foreign marginal product of labor. Following such shock, foreign households decrease consumption, and foreign GDP drops. Moreover, this sector and country specific shock to  $a_{Ft}^*$  results in a decrease of foreign productivity  $MPL_{Ft}^*$  relative to domestic homogenous sector productivity  $MPL_{Ht}$ . Consequently, wages decrease abroad, and relative wages increase at home. This change in relative wage encourages offshoring, as foreign labor becomes relatively cheaper.

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<sup>35</sup> However, the reasoning of BHF (2011) on page 170 of their paper is based on literature findings for a two sectors economy.

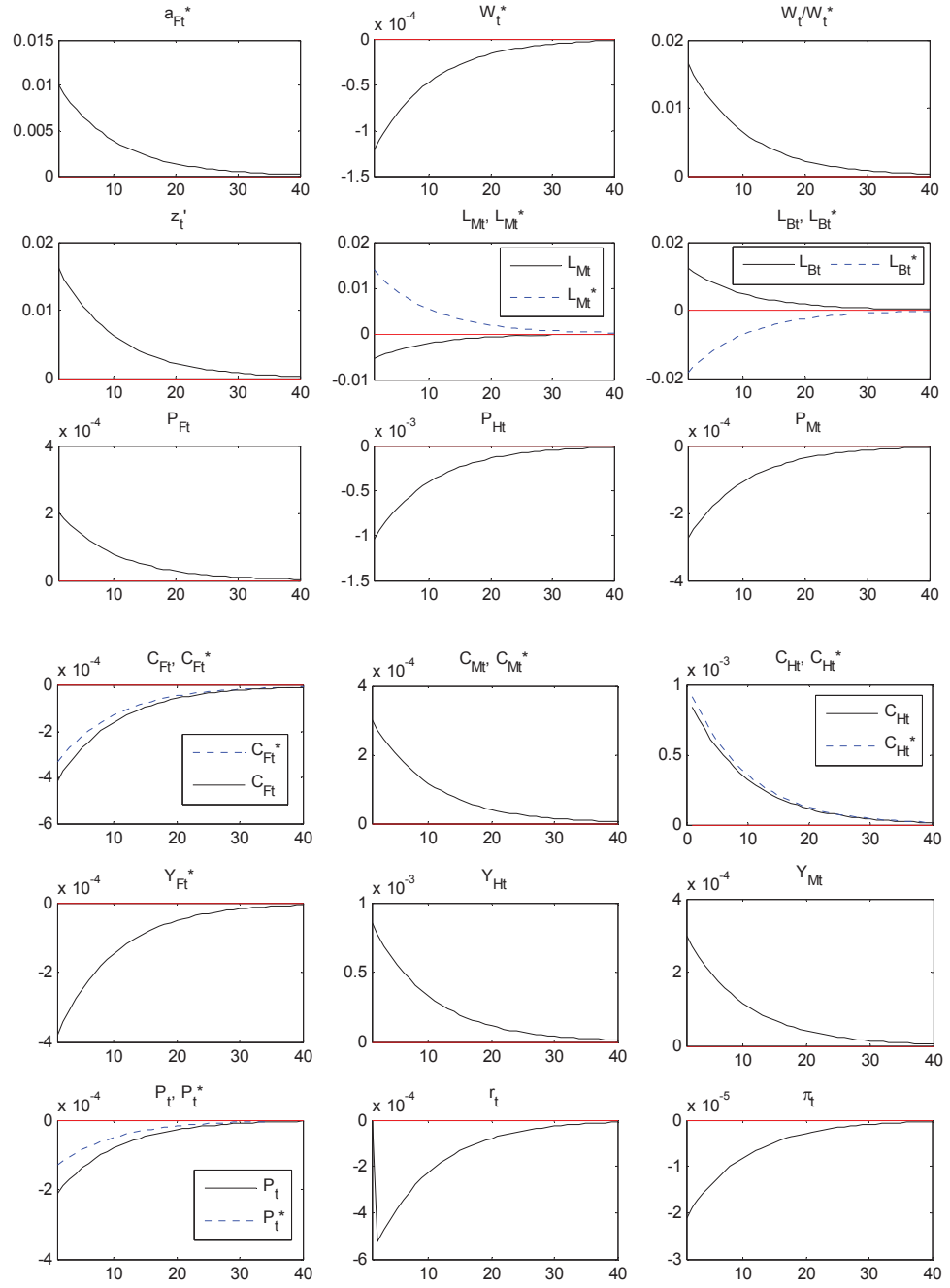


Figure 2.5 Impulse response functions to the foreign unit labor cost  $a_{Ft}^*$  shock,  $\bar{z}' = 0.06$ .

Note: See Table A1 on page 112 of Appendix A for variables description.

A rise of the offshoring margin, equivalent to a shift of  $z'_t$  towards the right in Figure 2.4, transfers some of the domestic production of the multinational good abroad. As a result, the foreign country's share of production of goods  $z$  increases, while the home country's share falls. This shift of  $z'_t$  influences the labor market. It creates new jobs, and the labor demand increases both in the assembly offshoring labor abroad  $L_{Mt}^*$  and in the managerial offshoring sector at home  $L_{Bt}$ . At the same time, due to the high wage premium at home, the demand for offshoring sector jobs  $L_{Mt}$  falls. Also, low wages abroad result in a low demand for managerial jobs  $L_{Bt}^*$ . Overall, labor at home increases due to the stimulus from the growth of high wage jobs in the offshoring sector, while abroad the stimulus originates in the assembly jobs.

The increase in offshoring to the less productive foreign country leads to a decrease of the multinational good price  $P_{Mt}$ . The extended supply capacity provided by offshoring acts as a downward force on the prices  $P_{Ht}$  of goods. The decreasing relative prices in the home country dominate the overall price index and exert a deflationary pressure on the home economy, decreasing inflation  $\pi_t$ . Lower prices at home stimulate consumption of the homogenous good, increasing  $C_H$  and  $C_H^*$ , and in turn raising the domestic output  $Y_{Ht}$ . Lower domestic and multinational prices keep low interest rates, and this in turn leads to low inflation. This effect is common in the globalized world.

Lower multinational prices stimulate consumption and increase output in the multinational sector  $Y_{Mt}$ .

In the foreign country, a negative productivity shock to  $a_{Ft}^*$  decreases the marginal product of labor. The labor force is less productive, which leads to an increase in prices  $P_{Ft}$ , a decrease in consumption and  $C_{Ft}$  and  $C_{Ft}^*$  and a decrease in output  $Y_{Ft}^*$ .

Offshoring in general has a positive effect on the home economy, raising employment in the domestic managerial offshoring sector, contributing to the lowering of the price index and mitigating inflation. It also fosters employment in the multinational sector abroad, but at the

cost of increasing the wage gap. This is consistent with the results of Borjas and Ramey (1995) and Roberts (2010), who point to the role of foreign competition and jobs offshoring in the rise of income inequality.

A negative domestic productivity shock transmitted through a rise in  $a_{Ht}$  propagates in a way similar to a negative foreign productivity shock. The results are mirrored. Following the negative domestic productivity shock, the domestic marginal product of labor decreases. This means that domestic labor becomes cheaper and the offshoring production abroad becomes equivalently more costly. It leads to an increase in in-shoring or to an equivalent decrease of the offshoring margin  $z'_t$ . The offshoring sector increases at home and decreases abroad. This effect is illustrated in Figure 2.6.

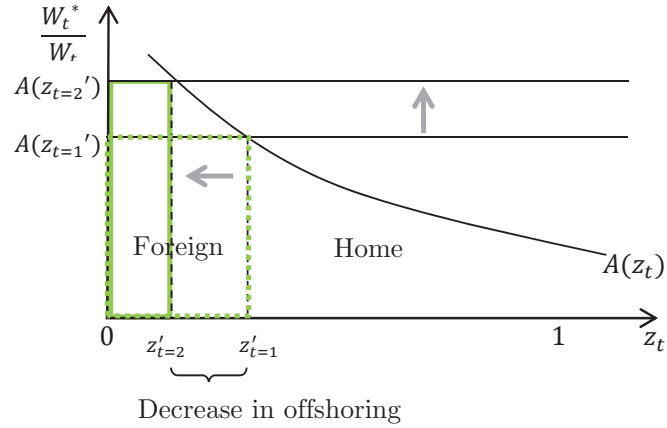


Figure 2.6 The decrease in offshoring margin due to a negative domestic productivity shock.

Figure 2.7 illustrates the impulse response functions of the model variables to a negative home productivity  $a_{Ht}$  shock.

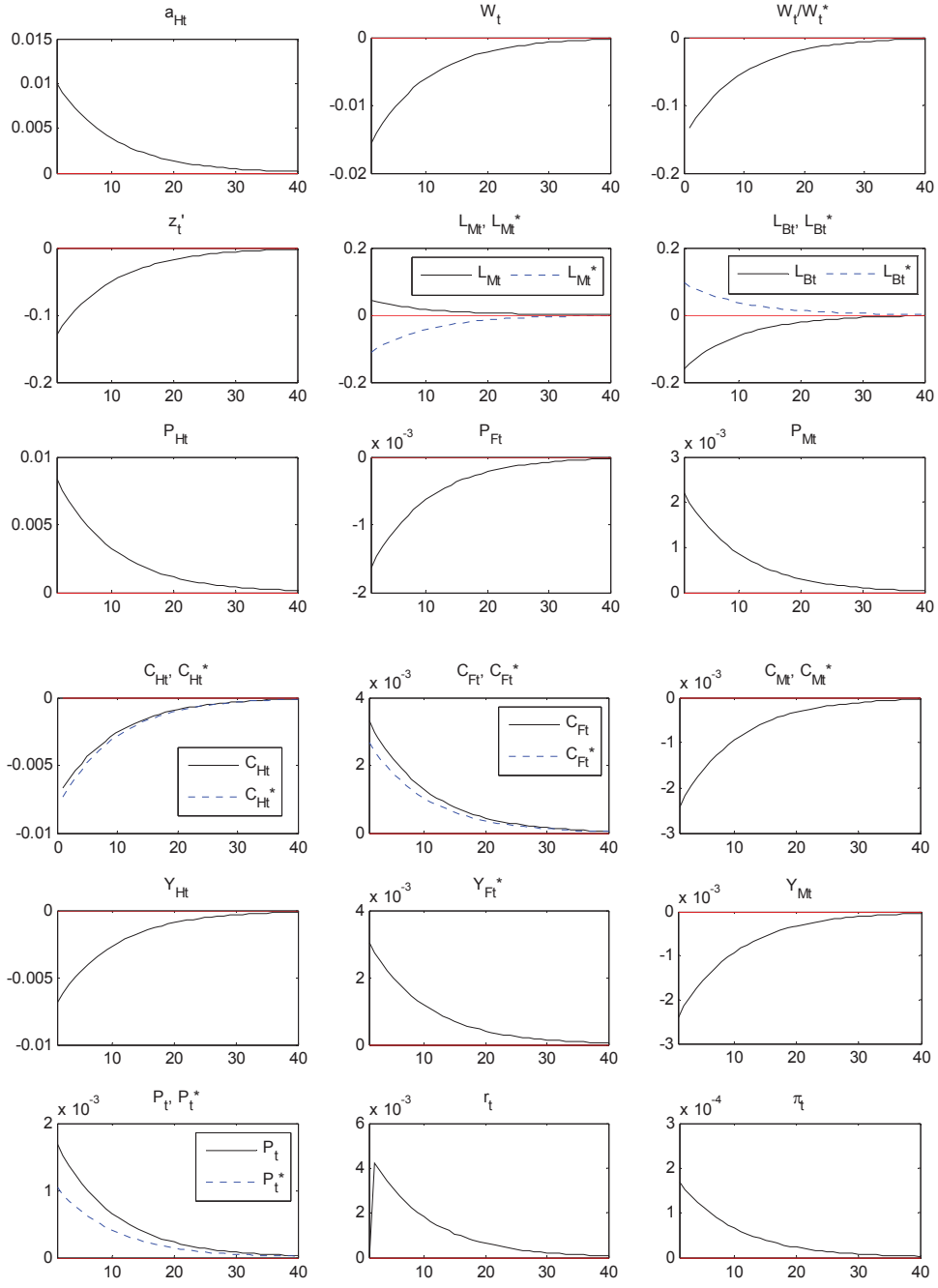


Figure 2.7 Impulse response functions to the domestic unit labor cost  $a_{Ht}$  shock,  $\bar{z}' = .06$ .

Note: See Table A1 on page 112 of Appendix A for variables description.

Following a negative domestic productivity shock, the increase in in-sourcing or the equivalent decrease in offshoring margin  $z'_t$  is equal to 0.12%. This response of offshoring is stronger than the increase of 0.016% that occurs after a negative foreign productivity shock  $a_{Ft}^*$ . A negative productivity shock decreases domestic output and consumption in the domestic homogenous sector. Foreign wage increases relative to domestic wage and correspondingly, relative prices follow. Consequently, the price of foreign goods falls relative to the domestic prices. The prices in the multinational sector increase as production is reallocated back to the home country.

### Productivity effect

In the long run, the offshoring decisions of firms can be interpreted in the context of developing economies progressing or developed countries being hit by a crisis. Indeed, an increase in productivity is traditionally associated with an expansion period, and adverse productivity shocks, with crises. In that light, let us consider the offshoring movements present in the model. When production is cheaper abroad, domestic firms decide to offshore, but when it becomes more profitable to produce at home again, this production is ‘brought’ back, or in-sourced. In this model, offshoring is encouraged by a shock to  $a_{Ft}^*$ , and in-sourcing, by a shock to  $a_{Ht}$ . An alternative explanation of in-sourcing sequentially following offshoring is that the latter results in a *productivity gain* in the foreign country (Mitra and Rajan 2007) of a greater magnitude than the offshoring-related rise of productivity happening in the home country. Indeed, the productivity enhancing effects of offshoring at home are generally small (Olsen 2006, Houseman 2007).

I find some evidence of this productivity gain in the foreign country by comparing the IRFs for various macroeconomic variables following shocks to  $a_{Ft}^*$  and  $a_{Ht}$  in Figures 2.5 and 2.7. I observe that the responses for those two shocks are not exactly symmetrical.

In the home country there are small increases in IRFs when offshoring (after  $a_{Ft}^*$  shock), and steeper decreases when in-sourcing (after  $a_{Ht}$  shock). Contrary to offshoring, in-sourcing negatively affects the home economy. Even though the labor demand increases by 0.045% in the domestic offshoring sector  $L_{Mt}$ , wages are lower by 0.015% at home, the labor demand declines by 0.16% in the domestic managerial sector  $L_{Bt}$ , and inflation increases by 0.0016%. These adverse effects are generally higher than their positive counterparts after a foreign productivity shock and the resulting offshoring upsurge.

I observe quite opposite effects for the foreign country. In the foreign economy, there are small decreases in IRFs when the home country offshores (after  $a_{Ft}^*$  shock), and comparatively larger increases when the subsequent in-sourcing takes place (after  $a_{Ht}$  shock). There are some, albeit few, positive outcomes of offshoring, most notably in the labor market, where, for instance, a 0.015% growth of jobs in the multinational sector  $L_{Mt}^*$  is observed. In-sourcing brings a steeper contraction in the foreign multinational sector,  $z_t'$  decreases by 0.1%. However, in the foreign country, the negative effects of offshoring tend to be lower in magnitude than the positive effects of in-sourcing. For instance, the wage gap diminishes by 0.13% after in-sourcing, whereas it only had widened by 0.016% when offshoring had happened. Similarly, the reduction in managerial jobs demand  $L_{Bt}^*$  amounts to 0.02% in case of offshoring, while the demand for those jobs abroad increases by almost 0.1% when in-sourcing takes place.

Thus, productivity-driven offshoring seems to have little positive effects for the home economy at start, but the foreign economy experiences an increase in productivity that persists.

### **The interest rates link of productivity shocks**

Interest rates respond to productivity shocks and are driven primarily by the domestic homogenous goods sector and amplified by the multinational sector, for both foreign and domestic shocks.

The home economy displays a standard response to negative domestic productivity shocks in terms of interest rates. A negative productivity shock decreases the consumption of domestic goods ( $C_{Ht}$  and  $C_{Ht}^*$ ), and the GDP. This results in an increase of interest rates  $r_t$ . In case of foreign productivity shock, the transmission is through the reduction of relative prices at home, which increases domestic consumption, and in turn contracts interest rates. These changes in interest rates further affect the intertemporal decisions of households in both countries. Hernandez and Leblebicioglu (2011) arrive at similar results. Aside from the standard international macroeconomic effects, offshoring appears to play a role in the interest rates transmission channel in presence of productivity shocks. *Offshoring amplifies the effects of productivity on domestic sector prices and consumption* through the changes in supply capacity that follow the changes in offshoring margin. It triggers sectoral reallocations of labor adjusting to movements in offshoring.

### 2.5.2 Impulse Response Functions to Demand Shocks

Assuming that the home country is more productive than the foreign country, that is  $a_{Ht} < a_{Ft}^*$ , a shock to demand increases the offshoring margin  $z_t'$ . This increase is caused by the pro-cyclicality of the wages: a surge in domestic demand raises wages at home. Home workers become too expensive, and firms decide to offshore more production abroad, as it is now profitable. This effect is illustrated in Figure 2.8.



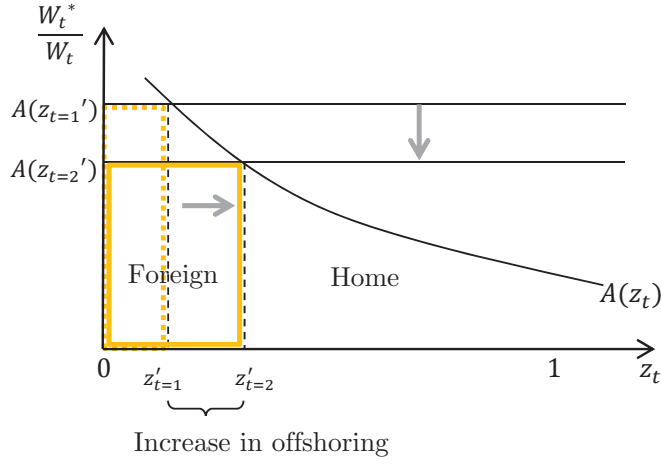


Figure 2.8 The increase in offshoring margin due to domestic demand shock.

The effects of a positive domestic demand shock on key macroeconomic variables of the model are illustrated in Figure 2.9.

In the homogenous sector, a rise in output  $Y_{Ht}$  shifts the  $MPL_{Ht}$  up and in turn increases the domestic wages  $W_t$ . Domestic prices fall and consumption at home rises. A shock to government demand at home increases labor demand in the multinational sector in the foreign country  $L_{Mt}^*$ , and relative wages abroad drop. This effect decreases the foreign marginal product of labor and in result, prices abroad increase and output falls.

The multinational sector is driven by the upturn in the demand for multinational goods  $D_{Mt}$ , mostly due to the surge in government demand  $G_{Mt}$ . Prices increase, but government consumption offsets the decrease of private consumption, and the output in the multinational sector is positive as well. Higher prices in the multinational sector drive inflation up.

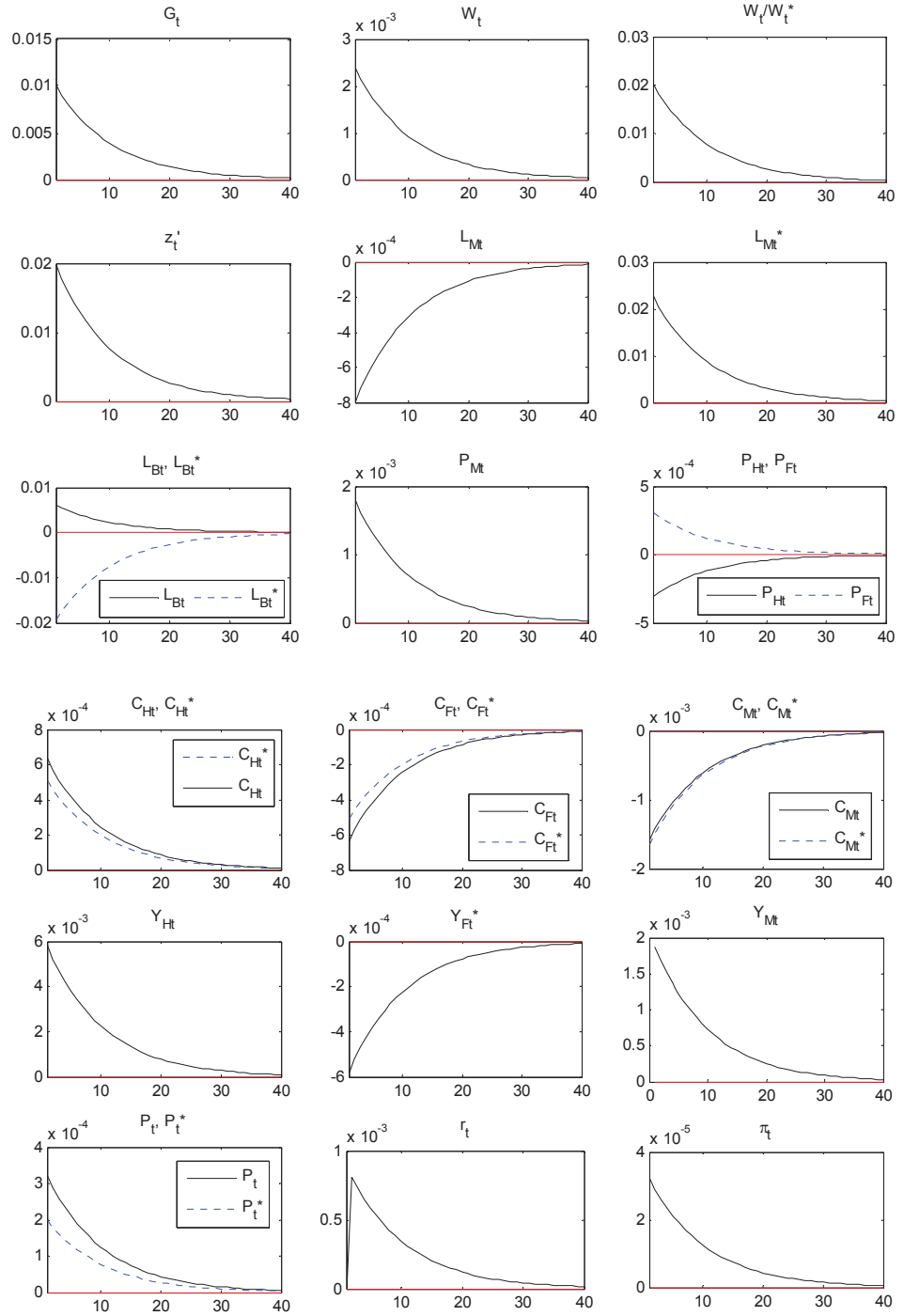


Figure 2.9 Impulse response functions to domestic demand  $G_t$  shock,  $\bar{z}' = .06$ .  
Note: See Table A1 on page 112 of Appendix A for variables description.

## Labor market implications of offshoring

An increase in offshoring has very similar implications for the labor market as in the case of shocks to foreign productivity  $a_{Ft}^*$ . The labor demand in the multinational domestic assembly sector  $L_{Mt}$  reacts negatively to a rise in offshoring margin  $z_t'$ , while the demand for multinational managerial jobs  $L_{Bt}$  is positively correlated with  $z_t'$ . When comparing IRFs for different types of labor at home and abroad, it appears that more offshoring increases the demand for labor in the multinational sector abroad  $L_{Mt}^*$ , while decreasing the demand for labor in the domestic multinational assembly sector  $L_{Mt}$ . Hence, these two types of labor act in this model as *substitutes* of each other. In contrast, the upturn in labor demand in the foreign multinational sector raises the demand for domestic managerial jobs  $L_{Bt}$ . Therefore, these two types of employment act as *complements*. These results find an intuitive parallel in the behavior of firms: more offshoring requires not only more low skill jobs abroad, but also an increase in managerial staff at home. This result contributes to the literature which often comes to opposite conclusions. Brainard and Riker (1997) find that labor employed by overseas affiliates substitutes at the margin for labor employed by the parent company at home, while Desai et al. (2009) conclude that employment abroad is positively correlated with employment at home and expansion abroad leads to job creation at home. A recent study of Harrison and MacMillan (2011) reveals that both the substitution and complementarity effects co-exist.

The responses to foreign government demand shock  $G_t^*$  follow similar transmission mechanisms as those of domestic demand shocks, with the exception that the government does not consume goods from the multinational sector. A foreign government demand shock results in a rise in pro-cyclical foreign wage; isomorphically, it results in more costly offshoring for the home economy. Figure 2.10 illustrates the movement of the offshoring margin  $z_t'$  resulting from these changes.

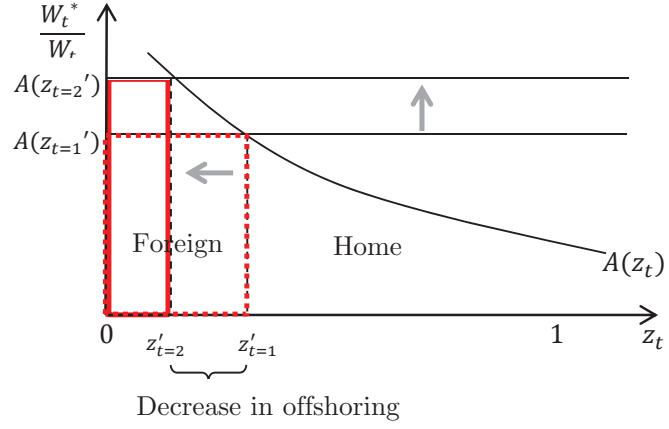


Figure 2.10 The decrease in offshoring margin due to foreign domestic demand shock.

The impulse responses to foreign demand shock  $G_t^*$  are depicted in Figure 2.11.

The labor market effects are counterparts to the effects of a domestic demand shock. Inshoring decreases the demand for labor in the multinational sector abroad  $L_{Mt}^*$ , while increasing the demand for labor in the domestic assembly sector  $L_{Mt}$ . The decrease in labor demand in the foreign multinational sector decreases the demand for domestic managerial jobs  $L_{Bt}$ . Like in the case of domestic demand shock, employment complementarity and substitutability is observed.

The foreign wage increases following the foreign output. The domestic output decreases and causes the lowering of relative wages and consumption. In the multinational sector, prices decrease as foreign government does not consume multinational good, and this decrease drives the reduction of inflation.

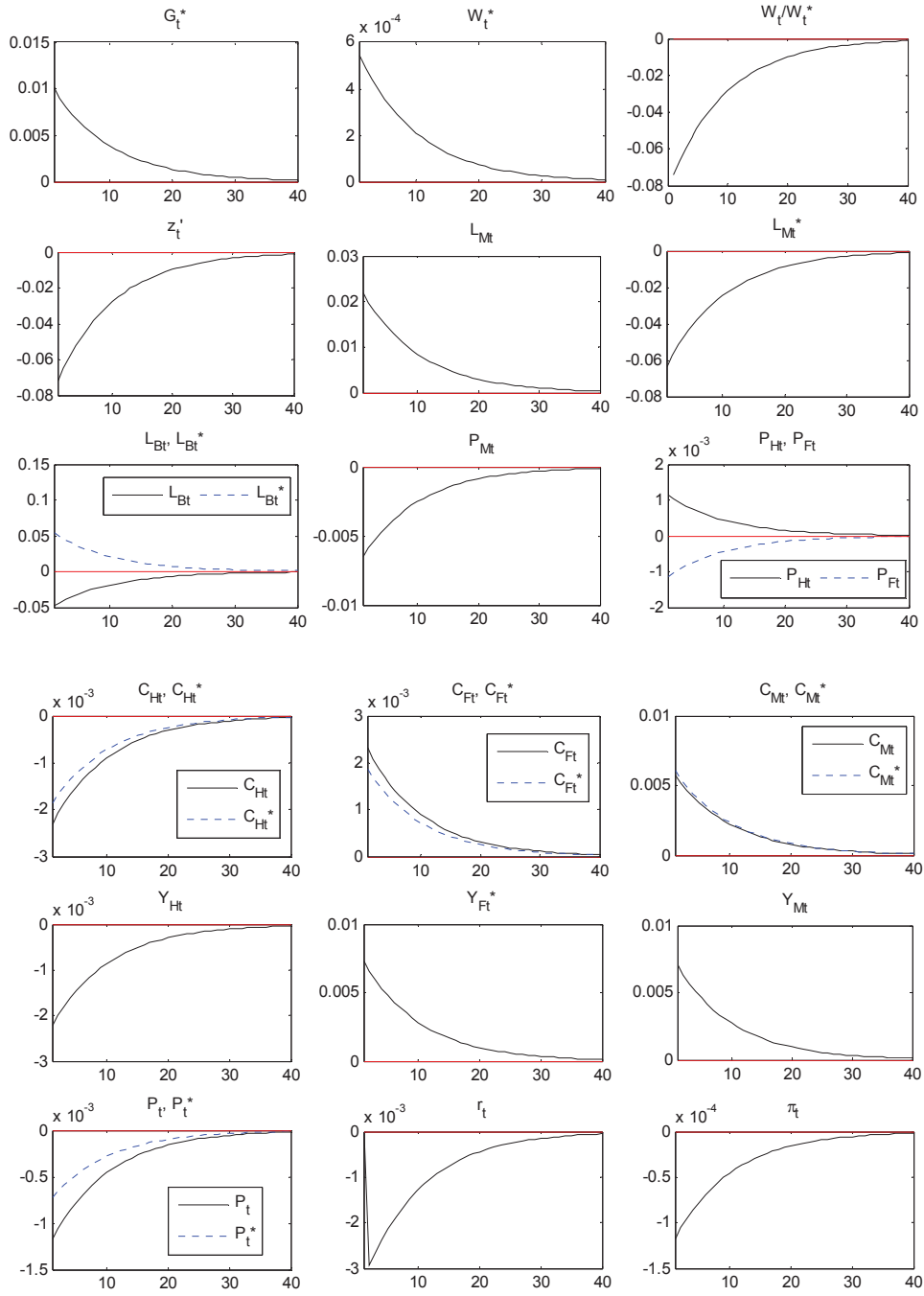


Figure 2.11 Impulse response functions to foreign demand  $G_t^*$  shock,  $\bar{z}' = .06$ .

Note: See Table A1 on page 112 of Appendix A for variables description.

### The interest rates link of demand shocks

Both supply and demand shocks trigger changes in interest rates which in turn affect the intertemporal decisions of households. This happens not only within one country but also across borders. However, in the case of demand shocks, multinational consumption plays an important role in the interest rates link between offshoring and volatility.

A foreign demand shock decreases the interest rates because of the increase in consumption in the multinational sector and of the foreign homogenous good. Similarly, a domestic demand shock results in higher interest rates driven by the lower consumption in the multinational sector and of the foreign homogenous good. *Offshoring influences interest rates through the multinational sector consumption.*

A summary of qualitative effects of both productivity and demand shocks in home and foreign country is presented in Table 2.2.

Table 2.2 Qualitative effects of productivity and demand shocks.

Variable	Benchmark			
	Foreign		Domestic	
	Productivity (supply) $a_{Ft}^*$ shock	Government spending (demand) $G_t^*$ shock	Productivity (supply) $a_{Ht}$ shock	Government spending (demand) $G_t$ shock
Multinational sector				
Offshoring ( $z_t'$ )	+	-	-	+
Foreign offshoring labor ( $L_{Mt}^*$ )	+	-	-	+
Domestic offshoring labor ( $L_{Mt}$ )	-	+	+	-
Prices ( $P_{Mt}$ )	-	-	+	+
Output ( $Y_{Mt}$ )	+	+	-	+
Domestic managerial labor ( $L_{Bt}$ )	+	-	-	+
Foreign managerial labor ( $L_{Bt}^*$ )	-	+	+	-
Homogenous sectors (domestic and foreign)				
Relative wages ( $W_t/W_t^*$ )	+	-	-	+
Domestic prices ( $P_{Ht}$ )	-	+	+	-
Foreign prices ( $P_{Ft}$ )	+	-	-	+
Domestic output ( $Y_{Ht}$ )	+	-	-	+
Foreign output ( $Y_{Ft}^*$ )	-	+	+	-
Interest rate ( $r_t$ )	-	-	+	+
Inflation ( $\pi_t$ )	-	-	+	+

Notes: A plus sign denotes the positive response of a variable to a given shock, while a minus sign denotes a negative response.

### 2.5.3 Other Results<sup>36</sup>

The stochastic simulations performed to solve the model numerically last 200 periods. The simulated data are HP-filtered to compute the theoretical moments and simulated paths of the model variables. I repeat the process 100 000 times and report the correlations in Table 2.3 and the standard deviations in Table 2.4.

Table 2.3 Selected correlations for different types of shocks for the benchmark model.

Correlated variables	Correlations				
	Benchmark $\bar{z}' = 0.06$ (1)	Benchmark, foreign supply $a_{Ft}^*$ shock (2)	Benchmark, domestic supply $a_{Ht}$ shock (3)	Benchmark, domestic demand $G_t$ shock (4)	Benchmark, foreign demand $G_t^*$ shock (5)
$L_{Mt}, L_{Mt}^*$	-0.989 (-0.80)	-1.000 (-0.99)	-0.999 (-1.00)	-0.997 (-1.00)	-1.000 (1.00)
$L_{Mt}^*, L_{Bt}$	0.958	1.000	0.959	1.000	0.996
$L_{Mt}, L_{Bt}^*$	0.941	0.999	0.945	1.000	0.981
$z_t', L_{Mt}$	-0.994	-1.000	-0.999	-0.997	-1.000
$z_t', L_{Bt}$	0.964	1.000	0.959	1.000	0.996
$z_t', L_{Mt}^*$	0.999	1.000	1.000	1.000	1.000
$z_t', L_{Bt}^*$	-0.942	-0.999	-0.929	-0.997	-0.976
$z_t', W_t$	1.000	1.000	1.000	1.000	1.000
$z_t', W_t^*$	-0.978	-1.000	-0.968	-0.999	-0.990
$z_t', r_t$	-0.368	-0.777	-0.762	0.778	0.777
$z_t', \pi_t$	-0.397	-1.000	-0.983	1.000	1.000
$z_t', Y_{Ht}$	0.878	1.000	1.000	1.000	1.000
$z_t', Y_{Ft}^*$	-0.999	-1.000	-0.997	-1.000	-1.000
$z_t', W_t/W_t^*$	0.999	1.000	0.999	1.000	1.000

Notes: All variables are in natural logs. Correlations are calculated for the model using 2<sup>nd</sup> order Taylor approximation. Simulated variables are HP-filtered. See Table A1 on page 112 of Appendix A for variables description. Corresponding values obtained by BHF (2011) are presented between brackets for easier comparison.

Table 2.3 compares the correlations between selected variables for the overall results of the benchmark model in column (1), and for individual shocks in columns (2)-(5). There is a

<sup>36</sup> In addition to the results discussed in this section, policy and transition functions can be found in part 7 of Appendix A.

negative co-movement of offshoring employment at home and abroad as  $\text{corr}(L_{Mt}, L_{Mt}^*)$  is negative for all shocks. Yet, it is positive between managerial and multinational assembly labor, for  $\text{corr}(L_{Mt}^*, L_{Bt})$  and  $\text{corr}(L_{Mt}, L_{Bt}^*)$ . These results support the substitutability and complementarity of different types of labor in presence of offshoring, discussed earlier. The offshoring margin  $z_t'$  is positively correlated with foreign offshoring multinational labor  $L_{Mt}^*$ , with labor in the domestic offshoring managerial sector  $L_{Bt}$ , with domestic wages  $W_t$ , and with output  $Y_{Ht}$ , revealing its positive impact on the domestic economy and on the foreign labor market. Offshoring is negatively correlated with labor in the foreign managerial sector  $L_{Bt}^*$ , foreign wages  $W_t^*$ , domestic assembly labor  $L_{Mt}$ , and it always increases the wage gap. It is also negatively correlated with foreign output. In general, offshoring is positively correlated with domestic output and negatively correlated with output abroad.

I do not find sufficient evidence that demand shocks matter more for volatility than productivity shocks (see Table 2.4). However, I find higher volatilities in employment and offshoring margin than BHF (2011)<sup>37</sup>. Coronado (2011) arrives at similar empirical results, finding higher volatility in employment and output.

The foreign offshoring sector also presents greater volatility. The standard deviation of employment in foreign offshoring industry is 23.19%, three times greater than the volatility in the domestic offshoring sector, equal to 8.49%. However, the managerial jobs created at home in relation to offshoring are more volatile than those created abroad. The offshoring margin exhibits high levels of volatility and is especially sensitive to in-sourcing related shocks, shocks to domestic productivity or foreign government demand. The standard deviation of offshoring is 26.58% for the benchmark model, only about 2.5% after either a foreign supply shock or a

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<sup>37</sup> The parameterization of the model matches closely the specification of BHF (2011), where the home economy is the US and the foreign country is Mexico.



domestic demand shock, but 9% after a foreign demand shock and 16% after a domestic productivity shock.

Table 2.4 Selected standard deviations for different shocks for the benchmark model  $\bar{z}' = 0.06$ .

Standard deviations (%)										
Variable	Benchmark model, aggregate		Benchmark model, foreign supply $a_{Ft}^*$ shock		Benchmark model, domestic supply $a_{Ht}$ shock		Benchmark model, domestic demand $G_t$ shock		Benchmark model, foreign demand $G_t^*$ shock	
	Order of approximation									
	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>
$L_{Mt}$	6.61 (0.99)	8.49	0.85 (0.31)	0.67	6.76 (0.40)	5.33	0.13 (0.65)	0.10	3.46 (0.12)	2.74
$L_{Mt}^*$	18.03 (5.18)	23.19	2.19 (0.03)	1.75	17.53 (0.97)	13.88	3.57 (4.66)	2.84	10.07 (2.17)	8.01
$W_t$	2.49	3.21	0.31	0.25	2.46	1.95	0.37	0.30	1.37	1.09
$W_t^*$	0.16	0.20	0.02	0.02	0.15	0.12	0.02	0.02	0.09	0.07
$C_{Ht}$	1.03	1.28	0.13	0.11	1.06	0.84	0.10	0.08	0.36	0.29
$C_{Ht}^*$	1.13	1.38	0.14	0.12	1.16	0.91	0.08	0.06	0.29	0.23
$C_{Ft}$	0.75	0.81	0.07	0.05	0.52	0.41	0.10	0.08	0.36	0.29
$C_{Ft}^*$	0.61	0.65	0.05	0.04	0.42	0.33	0.08	0.06	0.29	0.23
$C_{Mt}$	3.00	3.81	0.38	0.30	3.04	2.41	0.37	0.30	1.36	1.08
$C_{Mt}^*$	2.92	3.73	0.37	0.29	2.94	2.33	0.39	0.31	1.43	1.14
$P_{Ht}$	1.30	1.55	0.17	0.13	1.32	1.04	0.05	0.04	0.18	0.14
$P_{Ft}$	0.37	0.40	0.03	0.03	0.26	0.20	0.05	0.04	0.18	0.14
$P_{Mt}$	2.81	3.62	0.35	0.28	2.78	2.20	0.42	0.34	1.55	1.23
$z_t'$	20.62 (3.71)	26.58	2.55 (0.23)	2.03	20.40 (0.48)	16.16	3.10 (3.36)	2.47	11.36 (1.93)	9.04
$i_t$	0.95	1.03	0.08	0.07	0.66	0.52	0.13	0.10	0.46	0.37
$P_t$	0.38	0.41	0.03	0.03	0.27	0.21	0.05	0.04	0.19	0.15
$P_t^*$	0.24	0.25	0.02	0.02	0.16	0.13	0.03	0.03	0.11	0.09
$r_t$	0.94	1.04	0.08	0.07	0.67	0.52	0.13	0.10	0.47	0.37
$\pi_t$	0.04	0.04	0.00	0.00	0.03	0.02	0.01	0.00	0.02	0.01
$L_{Bt}$	24.71	29.88	1.96	1.56	25.15	21.45	0.94	0.75	7.54	6.10
$L_{Bt}^*$	15.10	20.45	2.91	2.34	14.96	12.22	3.06	2.47	8.62	6.81
$Y_{Ht}$	1.45	1.64	0.13	0.11	1.08	0.85	0.91	0.73	0.35	0.28
$Y_{Ft}^*$	1.11	1.42	0.06	0.05	0.48	0.38	0.09	0.07	1.15	0.91
$W_t/W_t^*$	21.17	27.21	2.62	2.09	20.94	16.52	3.19	2.54	11.66	9.25
$Y_{Mt}$	2.96	3.83	0.38	0.30	3.02	2.40	0.44	0.35	1.66	1.32

All variables are in natural logs. Simulated variables are HP-filtered. For explanations on the 1<sup>st</sup> and 2<sup>nd</sup> order of approximation and their use in DSGE simulation, see Section 2.5. See Table A1 on page 112 of Appendix A for variables description. Corresponding values obtained by BHF (2011) are presented between brackets for easier comparison.

Furthermore, the model exhibits a feature of the US-Mexico relationship that the BHF (2011) model does not replicate: employment in the US offshoring sector is more volatile than in the whole US economy. This is true for the benchmark model overall as well as for individual shocks, with the exception of the domestic demand shock.

In conclusion, across simulations, the benchmark results expose the offshoring margin as an important mechanism in shocks transmission. It follows that offshoring mitigates volatility in the home country and entails a greater variability in foreign variables, as discussed in details in the next section.

#### 2.5.4 Volatilities

Table 2.5 and Figures 2.12 and 2.13 show the standard deviations and simulation paths of selected macroeconomic variables for different levels of offshoring.

Moving from almost no offshoring ( $\bar{z}' = 0.01\%$ , Figure 2.12) to 6% of offshoring (Figure 2.13) generates volatility not only in the multinational labor at home and abroad  $L_{Mt}$  and  $L_{Mt}^*$ , but also in total labor. It also amplifies the volatility of the home and foreign managerial employments,  $L_{Bt}$  and  $L_{Bt}^*$ . The offshoring labor at home is less volatile than the foreign offshoring labor. The graphs also clearly illustrate the negative correlation between those two types of labor,  $L_{Mt}$  and  $L_{Mt}^*$ . Offshoring raises wages at home; this result is similar to those of Karabay and McLaren (2010), who observe that free trade negatively affects rich-country workers, while reducing the volatility of their wages. I also find a mild reduction in domestic wages volatility as offshoring increases. This is noticeable in the standard deviations for  $W_t$  as offshoring increases in Table 2.5. Nonetheless, compared to Karabay and McLaren (2010), the

results of my model are more nuanced, as an exception comes forth at very high levels of offshoring in column (4) of Table 2.5: wages abroad become more volatile than at home.

Other observations can be made upon examining Table 2.5 horizontally, by increasing offshoring levels. First, the size of the offshoring margin affects the scale of the volatility of many variables. Total foreign labor  $L_t^*$ , foreign labor in the multinational sector  $L_{Mt}^*$ , foreign wage and foreign output volatilities increase with higher levels of offshoring, while domestic total labor  $L_t$ , managerial labor  $L_{Bt}$ , domestic wages, and output volatilities decrease. Labor in the foreign managerial sector  $L_{Bt}^*$  becomes very volatile once offshoring accounts for over 50% of the production. These results confirm that endogenous movements in the offshoring margin transmit shocks from the home to the foreign economy. Second, the volatility of domestic output decreases with higher offshoring, while foreign output becomes more volatile, reaching 6.85% for offshoring levels close to 1.

The real exchange rate and wage gap exhibit higher levels of fluctuations with increasing offshoring.

Summing up, offshoring has a positive impact on the domestic economy, although it raises the volatility of its wages. However, the increased volatility brought by higher levels of offshoring is transmitted abroad. The international integration of factor markets, or offshoring, is an expression of globalization that positively affects the offshoring country. The phenomenon detailed above, that can be described as a transmission of volatility from the domestic economy to the offshoring recipient, further amplifies the positive effects of offshoring for the home country.

Table 2.5 Standard deviations for different levels of offshoring for the benchmark model.

Standard deviations (%)								
Variable	Low offshoring $\bar{z}' = .0005$ (export only)		Benchmark $\bar{z}' = 0.06$		Mid-point $\bar{z}' = 0.5$		High offshoring $\bar{z}' = .99$ (import only)	
	(1)		(2)		(3)		(4)	
	Order of approximation							
	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>
$L_t$	3.17	4.00	2.68 (1.13)	3.40	3.06 (1.11)	3.81	1.89	2.29
$L_t^*$	0.30	0.34	0.22 (0.81)	0.25	1.76 (0.96)	2.32	5.88	7.48
$L_{Mt}$	6.12	7.86	6.61 (0.99)	8.49	19.35 (0.65)	24.81	45.35	57.47
$L_{Mt}^*$	18.73	24.09	18.03 (5.18)	23.19	20.86 (2.01)	26.48	15.96	20.21
$W_t$	2.66	3.43	2.49	3.21	2.16	2.76	0.09	0.13
$W_t^*$	0.00	0.00	0.16	0.20	2.16	2.82	6.51	8.25
$C_{Ht}$	1.43	1.78	1.03	1.28	0.41	0.54	1.66	2.16
$C_{Ht}^*$	1.76	2.14	1.13	1.38	0.89	1.02	0.95	1.18
$C_{Ft}$	1.90	2.15	0.75	0.81	2.58	3.13	5.90	7.15
$C_{Ft}^*$	1.53	1.73	0.61	0.65	2.09	2.53	4.76	5.77
$C_{Mt}$	3.65	4.62	3.00	3.81	0.62	1.56	8.28	10.57
$C_{Mt}^*$	3.37	4.30	2.92	3.73	0.96	1.92	9.35	11.89
$P_{Ht}$	2.04	2.45	1.30	1.55	1.34	1.54	1.00	1.11
$P_{Ft}$	1.23	1.40	0.37	0.40	1.63	1.98	4.09	4.97
$P_{Mt}$	3.15	4.06	2.81	3.62	1.35	2.34	9.99	12.66
$z_t'$	22.06	28.43	20.62 (3.71)	26.58	17.92 (0.71)	22.87	0.75	1.05
$P_t$	0.67	0.75	0.38	0.41	0.95	1.15	1.80	2.18
$P_t^*$	0.30	0.34	0.24	0.25	0.45	0.55	0.66	0.80
$r_t$	1.64	1.92	0.94	1.04	2.36	3.03	4.46	5.50
$\pi_t$	0.07	0.08	0.04	0.04	0.10	0.12	0.18	0.22
$L_{Bt}$	4.99	6.14	24.71	29.88	5.13	6.16	2.51	2.97
$L_{Bt}^*$	0.52	0.53	15.10	20.45	88.09	158.64	255.37	873.07
$Y_{Ht}$	1.83	2.14	1.45	1.64	0.97	1.01	1.46	1.89
$Y_{Ft}^*$	1.58	2.09	1.11	1.42	2.41	3.17	5.38	6.85
$W_t/W_t^*$	21.33	27.44	21.17	27.21	34.63	44.21	52.81	67.08
$Y_{Mt}$	3.54	4.57	2.96	3.83	1.15	1.94	8.68	10.93

Notes: All variables are in natural logs. Simulated variables are HP-filtered. For explanations on the 1<sup>st</sup> and 2<sup>nd</sup> order of approximation and their use in DSGE simulation, see Section 2.5. See Table A1 on page 112 of Appendix A for variables description. Corresponding values obtained by BHF (2011) are presented between brackets for easier comparison.

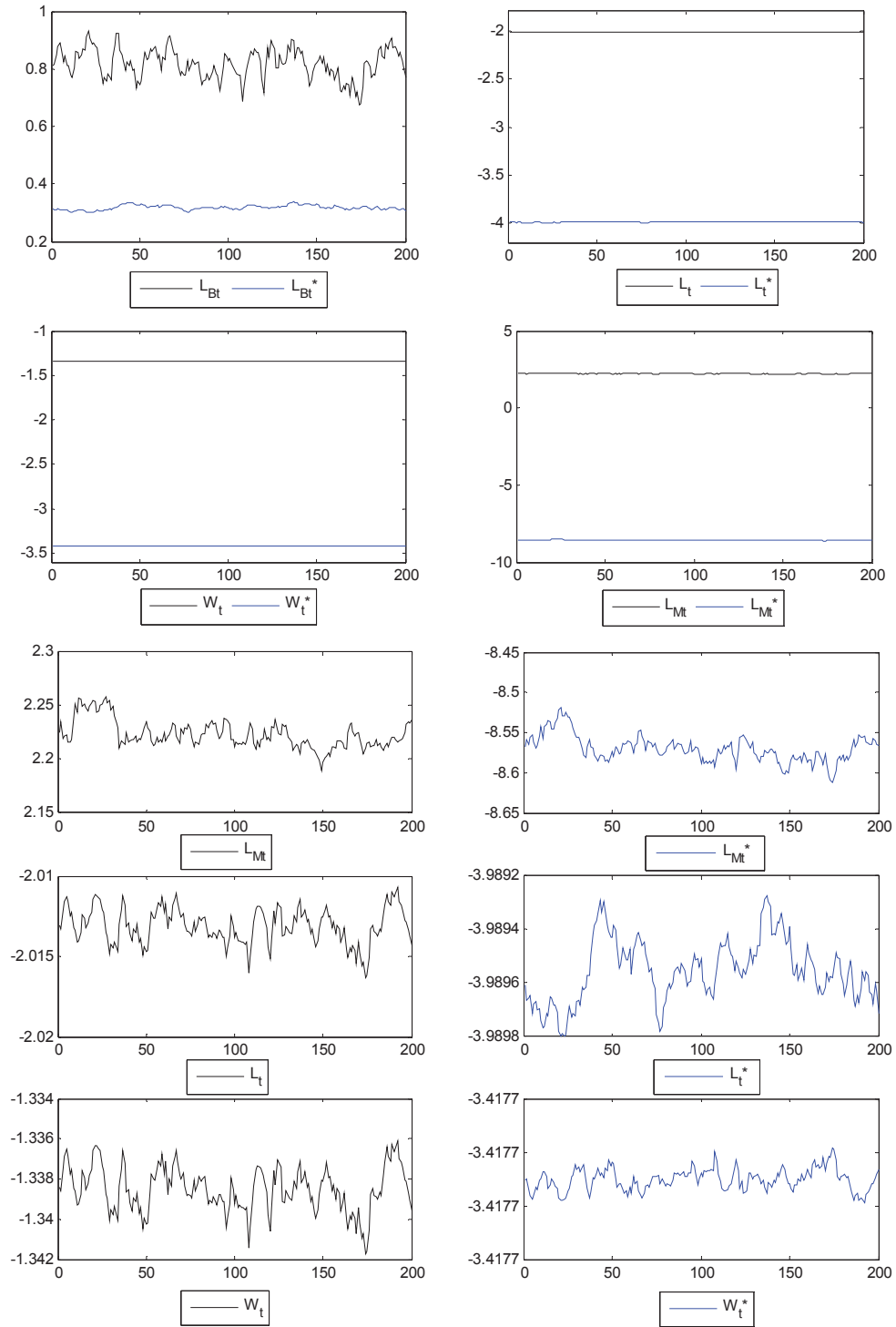


Figure 2.12 Volatility in a model with practically no offshoring margin ( $\bar{z}' = 0.0001$ ).  
Note: See Table A1 on page 112 of Appendix A for variables description.

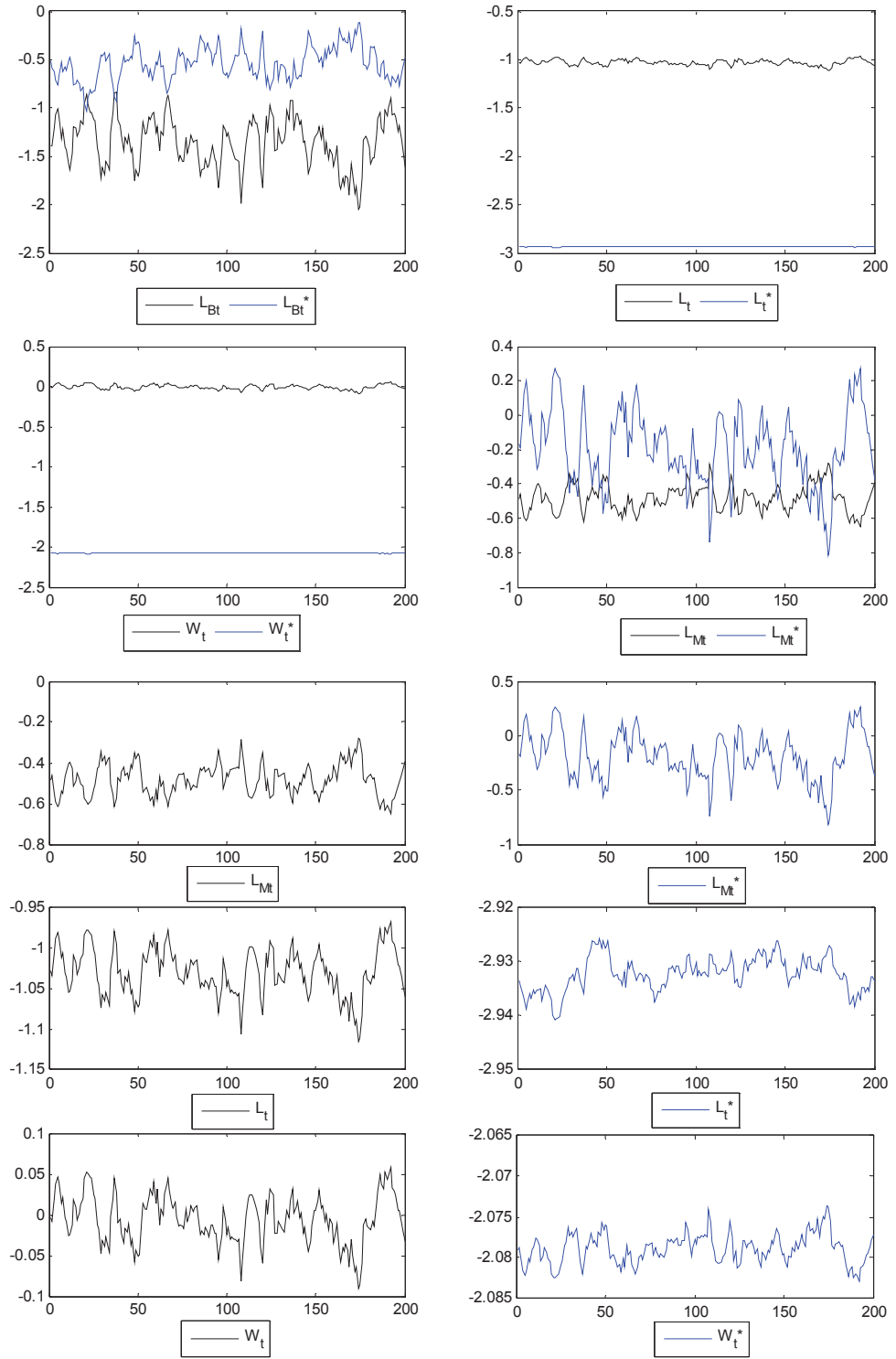


Figure 2.13 Volatility in the benchmark model with offshoring margin  $\bar{z}' = 0.06$ .  
Note: See Table A1 on page 112 of Appendix A for variables description.

### 2.5.5 Sensitivity Analysis

I examine how the benchmark model behaves when the specification is modified in some way, an exercise commonly referred to as robustness check. First, the sensitivity analysis addresses the issue of model behavior for different levels of offshoring margin  $\bar{z}'$ , including models with no offshoring (exports only) and full offshoring (imports only), and a mid-point model with offshoring equal to 0.5. I analyze the extreme cases (no offshoring or almost total offshoring) to give an exhaustive overview of the performance of the model on the whole range of offshoring. I also vary  $\alpha$ , the share of multinational goods in the country's production, and  $\omega$ , the home country bias parameter. Tables 2.5 in the previous section, 2.6 and 2.7 summarize the simulation results.

The results in Table 2.5, discussed earlier, reveal that higher degrees of offshoring lead to the greater volatility of some macroeconomic variables, especially in the foreign country, while the corresponding variables at home gain in stability.

The correlations in Table 2.6 are robust for the main variables of interest. Correlation is negative between the domestic and foreign offshoring sectors, and between the offshoring margin and several variables, among which domestic assembly labor, foreign wage, interest rate, inflation, and foreign output. Offshoring is in turn positively correlated with domestic managerial labor, foreign offshoring labor in the multinational sector, domestic wage and output as well as output gap. It confirms my earlier findings that offshoring influences the home country positively and the foreign economy rather negatively, aside from its labor market. Correlations between the total labors at home and abroad are ambiguous. This apparent inconsistency might be caused by the relative influences of the complementarity and substitutability of the components of composite labor. Domestic output starts decreasing for very high levels of offshoring, as  $\text{corr}(z'_t, Y_{Ht})$  for offshoring close to 1 is equal to -0.816. This

interesting result suggests that there exists a threshold beyond which offshoring starts to affect the domestic economy negatively. Similarly, the correlation of domestic output and offshoring is negative for low levels of domestic preferences  $\omega$ . At high level of  $\alpha$ , offshoring improves the foreign output; it happens when the share of offshorable goods at home is high.

Table 2.6 Sensitivity analysis: selected correlations.

Correlated Variables	Correlations							
	Low offshoring $\bar{z}' = .0005$ (export only)	Benchmark $\bar{z}' = .06$	Mid-point $\bar{z}' = .5$	High offshoring $\bar{z}' = .99$ (import only)	High $\alpha$ , $\alpha = .87$	Low $\alpha$ , $\alpha = .001$	High $\omega$ , $\omega = .9$	Low $\omega$ , $\omega = .07$
$L_{Mt}, L_{Mt}^*$	-0.987	-0.989 (-0.80)	-0.987 (-0.74)	-0.998	-0.992	-0.996 (-0.80)	-0.988	-0.175
$L_t, L_t^*$	0.790	-0.275 (-0.93)	-0.957 (-1.00)	-0.960	-0.999	0.987 (-0.93)	-0.057	0.974
$L_{Mt}^*, L_{Bt}$	0.973	0.958	0.977	0.945	-0.320	0.904	0.232	0.511
$L_{Mt}, L_{Bt}^*$	-0.170	0.941	0.797	0.380	0.632	-0.027	0.898	-0.063
$z_t', L_{Mt}$	-0.993	-0.994	-0.972	-0.895	-0.994	-0.997	-0.993	-0.664
$z_t', L_{Bt}$	0.979	0.964	0.978	0.854	-0.317	0.906	0.229	0.800
$z_t', L_{Mt}^*$	0.999	0.999	0.995	0.903	1.000	1.000	0.999	0.852
$z_t', L_{Bt}^*$	0.123	-0.942	-0.641	0.066	-0.611	0.025	-0.894	-0.165
$z_t', W_t$	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
$z_t', W_t^*$	-0.978	-0.978	-0.950	-0.895	-0.983	-0.944	-0.976	-0.999
$z_t', r_t$	-0.589	-0.368	-0.681	-0.737	0.792	-0.800	-0.312	-0.485
$z_t', \pi_t$	-0.687	-0.397	-0.821	-0.821	0.995	-0.966	-0.327	-0.609
$z_t', Y_{Ht}$	0.914	0.878	0.581	-0.816	0.994	0.640	0.881	-0.141
$z_t', Y_{Ft}$	-0.989	-0.999	-0.965	-0.901	0.975	-0.888	-0.706	-0.374
$z_t', W_t/W_t^*$	1.000	0.999	0.980	0.870	0.999	0.998	0.999	1.000

Notes: All variables are in natural logs. Correlations are calculated for the model using 2<sup>nd</sup> order Taylor approximation. Simulated variables are HP-filtered. See Table A1 on page 112 of Appendix A for variables description. Corresponding values obtained by BHF (2011) are presented between brackets for easier comparison.

The standard deviations in Table 2.7 indicate that volatility is generally higher for higher levels of  $\omega$ . A high value of  $\omega$  can reflect a higher preference towards home and multinational goods than towards foreign goods. With low levels of  $\omega$ , a high share of homogenous foreign goods is imported to the home economy, and volatility decreases



dramatically. High levels of domestic preferences  $\omega$  might be understood as *market contraction*, which leads to higher volatility.

Besides, a low value of  $\alpha$ , which expresses less diversity in offshoring, results in more volatility. This observation seems natural, as an *expanded market* with higher levels of  $\alpha$  has a higher “offshorability”, and offers more choices for firms. Hence, it is expected to be less volatile.

In general the model performance is robust.

Table 2.7 Sensitivity analysis: selected standard deviations.

Standard deviations (%)										
Variable	Benchmark $\bar{z}' = 0.06$		High $\alpha$ , $\alpha = .87$		Low $\alpha$ , $\alpha = .001$		High $\omega$ , $\omega = .9$		Low $\omega$ , $\omega = .07$	
	(1)		(2)		(3)		(4)		(5)	
	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>
$L_t$	2.68 (1.13)	3.40	1.13	1.44	7.20 (1.13)	8.69	2.73	3.46	1.90	2.06
$L_t^*$	0.22 (0.81)	0.25	1.17	1.53	1.16 (0.81)	1.31	0.32	0.36	0.42	0.49
$L_{Mt}$	6.61 (0.99)	8.49	5.99	7.83	16.06 (1.00)	19.99	6.64	8.57	2.47	2.52
$L_{Mt}^*$	18.03 (5.18)	23.19	22.82	29.37	37.71 (5.20)	45.75	18.04	23.34	3.39	3.61
$W_t$	2.49	3.21	2.92	3.75	5.45	6.60	2.49	3.23	0.45	0.48
$W_t^*$	0.16	0.20	0.18	0.26	0.34	0.51	0.16	0.20	0.03	0.03
$C_{Ht}$	1.03	1.28	5.71	7.19	0.20	0.24	1.02	1.28	1.49	1.70
$C_{Ht}^*$	1.13	1.38	4.92	6.17	0.47	0.58	1.13	1.38	0.41	0.49
$C_{Ft}$	0.75	0.81	4.13	5.32	1.41	1.72	0.78	0.84	0.12	0.13
$C_{Ft}^*$	0.61	0.65	3.34	4.29	1.14	1.39	0.61	0.66	1.21	1.36
$C_{Mt}$	3.00	3.81	1.50	1.91	7.89	9.47	3.04	3.87	1.95	2.10
$C_{Mt}^*$	2.92	3.73	2.30	2.93	7.62	9.15	2.96	3.79	0.89	0.94
$P_{Ht}$	1.30	1.55	3.93	4.89	1.97	2.38	1.39	1.64	0.12	0.15
$P_{Ft}$	0.37	0.40	2.35	3.01	0.35	0.41	0.26	0.29	1.66	1.86
$P_{Mt}$	2.81	3.62	3.29	4.21	6.15	7.38	2.81	3.65	0.51	0.55
$\bar{z}'_t$	20.62 (3.71)	26.58	24.14	31.05	45.14 (3.72)	54.61	20.65	26.78	3.74	4.00
$r_t$	0.94	1.04	4.42	6.33	4.35	5.51	1.27	1.37	3.79	4.46
$\pi_t$	0.04	0.04	0.18	0.25	0.18	0.23	0.05	0.06	0.15	0.17
$Y_{Ht}$	1.45	1.64	5.75	7.20	0.55	0.57	1.42	1.63	1.91	1.94
$Y_{Ft}^*$	1.11	1.42	4.13	5.09	1.32	1.76	1.23	1.56	0.24	0.32
$W_t/W_t^*$	21.17	27.21	24.78	32.36	46.34	57.92	21.19	27.39	3.84	4.07
$Y_{Mt}$	2.96	3.83	1.69	2.10	7.76	9.36	3.00	3.89	2.63	2.74

Notes: All variables are in natural logs. Simulated variables are HP-filtered. For explanations on the 1<sup>st</sup> and 2<sup>nd</sup> order of approximation and their use in DSGE simulation, see Section 2.5. See Table A1 on page 112 of Appendix A for variables description. Corresponding values obtained by BHF (2011) are presented between brackets for easier comparison.

## 2.6 CONCLUSIONS

In this chapter, I examine the relationships between offshoring margin and some key macroeconomic variables by numerically solving a DSGE model crafted to include three sectors and two countries in an open economy. This in-depth analysis of global production markets reveals their important role as channel of international shock transmission, in line with the traditional trade and financial channels.

I find that shifts in extensive margin of offshoring act as a mechanism of transmission of shocks abroad. There are four key influences of offshoring on the economy: the labor supply channel, the trade channel, the interest rates channel and the export of volatility. The trade channel is extensively discussed in other studies including Grossman and Rossi-Hansberg (2008), so I focus on the other effects in my analysis.

I find the substitutability and complementarity of labor among different sectors. More offshoring increases the demand for labor in the multinational sector abroad, and decreases the demand for labor in the domestic multinational sector. These two types of labor act in this model as *substitutes* of each other. However, the upturn in labor demand in the foreign multinational sector raises the demand for domestic managerial jobs and decreases it abroad. Therefore, these two types of employment act as *complements*.

The interest rates link works differently for productivity and demand shocks. In presence of productivity shocks, *offshoring amplifies the effects of productivity on domestic sector prices and consumption* through the changes in supply capacity that follow the changes in offshoring margin, which in turn affect the interest rates. For demand-driven offshoring, *it influences interest rates through the multinational sector consumption* directly.

I find higher volatilities in employment and offshoring margin than BHF (2011), and my results are consistent with Coronado (2011). Across simulations, the benchmark results expose the offshoring margin as an important mechanism in shocks transmission. It follows that offshoring mitigates volatility in the home country and entails a greater variability in foreign variables.

Both productivity and demand shocks alter offshoring decisions. Offshoring has generally positive effects on the home country, raising employment in the domestic managerial offshoring sector and output, while mitigating inflation. It also fosters employment in the multinational sector abroad, but at the cost of increasing the wage gap. However, these increases in domestic macroeconomic variables related to offshoring tend to be relatively small, as compared to contractions in these variables that happen on the subsequent in-sourcing. Reciprocally, the foreign country is a loser at first, when engaging in offshoring, but is positively affected on the in-sourcing that follows. This is particularly true for the cost-saving driven offshoring that follows productivity shocks. Thus, productivity-driven offshoring seems to positively affect the home economy a little at start, while the foreign economy experiences a *productivity rise* that persists.

I also identify the existence of a threshold beyond which offshoring negatively affects the domestic economy, decreasing its output.

For Zlate (2009), BFH (2007, 2009, 2011), and Zorell (2010), the offshoring sector may buffer the transmission of business cycle shocks in the US and in Europe. This has not yet been extensively studied, and one purpose of this research is to fill this gap in the literature. My results corroborate this idea of a buffering of shock transmission through offshoring.

While this part of the thesis focuses on modelling offshoring, its findings have some policy repercussions. Offshoring has some important implications for policymakers in terms of both opportunities and potential problems. Those problems will be different for the home

countries, such as the US, and for the destination countries, like China; they will consequently approach offshoring with very different policies<sup>38</sup>.

I find that the loss of less skill-intensive jobs is an implication of offshoring for the home country (substitution effect for multinational labor). However, the creation of new, more skill-intensive jobs is another effect of offshoring (complementary effect of managerial labor). In the source countries, public debates and policies tend to focus on addressing the unwanted effects of jobs ‘lost to offshoring’. Policies enacted to foster local hiring may include improving regulations that contribute to the high costs of low-skilled labor or change tax laws to reduce incentives to move jobs overseas. A possible mitigating response to the job loss consists in providing support to the workforce to accelerate adjustment to the new job market; for example, targeted skill-upgrade programs to help the unemployed re-enter the market. Although some jobs are lost to low-wage countries, the offshoring process creates new high value added jobs for the home country population. Hence, policies that create a climate of innovation and encourage talents can help fully accommodate these changes.

I also find that offshoring can have positive effects to the destination country, including jobs creation and a long-run productivity upsurge. But these come at the cost of preserving the inequality between the offshoring country and the recipient, as quantified by the wage gap. Some of the policy recommendations aimed at attracting offshoring include removing trade barriers, improving infrastructure, the education system, regulations on intellectual property, privacy, and data security, and attracting foreign investments. Some examples of policies to challenge inequality include laws preventing abuse of the labor force, both physical and financial.

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<sup>38</sup> Some countries are active on both sides of offshoring activities at the same time, for instance Australia.

Offshoring brings competitiveness to a global scale, with implications for both employers and employees in developed and developing world. Thus, policies encouraging competitiveness ensure that the country participates to the global value chain on the long-term.

Policymakers in both home and recipient countries need to follow developments in global offshoring, as they contribute to transmitting shocks between countries, interest rates movements and inflation changes, and result in changes in volatility, and the transmission of crises.

# APPENDIX A

## 1. Mathematical Derivation of the Model

### 1.1 Offshoring Sector

In this section, I derive equations present in section 2.2.2 of the thesis, and extend some of the concepts.

#### Discrete case

Dornbush, Firsher and Samuelson (1977) consider the case of a Ricardian model of trade between two countries with many commodities. For a start, I first examine the discrete case. Two countries, home and foreign, engage in trade. Technology is quantified by the number of workers required to produce one unit of commodity  $z$  in country  $i$ , as unit labor requirement  $a_z^i$ . We can order the  $Z$  goods  $z \in [1, 2, \dots, Z]$  according to the foreign country comparative advantage, which decreases as  $z$  increases, so that

$$\frac{a_1^*}{a_1} \leq \frac{a_2^*}{a_2} \leq \dots \leq \frac{a_z^*}{a_z} \quad (\text{A1.1})$$

Let  $\omega$  be the home wage relative to the foreign wage.

$$\omega = \frac{w_t}{w_t^*} \quad (\text{A1.2})$$

The foreign country produces goods  $1, \dots, (z-1)$  and the home country produces goods  $(z+1), \dots, Z$ . Let good 1 a numeraire.

Therefore, for goods  $2, \dots, (z-1)$ , the price is equal to  $p_i = \frac{a_i^*}{a_2^*}$ . For goods  $(z+1), \dots, Z$ , the price is equal to  $p_{i-1} = \frac{a_{i-1}^*}{a_1}$ . Good  $c$  must satisfy  $\frac{a_{c-1}^*}{a_{c-1}} \leq \omega \leq \frac{a_c^*}{a_c}$  for the foreign country to produce it.

### Continuous case

It is simpler to think about the continuous case. In section 2.2.2, I assume that in the multinational sector there is a continuum of goods  $z \in [0, 1]$  and that there is an offshoring cutoff at  $A(z_t') = \frac{W_t^*}{W_t}$ .

We know that the foreign country  $F$  will produce goods for which the unit cost is lowest. Hence, good  $z$  will be produced by foreign country  $F$ , if  $a_{Ft}^*(z)W_t^* \leq a_{Ht}(z)W_t$ , dividing by  $a_{Ft}^*(z)W_t^*$ , we get,

$$1 \leq \frac{a_{Ht}}{a_{Ft}^*} \frac{W_t}{W_t^*} \quad (\text{A1.3})$$

Define  $A(z_t)$  as  $\frac{a_{Ht}}{a_{Ft}^*} = A(z_t)$ , and the wages ratio  $\tilde{\omega} = \frac{W_t^*}{W_t}$ . Then

$$1 \leq A(z_t) \frac{1}{\tilde{\omega}} \quad (\text{A1.4})$$

$$\tilde{\omega} \leq A(z_t) \quad (\text{A1.5})$$

The foreign country  $F$  will produce goods  $z \in [0, z_t']$  whereas the home country  $H$  will produce goods  $z \in [z_t', 1]$ . These inputs are then combined into a final multinational good in sector  $M$ . So  $a_{Ht}(z_t')W_t = a_{Ft}^*(z_t')W_t^*$ ; dividing by  $a_{Ft}^*(z_t')W_t^*$ :

$$\frac{a_{Ht}(z_t')W_t}{a_{Ft}^*(z_t')W_t^*} = 1 \quad (\text{A1.6})$$

$$A(z_t') \frac{1}{\tilde{\omega}} = 1 \quad (\text{A1.7})$$

$A(z_t') = \tilde{\omega}$ : downward slopping supply schedule

The foreign country produces  $0 \leq z \leq z'_t(\tilde{\omega})$  and  $\tilde{\omega} = A(z)$ , so:

$$z'_t = A^{-1}(\tilde{\omega}) \quad (\text{A1.8})$$

$z'_t$  is decreasing in  $\tilde{\omega}$ , which means that it responds to changes in wages in both countries. Raising wages (booming demand) in the home country  $H$  will encourage offshoring, because labor becomes too expensive, thus shifting  $z'_t(\tilde{\omega})$  on Figure A1 to the left. A negative productivity shock will result in the reverse (in-sourcing) effect, shifting  $z'_t(\tilde{\omega})$  to the right.

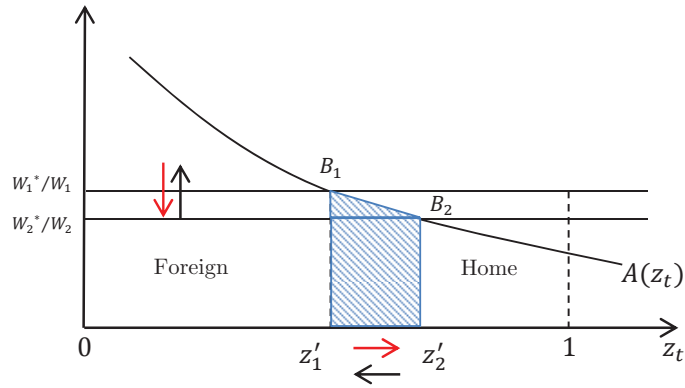


Figure A1. Movements in the offshoring cutoff due to changes in the relative wages.

## Demand

The overall demand in the multinational sector in the home country  $D_{Mt}$  is specified as the aggregate of the demands for all products  $z$ .

$$D_{Mt} = \int_0^1 d_{Mt}(z) dz \quad (\text{A1.9})$$

where  $d_{Mt}(z)$  denotes the demand for product  $z$ . The demand in the multinational sector of the foreign country is

$$D_{Mt}^* = \left( \frac{1-n}{n} \right) \int_0^1 d_{Mt}^*(z) dz \quad (\text{A1.10})$$



After integrating, the total demand for the multinational good  $\tilde{D}_{Mt}$  is equal to:

$$\tilde{D}_{Mt} \equiv \left[ D_{Mt} + D_{Mt}^* \left( \frac{1-n}{n} \right) \right] \quad (\text{A1.11})$$

## Labor

I obtain the total labor demand in the domestic multinational sector  $\tilde{L}_{Mt}$  by integrating over the fixed cost  $B_t$  and the variable labor input requirement for  $z \in [z'_t, 1]$ :

$$\tilde{L}_{Mt} = \int_{z'_t}^1 B dz + \int_{z'_t}^1 a_{Mt}(z) y_t(z) dz \quad (\text{A1.12})$$

where  $\tilde{L}_{Mt}$  is the total labor endowment in the home offshoring sector,  $a_{Mt}$  is the unit labor requirement to produce  $z$ , and  $y_t(z)$  represents the output of good  $z$  per firm.

The home country managerial labor demand  $L_{Bt}$ , which depends on the fixed cost  $B_t$  and only changes with the level of offshoring, can be obtained from the first integral:

$$L_{Bt} = \int_{z'_t}^1 B dz = B - B z'_t \quad (\text{A1.13})$$

$$L_{Bt} = B(1 - z'_t) \quad (\text{A1.14})$$

The second integral of (A1.12) yields the *home country labor demand in the multinational sector*,  $L_{Mt}$ :

$$L_{Mt} = \int_{z'_t}^1 a_{Mt}(z) y_t(z) dz \quad (\text{A1.15})$$

where consumption  $C = a(z)y(z)W$ ;  $C = WL$ , with the labor demand  $L = a(z)y(z)$ .

Profit maximization under the monopolistic competition implies that pricing is determined by the standard cost markup rule  $p_{it} = \frac{\sigma}{\sigma-1} \frac{W_{it}}{a_{it}}$ , where  $\frac{\sigma}{\sigma-1}$  is the markup factor,  $W_{it}$  is the wage and  $a_{it}$  represents the unit labor requirement. Furthermore, as  $y_t = C_{Mt} + C_{Mt}^* \left( \frac{1-n}{n} \right)$  and  $p_{it} = a_{it} W_{it}$ , we multiply the integral by  $\frac{\sigma}{\sigma-1} W_{it}$  to get the expenditure. The elasticity of

substitution  $\sigma$  is assumed to be 1. Therefore, the labor demand in the multinational sector in the home country can be written as:

$$\frac{\sigma}{\sigma-1} W_t L_{Mt} = \int_{z'_t}^1 C_{Mt} + C_{Mt}^* \left( \frac{1-n}{n} \right) dz \quad (\text{A1.16})$$

$$L_{Mt} = \int_{z'_t}^1 \left( \frac{C_{Mt} + C_{Mt}^* \left( \frac{1-n}{n} \right)}{W_t} \right) dz \quad (\text{A1.17})$$

and after integrating:

$$L_{Mt} = \frac{D_{Mt} + D_{Mt}^* \left( \frac{1-n}{n} \right)}{W_t} (1 - z'_t) \quad (\text{A1.18})$$

Equivalently, the total foreign country labor demand in the multinational sector  $\tilde{L}_{Mt}^*$  is:

$$\tilde{L}_{Mt}^* = \int_0^{z'_t} B^* dz + \int_0^{z'_t} a_{Mt}^*(z) y_t^*(z) dz \quad (\text{A1.19})$$

The foreign country fixed cost labor demand  $L_{Bt}^*$  is obtained from the first integral of (A1.19).

$$L_{Bt}^* = \int_0^{z'_t} B^* dz \quad (\text{A1.20})$$

$$L_{Bt}^* = B^* z'_t \quad (\text{A1.21})$$

And the foreign country labor demand in the multinational sector,  $L_{Mt}^*$ :

$$\frac{\sigma}{\sigma-1} W_t^* L_{Mt}^* = \int_0^{z'_t} C_{Mt} + C_{Mt}^* \left( \frac{1-n}{n} \right) dz \quad (\text{A1.22})$$

$$L_{Mt}^* = \int_0^{z'_t} \left( \frac{C_{Mt} + C_{Mt}^* \left( \frac{1-n}{n} \right)}{W_t^*} \right) dz \quad (\text{A1.23})$$

After integrating:

$$\left(\frac{1-n}{n}\right)L_{Mt}^* = \frac{D_{Mt} + D_{Mt}^* \left(\frac{1-n}{n}\right)}{W_t^*} z_t' \quad (\text{A1.24})$$

Alternatively, we can obtain the *variable cost labor* from the total demand assumption.

The total demand for the multinational good, denoted by  $\tilde{D}_{Mt}$ , is specified in (A1.11).

The earnings from labor in the home country  $H$  from activities  $z_t$ , such that  $z_t' \leq z_t \leq 1$ , are equal to  $W_t L_{Mt} = \tilde{D}_{Mt}(1 - z_t')$ . Dividing by  $W_t$ , the labor demand in the offshoring sector is equal to:

$$L_{Mt} = \frac{\tilde{D}_{Mt}(1 - z_t')}{W_t} \quad (\text{A1.25})$$

The earnings from labor in the foreign country  $F$  from activities  $z_t$ , such that  $0 \leq z_t \leq z_t'$ , are equal to  $\frac{1-n}{n} W_t^* L_{Mt}^* = \tilde{D}_{Mt} z_t'$ . Multiplying by the scaling factor  $\frac{n}{1-n}$ , we get  $W_t^* L_{Mt}^* = \tilde{D}_{Mt} z_t' \left(\frac{n}{1-n}\right)$ . After dividing by  $W_t^*$ , the employment demand in the multinational sector in the foreign country  $F$  equals to:

$$L_{Mt}^* = \frac{\tilde{D}_{Mt}}{W_t^*} z_t' \left(\frac{n}{1-n}\right) \quad (\text{A1.26})$$

We can obtain the *variable cost labor* at home by substituting in (A1.25) the total demand in the multinational sector  $\tilde{D}_{Mt} \equiv \left[D_{Mt} + D_{Mt}^* \left(\frac{1-n}{n}\right)\right]$ :

$$L_{Mt} = \frac{\left(D_{Mt} + D_{Mt}^* \left(\frac{1-n}{n}\right)\right)}{W_t} (1 - z_t') \quad (\text{A1.27})$$

Expanding  $\tilde{D}_{Mt}$  into (A1.26), we get the variable cost labor abroad:

$$L_{Mt}^* = \frac{\left(D_{Mt} + D_{Mt}^* \left(\frac{1-n}{n}\right)\right)}{W_t^*} z_t' \left(\frac{n}{1-n}\right) \quad (\text{A1.28})$$

## Prices

The price index of multinational goods  $P_{Mt}$  is calculated by integrating the relative unit cost at home and abroad over the offshoring cutoff range:

$$\begin{aligned}
P_{Mt} &= \int_0^{z'_t} W_t^* a_{Mt}^*(z_t) dz + \int_{z'_t}^1 W_t a_{Mt}(z_t) dz \\
P_{Mt} &= \int_0^{z'_t} W_t^* \frac{T^*}{(1-z)^{\frac{1}{\theta}}} dz + \int_{z'_t}^1 W_t \frac{T}{(z)^{\frac{1}{\theta}}} dz = \\
&= W_t^* T^* \int_0^{z'_t} (1-z)^{-\frac{1}{\theta}} dz + W_t T \int_{z'_t}^1 z^{-\frac{1}{\theta}} dz = \\
&= W_t^* T^* \frac{(1-z)^{1-\frac{1}{\theta}}}{\frac{1}{\theta}-1} \Big|_0^{z'_t} + W_t T \left( \frac{z^{1-\frac{1}{\theta}}}{1-\frac{1}{\theta}} \right) \Big|_{z'_t}^1
\end{aligned} \tag{A1.29}$$

which implies

$$P_{Mt} = T^* W_t^* \frac{\theta}{\theta-1} \left[ 1 - (1-z'_t)^{\frac{\theta-1}{\theta}} \right] + T W_t \frac{\theta}{\theta-1} \left[ 1 - (z'_t)^{\frac{\theta-1}{\theta}} \right] \tag{A1.30}$$

## 1.2 Households

The objective of a household is to maximize the instantaneous utility function  $U_t$  which is determined by the utility from consumption and the disutility from labor:

$$U_t = U(C_t) - U(L_t) \tag{A1.31}$$

$$U(C_t) = \frac{1}{1-\phi} C_t^{1-\phi} \quad \phi > 0 \tag{A1.32}$$

$$U(L_t) = \frac{1}{1+\mu} L_t^{1+\mu} \quad \mu > 0 \tag{A1.33}$$

$$U_t = \frac{1}{1-\phi} C_t^{1-\phi} - \frac{1}{1+\mu} L_t^{1+\mu} \quad (\text{A1.34})$$

where consumption  $C_t$  is a composite of three types of goods consumption, and  $L_t$  denotes overall labor. Consumption in the multinational sector is represented by  $C_{Mt}$ , while consumption of country specific goods are denoted as  $C_{Ht}$  and  $C_{Ft}$ .

The household consumption maximization problem, subject to the expenditure constraint, is formulated as:

$$\max C_t(C_{Mt}, C_{Ht}, C_{Ft}) = \left[ \omega^{\frac{1}{\chi}} \left( \left( \alpha^{\frac{1}{\eta}} C_{Mt}^{\frac{\eta-1}{\eta}} + (1-\alpha)^{\frac{1}{\eta}} (C_{Ht})^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}} \right)^{\frac{\chi-1}{\chi}} + (1-\omega)^{\frac{1}{\chi}} (C_{Ft})^{\frac{\chi-1}{\chi}} \right]^{\frac{\chi}{\chi-1}} \quad (\text{A1.35})$$

$$s.t. \quad P_t C_t = C_{Mt} P_{Mt} + C_{Ht} P_{Ht} + C_{Ft} P_{Ft} \quad (\text{A1.36})$$

The Lagrangian equation indicates that:

$$\mathcal{L}_t = C_t + \lambda_t (P_t C_t - C_{Mt} P_{Mt} - C_{Ht} P_{Ht} - C_{Ft} P_{Ft}) \quad (\text{A1.37})$$

$$\mathcal{L}_t = \left[ \omega^{\frac{1}{\chi}} \left( \left( \alpha^{\frac{1}{\eta}} C_{Mt}^{\frac{\eta-1}{\eta}} + (1-\alpha)^{\frac{1}{\eta}} (C_{Ht})^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}} \right)^{\frac{\chi-1}{\chi}} + (1-\omega)^{\frac{1}{\chi}} (C_{Ft})^{\frac{\chi-1}{\chi}} \right]^{\frac{\chi}{\chi-1}} + \lambda_t (P_t C_t - C_{Mt} P_{Mt} - C_{Ht} P_{Ht} - C_{Ft} P_{Ft}) \quad (\text{A1.38})$$

The first order conditions:

$$\frac{\partial \mathcal{L}_t}{\partial C_{Mt}} = \frac{\partial U_t}{\partial C_{Mt}} - \lambda_t P_{Mt} = 0 \quad (\text{A1.39})$$

$$\frac{\partial \mathcal{L}_t}{\partial C_{Ht}} = \frac{\partial U_t}{\partial C_{Ht}} - \lambda_t P_{Ht} = 0 \quad (\text{A1.40})$$

$$\frac{\partial \mathcal{L}_t}{\partial C_{Ft}} = \frac{\partial U_t}{\partial C_{Ft}} - \lambda_t P_{Ft} = 0 \quad (\text{A1.41})$$

$$\frac{\partial \mathcal{L}_t}{\partial \lambda_t} = P_t C_t - C_{Mt} P_{Mt} - C_{Ht} P_{Ht} - C_{Ft} P_{Ft} = 0 \quad (\text{A1.42})$$

After transformations, the first order conditions yield the optimal allocation between home, foreign and multinational goods:

$$C_{Ht} = (1 - \alpha)\omega \left(\frac{P_{Ht}}{P_t}\right)^{-\eta} C_t \quad (\text{A1.43})$$

$$C_{Ft} = (1 - \omega) \left(\frac{P_{Ft}}{P_t}\right)^{-\chi} C_t \quad (\text{A1.44})$$

$$C_{Mt} = \alpha\omega \left(\frac{P_{Mt}}{P_t}\right)^{-\eta} C_t \quad (\text{A1.45})$$

I assume that the elasticity of substitution between home and foreign goods  $\chi = 1$ , and that the elasticity of substitution between country specific and multinational goods  $\eta = 1$ . The demand allocations further simplify to:

$$C_{Ht} = (1 - \alpha)\omega \left(\frac{P_t}{P_{Ht}}\right) C_t \quad (\text{A1.46})$$

$$C_{Ft} = (1 - \omega) \left(\frac{P_t}{P_{Ft}}\right) C_t \quad (\text{A1.47})$$

$$C_{Mt} = \alpha\omega \left(\frac{P_t}{P_{Mt}}\right) C_t \quad (\text{A1.48})$$

A household also seeks optimal intertemporal allocation across time. It maximizes the expected discounted sum of utilities over feasible paths of consumption and work.

Define the value function at time  $t$  as:

$$\max_{\{C_t, L_t\}} V_t = \sum_{t=0}^{\infty} \beta^t U_t = \sum_{t=0}^{\infty} \beta^t [U(C_t) - u(L_t)] \quad (\text{A1.49})$$

$$U_t = U(C_t, L_t), \quad 0 < \beta < 1, \quad u'_t > 0 \text{ and } u''_t \leq 0$$

subject to the households' budget constraint at period  $t$  following BHF(2011):

$$P_t C_t + \sum_{s^{t+1}} Q(s^{t+1}|s^t) b(s^{t+1}) = W_t L_t + b_t - Tax_t \quad (\text{A1.50})$$

where  $P_t$  is the composite price of home, foreign and multinational goods,  $b$  is a numeraire good (identical across countries) purchased at  $s^{t+1}$  by the consumers, and  $Q$  denotes the price of one numeraire good in units of  $s^t$  state.

I form the Lagrangian  $\mathcal{L}_t$ :

$$\mathcal{L}_t = \sum_{t=0}^{\infty} \beta^t [U(C_t) - U(L_t)] - \lambda_t [P_t C_t + \sum_{s^{t-1}} Q(s^{t+1}|s^t) b(s^{t+1}) - W_t L_t - b_t + Tax_t] \quad (\text{A1.51})$$

There are the following first order conditions:

$$\frac{\partial \mathcal{L}_t}{\partial C_t} = \beta U'(C_t) - \lambda_t P_t = 0 \Rightarrow \lambda_t = \frac{\beta C_t^{-\emptyset}}{P_t} \quad (\text{A1.52})$$

knowing that  $U'(C_t) = \left(\frac{1}{1-\emptyset} C_t^{1-\emptyset}\right)' = C_t^{1-\emptyset}$ . Therefore  $\beta C_t^{-\emptyset} = \lambda_t P_t$  and  $(C_t^*)^{-\emptyset} = \lambda_t P_t^*$ . Through

this dual expression of  $\lambda_t$ , I obtain  $\frac{\beta C_t^{-\emptyset}}{P_t} = \frac{\beta (C_t^*)^{-\emptyset}}{P_t^*}$ . By rearranging the terms, we get the risk

sharing condition, where  $\xi$  is a constant I get  $\frac{P_t^{-1} C_t^{-\emptyset}}{(P_t^*)^{-1} (C_t^*)^{-\emptyset}} = \xi^{-1}$  or:

$$\frac{P_t C_t^{\emptyset}}{(P_t^*) (C_t^*)^{\emptyset}} = \xi \quad (\text{A1.53})$$

$$\frac{\partial \mathcal{L}_t}{\partial L_t} = -\beta U'(L_t) - \lambda_t W_t = 0 \quad (\text{A1.54})$$

It follows that  $U'(L_t) = \left(-\frac{1}{1+\mu} L_t^{1+\mu}\right)' = -L_t^{\mu}$  and  $-\beta(-L_t^{\mu}) - \lambda_t W_t = 0$ . Substituting  $\lambda_t$

from  $\frac{\partial \mathcal{L}_t}{\partial C_t}$ , I get  $\beta L_t^{\mu} - \frac{\beta C_t^{-\emptyset}}{P_t} W_t = 0$  which implies:

$$L_t^{\mu} = \frac{W_t}{P_t} C_t^{-\emptyset} \quad (\text{A1.55})$$

The intertemporal Lagrangian (Bellman equation):

$$\mathcal{L}_t = E_t \sum_{j=0}^{\infty} \beta^j \left[ \left( \frac{1}{1-\emptyset} C_t^{1-\emptyset} - \frac{1}{1+\mu} L_t^{1+\mu} \right) - \lambda_{t+j} (P_{t+j} C_{t+j} + E_{t+j} b_{t+1+j} - W_{t+j} L_{t+j} - Q_{t+j} b_{t+j} - Tax_{t+j}) \right] \quad (\text{A1.56})$$

where  $b_t$  – purchase of one period bonds at price  $Q_t$ . Financial assets yield a gross nominal

return of  $R_t = Q_t^{-1}$ , where  $Q_t = (1 + i_t)$ .

First order condition with respect to  $b_{t+1}$ :

$$\frac{\partial \mathcal{L}_t}{\partial b_{t+1}} = \lambda_t Q_t - \beta E_t \lambda_{t+1} = 0 \quad (\text{A1.57})$$

The Euler consumption equation is  $Q_t = \beta E_t = \left\{ \left( \frac{C_{t+1}}{C_t} \right)^{-\emptyset} \frac{P_t}{P_{t+1}} \right\}$ .

Therefore  $\beta E_t \left( \frac{C_{t+1}}{C_t} \right)^{-\emptyset} = R_t E_t \left( \frac{P_{t+1}}{P_t} \right)$ , and:

$$\beta E_t \left( \frac{C_{t+1}}{C_t} \right)^{-\emptyset} = \frac{1}{1 + i_{t+1}} E_t \left( \frac{P_{t+1}}{P_t} \right) \quad (\text{A1.58})$$

### 1.3 Firms

The country-specific sector is perfectly competitive. The home country production function for the homogenous good is defined as:

$$Y_{Ht} = \frac{L_{Ht}}{a_{Ht}} \quad (\text{A1.59})$$

where  $L_{Ht}$  - labor in the country  $H$  specific sector, and  $a_{Ht}$  - unit labor requirement.  $p_{Ht} = \frac{P_{Ht}}{P_{Mt}}$  is the relative price between the home and multinational goods. For a perfectly competitive firm, the zero profit condition  $\tilde{\pi}_{Ht} = 0$ , where  $\tilde{\pi}$  denotes profit, implies:

$$Y_{Ht} p_{Ht} = W_t L_{Ht} \quad (\text{A1.60})$$

Substituting  $Y_{Ht}$  using  $\frac{L_{Ht}}{a_{Ht}} p_{Ht} = W_t L_{Ht}$  yields  $\frac{p_{Ht}}{a_{Ht}} - W_t = 0$ , which implies that wages are equal to  $W_t = \frac{p_{Ht}}{a_{Ht}}$ , or:

$$W_t = \frac{P_{Ht}}{P_{Mt} a_{Ht}} \quad (\text{A1.61})$$

Equivalent calculations apply to the foreign country.



## 2. Collecting First Order and Other Conditions

For clarity, I list all conditions describing endogenous variables in the model. The conditions are numbered from 1 to 30 following the ordered list of equations of the model.

After some transformations, I have 30 endogenous variables:  $L_t, L_t^*, L_{Ht}, L_{Ft}^*, L_{Mt}, L_{Mt}^*, W_t, W_t^*, C_{Ht}, C_{Ht}^*, C_{Ft}, C_{Ft}^*, C_{Mt}, C_{Mt}^*, P_{Ht}, P_{Ft}, P_{Mt}, z_t', i_t, P_t, P_t^*, C_t, C_t^*, r_t, \pi_t$ , and additionally  $Y_{Ht}, Y_{Ft}^*, L_{Bt}, L_{Bt}^*, Y_{Mt}$  to close the model. They are described by 30 necessary conditions.

Labor-supply conditions:

$$L_t = \left( \frac{W_t}{P_t} (C_t^{-\phi}) \right)^{\frac{1}{\mu}} \quad (1)$$

$$L_t^* = \left( \frac{W_t^*}{P_t^*} (C_t^{*-\phi}) \right)^{\frac{1}{\mu}} \quad (2)$$

Demand for the multinational good in the home and foreign countries:

$$C_{Mt} = \alpha \omega \left( \frac{P_t}{P_{Mt}} \right) C_t \quad (3)$$

$$C_{Mt}^* = \alpha \omega^* \left( \frac{P_t^*}{P_{Mt}^*} \right) C_t^* \quad (4)$$

Demand for the home country-specific good:

$$C_{Ht} = (1 - \alpha) \omega \left( \frac{P_t}{P_{Ht}} \right) C_t \quad (5)$$

$$C_{Ht}^* = (1 - \alpha) \omega^* \left( \frac{P_t^*}{P_{Ht}^*} \right) C_t^* \quad (6)$$

Demand for the foreign country-specific good:

$$C_{Ft} = (1 - \omega) \left( \frac{P_t}{P_{Ft}} \right) C_t \quad (7)$$

$$C_{Ft}^* = (1 - \omega^*) \left( \frac{P_t^*}{P_{Ft}^*} \right) C_t^* \quad (8)$$

The labor demand in the country specific sector comes directly from the definition of the production function (2.30). Given a single factor of production, the labor demand is directly implied as a function of output by the production function. The labor demands for the country-specific sector are as in BHF (2011):

$$L_{Ht} = a_{Ht} \left( C_{Ht} + (1 - \alpha) \omega_G \left( \frac{P_t}{P_{Ht}} \right) G_t + \left( \frac{1-n}{n} \right) C_{Ht}^* \right) \quad (9)$$

$$L_{Ft}^* = a_{Ft}^* \left( C_{Ft} + \left( \frac{1-n}{n} \right) \left( C_{Ft}^* + \omega_G^* \left( \frac{P_t^*}{P_{Ft}^*} \right) G_t^* \right) \right) \quad (10)$$

Labor demand for the multinational sector:

$$L_{Mt} = \frac{C_{Mt} + \alpha \omega_G \left( \frac{P_t}{P_{Mt}} \right) G_t + C_{Mt}^* \left( \frac{1-n}{n} \right)}{W_t} (1 - z_t') \quad (11)$$

$$L_{Mt}^* = \frac{C_{Mt} + \alpha \omega_G \left( \frac{P_t}{P_{Mt}} \right) G_t + C_{Mt}^* \left( \frac{1-n}{n} \right)}{W_t^*} (z_t') \left( \frac{n}{1-n} \right) \quad (12)$$

Offshoring condition:

$$\frac{W_t^*}{W_t} = \left( \frac{T}{T^*} \right) \left( \frac{1-z_t'}{z_t'} \right)^{\frac{1}{\theta}} \quad (13)$$

Risk-sharing condition:

$$\frac{P_t C_t^\emptyset}{P_t^* C_t^{*\emptyset}} = \xi \quad (14)$$

Wages:

$$W_t = \frac{P_{Ht}}{P_{Mt} a_{Ht}} \quad (15)$$

$$W_t^* = \frac{P_{Ft}}{P_{Mt} a_{Ft}^*} \quad (16)$$

The Euler consumption equation:

$$\beta E_t \left( \frac{C_{t+1}}{C_t} \right)^{-\emptyset} = \frac{1}{1+i_{t+1}} E_t \left( \frac{P_{t+1}}{P_t} \right) \quad (17)$$

Composite home and foreign country consumptions in all sectors:

$$C_t = (C_{Mt}^\alpha C_{Ht}^{1-\alpha})^\omega C_{Ft}^{1-\omega} \quad (18)$$

$$C_t^* = (C_{Mt}^{*\alpha} C_{Ht}^{*1-\alpha})^{\omega^*} C_{Ft}^{*1-\omega^*} \quad (19)$$

Composite home and foreign country prices in all sectors:

$$P_t = (P_{Mt}^\alpha P_{Ht}^{1-\alpha})^\omega P_{Ft}^{1-\omega} \quad (20)$$

$$P_t^* = (P_{Mt}^{*\alpha} P_{Ht}^{*1-\alpha})^{\omega^*} P_{Ft}^{*1-\omega^*} \quad (21)$$

Prices in the multinational sector:

$$P_{Mt} = T^* W_t^* \frac{\theta}{\theta-1} \left[ 1 - (1 - z_t')^{\frac{\theta-1}{\theta}} \right] + T W_t \frac{\theta}{\theta-1} \left[ 1 - (z_t')^{\frac{\theta-1}{\theta}} \right] \quad (22)$$

Closing the model in the multinational sector:

$$\frac{\frac{L_{Mt}}{T}}{(z'_t)^{\frac{1}{\theta}}} + \left(\frac{1-n}{n}\right) \frac{\frac{L_{Mt}^*}{T^*}}{(1-z'_t)^{\frac{1}{\theta}}} = C_{Mt} + \alpha \omega_G \left(\frac{P_t}{P_{Mt}}\right) G_t + \left(\frac{1-n}{n}\right) C_{Mt}^* \quad (23)$$

Real interest rate:

$$r_t = i_t - \frac{P_{t+1}}{P_t} \quad (24)$$

Inflation:

$$\pi_t = \frac{P_{t+1}}{P_t} \quad (25)$$

Closing the model with the market clearing conditions for labor and output:

$$L_t = L_{Ht} + L_{Mt} + L_{Bt} \quad (26)$$

$$L_t^* = L_{Ft}^* + L_{Mt}^* + L_{Bt}^* \quad (27)$$

$$Y_{Ht} = C_{Ht} + (1 - \alpha) \omega_G \left(\frac{P_t}{P_{Ht}}\right) G_t + \left(\frac{1-n}{n}\right) C_{Ht}^* \quad (28)$$

$$Y_{Ft}^* = C_{Ft} + \left(\frac{1-n}{n}\right) \left(C_{Ft}^* + \omega_G^* \left(\frac{P_t^*}{P_{Ft}}\right) G_t^*\right) \quad (29)$$

Output in the multinational sector:

$$Y_{Mt} = C_{Mt} + \alpha \omega_G \left(\frac{P_t}{P_{Mt}}\right) G_t + \left(\frac{1-n}{n}\right) C_{Mt}^* \quad (30)$$

In Table A1, I summarize the meaning of each variable of the model.

Table A1. Variables description.

Variables	Variables descriptions
$L_t$	Total labor supply at home
$L_t^*$	Total labor supply abroad (*)
$C_{Mt}$	Consumption in the multinational (M) sector at home
$C_{Mt}^*$	Consumption in the multinational (M) sector abroad (*)
$C_{Ht}$	Consumption of home (H) produced homogenous good in the domestic market
$C_{Ht}^*$	Consumption of home (H) produced homogenous good in the foreign market (*)
$C_{Ft}$	Consumption of foreign (F) produced homogenous good in the domestic market
$C_{Ft}^*$	Consumption of foreign (F) produced homogenous good in the foreign market (*)
$L_{Ht}$	Labor demand at home in the homogenous good sector at home (H)
$L_{Ft}^*$	Labor demand abroad (*) in the homogenous good sector abroad (F)
$L_{Mt}$	Labor demand at home in the multinational (M) good sector
$L_{Mt}^*$	Labor demand abroad (*) in the multinational (M) good sector
$W_t$	Wage rate at home
$W_t^*$	Wage rate abroad (*)
$C_t$	Total consumption of homogenous and multinational goods at home
$C_t^*$	Total consumption of homogenous and multinational goods abroad (*)
$P_t$	Total composite price index at home
$P_t^*$	Total composite price index abroad (*)
$P_{Ht}$	Domestic (H) price index in homogenous goods sector
$P_{Ft}$	Foreign (F) price index in homogenous goods sector
$P_{Mt}$	Price index for multinational (M) good sector
$z_t'$	Offshoring margin
$L_{Bt}$	Fixed cost labor demand at home
$L_{Bt}^*$	Fixed cost labor demand abroad
$Y_{Ht}$	Output of the home (H) economy
$Y_{Ft}^*$	Output of the foreign (F) economy
$Y_{Mt}$	Output of the multinational (M) sector
$i_t$	Interest rate
$r_t$	Real interest rate
$\pi_t$	Inflation rate
$a_{Ht}$	Domestic productivity
$a_{Ft}^*$	Foreign productivity
$G_t$	Domestic government demand
$G_t^*$	Foreign government demand

### 3. Mathematical Derivation of the Necessary Conditions

This section presents the derivation of the first order and other conditions listed in section 2 of this Appendix.

The auxiliary equations are as follows:

Demands are defined as:

$$D_{Ht} = C_{Ht} + G_{Ht} \quad (\text{A2.1})$$

$$D_{Ft}^* = C_{Ft}^* + G_{Ft}^* \quad (\text{A2.2})$$

$$D_{Mt} = C_{Mt} + G_{Mt} \quad (\text{A2.3})$$

$$D_{Ht}^* = C_{Ht}^* \quad (\text{A2.4})$$

$$D_{Ft} = C_{Ft} \quad (\text{A2.5})$$

$$D_{Mt}^* = C_{Mt}^* \quad (\text{A2.6})$$

Exogenous government:

$$G_{Ht} = (1 - \alpha)\omega_G \left( \frac{P_t}{P_{Ht}} \right) G_t \quad (\text{A2.7})$$

$$G_{Mt} = \alpha\omega_G \left( \frac{P_t}{P_{Mt}} \right) G_t \quad (\text{A2.8})$$

$$G_{Ft}^* = \omega_G^* \left( \frac{P_t^*}{P_{Ft}^*} \right) G_t^* \quad (\text{A2.9})$$

The market clearing conditions for the country-specific and multinational sectors:

$$D_{Ht} + \left( \frac{1-n}{n} \right) D_{Ht}^* = Y_{Ht} \quad (\text{A2.10})$$

$$D_{Ft} + \left( \frac{1-n}{n} \right) D_{Ft}^* = Y_{Ft}^* \quad (\text{A2.11})$$

$$D_{Mt} + \left(\frac{1-n}{n}\right) D_{Mt}^* = Y_{Mt}^* \quad (\text{A2.12})$$

The condition (1) for labor demand at home  $L_t$ , and (2) for labor demand abroad  $L_t^*$  are derived from condition (2.26).

The derivation of all conditions (3)-(8) for the multinational  $(C_{Mt}, C_{Mt}^*)$ , home  $(C_{Ht}, C_{Ht}^*)$ , and foreign  $(C_{Ft}, C_{Ft}^*)$  demands, domestic and foreign, is shown in section 1.2 of Appendix A.

Substituting (A2.1), (A2.4) and (A2.7) in (A2.10) I get (A2.13):

$$Y_{Ht} = C_{Ht} + (1 - \alpha)\omega_G \left(\frac{P_t}{P_{Ht}}\right) G_t + \left(\frac{1-n}{n}\right) C_{Ht}^* \quad (\text{A2.13})$$

and plugging it into (2.30), I get the condition (9) for domestic labor demand  $L_{Ht}$  in the country specific sector.

Similarly, by combining (A2.11) with (A2.2), (A2.5) and (A2.9), I get (A2.14):

$$Y_{Ft}^* = C_{Ft} + \left(\frac{1-n}{n}\right) \left(C_{Ft}^* + \omega_G^* \left(\frac{P_t^*}{P_{Ft}^*}\right) G_t^*\right) \quad (\text{A2.14})$$

and plugging it into foreign equivalent of condition (2.30)  $Y_{Ft}^* = \frac{L_{Ft}^*}{a_{Ft}^*}$ , I get the condition (10) for foreign labor demand  $L_{Ft}^*$  in the country specific sector.

I derive condition (11) for labor demand in the domestic multinational sector  $L_{Mt}$ , and condition (12) for labor demand in the foreign multinational sector  $L_{Mt}^*$  from equations (2.9) and (2.12), by combining them with (A2.3), (A2.6), and (A2.8).

The offshoring condition (13) is identical to equation (2.3).

The risk sharing condition (14) is identical to equation (2.25) and is derived in section 1.2 of Appendix A.

I get the domestic wage condition (15), from equation (2.31)  $W_t = \frac{P_{Ht}}{P_{Mt}a_{Ht}}$  derived in section 1.3 of Appendix A.

Similarly, I derive the foreign wage condition (16) from the foreign equivalent of equation (2.31).

The Euler consumption condition (17) is equivalent to equation (2.27) and is derived in part 1.2 of Appendix A.

Conditions (18) and (19) for the composite home and foreign country consumptions in all sectors are obtained from equation (2.15) by assuming that the elasticity of substitution between home and foreign goods  $\chi = 1$ , and that the elasticity of substitution between country specific and multinational goods  $\eta = 1$ . I use the same simplifying assumption with equation (2.16) to arrive at conditions (20) and (21) for the composite home and foreign prices in all sectors.

The price index in the multinational sectors of both countries  $P_{Mt}$ , expressed in condition (22), comes from the equation (2.5). It is derived in section 1.1 of Appendix A.

To derive condition (23), I combine the production function in the multinational sector (2.34) and the market clearing condition in the offshoring sector (2.43). I substitute equation (2.43) with (A2.3) and (A2.6), and plug it into equation (2.34).

Condition (24) for the real interest rate and condition (25) for inflation are defined in section 2.2.3 as equations (2.28) and (2.29).

The closing conditions (26) and (27) for labor are the same as equation (2.44) and its foreign equivalent.

The closing conditions (28) for  $Y_{Ht}$  and (29) for  $Y_{Ft}^*$  were derived earlier as (A2.13) and (A2.14).

To arrive at closing condition (30) in the multinational sector for  $Y_{Mt}$ , I combine equation (A2.12) with (A2.3), (A2.6) and (A2.8).



## 4. Solving the Model

### 4.1 Choice of Autocorrelation and Standard Deviation Parameters

In the standard real business cycle models, productivity shocks are large and persistent (Tesar 1991). They can be persistent due to innovation and learning effect. Government expenditure shock is expected to be less persistent due to limited resources, political variability, or because it is often directed towards consumption.

Setting persistence parameter of government spending to 0.9 is in line with existing literature. Gali et. al (2007) find that the autoregressive coefficient in the government spending process is 0.9. They find it consistent with US evidence, including the impulse response of government spending to its own shock. Gali (2007) further argues that setting the autoregressive coefficient for government spending to 0.9 guarantees an average government size, while an alternative calibration of low persistence would imply an increase in  $G/Y$  ratio, and consequently a large government. It is also possible that a crowding-in of consumption takes place, which is an increase in consumption in response to a rise in government spending. Gali et al. (2007) obtain a crowding-in effect for values of  $\rho_G$  below 0.7.

However, the government shock requires some additional thought as it also brings some important quantitative implications to the model. The government expenditure persistence parameter has, especially in models without capital, crucial output effects, affecting the government spending multiplier, and in turn the magnitude of overall results. The effect of government spending on the economy can simply be summarized by a multiplier: a change of output caused by a one unit increase in government spending.

Kamps (2005) discusses in details the dependency of multipliers on government shock persistence. Christiano et al. (2009) finds that the multiplier is a decreasing function of the persistence of government purchases,  $\rho_G$ . Lower persistence would imply stronger multiplier effect. For instance, Barro (1981) argues that the multiplier is around 0.8 while Ramey (2011) estimates that the multiplier is between 0.6 and 1.2. These differences largely originate from the use of alternative identifying assumptions to isolate exogenous changes in government spending, including its persistence. Higher persistence guarantees moderate effect on the multiplier.

I decided to set common persistence parameters and standard deviations for practical reasons. I normalize all shocks in the model to follow a first-order autoregressive process with persistence parameter of 0.9 and an i.i.d shock standard deviation of 0.1. This choice helps to avoid overcomplicating the analysis and allows easily comparing productivity shocks with government spending shocks. It is straightforward to see the effects of offshoring and compare with different model specifications. Even when normalizing all of the shocks to follow the same exogenous process, it is evident that the offshoring adjustment plays an important role in understanding of how shocks propagate through the economy. Also, differences in response of offshoring to productivity and demand shocks can be identified.

## 4.2 Resolution Method Concepts in *Dynare*

### **Log-linearization of the model**

Log-linearizing can be done manually using the algorithm described in Uhlig (1995, 1997). The idea of is to perform a change in variables, rewriting the model in logs of the level variables and applying a first-order Taylor expansion. The hat above a variable denotes the log deviation from the steady state following the rule  $\hat{x} = \ln x - \ln \bar{x}$  where  $\bar{x}$  is steady state of  $x$ .

Then,  $x = \bar{x}e^{\hat{x}}$ , which is approximately equal to the percentage deviation of  $x$  from  $\bar{x}$ . Hence, log-linearizing a model amounts to expressing each variable in deviation from the steady-state. As, by definition, deviation is zero at steady-state, the steady-state value of each variable  $\hat{x}$  is zero.

As *Dynare* can be instructed to take a first-order Taylor approximation of the model, I automate the process of log-linearization by taking the logarithm of all strictly positive variables ( $lx = \log(x)$ ), and using their exponential ( $e^{lx}$ ) in the model equations. This allows using the Taylor approximation generated by *Dynare*, and the linearization *Dynare* performs on the variables expressed as exponentials will amount to a log-linearization.

## Jacobian Matrix

The Jacobian matrix, which is matrix of partial derivatives of the model equations, is of central importance in the analysis of a DSGE model. The Jacobian *specifies the local dynamics* of the model. The entries in the matrix indicate the influence of model variables on the rates of change.

Jacobian matrix can be used for local approximate linearization of non-linear systems around a given steady state. As such, it allows the use of linear algebra concepts. Among those, the calculation of eigenvalues lets us judge the *stability of the model*. If the eigenvalues are negative, then the system is stable at the operating point, but if any eigenvalue is positive, then the point is unstable.

The Jacobian matrix can *reveal problems* that are a common cause of failures of DSGE models. It allows checking manually if each variable affects the dynamics of the solution of the model. Systematically calculating the Jacobian and applying known steady state values is a good practice to verify early in the design of the system if there is no division by 0 in any

derivative. Such problems prevent Dynare from proceeding with the stochastic simulation and need to be fixed. I used such techniques to iteratively design and evaluate the model before reaching a solution.

*Dynare* does not allow ‘force inverting’ a Jacobian Matrix, contrary to Uhlig’s Toolkit. It has to be correctly specified, which ensures more accurate simulation results.

### **Blanchard and Kahn conditions**

Having a stable model is not sufficient to guarantee the good solution. The solution of the rational expectations model has to be unique, a condition satisfied if the number of unstable eigenvectors of the system is exactly equal to the number of forward-looking, control variables.

If this condition necessary for *the uniqueness of a stable equilibrium* is not met, *Dynare* returns error that the Blanchard and Kahn (1980) conditions are not satisfied.

The Blanchard-Kahn conditions state that in order to have a unique stable trajectory, a saddle-path stable system with an unique solution, there need to be as many eigenvalues (roots) larger than one in modulus as there are forward looking variables (variables with leads). Therefore to find a stable solution the number of explosive eigenvalues must be equal to the number of forward looking variables. In addition, the output matrix from the computation of the solution must have full rank.

The Blanchard-Kahn method used by *Dynare* to solve the planer’s problem is similar to Uhlig’s (1995, 1997) method of undetermined coefficients. As both methods crucially depend on linearizing the equations that characterize the solution, they can be categorized as linearizing Euler equation methods. Moreover, both are *local methods*: the non-linear equations that characterize the solution of the model, are linearized around the steady state of the model and the approximation is only valid around that steady state. A good global method does not exist yet.

## 5. Collecting Steady State Equations

In this section, I summarize all steady state equations. The numbering corresponds to the section 2 of this Appendix.

The model at steady-state is subject to the following constrains:

$$\bar{L}^\mu \bar{P} = \bar{W} \bar{C}^{-\emptyset} \quad (1s)$$

$$\bar{L}^{*\mu} \bar{P}^* = \bar{W}^* \bar{C}^{*\emptyset} \quad (2s)$$

$$\bar{C}_M \bar{P}_M = \alpha \omega \bar{P} \bar{C} \quad (3s)$$

$$\bar{C}_M^* \bar{P}_M = \alpha \omega^* \bar{P}^* \bar{C}^* \quad (4s)$$

$$\bar{C}_H \bar{P}_H = (1 - \alpha) \omega \bar{P} \bar{C} \quad (5s)$$

$$\bar{C}_H^* \bar{P}_H = (1 - \alpha) \omega^* \bar{P}^* \bar{C}^* \quad (6s)$$

$$\bar{C}_F \bar{P}_F = (1 - \omega) \bar{P} \bar{C} \quad (7s)$$

$$\bar{C}_F^* \bar{P}_F = (1 - \omega^*) \bar{P}^* \bar{C}^* \quad (8s)$$

$$\bar{L}_H = \bar{a}_H \left( \bar{C}_H + (1 - \alpha) \omega_G \left( \frac{\bar{P}}{\bar{P}_H} \right) \bar{G} + \left( \frac{1-n}{n} \right) \bar{C}_H^* \right) \quad (9)$$

$$\bar{L}_F^* = \bar{a} \left( \bar{C}_F + \left( \frac{1-n}{n} \right) \left( \bar{C}_F^* + \omega_G^* \left( \frac{\bar{P}^*}{\bar{P}_F} \right) \bar{G}^* \right) \right) \quad (10)$$

$$\bar{P}_M \left( \bar{L}_M \bar{W} - (1 - \bar{z}') \left( \bar{C}_M + \bar{C}_M^* \left( \frac{1-n}{n} \right) \right) \right) = \alpha \omega_G \bar{G} \bar{P} (1 - \bar{z}') \quad (11s)$$

$$\bar{P}_M \left( \bar{L}_M^* \bar{W}^* - \bar{z}' \left( \frac{n}{1-n} \right) \left( \bar{C}_M + \bar{C}_M^* \left( \frac{1-n}{n} \right) \right) \right) = \left( \frac{n}{1-n} \right) \alpha \omega_G \bar{G} \bar{P} \bar{z}' \quad (12s)$$

$$\bar{W}^* T^* (\bar{z}')^{\frac{1}{\bar{\theta}}} = \bar{W} T (1 - \bar{z}')^{\frac{1}{\bar{\theta}}} \quad (13s)$$

$$\bar{P} \bar{C}^\emptyset = \bar{P}^* \bar{C}^{*\emptyset} \xi \quad (14s)$$

$$\bar{W} = \frac{\bar{P}_H}{\bar{P}_M \bar{a}_H} \quad (15s)$$

$$W^* = \frac{\bar{P}_F}{\bar{P}_M \bar{a}_F^*} \quad (16s)$$

$$\beta = \frac{1}{\bar{l}+1} \quad (17s)$$

$$\bar{C} = \left( \bar{C}_M^\alpha \bar{C}_H^{1-\alpha} \right)^\omega \bar{C}_F^{1-\omega} \quad (18s)$$

$$\bar{C}^* = \left( \bar{C}_M^*{}^\alpha \bar{C}_H^*{}^{1-\alpha} \right)^{\omega^*} \bar{C}_F^{*1-\omega^*} \quad (19s)$$

$$\bar{P} = \left( \bar{P}_M^\alpha \bar{P}_H^{1-\alpha} \right)^\omega \bar{P}_F^{1-\omega} \quad (20s)$$

$$\bar{P}^* = \left( \bar{P}_M^\alpha \bar{P}_H^{1-\alpha} \right)^{\omega^*} \bar{P}_F^{1-\omega^*} \quad (21s)$$

$$\bar{P}_M = T^* \bar{W}^* \frac{\theta}{\theta-1} \left[ 1 - (1 - \bar{z}')^{\frac{\theta-1}{\theta}} \right] + T \bar{W} \frac{\theta}{\theta-1} \left[ 1 - (\bar{z}')^{\frac{\theta-1}{\theta}} \right] \quad (22s)$$

$$\bar{P}_M \left( T^* \bar{L}_M \bar{z}'^{\frac{1}{\theta}} + T \frac{1-n}{n} \bar{L}_M^* (1 - \bar{z}')^{\frac{1}{\theta}} - T T^* \left( \bar{C}_M + \frac{1-n}{n} \bar{C}_M^* \right) \right) = \alpha \omega_G \bar{G} \bar{P} T T^* \quad (23s)$$

$$\bar{r} = \bar{t} - 1 \quad (24s)$$

$$\bar{\pi} = 1 \quad (25s)$$

$$\bar{L} = \bar{L}_M + \bar{L}_B + \bar{L}_H \quad (26s)$$

$$\bar{L}^* = \bar{L}_M^* + \bar{L}_B^* + \bar{L}_H^* \quad (27s)$$

$$\bar{Y}_H = \bar{C}_H + \frac{1-n}{n} \bar{C}_H^* + (1 - \alpha) \omega_G \bar{G} \frac{\bar{P}}{\bar{P}_H} \quad (28s)$$

$$\bar{Y}_{Ft}^* = \bar{C}_{Ft} + \frac{1-n}{n} \left( \bar{C}_F^* + \omega_G^* \bar{G}^* \frac{\bar{P}^*}{\bar{P}_F^*} \right) \quad (29s)$$

$$Y_M = C_M + \frac{1-n}{n} C_M^* + \alpha \omega_G \bar{G} \frac{\bar{P}}{\bar{P}_M} \quad (30s)$$

## 6. *Dynare* Implementation of the Model

```
1. diary off;
2. // DYNARE code for the basic theoretical model of 3 sectors with offshoring following (BFH 2011) by
   Joanna Gravier-Rymaszewska
3. // July 2012
4.
5. // I first declare the endogenous variables, the exogenous variables, and the parameters
6.
7. var lL lL_star lLh lLf_star lLm lLm_star lW lW_star lCh lCh_star lCf lCf_star lCm lCm_star lPh lPf lPm
   lz_prime li lC lC_star lP lP_star lG lG_star lah laf_star eah eaf_star eG eG_star lr lpi lLb lLb_star
   lYh lYf_star lYm;
8.
9. varexo eps_eG eps_eG_star eps_eah eps_eaf_star;
10.
11. parameters omega omega_star alpha mu phi n zeta theta t t_star betty omegag omegag_star rho_eah
   rho_eaf_star rho_eG rho_eG_star ah_bar af_star_bar G_bar G_star_bar;
12.
13. predetermined_variables li;
14.
15. //Load parameters and ss values from one file:
16.
17. load params.mat;
18.
19. omega=paramvec(1);
20. omega_star=paramvec(2);
21. alpha=paramvec(3);
22. mu=paramvec(4);
23. phi=paramvec(5);
24. n=paramvec(6);
25. zeta=paramvec(7);
26. t=paramvec(8);
27. betty=paramvec(9);
28. omegag=paramvec(10);
29. omegag_star=paramvec(11);
30. t_star=paramvec(12);
31. theta=paramvec(13);
32.
33.
34.
35. //assign rho's, how fast shocks disappear
36.
37. rho_eah=paramvec(14);
38. rho_eaf_star=paramvec(15);
39. rho_eG=paramvec(16);
40. rho_eG_star=paramvec(17);
41.
42.
43. // SS values of shocked variables
44.
45. ah_bar=paramvec(18);
46. af_star_bar=paramvec(19);
47. G_bar=paramvec(20);
48. G_star_bar=paramvec(21);
49.
50.
51.
52. //Initialize endogs from steady state:
53.
54. initval;
55.
56. lL=log(ssvec(1));
57. lL_star=log(ssvec(2));
58. lCm=log(ssvec(3));
59. lCm_star=log(ssvec(4));
60. lCh=log(ssvec(5));
61. lCh_star=log(ssvec(6));
62. lCf=log(ssvec(7));
63. lCf_star=log(ssvec(8));
64. lLh=log(ssvec(9));
65. lLf_star=log(ssvec(10));
66. lLm=log(ssvec(11));
67. lLm_star=log(ssvec(12));
68. lW=log(ssvec(13));
69. lW_star=log(ssvec(14));
70. lC=log(ssvec(15));
```

```

71. lC_star=log(ssvec(16));
72. lP=log(ssvec(17));
73. lP_star=log(ssvec(18));
74. lPh=log(ssvec(19));
75. lPf=log(ssvec(20));
76. lPm=log(ssvec(21));
77. lz_prime=log(ssvec(22));
78. lLb=log(ssvec(23));
79. lLb_star=log(ssvec(24));
80. lYh=log(ssvec(25));
81. lYf_star=log(ssvec(26));
82. lYm = log(ssvec(27));
83. li=log(ssvec(28));
84. lr=log(ssvec(29));
85. lpi=log(ssvec(30));
86. lah=log(ssvec(31));
87. laf_star=log(ssvec(32));
88. lG=log(ssvec(33));
89. lG_star=log(ssvec(34));
90.
91.
92. end;
93.
94.
95. model;          //After proposal defense   (July 14, 2012)
96.
97. (exp(lL)^mu)*exp(lP) = exp(lW)*(exp(lC))^(-phi);          //1
98. (exp(lL_star)^mu)*exp(lP_star) = exp(lW_star)*(exp(lC_star))^(-phi);          //2
99. exp(lCm)*exp(lPm) = alpha*omega*exp(lP)*exp(lC);          //3
100. exp(lCm_star)*exp(lPm) = alpha*omega_star*exp(lP_star)*exp(lC_star);          //4
101. exp(lCh)*exp(lPh) = (1-alpha)*omega*exp(lP)*exp(lC);          //5
102. exp(lCh_star)*exp(lPh) = (1-alpha)*omega_star*exp(lP_star)*exp(lC_star);          //6
103. exp(lCf)*exp(lPf) = (1-omega)*exp(lP)*exp(lC);          //7
104. exp(lCf_star)*exp(lPf) = (1-omega_star)*exp(lP_star)*exp(lC_star);          //8
105. (1-alpha)*omegag*exp(lP)*exp(lG)*exp(lah) = exp(lPh)*(exp(lLh)-exp(lah))*(exp(lCh)+((1-n)/n)*exp(lCh_star));          //9
106. ((1-n)/n)*exp(laf_star)*omegag_star*exp(lP_star)*exp(lG_star) = exp(lPf)*(exp(lLf_star)-exp(laf_star)*(exp(lCf)+((1-n)/n)*exp(lCf_star)));          //10
107. exp(lPm)*(exp(lLm)*exp(lW)-(1-exp(lz_prime))*exp(lCm)+exp(lCm_star)*((1-n)/n)) = alpha*omegag*exp(lP)*exp(lG)*(1-exp(lz_prime));          //11
108. exp(lPm)*(exp(lLm_star)*exp(lW_star)-exp(lz_prime)*(n/(1-n))*(exp(lCm)+exp(lCm_star)*((1-n)/n))) = alpha*omegag*exp(lP)*exp(lG)*exp(lz_prime)*(n/(1-n));          //12
109. exp(lW_star)*t_star*(exp(lz_prime)^(1/theta)) = exp(lW)*t*((1-exp(lz_prime))^(1/theta));          //13 for z_prime
110. exp(lP)*(exp(lC)^phi) = exp(lP_star)*(exp(lC_star)^phi)*zeta;          //14
111. exp(lW) = exp(lPh)/(exp(lPm)*exp(lah));          //15
112. exp(lW_star) = exp(lPf)/(exp(lPm)*exp(laf_star));          //16
113. betty*(exp(lC(+1))/(exp(lC))^(-phi)) = (1/(1+exp(li(+1))))*(exp(lP(+1))/exp(lP));          //17
114. (((exp(lCm)^alpha)*(exp(lCh)^(1-alpha)))^omega)*exp(lCf)^(1-omega) = exp(lC);          //18
115. (((exp(lCm_star)^alpha)*(exp(lCh_star)^(1-alpha)))^omega_star)*exp(lCf_star)^(1-omega_star) = exp(lC_star);          //19
116. (((exp(lPm)^alpha)*(exp(lPh)^(1-alpha)))^omega)*exp(lPf)^(1-omega) = exp(lP);          //20
117. (((exp(lPm)^alpha)*(exp(lPh)^(1-alpha)))^omega_star)*exp(lPf)^(1-omega_star) = exp(lP_star);          //21
118. exp(lPm) = exp(lW_star)*t_star*(theta/(theta-1))*(1-(1-exp(lz_prime))^(theta-1)/theta) + exp(lW)*t*(theta/(theta-1))*(1-exp(lz_prime)^(theta-1)/theta);          //22
119. t_star*alpha*omegag*exp(lP)*exp(lG) = exp(lPm)*(t_star*exp(lLm)*(exp(lz_prime)^(1/theta))+t*((1-n)/n)*exp(lLm_star)*((1-exp(lz_prime))^(1/theta))-t*t_star*(exp(lCm)+exp(lCm_star)*((1-n)/n)));          //23
120. exp(lr) = exp(li) - exp(lP(+1))/exp(lP);          //24
121. exp(lpi) = exp(lP(+1))/exp(lP);          //25
122. exp(lLb) = exp(lL)-exp(lLm)-exp(lLh);          //26
123. exp(lLb_star) = exp(lL_star)-exp(lLm_star)-exp(lLf_star);          //27
124. exp(lYh) = exp(lCh)+(1-alpha)*omegag*(exp(lP)/exp(lPh))*exp(lG)+((1-n)/n)*exp(lCh_star);          //28
125. exp(lYf_star) = exp(lCf)+((1-n)/n)*(exp(lCf_star)+omegag_star*(exp(lP_star)/exp(lPf))*exp(lG_star));          //29
126. exp(lYm)=exp(lCm)+alpha*omegag*(exp(lP)/exp(lPm))*exp(lG)+((1-n)/n)*exp(lCm_star);          //30
127.
128.
129. //exogenous process
130.
131.
132. lah = log(ah_bar + eah);
133. eah = rho_eah*eah(-1) + eps_eah;
134.
135. laf_star = log(aaf_star_bar + eaf_star);
136. eaf_star = rho_eaf_star*eaf_star(-1) + eps_eaf_star;
137.
138. lG = log(G_bar + eG);
139. eG = rho_eG*eG(-1) + eps_eG;

```



```

140.
141.     lG_star = log(G_star_bar + eG_star);
142.     eG_star = rho_eG_star*eG_star(-1) + eps_eG_star;
143.
144.
145.end;
146.
147.// NOW SOLVE THE MODEL
148.
149.//Check if the residuals are 0
150.resid(1);
151.
152.steady(solve_algo=4);
153.
154.model_diagnostics(M,options_,oo_);
155.
156.check;
157.
158.    //Shocks declaration
159.shocks;
160.
161.    var eps_eG; stderr 0.01;
162.    var eps_eG_star; stderr 0.01;
163.    var eps_eah; stderr 0.01;
164.    var eps_eaf_star; stderr 0.01;
165.
166.//here optionally we can assign values
167.
168.end;
169.
170.stoch_simul(hp_filter=100000, order=1, periods=200, irf=40);
171.
172.write_latex_dynamic_model;
173.write_latex_static_model;
174.options_.TeX=1;
175.conditional_variance_decomposition = 1;

```

## 7. Other Results

### Policy and transition functions

Table A2 gives an overview of the *policy and transition functions* describing the model's law of motion. These functions are model solutions in recursive form: they express endogenous variables as functions of state variables.

Table A2. Selected policy and transition functions for the benchmark model (first order).

Variable	Constant	$G_t(-1)$	$G_t^*(-1)$	$a_{Ht}(-1)$	$a_{Ft}^*(-1)$	$\sigma_\epsilon^G$	$\sigma_\epsilon^{G^*}$	$\sigma_\epsilon^{a_H}$	$\sigma_\epsilon^{a_F}$
$L_{Mt}$	-1.04	-0.07	1.97	3.86	-0.48	-0.08	2.19	4.29	-0.54
$L_{Mt}^*$	-0.69	2.04	-5.75	-10.01	1.25	2.26	-6.38	-11.12	1.39
$W_t$	0.00	0.21	-0.78	-1.41	0.18	0.24	-0.87	-1.56	0.20
$W_t^*$	-2.08	-0.01	0.05	0.09	-0.01	-0.01	0.05	0.10	-0.01
$C_{Ht}$	0.21	0.06	-0.21	-0.60	0.08	0.06	-0.23	-0.67	0.08
$C_{Ht}^*$	-0.11	0.05	-0.17	-0.66	0.08	0.05	-0.19	-0.73	0.09
$C_{Ft}$	-1.51	-0.06	0.21	0.30	-0.04	-0.06	0.23	0.33	-0.04
$C_{Ft}^*$	-0.73	-0.05	0.17	0.24	-0.03	-0.05	0.19	0.27	-0.03
$C_{Mt}$	-1.20	-0.21	0.78	-1.74	0.22	-0.24	0.86	-1.93	0.24
$C_{Mt}^*$	-1.52	-0.22	0.82	-1.68	0.21	-0.25	0.91	-1.87	0.23
$P_{Ht}$	-0.68	-0.03	0.10	0.75	-0.09	-0.03	0.11	0.84	-0.10
$P_{Ft}$	-0.68	0.03	-0.10	-0.15	0.02	0.03	-0.11	-0.16	0.02
$P_{Mt}$	-0.42	0.24	-0.88	1.59	-0.20	0.27	-0.98	1.76	-0.22
$z_t'$	-2.83	1.77	-6.48	-11.64	1.46	1.97	-7.20	-12.94	1.62
$i_t$	3.18	0.07	-0.26	0.38	-0.05	0.08	-0.29	0.42	-0.05
$P_t$	-0.62	0.03	-0.11	0.15	-0.02	0.03	-0.12	0.17	-0.02
$P_t^*$	-0.63	0.02	-0.07	0.09	-0.01	0.02	-0.07	0.10	-0.01
$L_{Bt}$	-1.35	0.54	-4.30	-14.35	1.12	0.60	-4.78	-15.95	1.25
$L_{Bt}^*$	-0.53	-1.74	4.92	8.54	-1.66	-1.94	5.47	9.49	-1.85
$Y_{Ht}$	0.44	0.52	-0.20	-0.61	0.08	0.58	-0.22	-0.68	0.09
$Y_{Ft}^*$	-0.94	-0.05	0.66	0.27	-0.03	-0.06	0.73	0.30	-0.04

Note: All variables are in natural logs. Simulated variables are HP-filtered.

Solving the rational expectation model means finding an unknown function that could be used into the original model to satisfy the implied restrictions. The policy and transition functions table (Table A2) contains the coefficients of the first order approximation (log-

linearization) of this solution function. Policy and transition functions are an approximate time recursive representation of the model. Those functions show how the values of variables at period  $t$  depend on the state variables values at  $t - 1$  and on the shocks. For example, the function for  $\mathbf{z}'_t$  reflects that shocks resulting in in-shoring (to  $G_t^*$  and  $a_{Ht}$ ) have, in absolute terms, an order of magnitude larger impact on offshoring than shocks found to lead to offshoring ( $G_t$  and  $a_{Ft}^*$ ). Between the two shocks that result in in-shoring, domestic productivity has stronger negative coefficients than foreign government demand.

# Chapter 3

## Globalization, Offshoring and Volatility: European Perspective

### 3.1 INTRODUCTION

The study presented in this chapter aims at contributing to the research on global production markets and their role in transmitting shocks in Europe. Offshoring is found to influence the macroeconomic volatilities of the US and of Mexico (Bergin, Hanson and Feenstra 2007, 2009, 2011, BHF thereafter) and could be a factor of the economic volatility of the new and old member-states of the EU (Feenstra 2010; Burstein et al. 2008; Darvas and Szarpary 2008, Tesar et al. 2006).

In the last twenty years, a new division of labor has emerged in the world economy. Firms geographically separate different production stages to exploit differences in production costs. With the enlargement of Europe, Western European firms outsource and offshore production to Central Europe (CE). Egger and Egger (2005) observe that a major part of the offshoring of European Monetary Union (EMU) countries remains within Europe, and this trend shows no sign of receding, as Falk and Wolfmayr (2008) note. While India and China are widely recognized standard destinations for offshoring, Central and Eastern Europe (CEE) has become an attractive *nearshoring*<sup>39</sup> destination for the high-wage EU countries (Erber and Sayed-Ahmed 2005, Meyer 2006, Pickles and Smith 2011). Although labor cost remains significantly higher in

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<sup>39</sup> Nearshoring is the transfer of business processes to companies in neighbouring countries, often sharing borders, where both parties expect to benefit from the proximity. See for instance Bock (2008).

CEE countries than in traditional offshoring destinations, their location brings crucial benefits (Carmel and Abbott 2007). Central European countries are much closer in distance, share the same socio-cultural background and timezone as Western Europe, have compatible legal systems, and have the advantage of well-developed institutional frameworks and a better educated (compared to traditional offshoring destinations), English-speaking labor force. As a result, CE countries (CECs) are becoming more important for the internationalization of the production organization of European firms.

Evidence of the synchronization of the business cycles of European countries (Bergman and Jonung 2011) and the correlation between macroeconomic indicators of the Eurozone and the CECs (Fidrmuc and Korhonen 2006) and between responses to demand and supply shocks (Fidrmuc and Korhonen 2003, Frenkel and Nickel 2006) prove that, in Europe, common shocks matter. Economic fluctuations are transmitted within the enlarged European Union and shocks are key factors causing macroeconomic volatility. Tesar (2008) analyses offshoring between Western Europe and Central and Eastern Europe and concludes that increased production sharing between the two European regions leads to greater output correlation. These studies confirm that offshoring also matters for volatility in Europe, and the proposed exploration of the impact of offshoring seems reasonable.

In a first segment (Section 3.2), I apply panel data estimation techniques and descriptive statistics to analyze the roles of the intensive and extensive margins of offshoring in Central European Countries. In the second part (Section 3.3 to 3.5), I calibrate the Dynamic Stochastic General Equilibrium (DSGE) Ricardian model with continuum of goods developed in Chapter 2 using parameters matching European data. I intend to determine the extent to which offshoring from Western to Central Europe contributes to macroeconomic volatility in both trading regions, and to characterize the dynamics of offshoring in Europe.

## 3.2 EMPIRICAL MOTIVATION

The *empirical motivation exercise* that follows consists of stylized evidence (descriptive statistics) and a *panel data estimation* based on the Eaton, Kortun and Kramarz (2004) identity equations to determine the roles of the intensive and extensive margins for employment, import and export in the offshoring sector in the Central European Countries (CEC). All regressions are controlled for industry fixed effects and standard errors are clustered by industry.

I use *OECD data* for four CEC: Czech Republic, Hungary, Poland and Slovak Republic. The OECD data include the STAN database, I-O Tables and activity of multinationals from 1993 to 2008. Contrary to the study of Mexico and U.S. (BFH 2009), no specific subset of offshoring industries is selected for this research, but rather offshoring sectors in over 30 manufacturing industries. I use a higher level of aggregation than BHF (2009) due to data availability. I am limited to freely accessible annual industry level data for Europe, while BHF (2009) use plant level data for the US to which I don't have access. The data aggregation is likely to bias the coefficients in terms of their magnitudes, but their directions and the general effect should be preserved and arise with even more aggregated data. Since I am interested in motivating my research by finding this general effect, highly aggregated data proves sufficient<sup>40</sup>.

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<sup>40</sup> Using more aggregated industry data is a limitation. The purpose of this analysis is to motivate the use of the derived DSGE model with offshoring in the European context. Therefore, sections 3.1-3.2 in Chapter 3 are intended to determine whether offshoring is a channel of shocks transmission in Europe and to provide an extended argument rather than an in-depth analysis.

### 3.2.1 Offshoring in Central Europe – Stylized Facts

Offshoring, as an aspect of globalization, may be analyzed at the macro scale in a core-periphery setup. With the enlargement of the European Union in 2004, the opening of markets between the European Monetary Union (EMU) and Central Europe (CE) created a great opportunity for production mobility. On average, between 1997 and 2007, 84% of all newly established majority foreign-controlled firms (where more than 50% of the capital is held by one non-resident) in the biggest country of the region, Poland, were originating from the EU 15 (OECD data) and 78% of employees were employed in EU15 owned enterprises. In 2007, 74% of all Polish employees employed in foreign owned manufacturing companies in Poland worked in EU15 owned enterprises and 81% of establishments originated from EU15 (see Table 3.1 and Figure 3.1).

Table 3.1 Annual shares of EU15 enterprises to World enterprises in Poland and respective shares of Polish employees.

Share EU15/World		
Year	Enterprises or establishments	Employees
1995		0.772
1996		0.792
1997	0.836	0.811
1998		0.813
1999	0.839	0.783
2000	0.850	0.808
2001	0.844	0.808
2002	0.849	0.803
2003	0.853	0.802
2004	0.858	0.821
2005	0.836	0.760
2006	0.827	0.752
2007	0.820	0.739
Average	0.841	0.790

Source: Author's calculation based on OECD data.

Note: The data refer to majority foreign-controlled firms, i.e. where more than 50% of the capital is held by one non-resident. Indirectly foreign-controlled affiliates are not included and multiple foreign control is not considered. The data come from the Business Division of the Central Statistical Office of Poland (CSO). They are collected via an annual survey since 1993. Up to 1998, all enterprises were surveyed. From 1999, only enterprises employing more than 9 persons are covered.

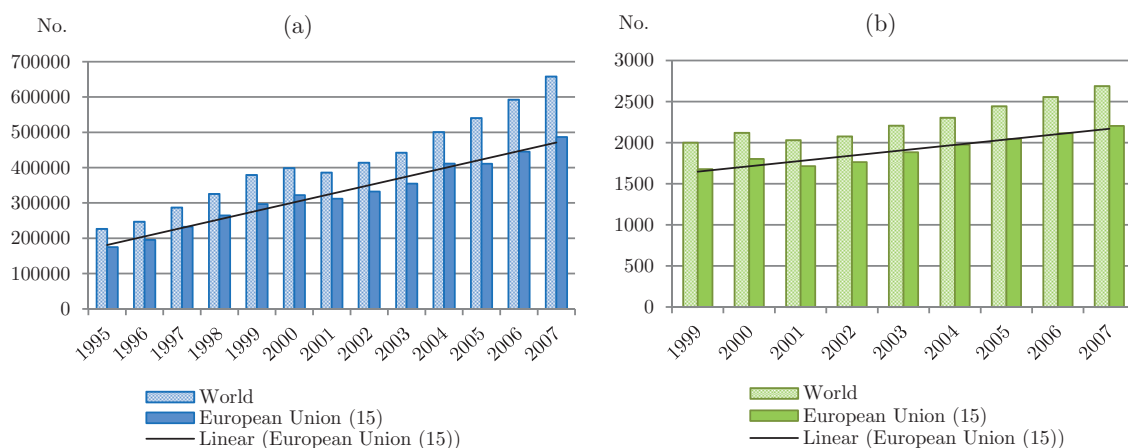


Figure 3.1 Number of employees in foreign affiliates (a) and number of foreign owned enterprises established (b) in Poland.

Source: Author's illustration based on OECD data.

The lack of research on offshoring and its macro effects is possibly due to the common belief that its impact is too small to matter in the macro scale and is only significant in some industries. This appears true in the case of USA or Japan, with the relatively low levels of imported intermediate inputs of 10.7% for Japan and 9.7% for USA in 2005. Table 3.2 reports OECD STAN Input-Output Intermediate Input Ratio for the years 1995, 2000 and 2005 measured as imported intermediates to total intermediate inputs used in the production process. Some interesting observations can be drawn from the data. Countries perceived as offshoring locations for manufacturing, like China, or for services, such as India, imported in 2005 only 11-12% of their total intermediate input. In contrast to those figures, EU 15, CECs and Mexico imported in 2005 almost one third of all processing intermediates and as much as half of them in the manufacturing sector. Small countries have usually a high offshoring ratio, with Singapore importing 84.8% intermediates in manufacturing in 2000, and Estonia 90% of high and medium-high technologies manufactures in 2005. But in more populous countries, in particular from Central Europe, the intermediate import ratio has been increasing since the last 20 years more



than anywhere else (see Table 3.3), and in 2005, it reached 69.6% in Hungary and 39.3% in Poland in the manufacturing sector. Offshoring, measured as the share of imported intermediate non-energy manufacture inputs to gross output, confirms those different offshoring levels (IMF 2007, Falk and Wolfmayr 2008). Therefore, offshoring can no longer be ignored as a macroeconomic phenomenon.

The macroeconomic consequences of offshoring are possibly most vivid in the core-periphery setup, of which the EU15 (as the core) and the new member states from Central Europe (as the periphery) is a very good example.

Several empirical studies find that a large part of European offshoring movements takes place between old and new member states. Just in 1999, 50% of the processing production of EU15 came from CECs (Eager and Eager 2005). Tesar (2008) suggests that the expansion of EU increased the East-West trade within Europe, including trade in intermediates.

Table 3.2 Imported intermediates ratio measured as imported intermediates to all intermediates.

Country or region	I38: Total			I39: MANUFACTURES (ISIC15-37)			I41: HIGH/MEDIUM HIGH TECHNOLOGIES MANUFACTURES (ISIC24,29-33,35)			I42: LOW/MEDIUM LOW TECHNOLOGIES MANUFACTURES (ISIC15-23,36-37)		
	mid- 1990s	early 2000s	mid- 2000s	mid- 1990s	early 2000s	mid- 2000s	mid- 1990s	early 2000s	mid- 2000s	mid- 1990s	early 2000s	mid-2000s
Period												
EU15	0.250	0.288	0.287	0.416	0.454	0.458	0.580	0.628	0.617	0.337	0.360	0.381
CECs	0.159	0.293	0.288	0.257	0.486	0.492	0.368	0.668	0.652	0.209	0.403	0.421
China	0.087	0.096	0.122	0.127	0.133	0.155	0.230	0.206	0.252	0.080	0.086	0.085
India	0.099	0.117	0.115	0.141	0.184	0.148	0.188	0.195	0.214	0.118	0.178	0.109
Mexico			0.271			0.527			0.720			0.417
Japan	0.064	0.070	0.108	0.074	0.092	0.125	0.095	0.131	0.188	0.066	0.074	0.099
USA	0.067	0.085	0.097	0.142	0.199	0.227	0.222	0.300	0.336	0.104	0.152	0.181
Hungary	0.355	0.450	0.426	0.603	0.661	0.696	0.799	0.827	0.852	0.478	0.530	0.588
Poland	0.128	0.182	0.212	0.210	0.333	0.394	0.357	0.490	0.550	0.150	0.277	0.333
Germany	0.153	0.201	0.216	0.272	0.339	0.357	0.327	0.412	0.429	0.242	0.299	0.318
France	0.158	0.184	0.179	0.297	0.351	0.343	0.419	0.508	0.461	0.242	0.263	0.276
Singapore	0.549	0.578		0.808	0.848		0.890	0.875		0.704	0.809	
Estonia	0.376	0.415	0.414	0.674	0.734	0.735	0.808	0.888	0.900	0.611	0.627	0.635

Source: Author's calculations based on OECD data.

Note: EU-15 includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom. CECs include Czech Republic, Hungary, Poland, Slovak Republic, Turkey, Estonia, Romania, Russia and Slovenia.

Table 3.3 Percentage change in intermediate import ratio between 1995 and 2005 for Central Europe.

Country or region	Total	MANUFACTURES	HIGH/MEDIUM HIGH TECHNOLOGIES MANUFACTURES	LOW/MEDIUM LOW TECHNOLOGIES MANUFACTURES
EU15	0.148	0.100	0.064	0.131
CECs	0.815	0.912	0.774	1.018
China	0.395	0.220	0.099	0.064
India	0.166	0.053	0.141	-0.074
Japan	0.675	0.688	0.984	0.496
USA	0.451	0.600	0.513	0.741
Hungary	0.200	0.154	0.066	0.230
Poland	0.651	0.878	0.541	1.217
Germany	0.408	0.315	0.310	0.312
France	0.136	0.155	0.098	0.143
Estonia	0.102	0.090	0.115	0.038

Source: Author's calculations based on OECD data.

Pooling yearly data from 1997 to 2007 for all offshoring industries in Czech Republic reveals that both employment and real value added are growing and follow a similar pattern, with value added showing a slightly greater volatility. Growth in both employment and value added between 1997 and 2007 reaches about 150 base points, which is more than on the same time span between U.S. and the maquiladora sector in Mexico. This is illustrated in the Figure 3.2.

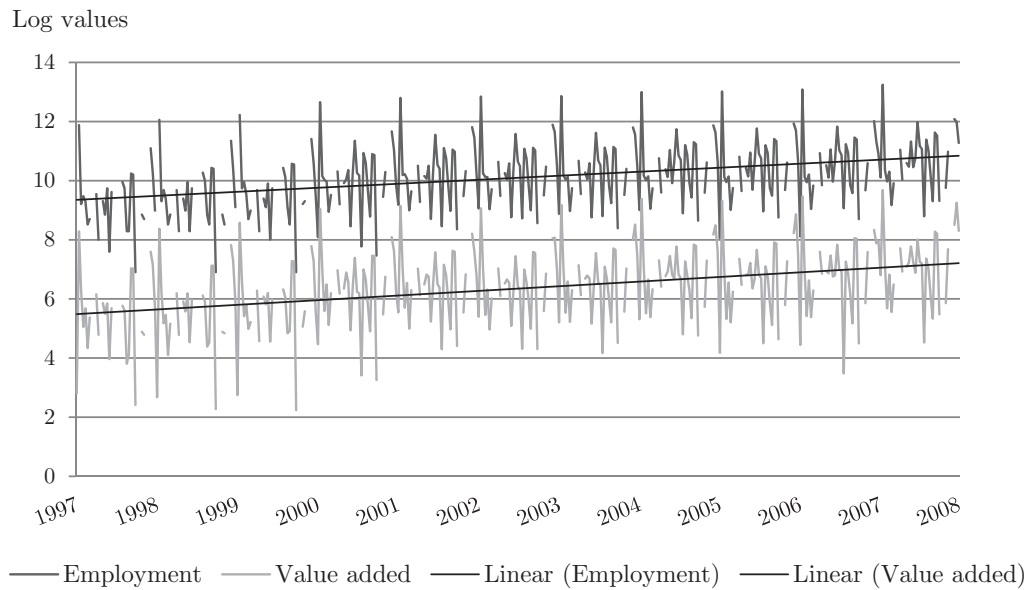


Figure 3.2 Offshoring sector activity in Czech Republic (log values).

Source: Author's illustration based on OECD data.

Another piece of evidence supporting the importance of EU15 offshoring to Central Europe comes from the comparison with popular offshoring and outsourcing destinations. Table 3.4 summarizes the offshoring activity of Germany, the biggest EU15 economy in terms of turnover of its foreign affiliates and of foreign affiliates' employment. It turns out that new member states of the EU are much more desired destinations by German investors than China and India. In 2007, only 8% of all employees of German foreign affiliates worked in China and 3% in India, while 17% worked in Central and Eastern Europe (see Figure 3.3). Additionally, 42% of the total employees of German-owned manufacturing companies in Europe are based in CECs. Turnover data show a similar pattern. Over 12% of the total turnover in German foreign affiliates happens in CECs, while only 3% and 1% happen in China and India respectively.

Table 3.4. Turnover and employment shares in German foreign affiliates.

Year	2001	2002	2003	2004	2005	2006	2007
Share of employment in German-owned manufacturing companies abroad as percentage of total employment in German-owned firms in the world							
European Union (25)	0.535	0.472	0.478	0.460	0.434	0.420	0.405
New EU members (10)	0.235	0.158	0.168	0.175	0.172	0.173	0.172
European Union (15)	0.299	0.314	0.310	0.286	0.262	0.246	0.233
China	0.033	0.032	0.036	0.042	0.056	0.065	0.085
India	0.030	0.020	0.019	0.020	0.023	0.024	0.030
Share of employment in German-owned manufacturing companies abroad as percentage of total employment in German-owned firms in EU25							
New EU members (10)	0.440	0.335	0.352	0.380	0.397	0.413	0.424
European Union (15)	0.560	0.665	0.648	0.620	0.603	0.587	0.576
Turnover in German manufacturing firms as a percentage of total turnover in German-owned firms abroad.							
European Union (25)	0.548	0.417	0.447	0.449	0.422	0.428	0.459
New EU members (10)	0.131	0.076	0.093	0.100	0.099	0.107	0.125
European Union (15)	0.416	0.341	0.353	0.348	0.322	0.321	0.334
China	0.011	0.013	0.014	0.017	0.020	0.024	0.035
India	0.009	0.005	0.005	0.006	0.007	0.009	0.012
Turnover in EU (15) and new member states (10) as a percentage of total turnover in EU25.							
New EU members (10)	0.240	0.182	0.209	0.224	0.236	0.251	0.272
European Union (15)	0.760	0.818	0.791	0.776	0.764	0.749	0.728

Source: Author's calculations based on OECD data.

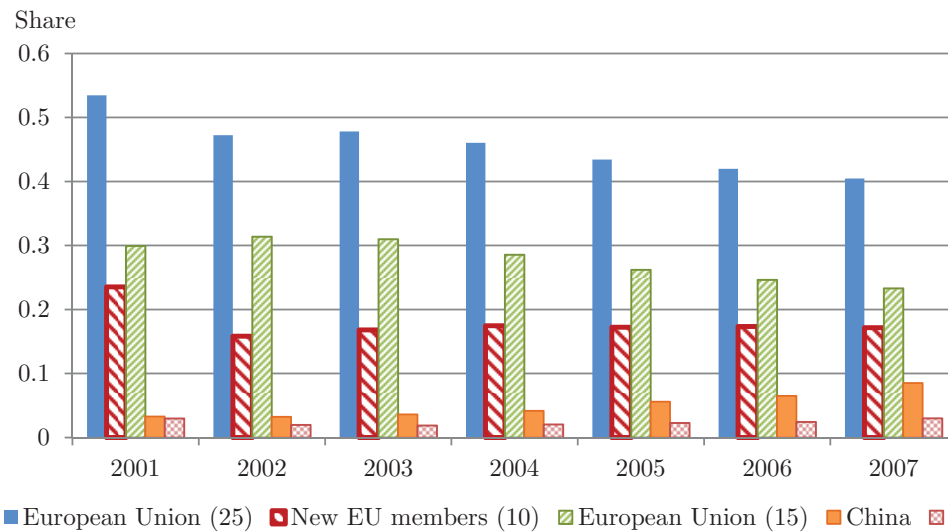


Figure 3.3 Share of employment in German-owned manufacturing companies abroad. German manufacturing offshoring sector.  
Source: Author's illustration based on OECD data.

### 3.2.2 Employment Evidence

Solely relying on intuition, one might expect CE countries' industries to be more volatile in their offshoring sector because they are relatively new establishments, smaller than their equivalent in Western Europe, where shocks can easily be smoothed by the size of employment in industries.

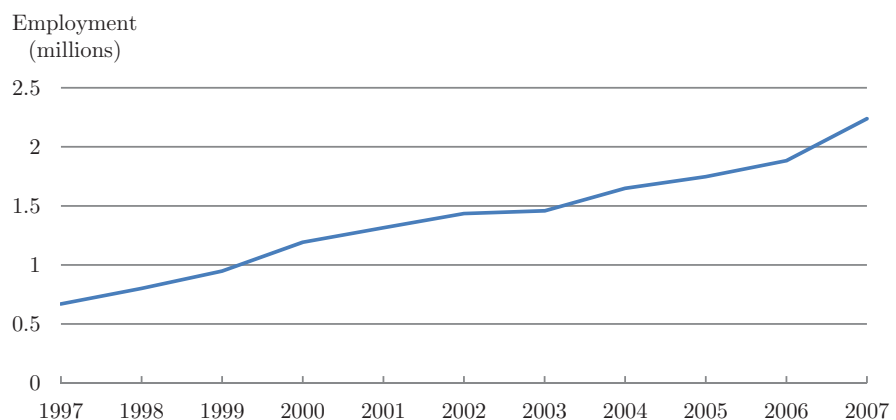


Figure 3.4 Size of aggregated offshoring sector in 4 CE countries.  
Source: Author's illustration based on OECD data.

I am limited to yearly data. From the broad picture (Figure 3.4), aggregated over industries and four countries, the offshoring sector is constantly growing in terms of employment. Over the last 10 years, it has increased four-folds, to reach 2.3 million employees in 2007, which only raises the importance of offshoring in this part of the world. However, even in that coarse picture, the growth is not smooth.

Applying the proposition of BHF (2009), changes in the employment of offshoring industries are partly driven by adjustments in the range of offshored activities (extensive margin). Aggregate shocks can disturb the wage relation between Western and Central Europe, resulting in an endogenous shift in outsourced production. Therefore, the trends in offshoring can determine the entry and exit of new firms in CE countries.

The stylized evidence comes from the number of new enterprises in the offshoring sector. In 1998-99, when a big part of EU15 was adopting the Euro and at the same time fearing spillovers from the Asian crisis, there was stagnation in manufacturing enterprises in Czech Republic, and a sharp drop of the same indicator in Poland. Subsequently, in 2000, when EU15 was affected by the bursting of the dot-com bubble and creation of inflation, new establishments once again slowed down in Czech Republic and dropped in Poland, to start growing again in 2003 (Figures 3.5 and 3.6).

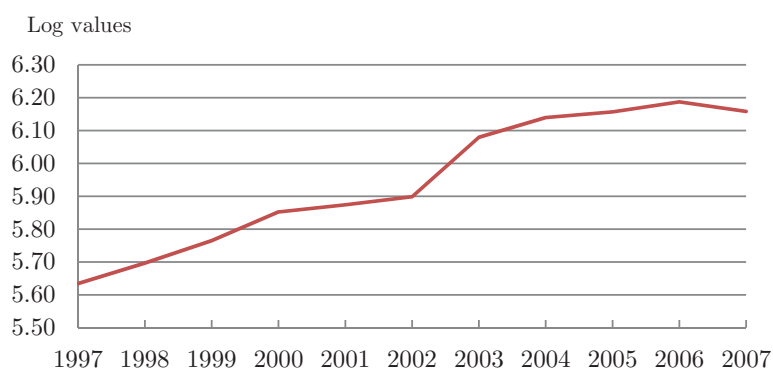


Figure 3.5 Employment in offshoring manufacturing sector in 4 CE countries (in logs).  
Source: Author's illustration based on OECD data.

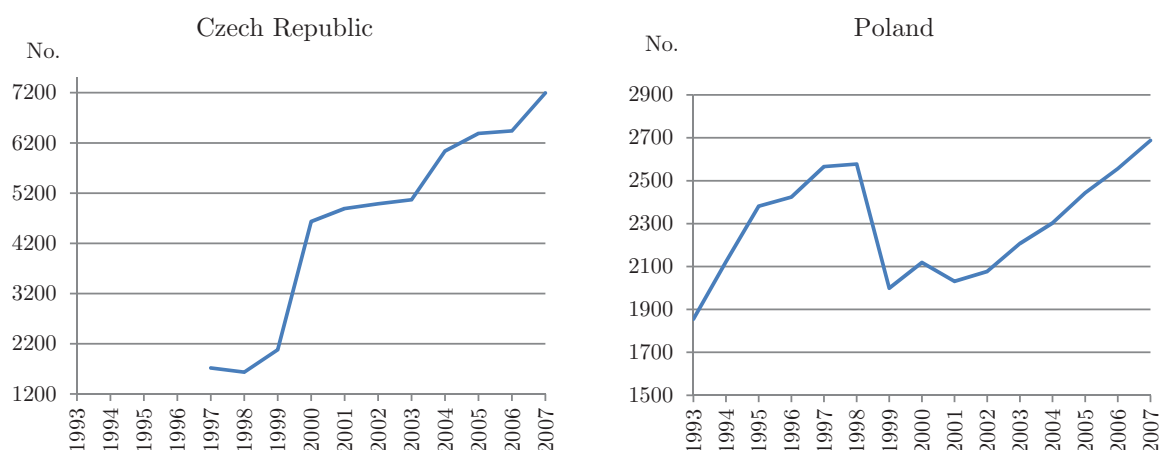


Figure 3.6 Number of enterprises or establishments in Manufacturing (S1537): 1993 - 2007.  
Source: Author's illustration based on OECD data.

To provide a visual confirmation of the similarities in employment variations in the industrial offshoring sector of Western and Central Europe, I plot employment for Germany and aggregated employment in four CE countries in four important offshoring sectors (Figure 3.7). The manufacturing sector is an aggregate of all offshoring industries. It can be definitely concluded that employment patterns in offshoring industries in Germany and CE countries are closely matched after 1999. In 1998, there is a sharp drop in employment, absent on German side. In that year there was a sudden increase in unemployment in the CECs due to the external demand shock from the Russian financial crisis, which led to a decrease in Russian demand for CECs products, but the German market remained unaffected.



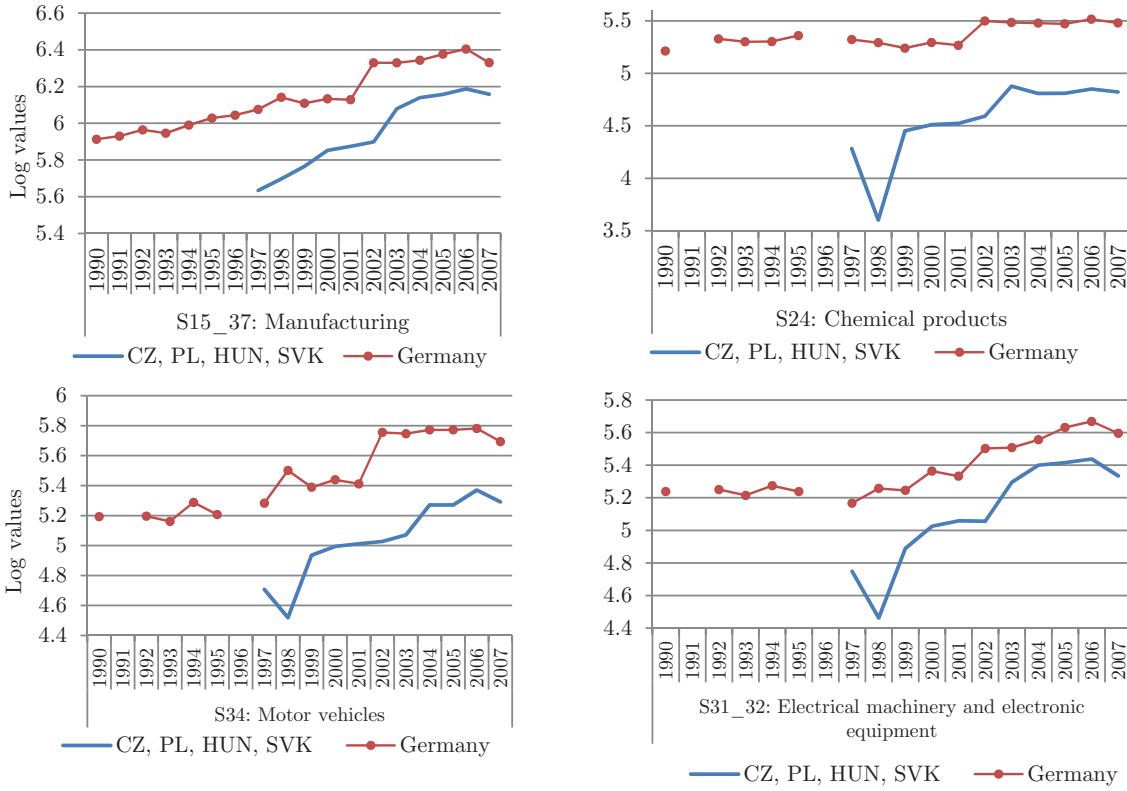


Figure 3.7 Employment in offshoring sectors of German and CEC industries (log values).  
Source: Author's illustration based on OECD data.

Following BHF (2009) I investigate how volatility in offshoring employment transmits into adjustments in the number of offshoring firms (extensive margin<sup>41</sup>). I examine the formal evidence of adjustment at the extensive margin linking industry employment to employment per company and the number of companies per industry<sup>42</sup>. As in BFH (2009) I apply the identity derived from Eaton et al. (2004) as follows:

$$E_{it} \equiv N_{it} \times \frac{E_{it}}{N_{it}} \equiv \frac{E_{it}}{E_t} \times E_t \quad (3.1)$$

<sup>41</sup> Due to limitations of the data I am constrained to use a higher level of aggregation than BHF (2009). Adjustments in the extensive margin are defined as changes to the number of offshoring firms in response to volatility in offshoring employment.

<sup>42</sup> The number of enterprises reflects the amount of companies from the EU15 involved in offshoring activities in a given industry to any of four Central European offshoring destinations.

where  $E_{it}$  is the employment in offshoring industry  $i$  at destination at time  $t$ <sup>43</sup>,  $N_{it}$  is the number of offshoring companies establishments in industry  $i$  at destination at time  $t$ , and  $E_t$  is the aggregate employment in the whole offshoring sector at time  $t$  in four CE countries. This specification allows defining the offshoring industry share of aggregate employment ( $E_{it}/E_t$ ).

From this identity, BHF (2009) derive two regressions, with the number of companies present in a given offshoring industry ( $N_{it}$ ) and the employment per company ( $E_{it}/N_{it}$ ) as dependent variables. To do so, they apply a simple logarithmic transformation:

$$\ln(E_{it}) \equiv \ln\left(N_{it} \times \frac{E_{it}}{N_{it}}\right) \equiv \ln\left(\frac{E_{it}}{E_t} \times E_t\right) \quad (3.2)$$

$$\ln E_{it} \equiv \ln N_{it} + \ln \frac{E_{it}}{N_{it}} \equiv \ln \frac{E_{it}}{E_t} + \ln E_t \quad (3.3)$$

Therefore, BHF (2009) find the regressions:

$$\ln N_{it} = \alpha_0 + \alpha_1 \ln \frac{E_{it}}{E_t} + \alpha_2 \ln E_t + \varepsilon_{it} \quad (3.4)$$

$$\ln \frac{E_{it}}{N_{it}} = \beta_0 + \beta_1 \ln \frac{E_{it}}{E_t} + \beta_3 \ln E_t - \varepsilon_{it} \quad (3.5)$$

where  $\alpha_0 + \beta_0 = 0$ ,  $\alpha_1 + \beta_1 = 1$  and  $\alpha_2 + \beta_2 = 1$

The relative magnitude of the coefficients identifies how aggregate shocks affect the number of enterprises (the extensive margin) and employment per offshoring enterprise (the intensive margin).

Table 3.5 reports the results of regressions on data on employment and number of enterprises in the offshoring sector in CE countries. All variables are statistically significant.

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<sup>43</sup> Employment in offshoring industry is defined as the number of employees working for the EU15 parent company.

Fixed industry effects are included. I am particularly interested in the adjustments in the extensive margin (number of firms) to changes in employment. From regression (3.4), I see that both the increase in the offshoring industry share of aggregate employment ( $E_{it}/E_t$ ) and more generally the increase in aggregate employment ( $E_t$ ) lead to an increase in the extensive margin; in the first case, the coefficient  $\alpha_1$  is 0.297, and  $\alpha_2$  is 0.822 and significant at the 1% level, so for the aggregate employment, more than 80% of the adjustment in industry employment occurs in the number of enterprises. Therefore, like in BHF (2009), firm entry and exit appear as an important channel through which the offshoring sector reacts to aggregate shocks.

Table 3.5 Adjustment in the offshoring industry in CE countries. Extensive margin (employment).

	Number of offshoring enterprises ( $N_{it}$ ) (1)	Employment per enterprise ( $E_{it}/N_{it}$ ) (2)
Industry share of aggregate employment ( $E_{it}/E_t$ )	0.297*** (0.032)	0.316*** (0.073)
Aggregate employment ( $E_t$ )	0.822*** (0.071)	0.409*** (0.162)
R2	0.75	0.27
n	384	384

Note: Column (1) shows the regression of the number of offshoring enterprises on total CE offshoring industry employment and the industry share of employment, while the column (2) regresses employment per enterprise on the same independent variables. The sample consists of all manufacturing industries of the four CE countries that are engaged in offshoring activities. OECD Globalization data is in yearly frequency from 1997 to 2007. All variables are in real terms and expressed in logs. All regressions control for industry fixed effects. Standard errors are clustered by industry and shown in parenthesis. \*\*\* indicates 1% significance level.

### 3.2.3 Export Evidence

Another way to measure the extensive margin is to analyze the export of the offshoring industry in CE countries. I use the total exports and the exports share of production between 1993 and 2007 for the offshoring industries in Czech Republic, Poland, Hungary and Slovak Republic.

Considering the export data for the offshoring sector in the four CE countries, it can be noticed that the value of export and export share in manufacturing increases dramatically after 1996 (see Figure 3.8), after the European Union Association Agreement comes into force. It only fell in the face of the 2008 economic crisis (Figure 3.9). The opening of the European markets raised exports in the offshoring sector.

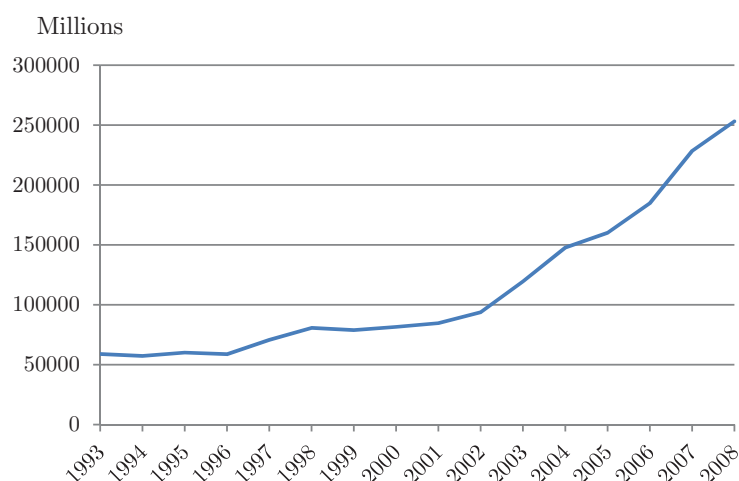


Figure 3.8 Export in manufactures (constant USD) in the offshoring industry in CE countries.  
Source: Author's illustration based on OECD data.

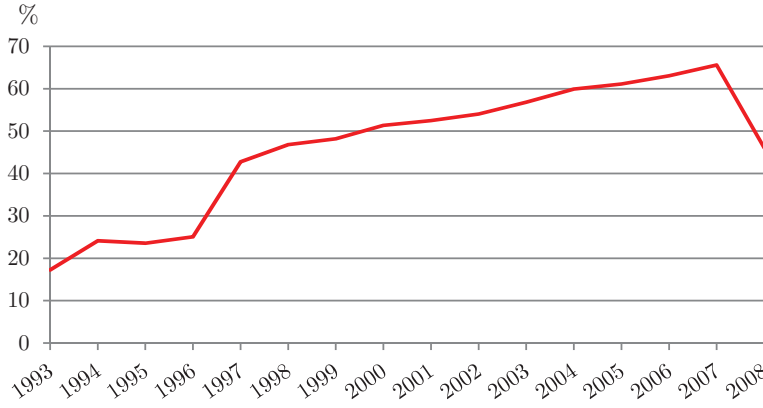


Figure 3.9 Export share (in percentage) of production in manufacturing in CECs.  
Source: Author's illustration based on OECD data.

To formally measure the extensive margin in number of varieties exported from the CE countries to the EU15, I follow Feenstra (2008, 2010) who specifies the corresponding relationship for export as the one for employment found in equations (3.4) and (3.5). To identify how changes to total and industry export affect export in the offshoring sector I specify the following equations:

$$\ln XS_{it} = \alpha_0 + \alpha_1 \ln \frac{X_{it}}{X_t} + \alpha_2 \ln X_t + \varepsilon_{it} \quad (3.6)$$

$$\ln \frac{X_{it}}{XS_{it}} = \beta_0 + \beta_1 \ln \frac{X_{it}}{X_t} + \beta_3 \ln X_t - \varepsilon_{it} \quad (3.7)$$

where  $XS_{it}$  represents the aggregated export share in the destination offshoring sector of the industry  $i$  at time  $t$ ,  $X_{it}$  is the value of export in the offshoring industry  $i$  at time  $t$ , and  $X_t$  denotes the total exports in the offshoring sector of CE countries.

Due to the higher level of data aggregation, I proxy the number of exported products from the destination by the export share in the offshoring part of that industry, aggregated over four CE states (variable  $XS_{it}$ ). The relative magnitude of the coefficients shows how the share of export (proxy for number of products), the extensive margin of exports and export per variety (the intensive margin) are affected by the aggregate shocks.

All series are pooled across offshoring industries in four CE countries, with controls for fixed effects. The coefficient  $\alpha_1$  is 0.390 and  $\alpha_2$  is 0.528 in column (1) of Table 3.6; they are statistically significant at the 1% level. The coefficient  $\alpha_1$  suggests that the export share of production in each offshoring industry responds to a shift in CECs exports towards that industry. The response is slightly higher than what I found for the number of offshoring enterprises (see column (1) in Table 3.5 and 3.6). This result is different from Feenstra (2008, 2010), for whom the adjustment in the number of plants due to changes in employment was larger. In this case, the explanation may lie in more mature markets that are under the EU regulations that mitigate fast turnover. The difference may also be due to different levels of data aggregation. I use industry data, while Feenstra (2008, 2010) uses plant level data. Nevertheless, the export share of production provides adjustment by a larger amount than the number of products found in Feenstra (2008, 2010) and seems to play a larger role as an adjustment mechanism in Europe than in the Maquiladora industry.

The second coefficient  $\alpha_2$  represents the increase in overall exports which, as expected, is causing an even greater response in the export share of production in the offshoring sector. The results for industry export per variety, in column (2) of Table 3.6, follow a similar pattern.

Table 3.6. Adjustment in the offshoring industry in CE countries. Extensive margin (export).

	Aggregated export share of production - the extensive margin of exports ( $XS_{it}$ ) (1)	Industry export per variety over export share in that industry - the intensive margin of exports ( $X_{it}/XS_{it}$ ) (2)
Industry share of exports ( $X_{it}/X_t$ )	0.390*** (0.076)	0.609*** (0.076)
Total exports ( $X_t$ )	0.528*** (0.042)	0.472*** (0.042)
R2	0.47	0.53
n	624	624

Note: Column (1) shows the regression of the aggregated export share of production in the offshoring sector on the total CE offshoring industry share of exports and total exports, while the column (2) regresses industry export per variety on the same independent variables. The sample consists of all manufacturing industries of the four CE countries that are engaged in offshoring activities. OECD Globalization data is in yearly frequency from 1997 to 2007. All variables are in real terms and expressed in logs. All regressions control for industry fixed effects. Standard errors are clustered by industry and shown in parenthesis. \*\*\* indicates 1% significance level.

### 3.2.4 Import Evidence

The last approach to confirm the significance of offshoring consists in analyzing the imported quantities of intermediate input in CE countries. For the manufacturing sector of CE countries, the intermediate input ratio, defined as the percentage of imported to domestically produced intermediates, increased for all four countries (Figure 3.10) with an average increase of 57% in 2005.

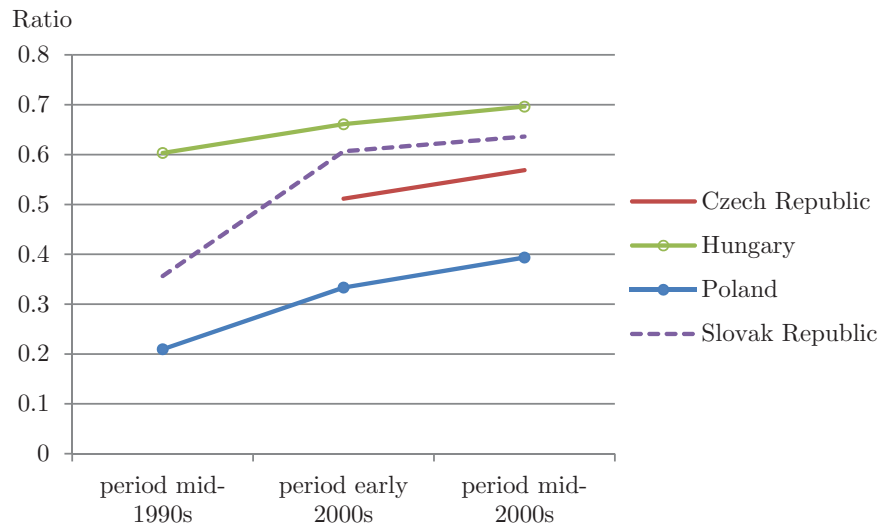


Figure 3.10 Intermediate input ratio in manufactures (ISIC15-37) in CEC countries.  
Source: Author's illustration based on OECD data.

The engagement of Central Europe in production sharing is even more visible when comparing the percentage change in imported intermediate ratio over the last decade between CEC, Western Europe, and China and India, countries commonly viewed as key offshoring and outsourcing destinations (Figure 3.11). The increase in imported production input is highest in CEC, in total over 80%, and 95% just for manufacturing, while for both China and India, the increase in imported intermediate ratio is below 20%.

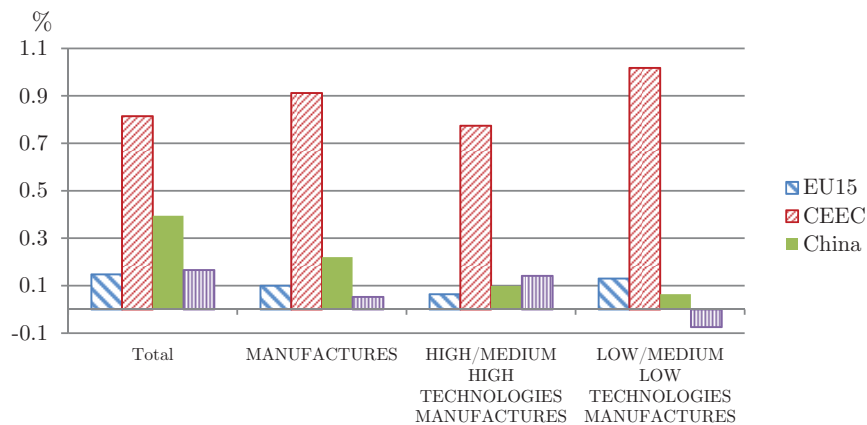


Figure 3.11 Percentage change in imported intermediates ratio between 1995 and 2005.

Note: CECs are Czech Rep., Hungary, Poland, Slovak Rep., Turkey, Estonia, Romania, Russia and Slovenia.

Source: Author's illustration based on OECD data.



BHF (2009) focus on offshoring by the U.S. manufacturing industry in Mexico's maquiladora sector. Offshoring in Central and Eastern Europe is likely to be equally important (Figure 3.12). The imported intermediate inputs in manufacturing seem very similar, if not higher for the four analyzed CE countries, where they account for almost 60% of the total manufacturing in 2005.

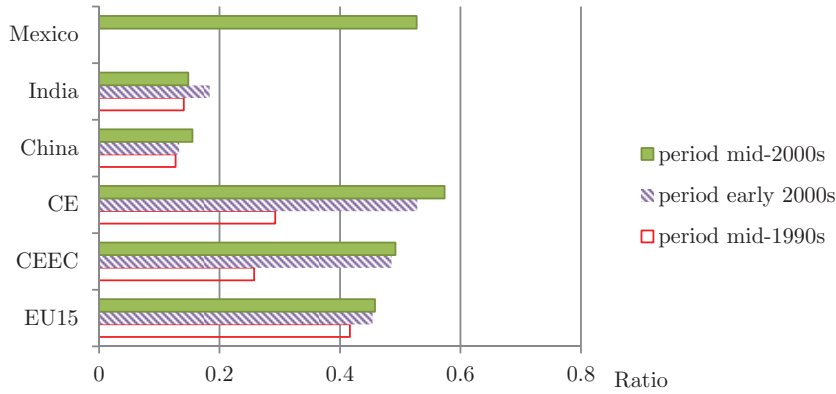


Figure 3.12 Imported intermediates ratio in manufacturing.

Note: CECs are Czech Rep., Hungary, Poland, Slovak Rep., Turkey, Estonia, Romania, Russia and Slovenia. Source: Author's illustration based on OECD data.

The following introduces import adjustments in the offshoring sector in CEE countries. I apply a reasoning analogical to the export evidence from the previous section where I follow Feenstra (2008, 2010). To account for the adjustment in the intensive margin, I consider the imported quantities for intermediate input. Let  $R_{it}$  be the share of imported intermediates (imported intermediates ratio) used in an offshoring industry  $i$  at destination at time  $t$ ,  $M_{it}$  the value of imports for offshoring industry  $i$  at  $t$ , and  $M_t$  the total imports at  $t$  in aggregated offshoring sector at  $t$ . I specify the equations:

$$\ln R_{it} = \alpha_0 + \alpha_1 \ln \frac{M_{it}}{M_t} + \alpha_2 \ln M_t + \varepsilon_{it} \quad (3.8)$$

$$\ln \frac{M_{it}}{R_{it}} = \beta_0 + \beta_1 \ln \frac{M_{it}}{M_t} + \beta_3 \ln M_t - \varepsilon_{it} \quad (3.9)$$

The regression results presented in Table 3.7 are controlled for fixed effects. Robust standard errors are ensured. The estimate for coefficient  $\alpha_1$  in column (1) is insignificant but  $\alpha_2$  is 0.538 and significant at 1% level. It shows that intermediate import ratio responds by a large amount to the increase in total imports.

The intermediate import ratio is calculated as the intermediate import amount over the total intermediate demand for each sector<sup>44</sup>. It is a measure of foreign input into production, and one may think of it as a proxy for the amount of imported intermediates in a given industry<sup>45</sup>. Therefore, in column (2), the industry import per imported intermediate input responds strongly to the increased import share of a given industry ( $\beta_1 = 1.031$ ) as well as to total imports ( $\beta_2 = 0.462$ ). In other words, the intermediate import ratio, the share of imported to total intermediate inputs, is a channel of adjustment in the shifts of an industry's imports.

Table 3.7 Adjustment in the offshoring industry in CE countries. Intensive margin (import).

	Intermediate Import Ratio ( $R_{it}$ ) (1)	Industry import to imported intermediates ratio (imports per imported intermediates) ( $M_{it}/R_{it}$ ) (2)
Industry share of imports ( $M_{it}/M_t$ )	-0.031 (0.071)	1.031*** (0.71)
Total imports ( $M_t$ )	0.538*** (0.052)	0.462*** (0.052)
R2	0.38	0.63
n	432	432

Note: Column (1) shows regression of the intermediate import ratio in CEC offshoring sector on the industry share of imports and total imports, while the column (2) regresses industry import per imported intermediate on the same independent variables. The sample consists of all manufacturing industries of the four CE countries that are engaged in offshoring activities. OECD Globalization data is in yearly frequency from 1997 to 2007. All variables are in real terms and expressed in logs. All regressions control for industry fixed effects. Standard errors are clustered by industry and shown in parenthesis. \*\*\* indicates 1% significance level.

<sup>44</sup> This definition follows the OECD STAN Input-Output Database.

<sup>45</sup> This measure takes into account the amounts of intermediate input imported from the EU15 into offshoring industries in four CEE countries.

### 3.2.5 Summary of the Motivation Exercise

The analysis of adjustments in the offshoring industry in CE countries reveals firm entry and exit as an important channel through which the offshoring sector reacts to aggregate shocks. Furthermore, the export share of production in each industry responds to shifts in CECs exports towards that industry, and the intermediate import ratio, representing the share of imported to total intermediate inputs, is a channel of adjustment in the shifts of an industry's imports.

Such observations attest the value of the BHF (2009) model of offshoring and macroeconomic volatility for Europe, and call for further analysis.

### 3.3 THEORETICAL MODEL

To analyze the effects of offshoring in the European context, I use a Dynamic Stochastic General Equilibrium (DSGE) model with a continuum of goods, two countries and three sectors. The model shares the analytical expression of the system with the baseline model developed in Chapter 2. Unlike the previous chapter, I only highlight the most important elements of the model<sup>46</sup>.

As in Chapter 2, I follow BHF (2011). The economy is populated by households, firms, and government authorities. The model has two countries: home and foreign, where the home country represents Western Europe and the foreign country represents Central Europe. In both countries, households consume baskets of two types of country-specific homogenous goods (domestic and foreign), and a continuum of differentiated multinational goods ( $z \in [0,1]$ ). These households solely derive their income from work. The government is a consumer in a similar manner as households. The multinational sector  $M$  is common to both countries and multinational firms, while the homogenous sectors  $H$  and  $F$  are country-specific. The foreign country is denoted by an asterisk. Each country produces two goods, a country-specific good  $j$  and a differentiated multinational good  $z$ . There is an offshoring relationship in the multinational sector between the two countries, such that the home country could offshore production of some of good  $z$  to the foreign country. The offshoring decisions of firms are driven by cost saving and are taken as responses to macroeconomic shocks. They determine the offshoring margin  $z'_t$ , which, as described below, is central to the model.

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<sup>46</sup> For the complete model specification, see Chapter 2, Sections 2.2 - 2.4.

### 3.3.1 Offshoring Sector

A continuum of goods  $z \in [0, 1]$  is produced in the multinational sector  $M$ . The unit labor requirements in the multinational sector  $M$  for tasks performed to produce good  $z$  are equal to  $a_{Mt}(z) = \frac{T}{(z_t)^{\frac{1}{\theta}}}$  at home, and  $a_{Mt}^*(z) = \frac{T^*}{(1-z_t)^{\frac{1}{\theta}}}$  abroad, where  $T$  and  $T^*$  are scaling parameters and  $\theta$  defines the curvature of the distribution of productivities.

Goods  $z$  are ordered so that  $A'(z) < 0$ ; i.e. the comparative advantage of country  $F$  decreases as  $z$  increases. It involves a downward sloping relative unit labor requirement  $A(z_t)$ . The offshoring condition defining  $z'_t$  requires the relative wages  $\frac{W_t^*}{W_t}$  to be equal to the relative unit labor requirement. Therefore the offshoring cutoff is defined as:

$$\frac{W_t^*}{W_t} = \frac{T}{T^*} \left( \frac{1-z_t}{z_t} \right)^{\frac{1}{\theta}} \quad (3.10)$$

As in Chapter 2, the offshored activities (performed abroad) are  $z_t < z'_t$ , and those not offshored and done in the home country are  $z_t > z'_t$ .

The price index of multinational goods  $P_{Mt}$  is specified by:

$$P_{Mt} = T^* W_t^* \frac{\theta}{\theta-1} \left[ 1 - (1-z_t')^{\frac{\theta-1}{\theta}} \right] + T W_t \frac{\theta}{\theta-1} \left[ 1 - (z_t')^{\frac{\theta-1}{\theta}} \right] \quad (3.11)$$

The market for each  $z$  is perfectly competitive with low entry and exit barriers, and no single buyer or seller large enough to influence the market price  $P_{Mt}$ .

The total labor demand in the multinational sector at home consists of the labor demand for variable cost (assembly) activities  $L_{Mt}$  performed at home (for  $z_t > z'_t$ , i.e. that are not offshored), and the labor demand for the fixed cost (managerial) activities  $L_{Bt}$ :

$$L_{Mt} = \frac{D_{Mt} + D_{Mt}^* \left( \frac{1-n}{n} \right)}{W_t} (1-z'_t) \quad (3.12)$$

$$L_{B_t} = B(1 - z'_t) \quad (3.13)$$

The corresponding equations apply to the total labor demand in the multinational sector abroad:

$$\left(\frac{1-n}{n}\right)L_{M_t}^* = \frac{D_{M_t} + D_{M_t}^* \left(\frac{1-n}{n}\right)}{W_t^*} z'_t \quad (3.14)$$

$$L_{B_t}^* = B^* z'_t \quad (3.15)$$

### 3.3.2 Households

The representative household's behavior is described by two stages. In the first stage, the representative household makes its consumption decisions on domestic and foreign goods. The consumption index is:

$$C_t = (C_{M_t}^\alpha C_{H_t}^{1-\alpha})^\omega C_{F_t}^{1-\omega} \quad (3.16)$$

where  $\alpha \in [0, 1]$ .  $\alpha$  is the share of home-produced multinational goods  $z$  in the total consumption,  $(1 - \alpha)$  represents the share of domestic-produced goods  $j$ ,  $\omega$  is the share of home produced goods and  $(1 - \omega)$  stands for the share of foreign-produced goods  $j$ . The utility-based consumer price index could be expressed as:

$$P_t = (P_{M_t}^\alpha P_{H_t}^{1-\alpha})^\omega P_{F_t}^{1-\omega} \quad (3.17)$$

The optimal allocation of any given expenditure between homogenous, domestic and foreign, or multinational goods yields the following consumption demands:

$$C_{Ht} = (1 - \alpha)\omega \left( \frac{P_t}{P_{Ht}} \right) C_t \quad (3.18)$$

$$C_{Ft} = (1 - \omega) \left( \frac{P_t}{P_{Ft}} \right) C_t \quad (3.19)$$

$$C_{Mt} = \alpha\omega \left( \frac{P_t}{P_{Mt}} \right) C_t \quad (3.20)$$

In the second stage, the domestic household maximizes:

$$E_t \sum_{t=0}^{\infty} \beta^t \left[ \frac{1}{1 - \phi} C_t^{1-\phi} - \frac{1}{1 + \mu} L_t^{1+\mu} \right] \quad (3.21)$$

where all parameters have the same meaning as in Chapter 2. In the dynamic phase, the household holds bonds, rents out its capital to the perfectly competitive firm, and derives income from working. Therefore, the household's budget constraint is written as:

$$P_t C_t + \sum_{s^{t+1}} Q(s^{t+1}|s^t) b(s^{t+1}) = W_t L_t + b_t - Tax_t \quad (3.22)$$

where  $b$  is the quantity of state-contingent assets (identical across countries) expressed in numeraire goods, purchased at period  $t$  and expiring at time  $t + 1$  provided that state  $s^{t+1}$  occurs. The first order conditions derived from the utility maximization of equation (3.21) and subject to the budget constraint of equation (3.22) with respect to  $C_t$ ,  $L_t$  and  $b_{t+1}$  are:

$$\frac{P_t C_t^{\phi}}{P_t^* C_t^{*\phi}} = \xi \quad (3.23)$$

$$L_t^{\mu} = \frac{W_t}{P_t} (C_t)^{-\phi} \quad (3.24)$$

$$\beta E_t \left( \frac{C_{t+1}}{C_t} \right)^{-\phi} = \frac{1}{1 + i_{t+1}} E_t \left( \frac{P_{t+1}}{P_t} \right) \quad (3.25)$$

Equation (3.23) defines the risk-sharing condition between home and the foreign country, where  $\xi$  is a constant indicating the relative per-capita wealth of the home country in the initial assets allocation and  $i_t$  is the nominal interest rate. Equation (3.24) states the relationship

between the utility from consumption and the disutility for labor. Equation (3.25) is the Euler equation governing the dynamic evolution of consumption. Given the nominal interest rate, if the current price level is low relative to the future price level, current consumption is encouraged over future consumption.

The real interest rate  $r_t$  and inflation  $\pi_t$  are defined as:

$$r_t = i_t - \pi_t \quad (3.26)$$

$$\pi_t = \frac{P_{t+1}}{P_t} \quad (3.27)$$

### 3.3.3 Firms

There are two types of firms. The first type is the perfectly competitive multinational firm producing a differentiated intermediate good indexed by  $z \in [0,1]$ . These goods are both tradable and offshorable. The second type of firm is the perfectly competitive firm producing homogenous goods which are tradable but not offshorable.

The representative home country firm is a perfectly competitive firm which uses labor as sole input, according to the following specification:

$$Y_{Ht} = \frac{L_{Ht}}{a_{Ht}} \quad (3.28)$$

where  $Y_{Ht}$  represents output,  $L_{Ht}$ , labor, and  $a_{Ht}$  is the country-specific unit labor requirement.

The first order condition (FOC) deduced from the profit maximization condition specifies wages and relative prices:

$$W_t = \frac{P_{Ht}}{P_{Mt}a_{Ht}} \quad (3.29)$$



The multinational firm uses labor from both home and the foreign country as input factors. The production function is described by the following equation:

$$Y_{Mt} = \frac{L_{Mt}}{a_{Mt}} + \left( \frac{1-n}{n} \right) \frac{L_{Mt}^*}{a_{Mt}^*} \quad (3.30)$$

There is no specific wage in the multinational sector; home and foreign wages apply.

### 3.3.4 Government

The government uses lump-sum taxes to finance its expenditures. To simplify the analysis, I assume that the government budget is balanced at each period. The government consumes fractions of the output of good  $j$  and of good  $z$  in a similar way as households. Government demands are described by the following equations:

$$G_{Ht} = (1 - \alpha) \omega_G \left( \frac{P_t}{P_{Ht}} \right) G_t \quad (3.31)$$

$$G_{Ft}^* = \omega_G^* \left( \frac{P_t^*}{P_{Ft}^*} \right) G_t^* \quad (3.32)$$

$$G_{Mt} = \alpha \omega_G \left( \frac{P_t}{P_{Mt}} \right) G_t \quad (3.33)$$

### 3.3.5 Market Clearing Conditions

The equilibrium in the home country goods market requires the total output to be equal to the total demand:

$$D_{Ht} + \left( \frac{1-n}{n} \right) D_{Ht}^* = Y_{Ht} \quad (3.34)$$

where domestic and foreign demands for the home country specific goods are  $D_{Ht} = C_{Ht} + G_{Ht}$  and  $D_{Ht}^* = C_{Ht}^*$  respectively. The corresponding condition applies to the foreign output.

The equilibrium in the domestic multinational market requires:

$$D_{Mt} + \left(\frac{1-n}{n}\right) D_{Mt}^* = Y_{Mt} \quad (3.35)$$

where  $D_{Mt} = C_{Mt} + G_{Mt}$  and  $D_{Mt}^* = C_{Mt}^*$  are the domestic and foreign demands for the multinational good.

The market clearing condition in the domestic labor market is:

$$L_t = L_{Ht} + L_{Mt} + L_{Bt} \quad (3.36)$$

The corresponding condition applies to the foreign labor market.

The general equilibrium model comprises 30 endogenous variables  $\{L_t, L_t^*, L_{Ht}, L_{Ht}^*, L_{Mt}, L_{Mt}^*, W_t, W_t^*, C_{Ht}, C_{Ht}^*, C_{Ft}, C_{Ft}^*, C_{Mt}, C_{Mt}^*, P_{Ht}, P_{Ft}, P_{Mt}, z_t', i_t, P_t, P_t^*, C_t, C_t^*, r_t, \pi_t, Y_{Ht}, Y_{Ht}^*, Y_{Mt}, Y_{Mt}^*, L_{Bt}, L_{Bt}^*\}$  and 4 exogenous variables  $\{G_t, G_t^*, a_{Ht}, a_{Ft}^*\}$ .

### 3.3.6 Exogenous Processes

The model includes structural shocks to demand and supply. Demand shocks enter through the terms  $G_t$  and  $G_t^*$ , while productivity supply shocks enter through the unit labor requirements  $a_{Ht}$  and  $a_{Ft}^*$ .  $\bar{a}_H$ ,  $\bar{a}_F^*$ ,  $\bar{G}$ , and  $\bar{G}^*$  represent steady state values.

$$a_{Ht} = \bar{a}_H + \rho_{a_H} a_{H,t-1} + \epsilon_t^{a_H} \quad (3.37)$$

$$a_{Ft}^* = \bar{a}_F^* + \rho_{a_F^*} a_{F,t-1}^* + \epsilon_t^{a_F^*} \quad (3.38)$$

$$G_t = \bar{G} + \rho_G G_{t-1} + \epsilon_t^G \quad (3.39)$$

$$G_t^* = \bar{G}^* + \rho_{G^*} G_{t-1}^* + \epsilon_t^{G^*} \quad (3.40)$$

## 3.4 PARAMETERS CALIBRATION AND STEADY STATE

### Parameters calibration

The model is calibrated to European data. ‘Home country’ refers to the group of countries forming the European Monetary Union (EMU), and the ‘foreign country’ corresponds to the ten Central European Countries (CECs) that joined the European Union in 2004 and 2007<sup>47</sup>. Since data are not available for some countries, the calibration mostly relies on data for Poland and the Czech Republic in the CECs group, and on Germany data for the EMU. The model is solved numerically with the parameter values summarized in Table 3.8. Following the business cycle literature, the inverse of the elasticity of intertemporal substitution  $\phi$  is set to 2, and the labor supply elasticity is  $\mu = 2.5$ .

Zorell (2009) reports that the euro area imported about 21.5 % of all intermediates in 2000, while Egger and Egger (2005) find that 48% of the euro area’s processing imports came from the CECs. Also, according to ECB data, goods imported from the CECs into the euro area averaged at 12% of the total imports in 2008. Hence, I calibrate the offshoring share parameter  $\alpha$  at 0.12. I adopt the annual discount factor  $\beta$  of  $1.03^{-0.25}$  from Laxton and Pesenti (2003), who calibrate their model using euro area and Czech data.

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<sup>47</sup> The twelve EMU countries are: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Spain. The ten CECs are: Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia.

Table 3.8 Calibration of the parameters for the EU-CECs model.

Parameters		BHF (2011)	Benchmark model (Ch. 2)	Benchmark Europe
$\omega$	Home bias in home country	0.88	0.88	0.45
$\omega^*$	Home bias abroad	0.71	0.71	0.40
$\alpha$	Offshoring expenditure share	0.24	0.24	0.12
$\beta$	Discount factor	-	0.96	$1.03^{-0.25}$
$\mu$	Labor supply elasticity	1	1	2.5
$\phi$	Risk aversion	2	2	2
$n$	Relative size of home country	0.74	0.74	0.785
$\xi$	Relative wealth of home country	4.3	1.97	2.5
$\theta$	Curvature of distribution	8.28	8.28	8.28
$T$	Home country technology	0.712	0.712	0.895
$T^*$	Foreign country technology	7.94	7.94	5
$\omega_G$	Home country government preferences	1	1	1
$\omega_G^*$	Foreign country government preferences	1	1	1
$B$	Fixed cost incurred at home	-	0.275	1.416
$B^*$	Fixed cost incurred abroad	-	10.042	29.463
$\bar{W}^*$	Wage ratio	1	1	1
$\bar{W}$		8	8	4
$\bar{z}'$	Offshoring margin	0.06	0.06	0.06
$\rho_{a_H}$	Serial correlation parameter for domestic productivity	-	0.9	0.9
$\rho_{a_F^*}$	Serial correlation parameter for foreign productivity	-	0.9	0.9
$\rho_G$	Serial correlation parameter for domestic government demand	-	0.9	0.9
$\rho_{G^*}$	Serial correlation parameter for foreign government demand	-	0.9	0.9
$\sigma_\epsilon^{a_H}$	Standard deviation of home productivity	-	0.01	0.01
$\sigma_\epsilon^{a_F}$	Standard deviation of foreign productivity	-	0.01	0.01
$\sigma_\epsilon^G$	Standard deviation of domestic government demand	-	0.01	0.01
$\sigma_\epsilon^{G^*}$	Standard deviation of foreign government demand	-	0.01	0.01

Note: See Table A1 on page 112 of Appendix A for variables description.

The home bias parameter for the home country  $\omega$  is set to 0.45, while for the foreign country,  $\omega^* = 0.40$ . I assume that the government has complete bias towards domestic goods, so the parameters  $\omega_G$  and  $\omega_G^*$  are equal to 1. I address the stylized fact that the private consumers bias is smaller than the government bias in both countries by ensuring that  $\omega < \omega_G$  and  $\omega^* < \omega_G^*$ . The parameter  $n$  is calibrated to reflect the approximate 0.785 share of the home

country in the combined population of the two countries. The total population of EU-15 was 324 477 895 in 2010, while the CECs totaled 88 957 962 people. Therefore, the relative size of the home country is  $n = 0.785$ .<sup>48</sup>

Calibrating the relative unit labor requirement distribution  $A(z)$  involves choosing  $\theta$ ,  $T$ , and  $T^*$  so that the steady state offshoring margin  $\bar{z}'$  equals 0.06, as in Chapter 2. The curvature parameter  $\theta$  is calibrated at 8.28 based on the estimation by Eaton and Kortum (2002). The technology parameter for the domestic offshoring sector,  $T$ , is calibrated to satisfy the equation  $a_{Mt}(\bar{z}') = \frac{T}{(\bar{z}')^{\frac{1}{\theta}}} = 1.25$ , so  $T = (\bar{z}')^{\frac{1}{\theta}} = 0.895$ . The foreign technology parameter  $T^*$  is calibrated to equalize the relative labor unit requirement from condition (2.1) in Chapter 2 to the relative wage. As I assume the relative wage  $\frac{\bar{W}^*}{\bar{W}} = 1/4$ ,  $T^*$  is equal to 5. The relative wealth parameter  $\xi$  is chosen to allow the relative wage ratio of 1/4. The fixed cost labor parameters  $B$  and  $B^*$  are multiplicative coefficients tied to the offshoring margin  $\bar{z}'$ .

The serial correlation parameters  $\rho_{a_H}$ ,  $\rho_{a_F^*}$ ,  $\rho_G$  and  $\rho_{G^*}$  describe how fast the shocks disappear, and are all set to 0.9, as often encountered in the macroeconomics literature<sup>49</sup>. The standard deviations of all shocks  $\sigma_{\epsilon}^{a_H}$ ,  $\sigma_{\epsilon}^{a_F^*}$ ,  $\sigma_{\epsilon}^G$ , and  $\sigma_{\epsilon}^{G^*}$  are equal 0.01, therefore shocks have a 1% standard deviation<sup>50</sup>, which is a common practice in macroeconomic literature.

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<sup>48</sup> Calculations are based on the OECD database available at [www.stats.oecd.org](http://www.stats.oecd.org).

<sup>49</sup> As in Chapter 2, I follow Gali et al. (2007) and set the persistence parameter of government spending to 0.9, like productivity, which is a common choice in the literature. See part 4.1 in Appendix A for further discussion about serial correlation parameters.

<sup>50</sup> I normalize all persistence parameters values to 0.9 and all standard deviations to 0.1, like in Chapter 2. It helps to avoid overcomplicating the analysis and allows easily comparing the responses to both types of shocks, productivity and demand. It is straightforward to see the effects of offshoring and compare them with different model specifications, and with the benchmark model in Chapter 2.

## Steady state

After finding all necessary conditions<sup>51</sup> and calibrating the parameters, I calculate the steady state. At steady state, all variables are assumed constant. Shocks are non-existent at the stationary state.

Like in Chapter 2, the numerical steady state needs to be calculated first to let *Dynare* compute Taylor series expansion of the model when it executes the program to perform the stochastic simulation. As the analytical expression of the model follows the specification from Chapter 2, the steady state equations are obtained by the same reasoning. Also, because parameters  $\mu$  and  $\phi$  differ, equation (2.62), with reference to section 2.4.1, is, for this model:

$$\bar{L} = \left( \frac{\bar{W}}{\bar{P}\bar{C}^2} \right)^{\frac{2}{5}} \quad (3.41)$$

and (2.63):

$$\bar{L}^* = \left( \frac{\bar{W}^*}{\bar{P}\bar{C}^{*2}} \right)^{\frac{2}{5}} \quad (3.42)$$

As the parameter values differ, a different steady state equilibrium emerges, and different laws of motion, which govern the dynamics of the model, eventually appear.

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<sup>51</sup> The list of all first order and other conditions can be found in part 2 of Appendix A.

## 3.5 STOCHASTIC SIMULATION RESULTS

I study the dynamic properties of the model using impulse response functions, correlations, and standard deviations. Impulse responses graphically depict the immediate response of a variable to an orthogonal shock, correlations describe the direction of the co-movements between variables and their level of synchronization, and standard deviations are indications of volatility levels.

### 3.5.1 Benchmark Results

Figures 3.13 – 3.16 illustrate the effects of productivity and demand shocks on key macroeconomic variables. Generally, the results show patterns similar to the baseline model in Chapter 2, although the magnitudes of the effects differ as the model is calibrated for the European data.

I observe similar responses, including movements of the offshoring margin due to changes in the relative wage, the substitution and complementarity of labor, the effects of the interest rates channel of offshoring, the volatility transmission phenomenon, and generally positive outcomes for the home economy.

In response to a negative foreign productivity shock (see Figure 3.13), the marginal product of foreign labor decreases and hence the foreign wage decreases. This cost saving incentive for firms encourages offshoring, and  $\bar{z}'$  increases. Production is reallocated abroad. This augmentation in offshoring triggers changes in the labor market: the demand for labor in

the multinational sector abroad rises, but it falls at home. Home prices go down relatively to foreign prices, lowering inflation. The lowering of prices amplified by offshoring increases domestic consumption, and results in lower interest rates. A similar but mirrored mechanism takes place after a domestic productivity shock (Figure 3.14), with the home country in-sourcing production back as offshoring stops being profitable.

In response to a domestic demand shock (see Figure 3.15), the pro-cyclical wage increases, creating incentives to offshore. There are similar movements in the sectoral labor in both countries as in the case of negative productivity shocks, with the exception that multinational labor demands  $L_{Mt}$  and  $L_{Mt}^*$  increase in both countries. However, at home, the growth of managerial positions  $L_{Bt}$  is more significant. The rising multinational and foreign prices drive the total prices up, increasing inflation. Lower consumption encourages higher interest rates. Offshoring due to the surge in demand does not only amplify prices, but also influences interest rates by changing consumption decisions. Demand driven offshoring brings more positive effects for both countries compared to the cost-saving driven offshoring that occurs in case of a negative productivity shock. The decrease in foreign output is smaller than in the case of an  $a_{Ft}^*$  shock. The wage gap widening is smaller and the substitutability of home assembly labor by its foreign counterpart is lower. Figure 3.16 shows the responses to a foreign demand shock  $G_t^*$ . The decrease in offshoring due to too high wages abroad leads to a cut back in assembly labor abroad  $L_{Mt}^*$ . In this case, foreign labor is substituted by the domestic workforce.

As in Chapter 2, an increase in offshoring decreases the multinational price level and increases consumption in the multinational sector.

Despite the generally similar pattern of the impulse response functions to those of the baseline model in the previous chapter, there are several salient differences. The domestic demand shock (Figure 3.15) creates jobs in the multinational sector at home and abroad, and



additional jobs in domestic managerial sector. It also triggers an upsurge of domestic output by 0.01%.

Also, as compared to the benchmark model from Chapter 2, the increase in offshoring margin is more sensitive to negative foreign productivity shock. At the same time, the insourcing following negative domestic productivity shock is of smaller magnitude. Thus, the offshoring margin appears directionally biased towards expansion abroad, compared to the baseline open economy model.

The offshoring margin is also less sensitive to demand shocks in the European model: following domestic demand shocks, offshoring rises by 0.014% and it decreases by 0.018% after a foreign demand shock. In the case of the US-Mexico model in Chapter 2, the increase in offshoring is 0.02% and the reduction is 0.075%.

I also find a foreign productivity effect similar to the one in Chapter 2 (see Figures 3.13 and 3.14). When a negative domestic productivity shock  $a_{Ht}$  follow a negative foreign productivity shock  $a_{Ft}^*$ , we can observe offshoring followed by in-shoring back to the home country. At the offshoring stage, the foreign country wage and output decrease, but these effects are smaller in magnitude than their positive counterparts in those variables after an  $a_{Ht}$  shock. There is a positive and persistent effect of offshoring on foreign productivity.

However, this is not the case for the foreign labor market. Offshoring increases the demand for multinational labor abroad, but in-shoring decreases it more.

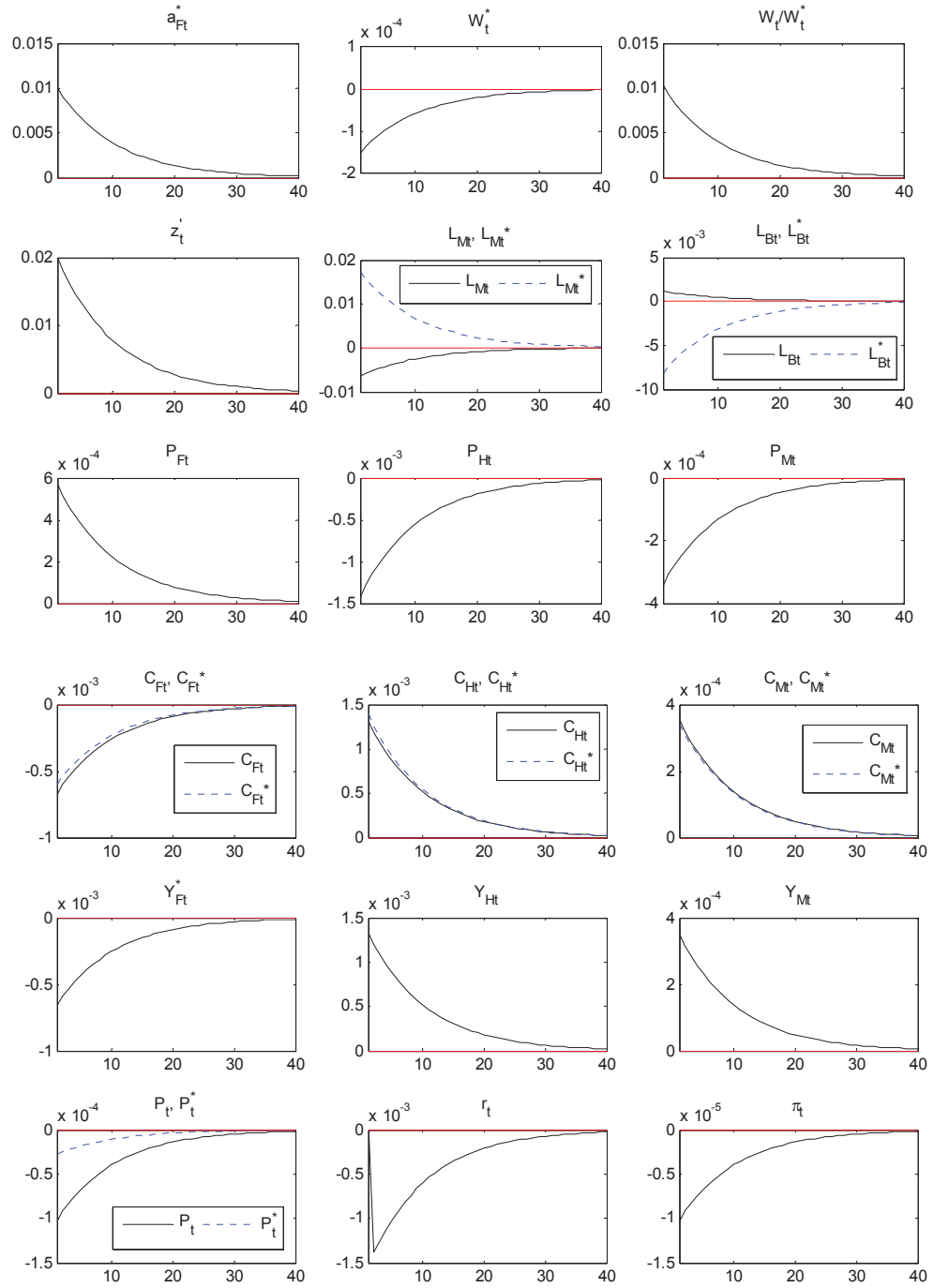


Figure 3.13 Impulse response functions to the negative foreign productivity  $a_{Ft}^*$  shock.  
Note: See Table A1 on page 112 of Appendix A for variables description.

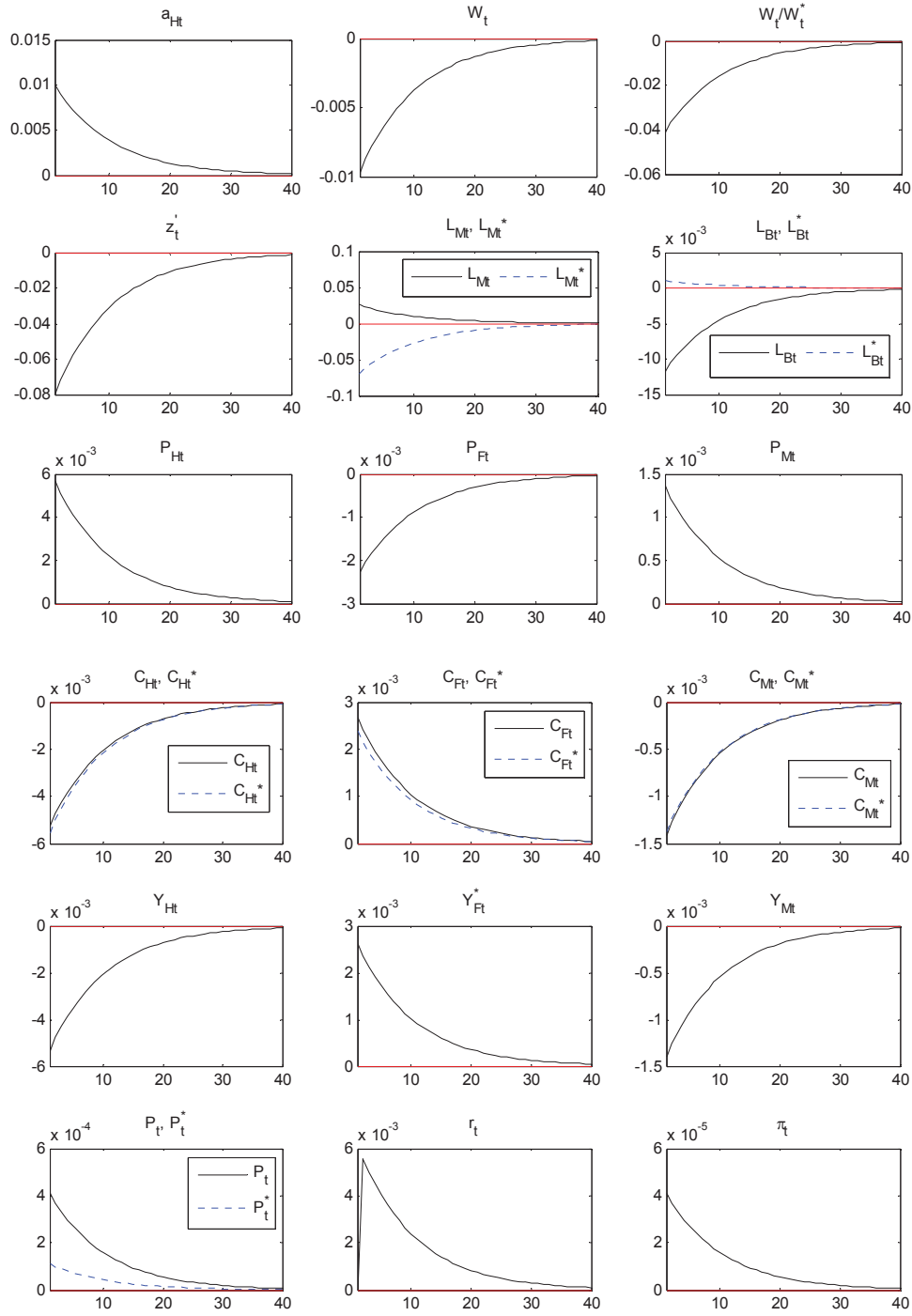


Figure 3.14 Impulse response functions to the negative domestic productivity  $a_{Ht}$  shock.  
Note: See Table A1 on page 112 of Appendix A for variables description.

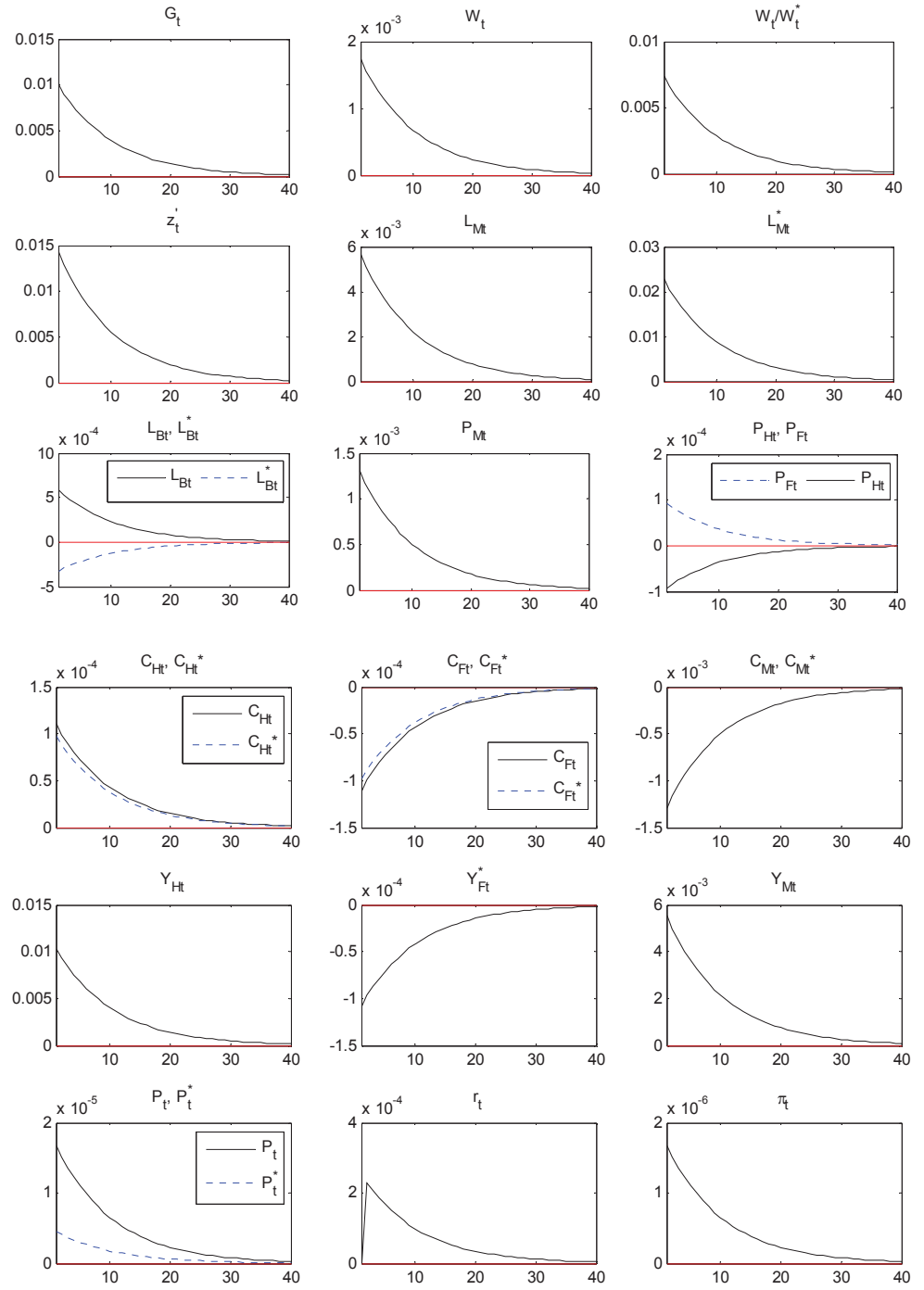


Figure 3.15 Impulse response functions to domestic demand  $G_t$  shock.  
Note: See Table A1 on page 112 of Appendix A for variables description.

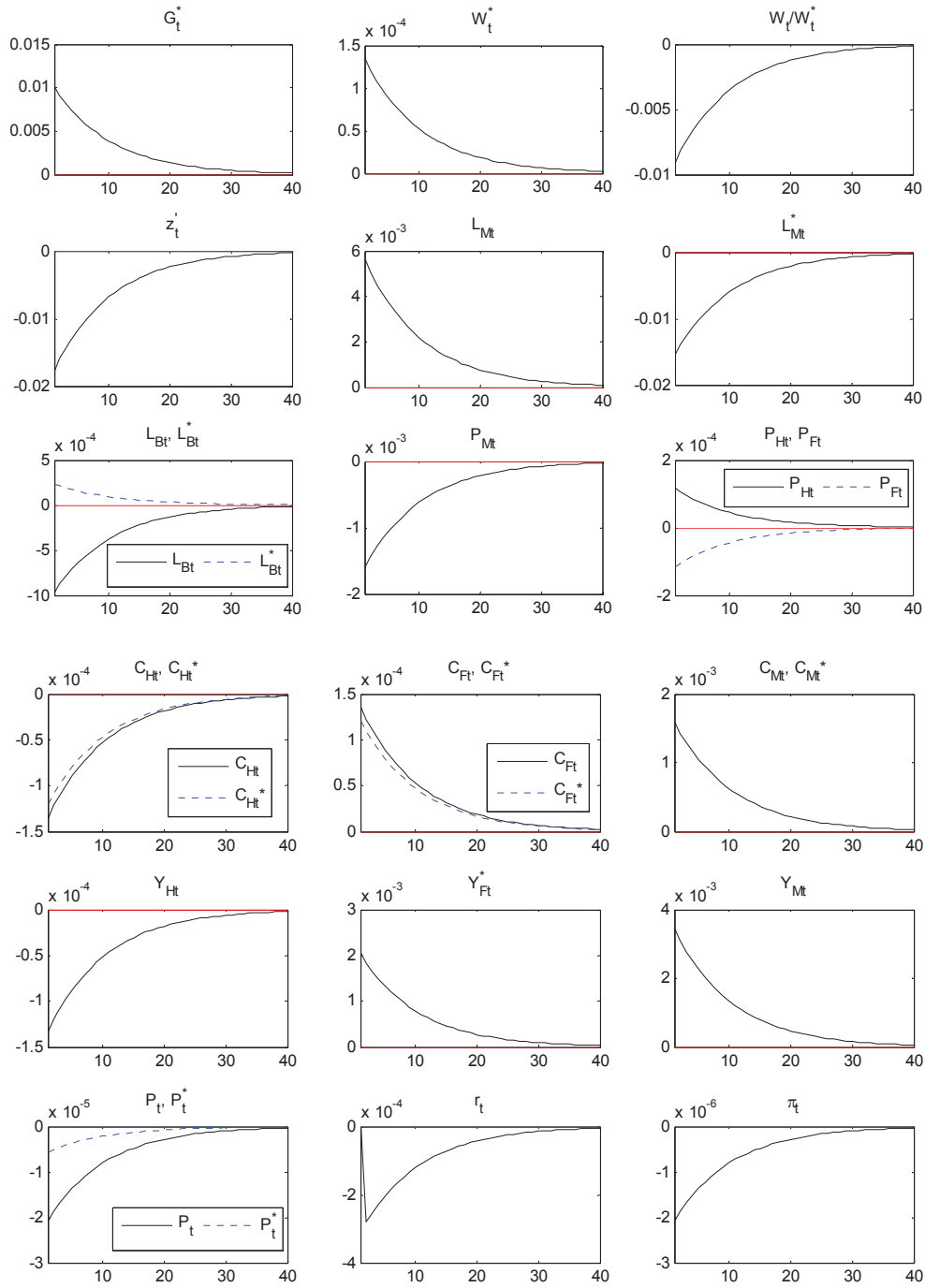


Figure 3.16 Impulse response functions to foreign demand  $G_t^*$  shock.  
Note: See Table A1 on page 112 of Appendix A for variables description.

### 3.5.2 Sensitivity Analysis

Table 3.9 and 3.10 summarize the correlations and standard deviations of selected macroeconomic variables for different degrees of offshoring. I also change  $\alpha$ , the share of multinational goods in the country production, and vary  $\omega$ , the home country bias parameter to check the robustness of the model.

The correlations in Table 3.9 are robust for the main variables of interest. The correlation are negative between the domestic and foreign offshoring assembly labor  $L_{Mt}$  and  $L_{Mt}^*$ , and between the offshoring margin  $\bar{z}'$  and domestic assembly labor, foreign managerial labor, foreign wage, interest rate, inflation, and foreign output. Offshoring is in turn positively correlated with domestic managerial labor, foreign offshoring labor in the multinational sector, domestic wage and output, as well as output gap. Similar to the results of Chapter 2, I find that offshoring has generally positive effects for the home economy and rather negative for the foreign country, apart from its labor market. Foreign output turns positive for high values of the parameter  $\alpha$ , when the share of offshorable goods at home is high, and the correlation  $corr(z'_t, Y_{Ft}^*)$  is equal to 0.615. This interesting result suggests that there exists an “offshorability” threshold beyond which offshoring increases output of the foreign economy.

When it comes to domestic output, it is positively correlated with offshoring at any level. This result is very persistent, even more than in Chapter 2. However, with offshoring close to 1,  $corr(z'_t, Y_{Ht})$  is only 0.047. It indicates that at some high level of offshoring margin above 0.5, offshoring becomes less profitable, but still does not lead to a decrease in output for the domestic economy, unlike what was found in Chapter 2.

Table 3.9 Sensitivity analysis: selected correlations for the EU-CECs model.

Correlated Variables	Correlations							
	Low offshoring $\bar{z}' = .0005$ (export only)	Benchmark $\bar{z}' = .06$	Mid-point $\bar{z}' = .5$	High offshoring $\bar{z}' = .99$ (import only)	High $\alpha$ , $\alpha = .87$	Low $\alpha$ , $\alpha = .001$	High $\omega$ , $\omega = .9$	Low $\omega$ , $\omega = .07$
$L_{Mt}, L_{Mt}^*$	-0.891	-0.908	-0.981	-0.997	-0.502	-0.950	-0.949	0.816
$L_t, L_t^*$	0.963	-0.993	-0.987	-0.981	-0.999	-0.990	0.983	0.906
$L_{Mt}^*, L_{Bt}$	0.970	0.949	0.971	0.924	0.837	0.962	0.922	0.530
$L_{Mt}, L_{Bt}^*$	-0.091	0.063	0.524	0.555	-0.103	-0.046	0.867	-0.246
$z_t', L_{Mt}$	-0.935	-0.948	-0.988	-0.836	-0.714	-0.972	-0.981	0.335
$z_t', L_{Bt}$	0.986	0.970	0.983	0.819	0.930	0.975	0.957	0.769
$z_t', L_{Mt}^*$	0.994	0.994	0.995	0.838	0.964	0.997	0.992	0.819
$z_t', L_{Bt}^*$	-0.008	-0.161	-0.538	-0.018	-0.143	-0.018	-0.928	-0.137
$z_t', W_t$	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
$z_t', W_t^*$	-0.995	-0.995	-0.985	-0.834	-0.999	-0.993	-0.984	-1.000
$z_t', r_t$	-0.766	-0.755	-0.769	-0.667	0.766	-0.780	-0.660	0.563
$z_t', \pi_t$	-0.952	-0.936	-0.956	-0.789	0.989	-0.971	-0.900	0.726
$z_t', Y_{Ht}$	0.902	0.713	0.871	0.047	0.760	0.695	0.935	0.650
$z_t', Y_{Ft}^*$	-0.987	-0.863	-0.989	-0.869	0.615	-0.925	-0.856	-0.905
$z_t', W_t/W_t^*$	1.000	1.000	0.994	0.801	1.000	1.000	0.999	1.000

Note: All variables are in natural logs. Correlations are calculated for the model using 2<sup>nd</sup> order Taylor approximation. Simulated variables are HP-filtered. See Table A1 on page 112 of Appendix A for variables description.

I define the volatility of a variable as its standard deviation. Higher degrees of offshoring do not unveil as a clear picture of volatility transmission to the foreign country as in Chapter 2. The ‘export’ of volatility from Western Europe (home country) to Central Europe (foreign country) is visible in the relative wage: with increasing levels of offshoring, the domestic wage is less volatile and the foreign wage becomes more volatile. A similar effect can be observed in total labor. The assembly labor volatility rises in both countries, but at a faster pace abroad, except for high levels of offshoring.

The wage gap volatility increases and the offshoring margin volatility recedes when offshoring intensifies.

At very low levels of offshoring, in column (1) of Table 3.10, many variables tend to be more volatile than for the benchmark model, in column (2). Beyond that, in column (3), the volatility increases again and often falls back in column (4) at very high levels of offshoring. This is the case for homogenous labor at home and abroad, foreign and domestic consumptions and prices, and outputs at home, abroad and in the multinational sector. The volatility distribution follows a J-curve shape for many variables, including consumption in the multinational sector, multinational prices, and demand, interest rates and relative labor.

This finding suggests two immediate conclusions. First, increasing offshoring is not as positive for the home country in terms of volatility transmission as it was in Chapter 2. Second, there exists an optimal offshoring level  $z_t''$  in the European market at which volatility is the lowest (see Figure 3.17).

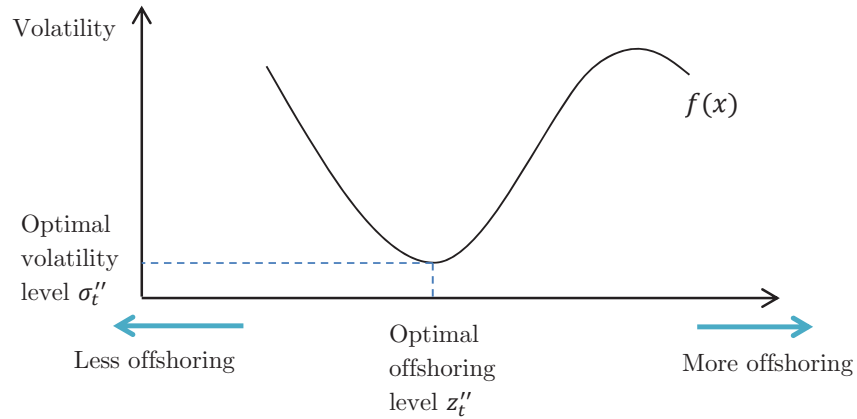


Figure 3.17 The optimal level of offshoring in the European market.

The robustness checks on volatilities for different values of parameters  $\alpha$  and  $\omega$  yield similar results as in Chapter 2. In general, volatility tends to be higher for high levels of  $\omega$  and for low levels of  $\alpha$ . Both settings represent different types of market contractions. Lower  $\alpha$



represents lower “offshorability”, while higher  $\omega$  reflects a bias towards home or multinational goods at the expense of foreign goods, amounting to less diverse preferences.

I conclude that the model performance is robust.

Table 3.10 Sensitivity analysis: selected standard deviations for the EU-CECs model.

Variables	Standard deviations (%)							
	Low offshoring $\bar{z}' = .0005$ (export only) (1)	Benchmark $\bar{z}' = .06$ (2)	Mid- point $\bar{z}' = .5$ (3)	High offshoring $\bar{z}' = .99$ (import only) (4)	High $\alpha$ , $\alpha = .87$	Low $\alpha$ , $\alpha = .001$	High $\omega$ , $\omega = .9$	Low $\omega$ , $\omega = .07$
$L_t$	0.85	0.76	0.77	0.13	0.27	0.90	3.29	0.20
$L_t^*$	0.01	0.04	0.73	4.15	0.02	0.04	1.61	0.10
$L_{Mt}$	4.26	4.72	15.52	70.18	2.25	5.62	13.35	2.76
$L_{Mt}^*$	14.30	13.68	17.79	27.64	5.93	15.88	19.59	4.53
$W_t$	1.96	1.83	1.72	0.11	0.74	2.15	3.29	0.28
$W_t^*$	0.00	0.12	1.86	10.44	0.05	0.14	0.22	0.02
$C_{Ht}$	2.32	0.97	1.93	0.40	1.77	0.81	1.38	1.35
$C_{Ht}^*$	2.47	1.03	2.10	0.28	1.73	0.88	2.26	0.91
$C_{Ft}$	1.43	0.50	1.50	1.30	0.38	0.66	1.61	0.09
$C_{Ft}^*$	1.27	0.44	1.34	1.15	0.34	0.59	0.72	0.53
$C_{Mt}$	2.49	2.13	1.27	15.90	0.78	2.52	8.62	0.49
$C_{Mt}^*$	2.34	2.08	1.42	16.05	0.82	2.45	7.74	0.22
$P_{Ht}$	2.50	1.05	2.13	0.23	1.72	0.92	6.49	0.68
$P_{Ft}$	1.25	0.42	1.31	1.07	0.33	0.56	3.51	0.77
$P_{Mt}$	2.32	2.06	1.45	16.13	0.84	2.42	3.70	0.32
$z_t'$	16.22	15.14	14.28	0.89	6.14	17.82	27.24	2.33
$r_t$	2.53	1.05	2.71	3.13	0.77	1.46	55.29	9.71
$\pi_t$	0.02	0.01	0.02	0.02	0.01	0.01	0.52	0.07
$L_{Bt}$	1.49	2.16	1.47	1.90	1.08	2.52	20.48	0.56
$L_{Bt}^*$	0.95	1.43	1.26	2331.34	4.13	1.48	3.67	3.35
$Y_{Ht}$	3.02	1.98	2.69	1.41	2.58	1.69	1.76	3.37
$Y_{Ft}^*$	1.38	0.58	1.46	1.34	0.38	0.69	1.34	0.18
$W_t/W_t^*$	7.88	7.82	14.43	43.24	3.15	9.24	14.09	1.20
$Y_{Mt}$	2.60	2.35	2.41	16.45	1.80	2.57	8.40	3.24

Note: All variables are in natural logs. Standard deviations are calculated for the model in the 2<sup>nd</sup> order of approximation. Simulated variables are HP-filtered. See Table A1 on page 112 of Appendix A for variables description.

## 3.6 CONCLUSIONS

In this chapter, I first use panel data estimation and descriptive statistics to analyze the roles of the intensive and extensive margins of offshoring in Central European Countries. I obtain statistically significant results that considerably help to understand the phenomenon of offshoring in Europe. The offshoring sector reacts to external shocks through firm entry and exit. I note that the share of imported to total intermediate inputs is sensitive to shifts in industry imports, and also that the shares of export and export per variety of product are affected by the shocks. My results are consistent with the findings of BHF (2009, 2011) for the US and Mexico. They also corroborate the reasoning of Tesar (2008), who suspects offshoring to be an important contributor to the business cycle volatility.

Second, I formally examine the relationships between offshoring margin, volatility, and some key macroeconomic variables. For that purpose I numerically solve a two-country, three-sector DSGE model calibrated to match European data. The theoretical model is extended from the model of BHF (2011). In the model, firms from the European Monetary Union countries offshore to Central European countries, and the offshoring margin is determined endogenously.

I observe movements of the offshoring margin due to changes in relative wage, the substitution and complementarity effects between home and foreign labor, and the interest rates channel of offshoring transmission. I also find that the offshoring margin is biased towards expansion, rather than in-sourcing. This bias coincides with the slow augmentation of offshoring in the EU (Falk and Wolfmayr 2008). I also find that the offshoring margin is less sensitive to demand shocks in the European model than in the benchmark model presented in Chapter 2.

Numerical simulations show that offshoring has mostly positive effects for the EMU and negative for the CECs, aside from their labor markets. Offshoring mostly lessens volatility for the EMU but increases volatility for the CECs. For the Eurozone, offshoring increases output and the managerial labor demand, and decreases inflation and interest rates, but it comes at the cost of a widening of the wage gap. However there exists an offshoring threshold beyond which the profitability of offshoring for the Western European economies decreases.

The model shows generally similar shocks responses to the benchmark model in Chapter 2. The most important difference lies in the creation of jobs in the multinational sector in both countries following a domestic demand shock.

I find some evidence that instability is ‘exported’ along with offshoring from Western to Central Europe, in particular for wage and total labor, and to some extent for multinational labor. I also observe that many variables related to the offshoring sector follow J-shaped volatility curves, a specificity of European offshoring that is absent from the open economy model developed in the previous chapter. Consequently, there exists an *optimal level of offshoring* for which volatility levels tend to be the lowest. This finding is consistent with Zorell (2008), who finds that, to some extent, offshoring decreases volatility.

These results have several policy implications. Offshoring may contribute to preserve differences between new and old EU members by positively affecting Western Europe, and negatively affecting Central European countries. This effect calls for policies promoting convergence and targeting the negative effects of offshoring at destination. Other policies, both at home and at destination, should ensure that labour markets are able to meet the demands of globalizing firms, for instance by fostering the creation of an innovation-friendly environment and of an adaptive labour force. To avoid a middle income trap and to stay competitive, Central Europe needs to move towards modern high-value added industries that do not rely on the advantages of geographical proximity.

## CHAPTER 4

# How Aid Supply Responds to Economic Crises: A Panel VAR Approach<sup>52</sup>

### 4.1 INTRODUCTION

The two previous essays analyze the macroeconomic consequences of the global interdependence of economies through offshoring – a sophisticated component of trade. This interdependence leads to transmitting volatility and shocks to the more cost-effective destination countries. This chapter investigates international aid as another dimension of this global interconnection, which ties the developing regions to their developed counterparts. The late 2000s crisis originating in the US spilled to poorer parts of the world mainly by two channels: contracting global trade and lower corporate financial inflows. For the first time, the crisis was global rather than regional. It was unprecedented, as developed and developing countries fell into recession almost at the same time. In this particular situation, the response of international aid, which is the main funding source in many recipient countries, may have acted as a potential contributor to shocks and volatility transmission from developed to developing countries. It is

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<sup>52</sup> This chapter of the dissertation was carried out under the co-supervision of Professor Finn Tarp, United Nations University, World Institute for Development Economics Research, Helsinki, Finland, as an Overseas Research Attachment co-funded by the UNU-WIDER Ph.D. research grant and NTU Research Scholarship, and contributes to the UNU-WIDER project ‘Foreign Aid: Research and Communication (ReCom)’. It is published in the UNU-WIDER Working Papers series, No. 2012/25.

the first time that the economic weakness of donors and the crisis-induced fragility of recipients coincide in time.

The financial crisis of the late 2000s, that followed the collapse of the housing bubble and led to a liquidity shortfall in the US banking system, spilled all over the world. Due to the global character of the economy, the crisis affected not only the North but also the South. The decline in economic activity between 2007 and 2009 lowered the economic growth of numerous developing countries on all continents. This effect is attributable to the drop in world trade volume, driven by the lower demand from industrialized countries. Developing countries were greatly affected by the *trade transmission mechanism* of the crisis, as they are mostly dependent on exporting a small range of products. Lower export demand and drop in commodity prices in the West resulted in declining revenues in developing states. In addition to that, declining investments and remittances from migrant workers constituted the other, *financial channel* of shocks transmission from the North to the South (Lin 2008, OECD 2009, Gurtner 2010).

Consequently, the financial crisis led to a dramatic rise in the number of households living below the poverty line (te Velde 2009). In parallel, the alarming presence of simultaneous and interconnected crises in climate change (IPCC 2007) and food provision, with deteriorating effects on global wealth is to be noted, as Addison et al. (2010) underline, calling the phenomenon the *triple crisis*. Bloem et al. (2010) render the three interlaced crises in the light of malnutrition. With the financial crisis having both contracted economic performance and increased food prices, climate change is expected to further confront the South with overwhelming challenges (Stern 2007; Eriksen et al. 2007; UNFCCC 2007), deepening the food crisis (Schmidhuber and Tubiello 2007) and amplifying the incidence of natural disasters and health issues (Jones et al. 2008). In the presence of crisis, developing countries rely crucially on aid, while developed countries reduce aid volumes, a conflict that gives rise to a discussion on

the under-provision of aid by donors. I attempt to answer the question of whether and how donors adjust aid budgets in response to various macroeconomic shocks.

At the global level, the crisis affects stability, peace, wealth and many other important global public goods (Kanbur 2001; Reisen et al. 2004; Samuelson 1954), and as such calls for attention and action at the international level (Stiglitz 1995, 2006).

The strong interdependence between the developed and developing worlds surfaced during the recent economic downturn. Global economic stability was affected, as the financial crisis in the developed economies negatively influenced the developing world. With developing countries facing further challenges, including food undersupply and climate change, it becomes evident that the under-provision of Official Development Assistance (ODA) in developing countries may have serious adverse effects.

Donor aid support is needed now more than before the crisis, for both short- and long-term objectives. For developing countries, it is an immediate counterbalance to the negative effects of the crisis and a stimulus to sustain long-term growth prospects. In the face of crisis, ODA plays a countercyclical role to rebalance the sharp drop in overall financial flows to developing countries (OECD 2009). Reduction in foreign aid would bring additional difficulties to developing countries already indirectly affected by the crisis through the decreases in trade and in financial flows (Lin 2008, Gurtner 2010). The main dangers include: increase in poverty, food crisis, disturbed development continuity or even a regress by hindering projects aimed towards the Millennium Development Goals. Those fragile societies are also at risk of a decrease in education and health provision, as well as economic and political unrest, as low-income countries are particularly vulnerable due to their already weak balance of payments positions.

Indeed, ODA, despite being criticized as ineffective, remains a major element in the budget of many developing countries since the 1960s (World Bank 2001a; te Velde 2002; Samuelson 2000), and has been found to have a positive effect on growth (Arndt et al. 2010,

2011). Nevertheless, conventional bilateral aid faces a pro-cyclical trend in aid (Arellano et al. 2009), which falls when the donors encounter recessions. This situation leads to a conflict: in the presence of crises, developing countries rely even more on aid (Brautigam 2000), while developed countries reduce aid volumes (Addison et al. 2010). This vicious circle is not theoretical, but is at the heart of the current crisis, and raises important questions. Will the North manage to respond to the growing need for aid? Will donors decrease their disbursements? How will different sectors of aid be affected?

This study focuses on the influence of economic crises on aid supply from the major ODA donor countries. The research question that ought to be addressed is: *how does the financial crisis influence aid flows?* This chapter seeks to answer this question from a donor-centred frame of reference. In particular, which shocks matter: those linked to financial variables, to political preferences or to social needs? Do donors adjust aid budgets in response to those unexpected macroeconomic shocks? What are the dynamics of the response of aid?

The main objective of the research is to explore the channels and behavioural consequences of unexpected financial shocks on aid budgets. I show the effects of shocks on a set of macroeconomic variables on aid in 23 ODA donor countries. For this I use panel vector autoregression (PVAR) analysis<sup>53</sup> and examine orthogonalized impulse response functions, coefficients and variance decompositions.

Country-level data are used to study the dynamic relationship between donors' financial and economic conditions and aid disbursements. My main interest is to determine whether the dynamics of aid differ during crises of different magnitudes, or before and after the downturns. I am also interested in determining if the relationship is of purely economic nature, or if it is

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<sup>53</sup> PVAR is an extended vector autoregressive (VAR) analysis (Sims 1980) allowing the use of panel data. This class of models is particularly suited for policy analysis as they attempt to capture both static and dynamic interdependencies between variables, allow for unrestricted links across units, incorporate time variations in the coefficients and in the variance of the shocks, and take cross sectional dynamic heterogeneities into account. See Canova and Ciccarelli (2013) for a detailed discussion about panel VAR models.

influenced by politics as well. I approach the problem from the donor's standpoint, which remains relatively unexplored, and build on an existing body of literature on aid, growth and aid supply, as well as contribute to the field in several ways. I propose a simple theoretical consumption model to capture donors' decisions on aid disbursements versus internal country needs. Using vector autoregressions on panel data I consider the complex relationship between a country's financial situation and aid provision, while controlling for country-specific unobserved heterogeneity (i.e. fixed effects). By analyzing orthogonalized impulse-response functions, I am able to distinguish the response of ODA to shocks coming through various channels transmitting financial and economic crises. The work also aims to contribute to the discussion on aid supply during unexpected, worldwide economic downturns.

#### 4.1.1 Aid

Most of the literature addresses the issue of aid from the standpoint of the recipients rather than the donors (Easterly 2003; Hansen and Tarp 2001). There exist studies on the donors' motivations to provide aid (political influences, poverty reduction) (Alesina 2000), as well as some recent studies on the determinants of aid supply. The extensive corpus of literature available on aid and growth in recipient countries gives some insights in to the instruments of aid.

Overall, aid is currently about 70% bilateral, directly from the donor country to the recipient, and 30% multilateral, transferred through international organizations such as the World Bank or the United Nations (OECD-DAC database). Nearly 85% of developmental aid comes from government sources as official development assistance (ODA); the remaining 15% flows from non-governmental sources (OECD-DAC database, Official and Private Flows). There



is a growing discussion about emerging donors, like China, Brazil or Russia (McCormick 2008; Woods 2008); however the majority of aid still originates from the traditional ODA donors of the Development Assistance Committee (DAC) (see Figure 4.1).

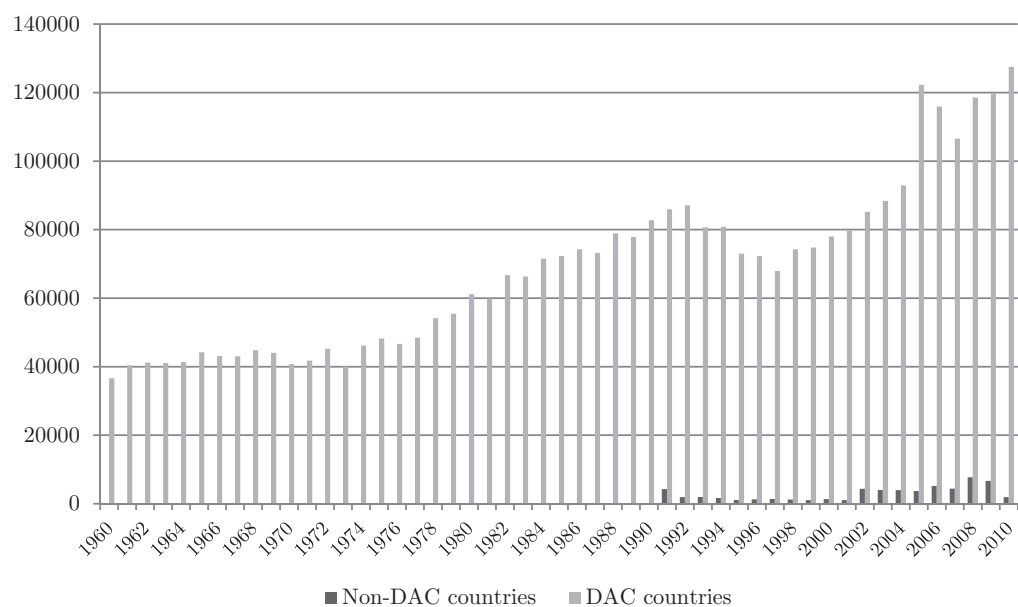


Figure 4.1 Net ODA disbursements

Note: Net ODA disbursements in USD millions, constant 2009.

Source: Author's illustration based on data from OECD Database on Aid from Development Assistance Committee Members.

Development aid has always been a marginal fraction of donors' GDP, between 0.1% and 1%; however, it constitutes a large share of the GDP of several developing countries. World Bank records indicate that it constituted 70% of the GNI of Liberia in 2009, 21% of the GNI in Mozambique, and 18% in Togo. Africa and Asia are the two main regions receiving aid, accounting for 38% and 30% respectively of the total ODA received worldwide (OECD-DAC 2009). The sectorial allocation of aid evolved over the last 50 years and currently most development assistance is allocated into social and economic sectors (see Figure 4.2). Therefore, decreases in aid following donors' economic woes may significantly deteriorate the living conditions in recipient countries.

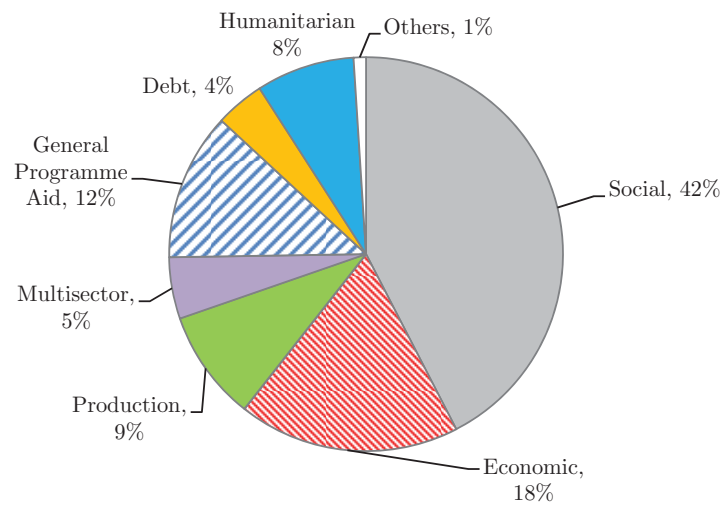


Figure 4.2 ODA to Africa by sector

Source: Author's illustration based on data from OECD-DAC database, commitments 2009.

In the last years, the trajectory of aid has remained constantly, significantly below the target agreed by donors of 0.7% ODA to GNI by 2015. Indeed, ODA to GNI for all DAC donors was just 0.32% in 2010 (Figure 4.4).

#### 4.1.2 Financial Crisis and Aid

The financial crisis of the late 2000s has two distinguishing features. First, it was unexpected and incorrectly predicted by the OECD and the IMF. The second unprecedented feature of this crisis is that its effects were truly global, as all regions of the world have been affected. Even simple evidence such as the correlation of GDP growth rates between major regions of the world reveals how coordinated the recent crisis was (Figure 4.3). Real GDP growth rates fall sharply during the 2007 and 2008 crisis outbreak, and most advanced economies record negative growth rates. Originating in the US, the crisis rapidly develops and

spreads into a global economic shock, resulting in a number of not only American but also European bank failures. Governments pour billions of dollars and Euros into their banking systems.

During the second phase of the crisis, in 2010 and 2011, many European economies experience debt crisis, budget cuts, and massive job losses. Entire countries are in danger of bankruptcy, including Iceland, Greece, Spain, Portugal and Italy. From the North, the crisis has a spillover effect on the developing South through various channels including reduced demand, declining investments, lower remittances, declining exports and lower prices for imports from the South (Addison et al. 2010). Yet, evidence flourishes in the literature for cyclical co-movement in output, investments and consumption among industrialized, and recently, among developing economies (Kose et al. 2004; Prasad 2003). Globalization has opened new channels for the transmission of shocks.

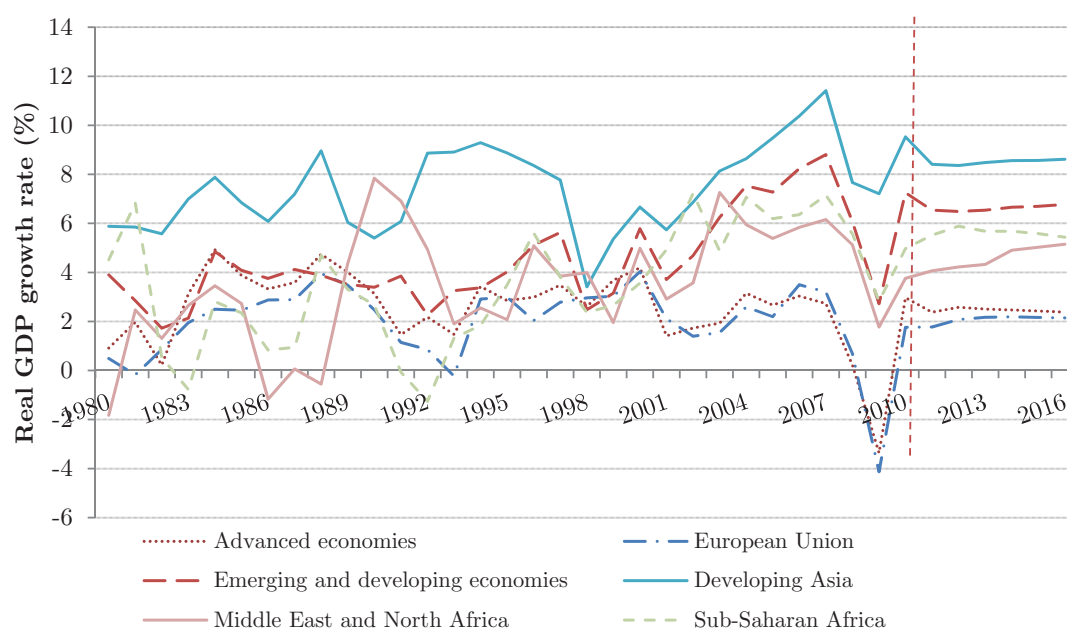


Figure 4.3 Real GDP growth in the world (1980-2016)

Source: Author's illustration based on data from IMF World Economic Outlook (WEO) database, April 2011.

Although the crisis began among the richest nations, concerns for the financial security of the poor are justified. The developed world is expected to prioritize its own economic situation, and it would not come as a surprise if donor countries identified development aid as an unproductive spending of their budgets, and decided to cut it.

There is a widespread concern that ODA will suffer from cuts due to revenue shortfalls resulting from both lower growth and higher expenditures to support financial sector and to stabilize the economy (Hallet 2009). The discussion is actively developing in the literature, appraising whether donors will reduce aid when recipients need it even more. In a discussion about financial crisis and aid disbursements, Roodman (2008) concludes that based on the historic evidence of the Finnish 1990s crisis aid disbursements are likely to decline. This effect, of a donor economic downturn reducing aid expenditure, is also confirmed by Frot (2009), who finds GDP shocks in donor countries to have significant and deteriorating effects on aid, and Dang et al. (2009), who observe a 20-25% decline in ODA from donors who experienced the banking crisis. Indeed, declining aid flows are an expected consequence of recessions. If the donors' GDPs fall they are likely to provide less aid in monetary terms, as reductions will occur.

There is less evidence of the impact of economic crises on donors' budgetary aid. Some studies suggest that crises may not imply reductions in a donor's share of GDP devoted to aid (Pallage and Robe 2001). Mold et al. (2010) argue that aid is not sensitive to recessions and is not correlated with GDP growth. Dabla-Norris et al. (2010) discuss the link between donor-recipient cycles<sup>54</sup> and aid flows. They conclude that development aid is pro-cyclical with respect to both the output cycles of the donor and of the recipient. Donors will raise their aid disbursements during economic expansions and decrease it during recessions, while recipients get more aid if their economic conditions are good. Therefore aid is not working as insurance in aid-receiving countries.

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<sup>54</sup> For a literature review on business cycle and aid see Hallet (2009).

Figure 4.4 presents the ODA pattern from both perspectives: as a percentage of gross national income (GNI) and in real terms. Between 1960 and 1990, ODA flows from Development Assistance Committee (DAC) countries to developing countries rise steadily, while the total ODA as a share of GNI aggregate in DAC countries shows a decreasing trend up to the 1970s, from when it oscillates between 0.27% and 0.36%. In the mid-1990s, an *aid fatigue* occurs (Gibbon 1993). The ODA flows fall by 16% in real terms due to the fiscal consolidation happening in donor countries after the recession, the donors' perception of aid as ineffective, and the end of the Cold War (Boschini and Olofsgard 2007). The ODA starts rising again in real term in 1998. More recently, several international meetings have encouraged ODA outflows, including the International Conference on Financing for Development (Mexico, 2002) and the UN Millennium + 5 Summits (2005). Aid peaks in 2005-06, corresponding to large debt relief operations in Iraq and Nigeria. ODA flows experience a decline in 2007 because of the financial crisis, but continue to rise. In 2010 they reach their highest real level ever, at USD 129 billion.

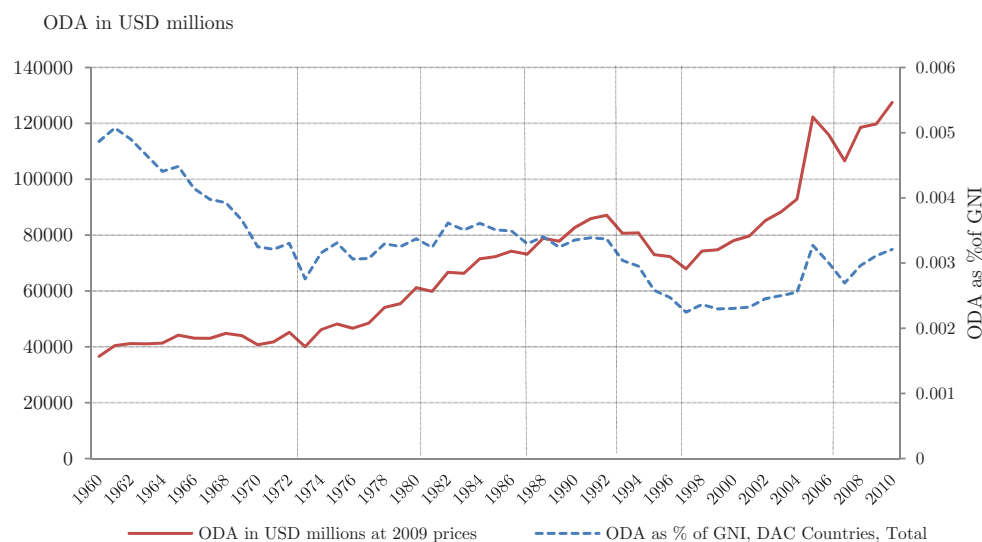


Figure 4.4 Financial crises and pro-cyclical ODA outflows trend following ups and downs of donors' economies

Source: Author's illustration based on data from OECD-DAC database.

Historical evidence of the decrease in ODA provision during crises is marked with vertical lines. Major reductions in aid flows occur as a consequence of economic downturns in 1973 and 1979 (oil crises), 1987 (Black Monday), 1992–93 (Black Wednesday), 1997–98 (Asian Financial Crisis), 2007–10 (financial crisis followed by the late 2000s recession and the 2010 European sovereign debt crisis). It supports the pro-cyclicality hypothesis that as donors go through economic recessions, their GDP falls and they provide less aid.

Two large declines in the aid to GNI ratio occurred in 1990-96 and 2005, preceding the Asian crisis of 1997 and the financial crisis of 2008 respectively. The former happened because DAC donors were not seriously affected by the Asian crisis and the latter reflects a one-time large debt relief operation to Iraq, Afghanistan, Democratic Republic of Congo and Nigeria driven by the U.S. (Radelet et al. 2008). The 2004 spike in aid is artificial and the apparent subsequent reduction in aid afterwards is an artefact corresponding to the return of aid to its average level.<sup>55</sup>

Another noteworthy issue illustrated in Figure 4.5 is the evidence indicating that the volatility of foreign aid has increased in recent years, starting in the early 2000s.<sup>56</sup> Fielding and Mavrotas (2011) find that programme aid tends to be more volatile than project assistance, which makes sense, since programme aid as a part of budget support is often used as a policy conditionality tool and is easier and more likely to be suspended. The *unpredictability of aid disbursements*, referred to by Bulir and Hamann (2008), together with the *pro-cyclical* nature of capital flows, have become a concern. These patterns are usually associated with adverse economic consequences for developing countries which undermine the positive impacts of foreign inflows.

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<sup>55</sup> I control for this problem by dropping the US aid observations for years 2004-06.

<sup>56</sup> See also Hudson and Mosley (2008) for further evidence of recent increase in volatility in ODA.

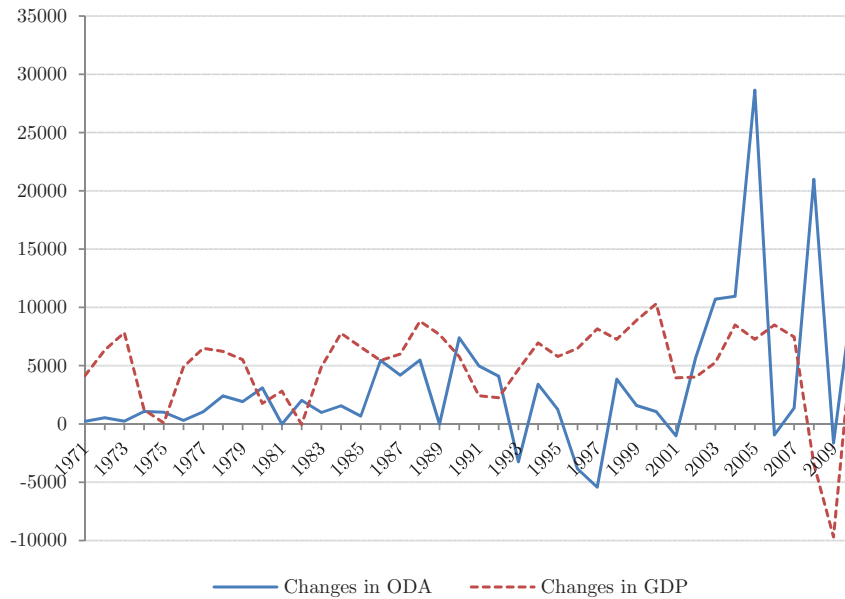


Figure 4.5 First differences in net ODA and GDP

Note: ODA and GDP shown in USD millions, constant 2009.

Source: Author's illustration based on data from OECD and OECD-DAC databases.

Aid volatility literature focuses mostly on aid inflows into recipient countries, which may fluctuate for a number of reasons including aid selectivity or conditionality. The issue of aid outflows variability has received only limited attention in the empirical literature. There are also no clear results on the link between donors' economic cycles and their aid budgets.

A result of the lack of studies on donors was that, following the latest crisis, the nascent discussion in this branch of the literature was still investigating whether and to what extent the crisis would affect aid, and was looking at reasons why *aid might not decline at all*. Confusingly there is historical evidence of both phenomena: aid sharply decreasing, and remaining unchanged. For instance, the early 1990s crisis in Nordic countries resulted in a large decrease in aid flows. But it did not happen during the stagflation period in the 1970s and the dot com bubble of the 2000s (Mendoza et al. 2009). Roodman (2008) and Frot (2009) explore historical evidence of aid reduction after the donor has suffered a crisis. They mention the US in 1988,

Japan in 1990, Finland, Norway and Sweden in 1991 and South Korea in 1997. Figure 4.6 illustrates the evolution of aid supply from some of the main DAC donor countries from 1995 to 2010. Top donors include Germany, Norway and Sweden,<sup>57</sup> while at the bottom I find countries worst hit by the 2007 crisis. The pattern shows an immediate fall in aid in 2008-09 from Germany, Ireland, Spain and Greece while the volatility of aid from Nordic countries, Norway and Sweden, increases. Although this may seem solid evidence, some other countries take milder actions during the crisis. But as all countries are not affected equally by the crisis, so aid budgets do not contribute in the same way to all countries' expenditure. Donors tend to be generally more persistent in increasing rather than in reducing aid, and a coordinated decrease of aid among many donors indicates that it is triggered by a common incident of a global scale, i.e. a crisis. The latest data from the UN EFA (2010) report confirms these trends. After Italy announced cuts of 56% in its aid budget in 2009, Greece and Ireland followed suit with Greece deferred its EU 2010 aid commitment to 2012, cut aid by 12%, resulting in a decrease of the aid to GNI ratio from 0.21% to 0.19%, and Ireland planned to decrease aid by 24%, dropping the same ratio by 5 points from 0.59%. This decrease of the aid-to-GNI ratio indicates that ODA was cut in greater proportion than the economic contraction. In the same trend, Spain announced cuts in its ODA budgets for 2010 and 2011; Norway planned to decrease its ODA by 4.4%, and Sweden, by 7.8%.

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<sup>57</sup> I exclude the USA which, whilst the largest donor in terms of US\$, maintains this position due to its large aid relief programs that do not reflect crisis-related adjustments.





Figure 4.6 Aid for selected DAC donors

Note: Aid in USD millions, constant 2009.

Source: Author's illustration based on data from OECD-DAC database.

The type and severity of financial crisis may be one of the factors explaining differences in behaviour of aid budgets allocation. It is already clear that the recent prolonged global crisis did not just lead to the negative growth rates of donors' GDP but also, to a relatively greater extent, to the fall of ODA (see Table 4.1). In 2009, 13 out of 23 donors decreased their aid contribution compared to the previous year. On average the decrease occurred one year after the beginning of the recession. This shows the somewhat quick response of governments and the

flexibility of aid, even on a rather short time span of one to two years, and that aid budgets are subject to revisions and adjustments. It justifies using a panel VAR approach which focuses solely on the short-run effects.

Table 4.1 Percentage changes in ODA and GDP for selected DAC donors

Selected donor countries	Year	% change in ODA	% change in GDP
Australia	1990	-3.5	-.02
	2009	-7	2.2
Austria	2009	-48	-4
Canada	2009	-22	-3
Denmark	1981	-8	-.08
	2009	.06	-5.4
Finland	1992	-43	-4
	1993	-78	-.08
Germany	2009	-15	-5
Greece	2009	-14	-2
	2010	-18.4	-4.6
Iceland	2009	-29.3	-7.4
	2010	-13.2	-3.5
Ireland	2009	-37.5	-8.2
	2010	-15.3	-1
Italy	1993	-30.3	-.08
	2009	-44	-5.5
	2010	-5.3	1.2
Netherlands	2009	-9	-4
Norway	1993	-22.7	2.7
	2009	-4	-1.7
Portugal	1993	-16	-2
	2009	-20.3	-2.5
Spain	1993	-11.4	-1
	2009	-3.7	-3.8
	2010	-10.2	-.1
Sweden	1993	-35	-2
	2009	-2	-5
Switzerland	1993	-40	1
USA	2007	-5	1

Source: Author's calculations based on data from OECD-DAC database.

## 4.2 MODEL DISCUSSION

### 4.2.1 Channels of Impact of the Crisis on ODA Provision

My objectives are to identify channels of influence of financial and economic crises on aid supply, and to compare the response of ODA to different types of unexpected shocks. I base the variables selection on the literature on instrumental variables of aid in growth regressions (Hansen and Tarp 2001; Dalgaard et al. 2004; Rajan and Subramanian 2008; Arndt et. al 2010; Arndt et. al 2011), aid supply (Alesina et al. 2000; Chong and Gradstein 2008; Jones 2011), VAR models of aid (Frot 2009; Juselius et al. 2011), panel regressions of aid supply (Dang et al. 2009), and banking crisis (Laeven and Valencia 2010; Caprio et al. 2005). Table 4.2 summarizes and classifies the variables into three categories: domestic social needs, financial conditions and political preferences of the donor country. The variables employed in the analysis have each been found significant in one or more previous studies in the literature. They include GDP, GDP per capita or GDP growth rate (see for instance Chong and Gradstein 2008) as the most important economic factor influencing aid, as well as fiscal balance or government debt (Faini 2006; Boschini and Olofsgard 2007), Misery Index (Mendoza et al. 2009) or more directly, inflation (Dang et al. 2009; Mendoza et al. 2009) and unemployment (Frot 2009) rates, government expenditures, real exchange rates (Dang et al. 2009), a banking crisis dummy (Dang et al. 2009; Jones 2011), and the political orientation of the governing party (Round and Odedokun 2004; Chong and Gradstein 2008; Tingley 2010).

Table 4.2 Variables description

Dependent variable: $\frac{Aid}{GDP}$		
Channels		
Domestic social needs $d$	Financial conditions $f$ of the donor country	Political and socio-economic preferences $p$
<ul style="list-style-type: none"> <li>• unemployment rate</li> <li>• inflation rate</li> <li>• Misery Index</li> <li>• fiscal balance as a share of GDP</li> <li>• public debt as a fraction of GDP</li> <li>• government expenditures</li> </ul>	<ul style="list-style-type: none"> <li>• wealth of the country: <math>\frac{GDP}{POP}</math></li> <li>• GDP growth rate</li> <li>• financial volatility of the stock market (S&amp;P Global Equity Indices)</li> <li>• real exchange rate</li> <li>• banking crisis dummy</li> <li>• trade volumes</li> </ul>	<ul style="list-style-type: none"> <li>• ruling party dummy (left/centre/right)</li> </ul>

Note: All variables are in first differences.

A simple panel VAR model is specified with GDP, fiscal balance and aid as variables, while the extended panel VAR models include up to 6 variables from Table 4.2.

The financial conditions of the country are captured by several variables. GDP is a good proxy for the general amount of resources available in the country. It is natural to assume that a donor country will tie their actual yearly aid disbursements to their own available wealth. Richer societies are expected to provide more aid. Yet, GDP is correlated to economic crises; given a certain GDP, governments are constrained by other needs of the country than aid provision. *GDP growth rate* is used for robustness checks, while increasing *government expenditures* contribute to the budget deficit and decrease the resources available for aid. The *fiscal balance* is a short-term flow variable, while the *public debt* represents a longer term stock variable. The rationale behind those two variables is twofold. First, indebted governments are likely to decrease aid spending and prioritize other expenses. Second, these variables also serve as a buffer from aid to GDP in the VAR model specification, explaining the effect of donating aid on the donor's GDP. The *Misery Index*, *unemployment rate* and *inflation* proxy domestic

social needs.<sup>58</sup> Raising unemployment and high inflation indicate strong internal priorities for the government, and may require more funds to be reallocated at the detriment of the availability of resources for aid. Greater economic difficulties will then lead to lower support for foreign aid. *Financial volatility* is measured by the S&P global equity indices proxy for the financial market conditions, which especially reflects the volatility of stock markets. Higher stock market volatility indicates higher financial volatility in general, as well as higher uncertainty. Mendoza et al. (2009) find that financial volatility in the US (measured using the S&P500 index) adversely affects ODA, especially for the late 2000s financial crisis.

The *banking crisis dummy* is introduced to capture the difference in magnitude between different types of crises. As not all recessions are equal it is possible that their nature and causes may particularly affect aid. The banking crisis dummy allows me to differentiate between different magnitudes of crises and capture their effects on aid.

*Changes in trade volumes* are taken into account as the financial crisis had serious implications on international trade, severely decreasing exports. Younas (2008) found that OECD-DAC countries prefer to allocate aid to the recipients who are likely to import their goods. The *real exchange rate* adds to the effect of trade on aid; it is a measure of the loss of domestic power in the donor country. I expect it to have a small effect on aid.

I only have one dummy variable to control for political pressure. Political factors related to the ruling party orientation, which may influence aid budgets, are captured by the *party dummy*. Left wing and right wing parties are expected to have different priorities regarding aid decisions, with the left being egalitarian and the more conservative centre to right parties maintaining social hierarchies and spending less on aid.

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<sup>58</sup> Any measure of poverty would be a more natural variable to reflect social needs. However, as I only consider high income countries, and are concerned about crises, unemployment and inflation seem more appropriate.

### 4.2.2 Banking Crises and Aid

Motivated by the contrasting effects of different financial crises on aid I check the response of aid to macroeconomic variables under crises of various magnitudes, which in turn impact aid differently, and result in ambiguities and in the unpredictability of aid. To account for these magnitudes, I include a banking crisis dummy. I divide the sample into three groups: the full sample group, the expansion group, and the banking crisis or recession group.<sup>59</sup> By applying shocks to different sub-samples I take advantage of the contrasting magnitudes of their standard deviations. Therefore, shocks applied to the expansion data sample model *mild recession*; they model *recession* when applied to the full sample model, and they model *severe crisis* when applied to banking crises data.<sup>60</sup>

I define banking crisis after Laeven and Valencia (2010) who put forward that systemic banking crisis occurs when two conditions are met in addition to falling GDP growth rates: there is financial distress in the banking system in the form of significant bank runs, losses in the banking system, or bank liquidations; and it is followed with banking policy intervention.

Dang et al. (2009) find a large impact of banking crisis on aid and give some possible explanations of this effect. The banking crisis may affect aid both indirectly and directly. The indirect effect happens through ordinary recession and is supported by historical evidence of donors reducing aid flows following crises due to lower revenues (Roodman 2008). The direct effect of banking crisis on aid happens by adding additional fiscal costs and further lowering the GDP e.g. through bailouts (Lancaster 2007). Reinhart and Rogoff (2008) find that banking

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<sup>59</sup> I use data for several crises over different time spans and different countries, so I avoid cross-correlation in the error-term due to crises.

<sup>60</sup> To model different crises I take advantage of the specification of shocks in panel VAR analysis. A shock is equal to one standard deviation and is different for different samples of data: for instance a shock applied to banking crisis observations has a larger magnitude than a shock to the full sample.

crises have especially deep and prolonged effects on growth and fiscal balance and cause major disturbances to government revenues. Banking crises have an amplifying effect on aid contraction. With these additional costs added to the costs of recession, donors may find it even more difficult to continue giving aid during and after those crises, than they would in a normal downturn of the same magnitude (Dang et.al 2009).

It is important to mention that there are also counter arguments rejecting any possible role of banking crisis as a determinant of aid, with the central argument that aid simply does not depend on economic factors. Such critical argument can be found in Paxton and Knack (2008). To address these concerns, I check the influence of political factors on aid decisions, and I indeed find them driving aid decisions. However, I find that economic indicators also significantly impact aid budgets.

## 4.3 DATA

Most data used in this project come from the standard source of the OECD - International Development Statistics (OECD-DAC) database, which contains aid activity. I follow the literature and use net aid disbursements rather than commitments. There is a large gap between the usually higher commitments and lower disbursements, and disbursements are what matter for the budgetary decisions of donor countries, as commitments are but ‘promises’, more prone to the influence of factors other than economic. All variables are in real US dollars. I use the *net aid disbursements* of 23 DAC donor countries<sup>61</sup> between 1960 and 2010. Data on

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<sup>61</sup> Donor countries include Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden,

*GDP*, *population*, *fiscal balance*, *inflation*, *unemployment*, *S&P index*, *foreign exchange rate*, *trade*, *GDP growth rate*, *government expenditures* come from the OECD National Accounts database, the World Bank World Development Indicators database and the IMF World Economic Outlook. I calculate the *Misery Index* by adding inflation rate and unemployment rate. *Aid disbursements net of debt relief* used for robustness checks come from the Net Aid Transfers (NAT) data (Roodman 2009). My primary source of *banking crisis* data is the paper by Laeven and Valencia (2010) and my secondary source is the less recent publication by Caprio et al. (2005). Finally, I use the *party dummy* from the Database of Political Institutions (2010) to account for party orientation.

The *fiscal balance* data limits the span of data to 30 year, from 1980 to 2010<sup>62</sup> for all models except those with a S&P index, for which I only have observations since the last 20 years, from 1990 to 2010. The *unemployment rate* is defined as the ratio of the number of persons unemployed to the total size of the labour force. The data are primarily taken from the OECD Labor Force Statistics database, but some missing observations are added from the World Bank WDI (e.g. France). Data on *inflation* comes primarily from the World Bank World Development Indicators Database, but missing data before 1989 for the UK and before 1992 for Germany are supplemented by OECD observations. Similarly, data for year 1961 for almost all countries, except Denmark, Ireland and the Netherlands, for which data are not available, are taken from the OECD database.

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Switzerland, the UK and the USA. I omit some more recent donors, including Czech Republic, Hungary, Poland, Slovak Republic, Thailand and South Korea.

<sup>62</sup> It may be argued that the PVAR technique using GMM estimator is more suitable for short panel data rather than long panel due to serial correlation in the long run. However, I work on sub-samples and avoid this issue. I perform robustness checks for the full sample using shorter panel which yield similar results.



### 4.3.1 Adjustment of ODA for Debt Relief

I stress the particular importance of carefully selecting the aid variable. It is disputable whether aid should be net of debt relief or if debt relief should be counted as aid. Debt relief initiatives from the 1980s till now have steadily become more generous. The most important include the Heavily Indebted Poor Countries (HIPC) initiative launched in 1996 by the IMF and World Bank and the Multilateral Debt Relief Initiative (MDRI) supplementing the HIPC since 2005 in order to achieve the Millennium Development Goals. Recently, donors granted very generous debt cancellations to Afghanistan, Iraq and Nigeria which inflated the aid figures for 2005-06. In 2007, the Inter-American Development Bank also decided to provide additional debt relief to the 5 HIPCs in the Western Hemisphere, beyond the existing HIPC. Figure 4.7 shows the difference between ODA and ODA net of debt relief.

Debt relief is one way of delivering aid (Berlage et al. 2003). It is a tool for poverty reduction and impacts development through two main channels: by enhancing incentives for private investment and relaxing constraints for the government, as well as by releasing resources otherwise spent on debt-servicing (Addison 2006). It is considered by some as a more effective mode of aid delivery (IMF and World Bank 2011) but following complex dynamics (Cassimon and Van Campenhout 2007), while others argue that the economic benefits of debt relief are minimal (Bird and Milne 2003; Chauvin and Kraay 2005). A large theoretical literature discussing arguments both in favour and against debt relief has evolved since.<sup>63</sup>

Debt is a complex issue. Its cancellation is granted to developing countries which fulfil certain conditions, upon coordinated agreement of donors. It is also a cost for donors and they may be less willing to cancel debt when their economic conditions are worsening. It constitutes a

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<sup>63</sup> See Cassimon and Vaessen (2007).

cost both as forfeited debt repayment and as debt relief related administrative costs. Cordella et al. (2003) address the issue of indebted donors who keep providing aid without granting debt relief, while Birdsall and Williamson (2002) discuss the costs of debt relief for donors.

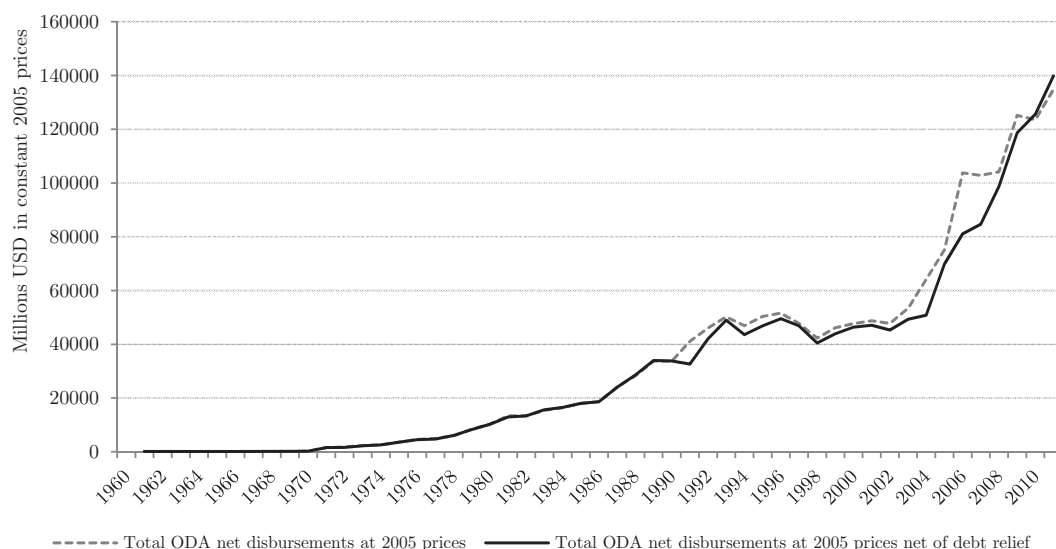


Figure 4.7 Total ODA net disbursements versus total ODA net disbursements net of debt relief

Note: Figures relate to all DAC donors.

Source: Author's illustration based on data from OECD-Development database, 2011.

One criticism is that large variations in aid that are caused solely by debt relief may be weakly related to the preceding economic conditions. In his VAR analysis, Frot (2009) uses this argument and subtracts debt relief from ODA. However, he gets very similar results when using unadjusted ODA. This is my case as well. My results are very similar when ODA as share of GDP is adjusted for debt relief as when it is unadjusted for it. I decide to use net ODA including debt relief. The primary reason for this is the assumption that debt relief is part of aid flows and serves similar development goals as monetary transfers. It is a cost for donors and therefore it is likely to be affected by adverse economic conditions in donor countries. Finally, there is a more technical reason. The debt relief adjustment is not comprehensive, as many

observations are missing. For some countries like Greece, Iceland or Ireland no data on debt relief are available. By only adjusting some years and not others, or some countries and not the others, I am partially removing aid variability due to debt relief, but I am introducing a new variability due to incomplete information.

For robustness checks, I use two alternatives to the net aid disbursements ODA measures, adjusted for debt relief. The first one is the NAT measure (Net Aid Transfers) by Roodman (2009), and the second one is the net ODA disbursements net of debt relief calculated by subtracting the OECD debt relief data from net aid disbursements. Results can be found in Table 4.9.

## 4.4 A THEORETICAL FRAMEWORK

There are  $i = 1, \dots, I$  donor countries contributing part of their budgets towards different types of foreign aid  $j = 1, \dots, J$ . Governments' motives for aid supply are not purely altruistic: they expect to receive some returns in the form of political interests or influences, economic benefits (e.g. through trade), or gratitude. Therefore, they consume aid indirectly. For simplicity, this framework portrays aid as a private rather than a public good. Implementing aid as a public good would allow me to assume that larger donors give on average less aid per capita than smaller donors as public goods in larger donor countries are shared among a larger population. However, my motive is to explore the choice of donors when facing economic crisis; whether to continue financing foreign aid or rather to re-prioritize internal needs.

Consumers in the donor country choose to consume either indirect aid good or the other good or both. Therefore, let the donor country's individuals have the following utility function (Duddley and Montmarquette 1976):

$$U_{i,t} = f(A_{ij,t}; C_{i,t}) \quad (4.1)$$

where  $A_{ij,t}$  is the aggregate amount of donated foreign aid  $j$  by country  $i$  at time  $t$ , and  $C_{i,t}$  represents the total consumption in country  $i$  at time  $t$  of the other good.

Individuals' preferences can be expressed similarly to Chong and Gradstein (2008):

$$U = U_A(A_{ij,t}) + U_C(C_{i,t}) = \frac{1}{1-\sigma} \alpha A_{ij,t}^{1-\sigma} + \frac{1}{1-\sigma} C_{i,t}^{1-\sigma}, \quad \alpha > 0 \quad (4.2)$$

where the parameter  $\alpha$  captures preferences for foreign aid, and  $\sigma$  is the elasticity of substitution between the two goods. Tarp et al. (1999: 149-69) put emphasis on a two-step aid allocation model. In the first step a donor country decides to which of all potential recipients it will allocate some amount of aid, and the actual amount is determined in a second step. Vázquez (2008) proposes a three-step model, in which the first step is the decision of the donor country's government on the size of its ODA budget. I am only concerned about this first step, the total amount of aid allocated in the budget of the donor.

Income is allocated between consumption, internal government expenditures and foreign aid. So, assuming price is the numeraire, the donor country budget constraint is:

$$Y_{i,t} = C_{i,t} + A_{ij,t}^\alpha + D_{i,t}^\beta, \quad \beta > 0 \quad (4.3)$$

where  $\beta$  represents the preferences for internal expenditures and  $D$  stands for the domestic expenditures related to the crisis. I assume  $\beta > \alpha$  as consumers will prefer to consume directly good  $C$  rather than to indirectly consume good  $A$ .

Revenues  $R_{i,t}$  come from the income tax  $T_{i,t}$  and foreign borrowing  $B_{i,t}$ , and are used entirely to finance both foreign aid donations  $A_{ij,t}$  and internal economic needs  $D_{i,t}$ . Therefore, they constitute together the government spending  $G_{i,t}$ :

$$R_{i,t} = B_{i,t} + T_{i,t} \quad (4.4)$$

$$R_{i,t} = \alpha A_{ij,t} + \beta D_{i,t} = G_{i,t} \quad (4.5)$$

$$\alpha A_{ij,t} + \beta D_{i,t} = G_{i,t} \quad (4.6)$$

Similarly to Jones (2011), donors follow their target level of aid, which is subject to external shocks and deviations. Adjustments to shocks may take more than one period.

The supply of foreign aid expenditures by a government  $i$  is influenced by the donors' available resources  $Y_{i,t}$ , by the expenditures  $D_{i,t}$  related to the unstable economic conditions, prone to crises, by the target aid level  $A_{ij,t-s}$ , and by other economic long-run impacts expressed as lagged variables  $D_{i,t-s}$ :

$$A_{ij,t} = A_{ij,t-s} \sum_{i=1}^{I,T} D_{i,t} \sum_{i=1}^{I,T} D_{i,t-s} (Y_{i,t}) (\varepsilon_{i,t}) \quad (4.7)$$

where the parameter  $\varepsilon_{i,t}$  represents other country or time-specific shocks, and  $s$  indicates the number of lagged periods. The impact of crisis  $D_{i,t}$  is a function of domestic needs  $d$ , financial conditions of the donor country  $f$ , political preferences and social conditions  $p$ :

$$D_{i,t} = f(d_{i,t}; f_{i,t}; p_{i,t}) \quad (4.8)$$

I expect the aid supply to be an increasing function of  $i$ 's better financial conditions, political and social preferences (more egalitarian) and available resources, but a decreasing function of the domestic donor's needs:

$$\frac{\partial D}{\partial d} < 0, \quad \frac{\partial D}{\partial f} > 0, \quad \frac{\partial D}{\partial p} > 0, \quad \frac{\partial D}{\partial Y} > 0 \quad (4.9)$$

## 4.5 EMPIRICAL STRATEGY

My empirical strategy is suited for the analysis of the consequences of unexpected macroeconomic shocks. I employ a panel vector autoregression (PVAR),<sup>64</sup> which extends the traditional vector autoregression (VAR) introduced by Sims (1980) with a panel data approach<sup>65</sup>. The analysis based on VAR offers several advantages. It is a flexible method that treats all the variables in the system as endogenous and independent, without worrying about causality direction. Each variable is explained by its own lags, and by lagged values of the other variables. It is a system of equations rather than a one equation model. Panel VAR allows for unobserved individual heterogeneity and improves asymptotic results. Panel VAR simplifies some common aid related issues, e.g. the choice of suitable instrumental variables. The results of a panel VAR analysis are insightful and go beyond coefficients, revealing the adjustments and resilience of aid to unexpected shocks, as well as the importance of different shocks.

The general form of a PVAR analysis is exemplified by Canova and Ciccarelli (2004):

$$y_{i,t} = A_0 a_{i,t} + L_1 y_{i,t-1} + \dots + L_p y_{i,t-p} + u_t \quad (4.10)$$

where  $y_{i,t}$  is a  $K \times 1$  vector of  $K$  panel data variables,  $i = 1, \dots, I$ ,  $a_{i,t}$  is a vector of deterministic terms such as linear trends, dummy variables or constants,  $A_0$  is the associated parameter matrix, and the  $L$ 's are  $K \times K$  parameter matrices attached to the lagged variables  $y_{i,t}$ . The lag order (VAR order) is denoted by  $p$ . The error process  $u_t$  consists of three components:

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<sup>64</sup> I use modified versions of the STATA `pvar` and `helm` programs by Inessa Love, first used by Love and Zicchino (2006). The original programs are available at <http://go.worldbank.org/E96NEWM7L0>.

<sup>65</sup> The PVAR approach used in macroeconomics and finance differs from the micro approach (see Holz-Eakin 1988, Vidangos 2009) or other macro setups (e.g. Beetsma and Giuliodori 2011) as it includes static and dynamic interdependencies and cross-sectional heterogeneity. See Canova and Ciccarelli (2013) for detailed explanations.

$$u_t = \mu_i + \gamma_t + \varepsilon_{i,t} \quad (4.11)$$

with  $\mu_i$  representing the country specific effect,  $\gamma_t$  capturing the yearly effect, and  $\varepsilon_{i,t}$ , the disturbance term. The error term  $u_t$  is assumed to have zero mean,  $E(u_t) = 0$ , and the time invariant covariance matrix and  $u_t$  are independent.

This specification imposes two restrictions: it assumes common slope coefficients, and it does not allow for interdependencies across units. Given these restrictions, the estimated matrices  $L$  are interpreted as average dynamics in response to shocks. As with standard VAR models, all variables depend on the past of all variables in the system, the main difference being the presence of the individual country-specific terms  $\mu_i$ .

Previous studies (Dang et al. 2009, Mendoza 2009) established that financial crises have an intrinsic effect on aid supply. These studies applied panel data analysis to past crises. There are also some studies using the PVAR technique in the aid literature: Osei et al. (2005) focused on the fiscal effects of aid in developing countries, while Morrissey et al. (2006) and Gillanders (2011) examined the impact of aid on growth. This technique appears rarely in aid-related research. Juselius et al. (2011) used VAR to analyse impact of foreign aid in African countries, Frot (2009) used VAR in the context of aid and financial crisis, while Hansen and Headey (2010) used PVAR to analyse the impact of aid on net imports and spending.

I am using the PVAR approach to estimate the effects on aid supply of unexpected macroeconomic shocks to variables that are particularly responsive to economic downturns. VAR modelling does not require the imposition of strong structural relationships, although theory is involved to select the appropriate normalization and to interpret the results. Another advantage is that only a minimal set of assumptions is necessary to interpret the impact of shocks on each variable of the PVAR system.

The reduced form VAR, once the unknown parameters are estimated, permits implementing dynamic simulations. This method only allows for the analysis of *short-run adjustment effects* and not of structural long-run effects. The results come in the form of *impulse response functions (IRFs)* and their *coefficients* analysis, as well as *forecast error variance decompositions (FEVDs)* that let one examine the impact of *innovations*<sup>66</sup> or shocks to any particular variable on other variables in the system. IRFs model the dynamics of the response; the coefficients represent the average effects of IRFs and permit recognizing the significance of the overall response, while variance decompositions give information about the variation in one variable due to shock to the others. The response corresponds to a one-time shock in other variables, holding all the other shocks constant at zero. In other words, *orthogonalizing* the response allows me to identify the effect of one shock at a time, while holding other shocks constant. I am particularly interested in the impact of shocks to macroeconomic variables and the response of the aid variable.

To obtain orthogonalized impulse response functions, I decompose the residuals in a way that makes them orthogonal. Such exercises require applying a careful VAR identification procedure. The most common way to deal with this problem is to choose a *causal ordering*. I adopt the Cholesky decomposition<sup>67</sup> of variance-covariance matrix of residuals. This process is called VAR identification and involves a particular ordering of variables in the VAR system. I allocate any correlation between the residuals to the variable that appears earlier in the ordering. The identifying assumption is that the variables that appear earlier in the system are more exogenous, and those which appear later are more endogenous. That implies that the

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<sup>66</sup> There is a substantial body of literature showing that responses to positive and negative shocks are *asymmetric* (Cover 1992; Edwards and Levy Yeyati 2005). However, these studies mostly address the responses of the main macroeconomic variables, like output, of which aid is not part. I therefore assume for simplicity that positive and negative shocks are symmetric.

<sup>67</sup> See Hamilton (1994) for discussion about impulse response functions and derivations.



variables that appear earlier affect the following variables contemporaneously and with lags, while the variables that appear later only affect the previous variables with lag<sup>68</sup>.

The simple model has 3 variables: GDP per capita, fiscal balance and aid as a share of GDP, in this particular order required for the identification of the VAR system. Hence,  $GDP\ per\ capita_{it}$  is the most exogenous variable, and  $(\frac{Aid}{GDP})_{it}$ , the most endogenous.

$$GDP\ per\ capita_{it} \rightarrow Fiscal\ balance_{it} \rightarrow (\frac{Aid}{GDP})_{it} \quad (4.12)$$

As it is a set of endogenous equations, all variables influence each other. Aid is contemporaneously affected by GDP and fiscal balance as lower GDP will result in lower aid, and higher deficit lowers aid as well. There is no reasonable justification of why ODA would affect GDP in donor countries, but inserting fiscal balance in between makes it a buffer from aid to GDP. Aid only affects GDP and fiscal balance with some lag as public spending contributes positively to the budget deficit, which in turn lowers GDP. This impact is probably of negligible importance, but allows for the correct specification of the VAR system. The theoretical explanation of the model requires a delay in the indirect observation and consumption of aid by donor countries, thus GDP only responds to aid with lag.

The simplest 3-variable PVAR model is specified and can be represented as:

$$\begin{bmatrix} 1 & a_{12} & a_{13} \\ a_{21} & 1 & a_{23} \\ a_{31} & a_{32} & 1 \end{bmatrix} \begin{bmatrix} (\Delta \frac{gdp}{pop})_{i,t} \\ (\Delta fb)_{i,t} \\ (\Delta \frac{aid}{gdp})_{i,t} \end{bmatrix} = \begin{bmatrix} a_{10} \\ a_{20} \\ a_{30} \end{bmatrix} + \begin{bmatrix} L_{11} & L_{12} & L_{13} \\ L_{21} & L_{22} & L_{23} \\ L_{31} & L_{32} & L_{33} \end{bmatrix} \begin{bmatrix} (\Delta \frac{gdp}{pop})_{i,t-p} \\ (\Delta fb)_{i,t-p} \\ (\Delta \frac{aid}{gdp})_{i,t-p} \end{bmatrix} + \begin{bmatrix} u_{1,t} \\ u_{2,t} \\ u_{3,t} \end{bmatrix} \quad (4.13)$$

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<sup>68</sup> This technique is often referred as *recursive VAR* and differs from the *reduced form VAR*. A recursive VAR attempts to identify the structure of the model by constructing uncorrelated error terms across equations. In addition to lags, it includes contemporaneous variables as regressors. In consequence, the results of recursive VAR are sensitive to the ordering of variables. However, recursive VAR avoids the usual criticism of *structural VAR* (see Cooley and Dwyer 1998; Chari et al. 2008).

where  $y_{i,t}$  is a 3-variable vector including 3 endogenous variables: gdp per capita  $\Delta \frac{gdp}{pop}$ , fiscal balance  $\Delta fb$ , and aid  $\Delta \frac{aid}{gdp}$ . The  $3 \times 3$  matrix  $L$  contains the coefficients of contemporaneous relationships between the 3 variables.  $u_t$  is a  $K \times 1$  vector of structural shocks defined as being uncorrelated with one another. The element  $u_{1,t}$  is a GDP shock,  $u_{2,t}$ , a fiscal balance shock and  $u_{3,t}$ , an aid shock. I am interested in the impulse responses of aid to shocks in GDP and fiscal balance.

#### 4.5.1 Data Preparation

Applying the VAR technique requires some data transformations to remove the trend and only keep the variations. The use of panel data imposes that the underlying structure is the same for each cross-sectional unit, i.e. that the coefficients in the matrices  $L$  are the same for all countries in the sample. This constraint is violated in practice, so to overcome this restriction and allow for country heterogeneity, fixed effects ( $\mu_i$ ) are introduced. However, fixed effects are correlated with the regressors due to lags of the dependent variables (Arellano and Bond 1991; Blundell and Bond 1998). I employ forward mean-differencing (Arellano and Bover 1995) to eliminate the *fixed effects*<sup>69</sup>. This procedure is also called a *Helmert transformation*, and keeps

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<sup>69</sup> Fixed effects need to be eliminated from the data to avoid biased panel VAR estimates. The estimation bias arises from some unobserved country-specific effects in any type of panel estimation. Including country fixed effects in the estimation is a way of dealing with this issue. However, in panel VAR, the colinearity (correlation) between the fixed effects and the regressors (including lagged variables) leads to unstable coefficient estimates (Wachtel 2001). Eliminating fixed effects improves those estimates. Since the PVAR technique eliminates common effects, standard tests used in panel data analysis (e.g. Hausman test) are not applicable.

the orthogonality between variables and their lags, so I can use lags as instruments.<sup>70</sup> Another issue is that of the cross section autocorrelation related to the *common factors* (Levin and Lin 2002). Indeed, panel data with groups of countries sharing some homogeneity presents some interdependence between countries which may affect the results. To adjust for such common factors, I subtract from each series at any time the average of the group (e.g. Nordic, South). The last transformation, *time-demeaning*, is performed to control for time fixed effects ( $\gamma_t$ ). I subtract the mean of each variable calculated for each country-year.

I then run the model in first differences to focus on the dynamics of aid adjustments and short-run effects.<sup>71</sup> In the context of crisis, short-run effects are the most interesting. I need stationary data in order to proceed with panel VAR. The data I use is necessarily stationary as it is in first differences; however, for the sake of scrutiny, I still test whether the main variables of interest are stationary by examining three different panel unit root tests: the Levin and Lin (2002) test, the Breitung (2001) test and the Im, Pesaran and Shin (2003) test. All unit root tests are reported in Table 4.3. The results strongly suggest that the net development aid as share of GDP, the GDP per capita, the fiscal balance as well as other variables do not follow a unit root process. Non-stationarity is not a major concern for the variables included in the analysis; therefore it seems appropriate to proceed with data preparation for the estimation of the panel VAR models.

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<sup>70</sup> The coefficients are estimated by the GMM, which, in my case, is just identified with the number of regressors equal to the number of instruments. It is equivalent to 2SLS. See Binder et al. (2005) for a discussion on GMM estimator in Panel VAR.

<sup>71</sup> Another way to proceed would be to test for stationarity variables in levels and if they are found non-stationary, to test for cointegration relationship between variables. The absence of cointegration relationship would justify solely focusing on short-run and using variables in first differences, while the presence of cointegration would call for structural VAR analysis of long-run effects. This paper does not address long-run effects and therefore I directly use variables in first differences.

Table 4.3 Panel unit root tests

	$ODA_{it}$	$GDP_{it}$	$FB_{it}$	$GD_{it}$	$Misery_{it}$	$Unempl_{it}$	$Infl_{it}$	$SP_{it}$	$FOREX_{it}$	$Trade_{it}$	$GX_{it}$
Levin-Lin-Chu unit-root test											
Adjusted t*	-5.3835	-10.0245	-9.7461	-6.5271	-5.8598	-5.4244	-19.5860	-13.9910	-12.3311	-15.5764	-10.4716
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
$H_0$ : Panels contain unit roots, $H_a$ : Panels are stationary Common AR parameter.											
Breitung unit-root test											
Lambda	-7.2982	-12.3831	-10.9010	-2.6310	-10.5937	-6.1151	-18.3369	-11.7802	-8.4662	-14.5417	-10.1163
p-value	0.0000	0.0000	0.0000	0.0043	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
$H_0$ : Panels contain unit roots, $H_a$ : Panels are stationary Common AR parameter.											
Im-Pesaran-Shin unit-root test											
Z-t-tilde-bar	-6.4688	-11.5218	-9.9877	-1.3619	-11.8022	-5.3954	-20.3643	-10.5399	-11.6682	-15.2542	-11.2238
p-value	0.0000	0.0000	0.0000	0.0866	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
$H_0$ : All panels contain unit roots, $H_a$ : Some panels are stationary Panel-specific AR parameter.											

Note: Number of panels = 21 (SP), 23 otherwise.

Number of periods = ODA (13), GDP (39), FB (26), GD (11), Misery (22), Unempl (16), Infl (48), 14 (SP), FOREX (29), Trade (37), GX (30).

## 4.6 RESULTS

I evaluate the effects of shocks to a set of macroeconomic variables on aid in 23 ODA donor countries. My main findings confirm the strong positive relationship between aid supply and GDP, on mid-term: lower GDP entails aid cuts, while higher GDP increases aid. GDP is the most important determinant of aid. This result is significant considering the whole sample or only expansions. For those two samples, there is one period of lag in the response of aid to GDP shocks. During recessions, the response of aid to shocks to GDP is stronger and significant but only appears in the second lag of GDP. This suggests that donors do not adjust aid budgets immediately during recessions.

GDP explains more of the ODA variations during the crisis. It accounts for up to 12% three years after the negative shock, compared to 3.1% if I am not restricted to the crisis. This result indicates the large influence of the negative GDP shock on aid.

There exists a mid-run relationship between aid and fiscal balance, with a longer time span than in the case of GDP. This relation is positive and significant during recessions. The fiscal balance explains about 3% of variations in aid during the crisis, but only 1.3% otherwise.

The impulse response functions give information about the short-run dynamics of those impacts. Most shocks start to have a noticeable influence on the economy and on aid after 1 to 1.5 years, and are absorbed within 8 years.

My analysis results for shocks ‘before and after’ the crisis suggests that crises trigger some structural changes: while aid supply is negatively affected by a shock to GDP before the crisis, this effect disappears if the shock occurs after the crisis. Understandably, the economies and aid budgets are more resilient after having adjusted to the crisis.

I also find that right and center wing governments cut on aid supply in reaction to shocks, while left wing governments do not. Moreover, center parties appear driven by economic factors, while left and right-wing parties, by their ideological views.

Lastly, I extend the model to analyze the transmission of shocks to aid supply through other variables, including the Misery Index, S&P stock market index, government debt, trade, real exchange rate, government consumption and GDP growth rate. I find that financial volatility decreases aid and introduces some uncertainty to aid through fluctuations of its budget. Surprisingly, variables related to social needs of the donor country are negligible for aid policies, and do not influence aid budgetary decisions. Economic variables and governments in power are shaping aid.

The next sections expose the detailed results of the simple and extended PVAR models.

### 4.6.1 The Simple Three-Variable PVAR Model

The simplest model consists of only three variables: GDP per capita, fiscal balance and aid as a share of GDP. After applying the identifying assumptions and transforming the data, I run the panel VAR model. The impulse response functions include their confidence intervals,<sup>72</sup> represented by the lower and upper lines on the graphs on Figure 4.8 or 4.9; the middle lines are the actual response functions, depicting the dynamics of the response of aid to shocks to other variables. This layout allows recognizing the time-dependent significance of each response directly from the graph. I also report coefficients which are the average effects of the response (e.g. Table 4.3), as well as variance decompositions (e.g. Table 4.4) which explain variations in aid variable due to shocks in other variables.

#### Recessions and expansions analysis

To model the response of aid during mild recessions, severe global crises and ordinary recessions I divide the dataset into three sub-samples: expansion, recession, which uses strict definition of banking crisis by Laeven and Valencia (2010), and the full sample. One standard deviation shocks applied to those sub-samples differ and allow accounting for different crisis magnitudes. Figures 8 and 9 present the impulse response functions to one positive standard deviation shocks for the full sample of donor countries for 1-lag and 2-lags models, and serve as a sanity check of the proposed model.

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<sup>72</sup> Since the IRFs are computed using the estimated PVAR coefficients, the standard errors of these coefficients need to be taken into account. This is done with Monte Carlo simulation, in which the parameters of the model are recalculated 1000 times using the estimated coefficients and their variance-covariance matrices as underlying distribution. The 5<sup>th</sup> and 95<sup>th</sup> percentiles from the resulting distribution are then used to generate the lower and upper bounds of the impulse response functions.

A positive shock to GDP increases aid (see bottom left graph on Figure 4.8). This result is logical as an economy with more resources is expected to provide more development aid. The effect becomes significant only after the first year. The shock is stable and absorbed within six years. The IRF of aid to the shock to GDP in the 2-lag analysis (Figure 4.9) offers additional insights. The positive effect on aid is only in medium term, and lasts from one to four years after the shock. This seems reasonable as the response of aid budgets is not immediate and is constrained by the cycles of governments in the donor countries.

Improvement in fiscal balance has no significant effect for 1-lag PVAR although it increases aid in the medium run which is evident for 2-lag PVAR (see bottom row, middle graph on Figure 4.9). The response of ODA to fiscal balance shock becomes unstable in the 2-lag model. Responses of other variables are sound. Improvement in fiscal balance increases GDP which is plausible; it may happen due to increased government revenues. GDP falls in response to shock to ODA which is expected; more aid is an additional cost for the government so a decrease of GDP is natural. I also notice that six periods is insufficient for the economy to absorb shocks, therefore subsequently I increase the adjustment time to eight periods.

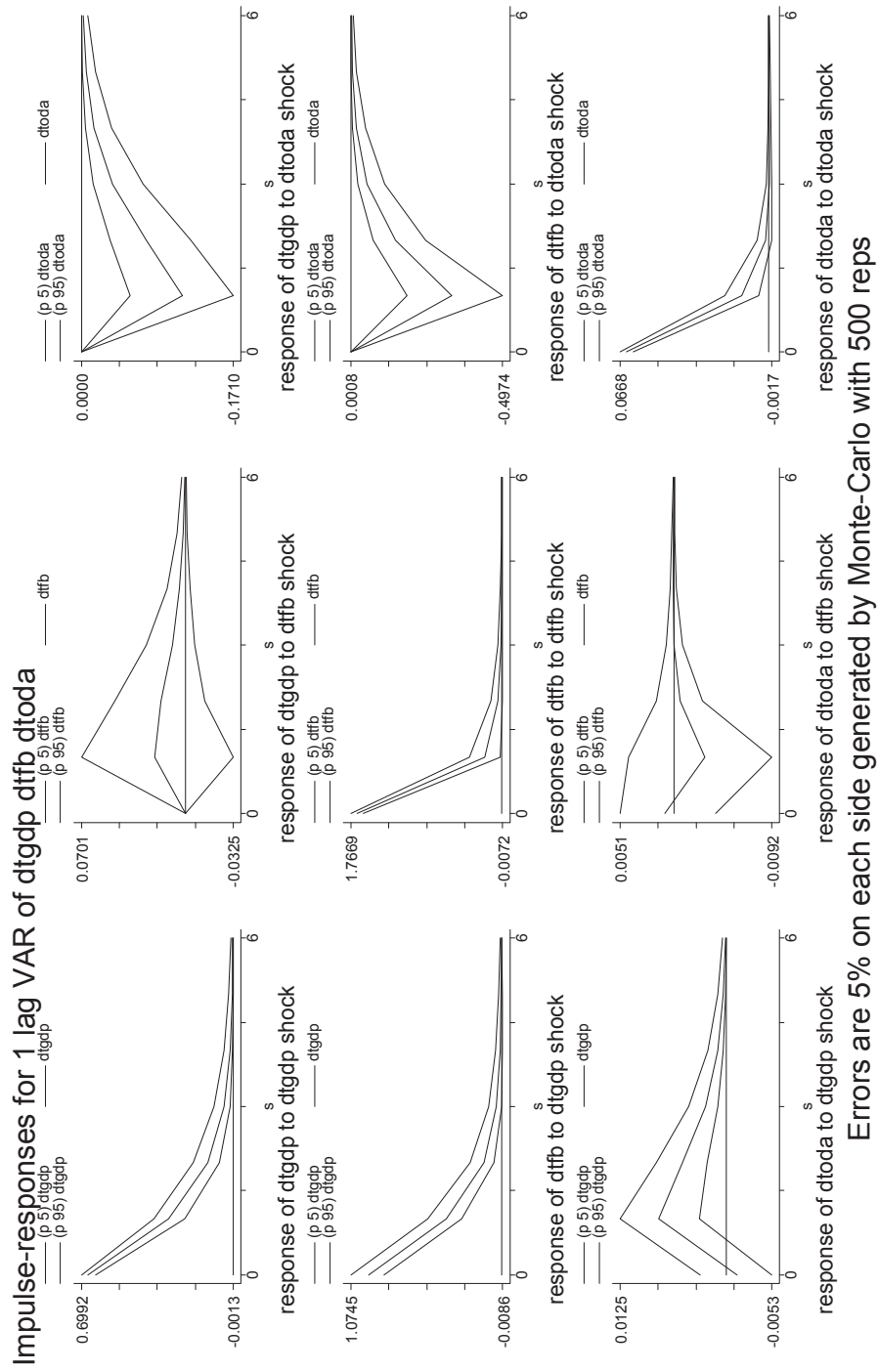


Figure 4.8 Estimation (1p): Impulse response functions of the GDP, fiscal balance and ODA to a positive standard deviation shock in 1-lag PVAR analysis



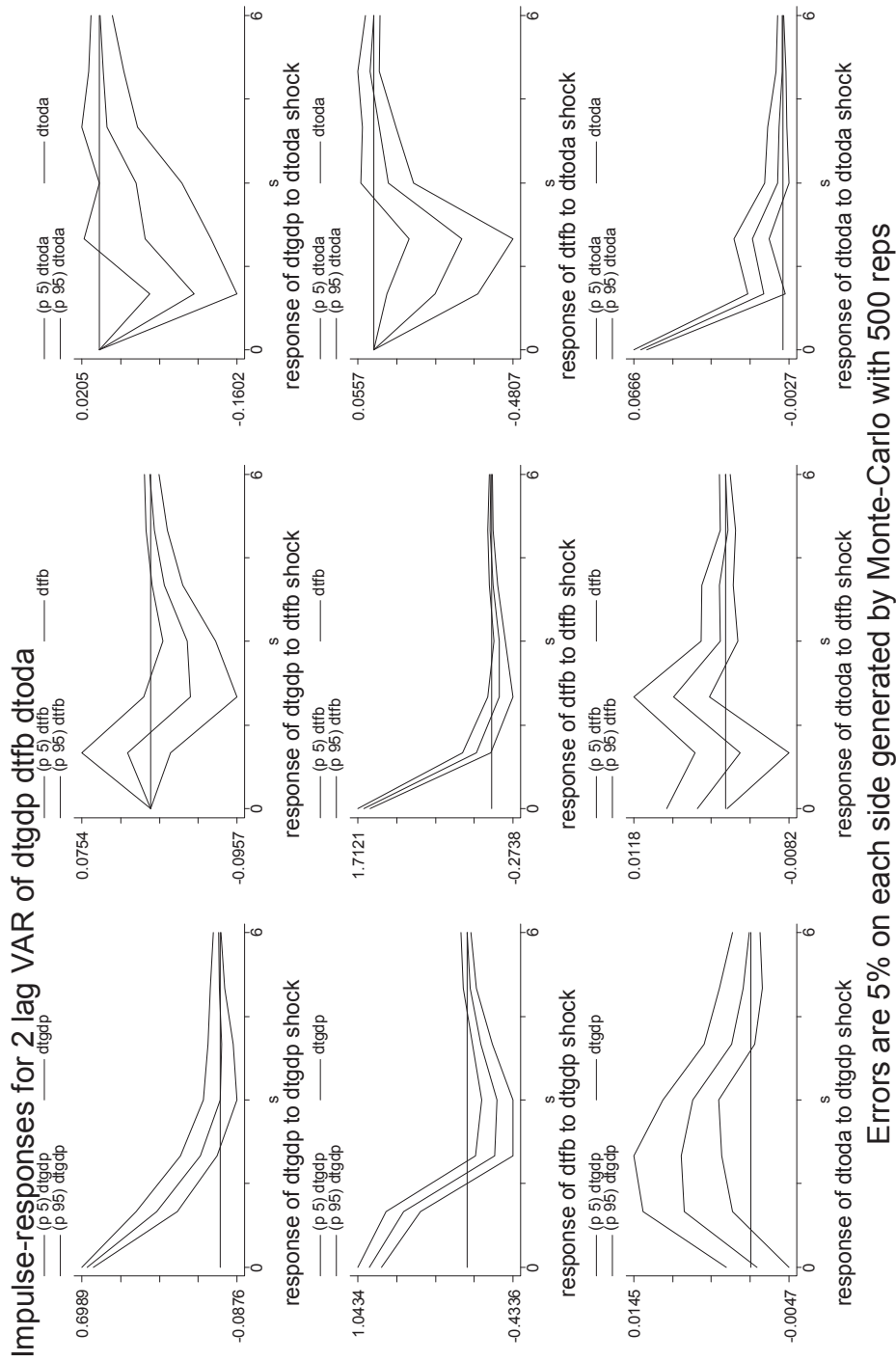


Figure 4.9 Estimation (2p): Impulse response functions of the GDP, fiscal balance and ODA to a positive standard deviation shock in 2-lag PVAR analysis

Table 4.4 Main results for the three-variable PVAR model of recessions and expansions

POSITIVE SHOCKS							
Response of	Response to						
	GDP <sub>t-1</sub>	fb <sub>t-1</sub>	ODA <sub>t-1</sub>	GDP <sub>t-2</sub>	fb <sub>t-2</sub>	ODA <sub>t-2</sub>	Obs.
<i>Full sample</i>							
(1p) ODA	.0149*** (.004)	-.002 (.002)	.184*** (.074)	-	-	-	633
(2p) ODA	.014*** (.005)	-.001 (.002)	.132* (.074)	.001 (.006)	.004** (.002)	.220*** (.074)	610
NEGATIVE SHOCKS							
Response of	Response to						
	NGDP <sub>t-1</sub>	Nfb <sub>t-1</sub>	ODA <sub>t-1</sub>	NGDP <sub>t-2</sub>	Nfb <sub>t-2</sub>	ODA <sub>t-2</sub>	
<i>Full sample (models ordinary recession)</i>							
(1n) ODA	-.0149*** (.004)	.002 (.002)	-	-	-	-	633
(2n) ODA	-.014*** (.005)	.001 (.002)	-	-.001 (.006)	-.004** (.002)	-	610
<i>Recession, banking crisis (models severe crisis)</i>							
(3n) ODA (bd=1)	.011 (.012)	-.011** (.005)	-	-	-	-	102
(4n) ODA (bd=1)	.025 (.018)	-.009 (.007)	-	-.037** (.018)	.000 (.004)	-	72
<i>Expansion (models mild recession)</i>							
(5n) ODA (bd=0)	-.015*** (.005)	.005 (.003)	-	-	-	-	488
(6n) ODA (bd=0)	-.012*** (.006)	.004 (.002)	-	-.003 (.006)	-.002 (.002)	-	455

Note: \*\*\* indicates 1% significance level (t-test>2.35); \*\* 5% (t-test>1.96); \*10% (t-test>1.65); standard errors are in parentheses; bd=1 indicates controlling for banking dummy; three variable VAR model is estimated by GMM; country-time fixed effects and common factors are removed prior to estimation.

Table 4.4 shows the estimated coefficients of the system of three variables: GDP per capita, fiscal balance and aid as a share of GDP. My results show that in response to shock, aid budgets are decreased. The results are significant, indicating a lasting influence. The average effects of shocks to GDP decrease aid after the first year for both the full sample (-.014) and the expansion sample (-.012), while this contraction comes after the second year and with more than double the magnitude for the banking crisis sample (-.037). There exists a positive relationship between aid and GDP; when GDP decreases, aid decreases as well. This relationship is not uniform and changes with the crisis itself. This finding is important because it confirms that aid

is cut in a response to deteriorating economic conditions. Increasing budget deficit contributes to aid contraction after the first year during banking crises (-.011), and has a mild effect after two years considering the full sample (-.004). Fiscal balance does not have any significant average effect on aid during expansions.

A few conclusions may be drawn from this analysis. Aid decreases in response to shocks to the main macroeconomic variables, and it happens earlier during expansions compared to banking crisis. Fiscal balance is used in a different way as a policy instrument, allowing increasing budget deficit during expansions but not during crises. I interpret these findings in two complementary ways, using business cycles and expectations, and fiscal stimulus. Business cycles are economy-wide fluctuations in activity, and include periods of rapid economic growth (expansions), and periods of relative stagnation or decline (recessions). During expansion, when GDP falls, there are expectations that the economy is entering a recession that may prolong. The government takes action and decreases aid immediately. In contrast, when a negative shock hits the economy during a recession, the GDP falls as well, but its decrease is consistent with the expectations, so the adjustment of aid is slower. The decrease in aid only occurs after the second year, but its negative effect is stronger. Fiscal stimulus is the proposition that the government can raise the overall state of the economy by borrowing money, raising output, which, as a corollary, makes it more likely to preserve aid levels. A shock to the fiscal balance decreases aid during the recession, as the government is not ready to run a higher budget deficit to keep aid at its increasing trend. This supports the hypothesis discussed earlier of higher fiscal costs of banking crises for the government.

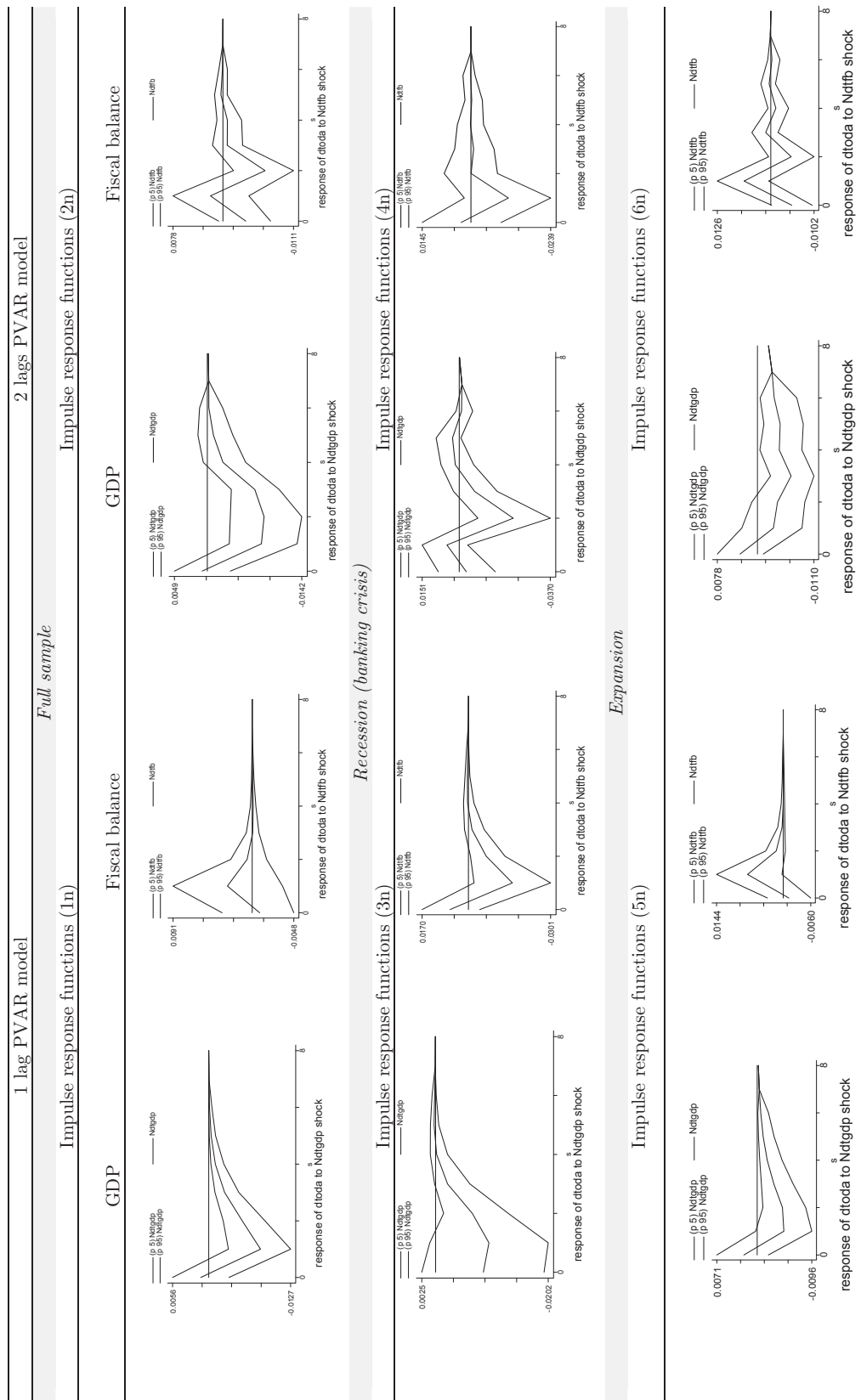


Figure 4.10 1 and 2-lag VAR response of ODA to negative shocks to GDP and fiscal balance for the full sample, crises or expansion  
Note: Errors are 5% intervals generated by Monte-Carlo with 1000 repetitions.

The impulse response functions of the recessions and expansions analyses are presented in Figure 4.10. The response of aid to GDP shock is robust and negative, as aid decreases, but this effect is significant after the first year regardless of the sample. The IRFs show that the decrease in aid is steeper and the adjustment is quicker during banking crises (estimation 3n on Figure 4.10) than during expansions (estimation 5n on Figure 4.10), for which the adjustment takes 8 years. This is consistent with the expectation that adjustments to GDP are faster during banking crises as per the higher GDP volatility and standard deviation. As a result aid adjusts faster. In contrast, expansions are associated with lower GDP volatility, a lower standard deviation, and slower aid adjustments.

The response of aid to a negative shock to the fiscal balance is *positive* during expansions (fiscal stimulus) and *negative* during banking crises (high fiscal costs). Although the positive impulse response function of aid to fiscal balance shock is insignificant, it shows the importance of fiscal policies. The impulse response functions of 2-lag PVAR models (estimations 4n and 6n in Figure 4.10) show that shocks to GDP have particularly persistent effects on aid during expansions and fiscal balance experiences some fluctuations in response.

Table 4.5 Forecast Error Variance Decomposition for recessions and expansions analysis

Variance of ODA as share of GDP explained by negative shock in each variable					
	t=2	t=3	t=4	t=6	t=10
<i>Full sample</i>					
GDP per capita	.016	.031	.042	.043	.043
Fiscal Balance	.004	.013	.013	.014	.014
ODA as share of GDP	.980	.955	.945	.943	.943
<i>Banking crisis</i>					
GDP per capita	.009	.120	.127	.128	.129
Fiscal Balance	.035	.031	.031	.031	.031
ODA as share of GDP	.956	.849	.842	.841	.840
<i>Expansion</i>					
GDP per capita	.006	.009	.019	.027	.032
Fiscal Balance	.017	.020	.020	.020	.020
ODA as share of GDP	.980	.971	.961	.953	.948

Note: 2-lag panel VAR models for two samples: full sample (estimation 2n), banking crisis sample (estimation 4n) and expansion sample (6n).

Table 4.5 gives the forecast error variance decomposition (FEVD) across variables in the PVAR system. Considering the full sample, I see that GDP can explain up to 4.3% of the forecast error variance in aid after ten periods, but nearly 13% during banking crisis, and only 3.2% during expansion. This result indicates a larger magnitude of the influence of the GDP shock on aid during banking crises. The fiscal balance follows a similar general pattern and explains 3.1% of the forecast error variation in aid during banking crises, but only 2% during expansion and 1.4% for the full sample. Overall these results serve as evidence that GDP plays a role in aid decisions and that economic factors should not be considered negligible. Clearly there exists a relationship between the economic conditions of the donor country and the amount of aid donated.

## Before and after the crisis analysis

I define the crises similarly to Laeven and Valencia (2010). However, I restrict the definition to the crises with a sharp decrease in GDP only. I consider the case of any crisis, including both systemic and non-systemic crises as well as cases of exclusively systemic or non-systemic crises. My objective is to determine whether crises have any structural effect on aid supply. Do donor countries change their aid strategy or just adjust aid flows in response to the crises?

The years before the crisis and the year of crisis are defined as ‘before the crisis’, while the years after the crisis are defined as ‘after the crisis’. I assume that it takes ten years of average before the economy fully recovers. Therefore, the period ‘after the crisis’ lasts ten years in most cases.

Table 4.6 Main results for the 3-variable PVAR model of before and after the crisis analysis

NEGATIVE SHOCKS					
Response of	Response to				Obs.
	NGDP <sub>t-1</sub>	Nfb <sub>t-1</sub>	NGDP <sub>t-2</sub>	Nfb <sub>t-2</sub>	
<i>Before the crisis</i>					
(7n) ODA, bd=0	-.016*** (.005)	.004 (.003)	-	-	453
(8n) ODA, bd=0	-.013* (.007)	.004 (.003)	-.003 (.007)	-.003* (.002)	421
<i>After the crisis</i>					
(9n) ODA, bd=1	.000 (.009)	-.006 (.004)	-	-	140
(10n) ODA, bd=1	.007 (.013)	-.003 (.005)	-.027*** (.011)	.001 (.003)	110

Note: \*\*\* indicates 1% significance level (t-test>2.35); \*\* 5% (t-test>1.96); \* 10% (t-test>1.65); standard errors are in parentheses; bd=1 indicates controlling for banking dummy; three variable VAR model is estimated by GMM; country-time fixed effects and common factors are removed prior to estimation.

The analysis yields similar coefficients (Table 4.6) and impulse response functions (Figure 4.11) to those found in the previous section (Table 4.4 and Figure 4.10). If the shock takes place before the crisis, I observe a negative and significant effect on aid. However, when it hits after the crisis, during the recovery period, the effect, albeit positive and very small, is insignificant. Aid decreases immediately before the crisis in response to falling GDP and additionally responds negatively to fiscal balance shocks but after two periods. After the crisis, aid is more resilient to shocks as policies are likely to be already adjusted for degraded economic conditions. Additionally, there is room for fiscal deficit. However, if the shock persists the contraction is stronger after the crisis. FEVDs show that variations in GDP after ten periods explain 5.3% of changes in aid for shocks after the crisis, and 3.9% before the crisis (Table 4.7). The magnitude of the effect is rather small.

Table 4.7 Forecast Error Variance Decomposition for before and after the crisis analysis

Variance of ODA as share of GDP explained by negative shock in each variable					
	t=2	t=3	t=4	t=6	t=10
<i>Before the crisis</i>					
GDP per capita	.010	.013	.025	.033	.039
Fiscal Balance	.016	.023	.023	.023	.023
ODA as share of GDP	.974	.964	.952	.944	.938
<i>After the crisis</i>					
GDP per capita	.003	.049	.053	.053	.053
Fiscal Balance	.016	.017	.017	.017	.017
ODA as share of GDP	.981	.934	.930	.930	.930

Note: Two lag panel VAR models for two samples: before the crisis (estimation 8n), after the crisis (estimation 10n).



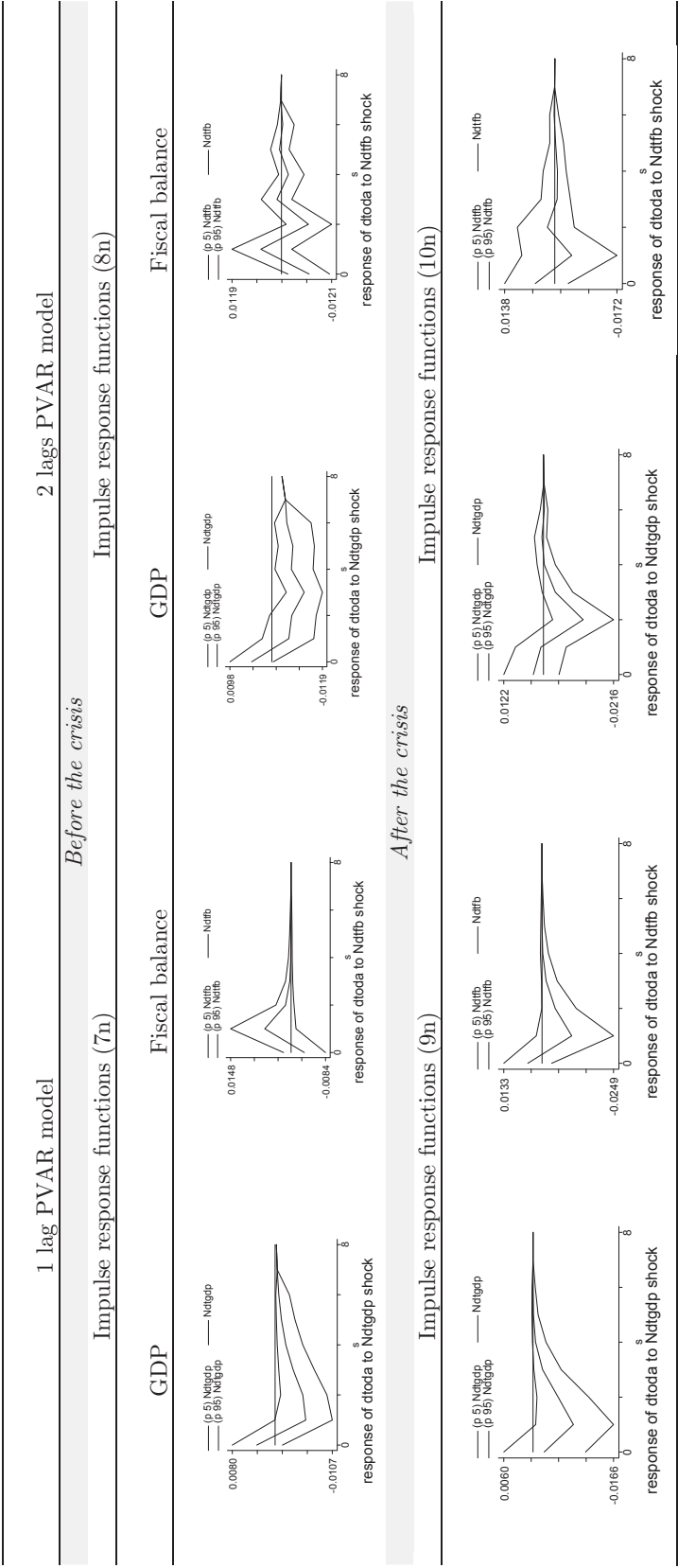


Figure 4.11 1 and 2-lag VAR response of ODA to negative shocks to GDP and fiscal balance for before and after the crisis

Note: Errors are 5% intervals generated by Monte-Carlo with 1000 repetitions.

## Do political influences matter for aid supply?

The previous sections established the relationship between economic indicators and aid supply. The current section accounts for the possibility that political pressure may regulate aid budgets in times of economic slowdown in donor countries. The literature on aid frequently highlights the role of politics as an explanation of aid allocation (McKinlay and Little 1977; Maizels and Nissanke 1984; Alesina and Dollar 2000; Burnside and Dollar 2000). However, the political variables employed in these studies do not represent the domestic politics of the donors, but rather analyse the role of politics at the international level. The importance of domestic politics in donors on aid policy is emphasized by Fleck and Kilby (2006), Lancaster (2007), Noel and Therien (1995) and Therien and Noel (2000). This corpus of literature suggests that political parties and domestic political institutions play an important part in shaping foreign aid policy. Recently, Tingley (2010) looks at how a donor's domestic political and economic environment influences aid supply, defining *aid effort*. He finds that, as governments become more conservative, their aid effort is likely to fall. Some research also exists that centres on voters in donor countries. For instance, Chong and Gradstein (2008) find evidence suggesting that populations satisfied with the governance of their country give more support for aid.

In times of crisis, political pressure might be even greater, and aid is a budget expense on which saving is easy. I divide the sample into right, left and centre governing parties. I then apply a one standard deviation shock which models recession. The average effects coefficients can be found in Table 4.8.

Table 4.8 Main results for the three-variable PVAR model of political influences

NEGATIVE SHOCKS					
Response of	Response to				
	NGDP <sub>t-1</sub>	Nfb <sub>t-1</sub>	NGDP <sub>t-2</sub>	Nfb <sub>t-2</sub>	Obs.
<i>Right wing ruling party</i>					
(11n) ODA, party=1	-.013 (.009)	-.001 (.004)	-	-	246
(12n) ODA, party=1	-.030*** (.011)	.005 (.003)	.008 (.013)	-.004* (.002)	209
<i>Centre</i>					
(13n) ODA, party=2	-.013** (.006)	-.008* (.005)	-	-	71
<i>Left</i>					
(14n) ODA, party=3	.003 (.012)	.005 (.005)	-	-	190
(15n) ODA, party=3	-.013 (.015)	.009 (.005)	.026 (.017)	-.006* (.004)	155

Note: \*\*\* indicates 1% significance level (t-test>2.35); \*\* 5% (t-test>1.96); \* 10% (t-test>1.65); standard errors are in parentheses; party dummy is used to control for political orientation; three variable VAR model is estimated by GMM; country-time fixed effects and common factors are removed prior to estimation.

The responses of different types of government to shocks to GDP and fiscal balance in their decision on aid supply vary widely. I observe that both right-wing and centrally aligned governments decrease aid when the economy is affected by a shock, while left-wing governments could increase aid; the result is however not significant for left-wing governments.

The more socialist stance of left-wing parties, as opposed to the more capitalist ideology of right-wing governments seems to be reflected in the result that left-wing governments hesitate to decrease aid in response to shocks, as this would contradict their ideological and political stance. Thence, the variance decomposition (Table 4.9) yields the conclusion that right and left-wing parties are more ideologically driven in their governance, contrary to the more variable and adaptable behaviour of central governments.

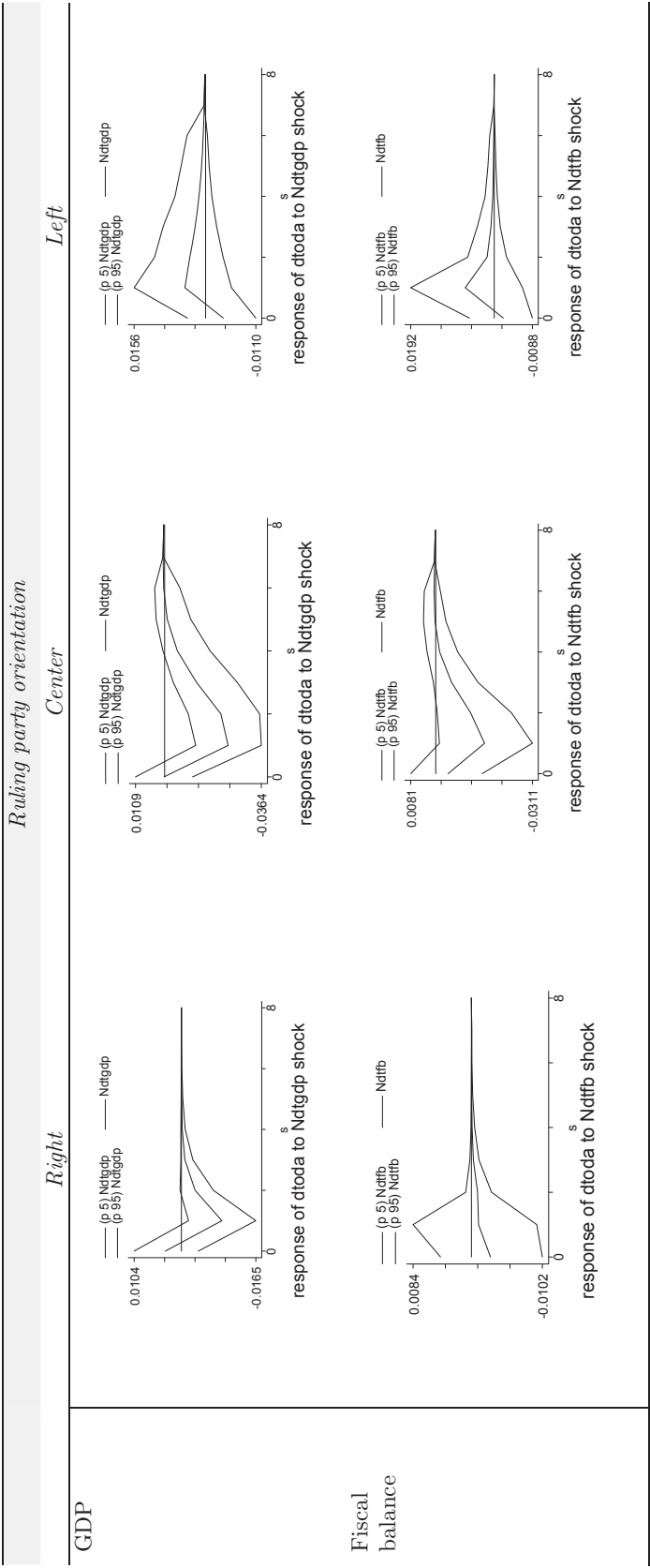


Figure 4.12 1-lag VAR impulse response functions of ODA to negative shocks to GDP and fiscal balance under different political orientations of the ruling party

Note: Errors are 5% intervals generated by Monte-Carlo with 500 repetitions.

The PVAR analysis produces evidence supporting politics as a main driver of aid budgetary decisions. Left-wing governments increase or otherwise do not decrease aid as a reaction to a negative shock to GDP or fiscal balance, while both right-wing and central governments will decrease aid. Governments in power are driving aid decisions. After five years, the right-wing parties account for 4.2% of the variations in aid due to shocks to GDP, the centre parties for 21.2%, and the left-wing parties for only 2.7%. This result demonstrates that centre parties' decisions seem more driven by economic conditions while left and right-wing parties tend to follow their ideologies.

Table 4.9 Forecast Error Variance Decomposition for ODA: Party influence analysis

Variance of ODA as share of GDP explained by negative shock in each variable					
	t=2	t=3	t=4	t=6	t=10
<i>Right wing</i>					
GDP per capita	.039	.038	.041	.042	.042
Fiscal Balance	.022	.036	.036	.036	.036
ODA as share of GDP	.939	.926	.923	.922	.922
<i>Centre</i>					
GDP per capita	.120	.190	.209	.212	.212
Fiscal Balance	.054	.072	.074	.074	.074
ODA as share of GDP	.826	.738	.716	.714	.714
<i>Left wing</i>					
GDP per capita	.022	.024	.025	.028	.029
Fiscal Balance	.049	.061	.063	.062	.061
ODA as share of GDP	.929	.915	.912	.910	.910

Note: Panel VAR models for three samples: right-wing party (estimation 12n), centre party (estimation 13n) and left-wing party (15n).

#### 4.6.2 Results - the Extended Model

In this section, I extend the simple three variable panel VAR model of aid, GDP and fiscal balance to account for other possible channels of transmission of unexpected shocks to aid.

In the PVAR model:

$$y_{i,t} = A_0 a_{i,t} + L_1 y_{i,t-1} + \dots + L_p y_{i,t-p} + u_t \quad (4.14)$$

where  $y_{i,t}$  is a  $K \times 1$  vector of  $K$  panel data variables,  $i = 1, \dots, I$ ,  $a_{i,t}$  is a vector of deterministic terms such as linear trends, dummy variables or constants,  $A_0$  is the associated parameter matrix, and the  $L$ 's are  $K \times K$  parameter matrices attached to the lagged variables  $y_{i,t}$ . The lag order (VAR order) is denoted by  $p$  and  $u_t$  is a vector of structural shocks to GDP, fiscal balance and aid. Vector  $y_{i,t}$  now has at least three and at most six variables among  $ODA_{it}$  (aid flows as a share of GDP),  $GDP_{it}$  (GDP as a share of population),  $FB_{it}$  (fiscal balance),  $GD_{it}$  (government debt),  $Misery_{it}$  (Misery Index),  $Unempl_{it}$  (unemployment),  $Infl_{it}$  (inflation),  $SP_{it}$  (financial volatility),  $FOREX_{it}$  (foreign exchange rate),  $Trade_{it}$ , and  $GX_{it}$  (government expenditures). Results are displayed in Table 4.10. Robustness checks for such variables as  $GDPGR_{it}$  (GDP growth rate),  $NAT_{it}$  (net aid transfers) and  $ODADR_{it}$  (aid net of debt relief) can also be found in Table 4.10.

I find that a negative shock to GDP significantly decreases aid after the first year. This result is consistent through all the models (Figure 4.13). The impulse response of aid to GDP is very persistent and robust to changes in the model specification. A shock to the fiscal balance has a significant and negative effect on aid, but only after the second year. The effect is very robust for all the models. This result supports fiscal stimulus and the room for some flexibility in budget deficit. Governments may react faster to a deterioration of GDP than to changes in

fiscal balance, as the fiscal balance can be traded in order to improve the falling GDP, so governments are ready to run a higher fiscal deficit. However this effect is short run; the government introduces a big fiscal stimulus only after the first year. After the second year, in case of a persistent economic shock also affecting the fiscal balance, the government reacts and adjusts aid in response.

The Misery Index has an unexpected positive impact on aid, but this result is insignificant. This is likely driven by inflation. A positive shock to inflation has a positive and consistently significant effect on aid supply. It is surprising and contradictory to some previous studies (e.g. Dang et al. 2009), where a negative relationship between aid and inflation is reported. As inflation decreases the real value of aid, the expected relationship is negative, and increasing inflation should lower aid. My findings suggest that inflation does not cause any decrease in aid; donors still meet their targets, and inflation is accounted for.

Financial volatility (S&P) has a consistent, negative, and significant impact on aid. Its impulse response function is unstable, indicating a higher level of uncertainty in aid due to financial frictions. Coming to the remaining variables, both shocks to government debt and shocks to unemployment have an expected negative sign, but their coefficients are insignificant. I do not find any significant average effect on trade and government expenditures.

Table 4.10 Main results for the extended model

	Response to																							
	GDP <sub>-1</sub>	GDP <sub>-2</sub>	FB <sub>-1</sub>	FB <sub>-2</sub>	Misery <sub>-1</sub>	Misery <sub>-2</sub>	GD <sub>-1</sub>	GD <sub>-2</sub>	Unempl <sub>-1</sub>	Unempl <sub>-2</sub>	Inf <sub>-1</sub>	Inf <sub>-2</sub>	SP <sub>-1</sub>	SP <sub>-2</sub>	FOREX <sub>-1</sub>	FOREX <sub>-2</sub>	Trade <sub>-1</sub>	Trade <sub>-2</sub>	GDPGR <sub>-1</sub>	GDPGR <sub>-2</sub>	GX <sub>-1</sub>	GX <sub>-2</sub>	Obs.	
Shocks	-	-	-	-	+	+	+	+	+	+	+	+	-	-	+	+	-	-	-	-	+	+	+	
Response of ODA																								
(1n)																								633
(2n)																								610
1																								564
2																								541
3																								619
4																								593
5																								616
6																								593
7																								388
8																								366
9																								388
10																								366
11																								366
12																								544
13																								521
14																								368
15																								346
16																								614
17																								369
Response of ODADR (ODA net of debt relief)																								
18																								366
Response of NAT (Net Aid Transfers)																								
19																								347
20																								346

Note: \*\*\* indicates 1% significance level (t-test>2.35); \*\* 5% (t-test>1.96); \* 10% (t-test>1.65); standard errors are in parentheses; VAR models of up to 6 variables are estimated by GMM; sample: full sample; country-time fixed effects and common factors are removed prior to estimation.



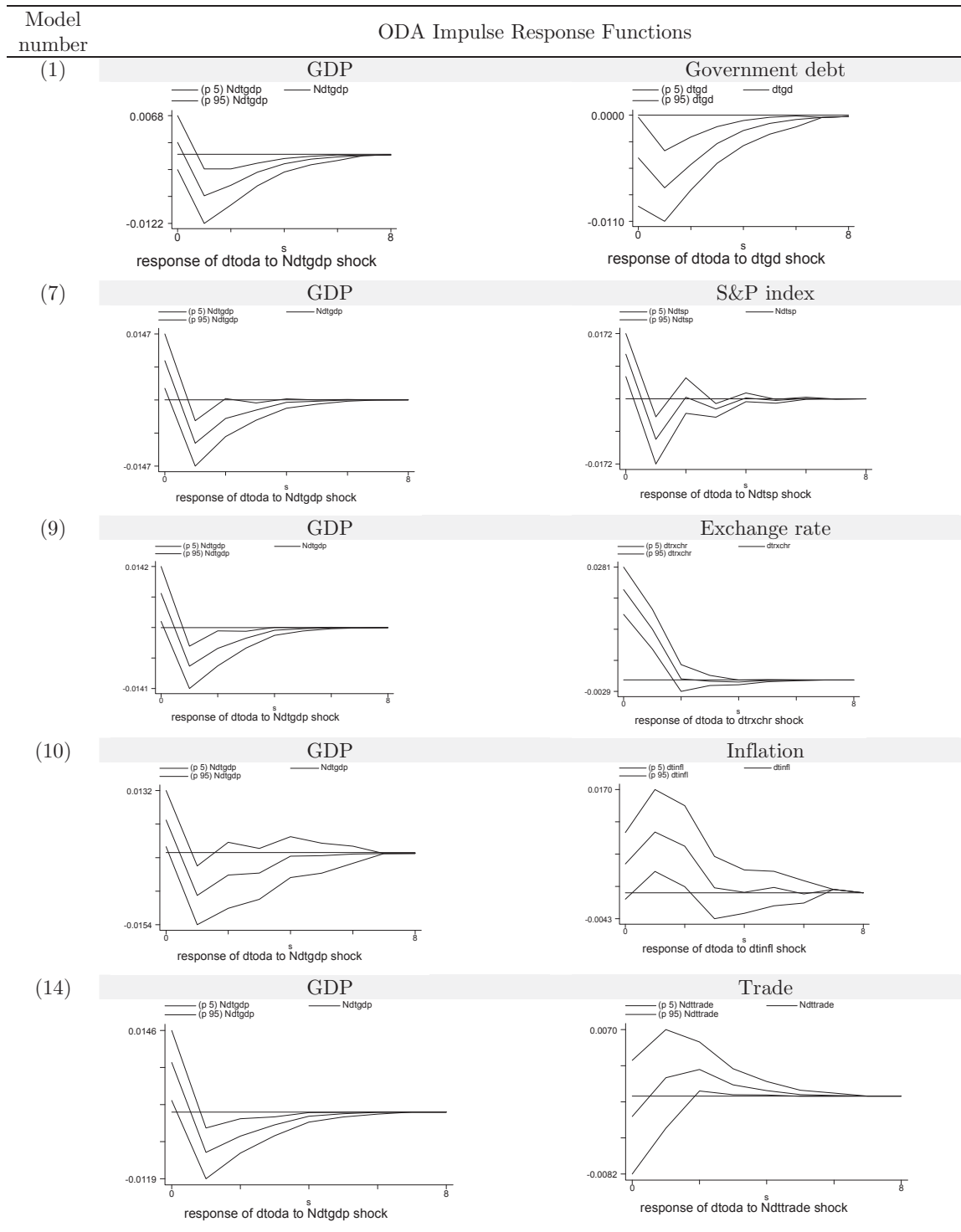


Figure 4.13 Impulse response functions of aid to shocks in selected variables of the extended model

Note: Errors are 5% intervals generated by Monte-Carlo with 500 repetitions.

Table 4.11 Variance decomposition for the extended model

Variance of ODA as share of GDP explained by a negative shock in each variable after 10 periods													
Estimation Variable	2	4	6	8	10	11	13	15	16	17	18	19	20
GDP	.035	.046	.046	.031	.028	.033	.037	.026		.020	.066	.073	.075
FB		.016	.013			.029	.008	.026	.025	.026	.019	.073	.031
Misery		.003											
GD	.026						.020						
Unempl			.009										.003
Inf			.004	.029	.030					.039			
SP				.036	.041	.045		.038		.027	.045	.021	.019
FOREX					.093	.115		.128					
Trade								.006					
GDPGR									.014				
GX							.005						.094
ODA	.939	.934	.928	.876	.779	.778	.930	.776	.961	.889	.870	.833	.778

Table 4.11 exposes the forecast error variance decomposition (FEVD) across variables for the extended PVAR models. I manage to explain almost a quarter of the variations in aid (23%) using other macroeconomic variables, which is substantial and indicates a major relation between the economy and aid decisions. The first row reveals that GDP can explain up to 7.5% of the forecast error variance in aid after ten periods. Fiscal balance explains about 2.5% of the total variation in aid, and government deficit 2%. Financial volatility accounts for up to 4.5% of the variations in ODA. This finding is consistent with Mendoza et al. (2009) who find that stock market volatility in the US is associated with a decrease in aid. I confirm this result for OECD-DAC donors. Another important finding is that a surprisingly large share of variations in aid is due to foreign exchange rate volatility in donor countries, up to 12.8%. The direct effect of falling aid is compounded by the indirect effect of the exchange rates movements. Donors allocate aid in their own currencies and hence the real value of aid may hinge on exchange rates.

The financial crisis resulted in the appreciation of the US dollar against many currencies, including the Euro, so if aid from the Eurozone was to stay nominally constant the exchange rate adjustment still leads to a loss of USD 3.9 billion in value in 2009 (World Bank and IMF 2009). Among major donor currencies, only the Japanese yen has appreciated, pushing up the value of Japan's aid contribution. Consistently with Frot (2009) I do not observe any effect that unemployment may have on aid. The Misery Index has no effect either despite Mendoza et al. (2009) having found some evidence that the Misery Index does affect aid. I treat both unemployment and the Misery Index as proxies for the internal social needs of the donor country but unemployment proves insignificant, having negligible power to explain variations in aid. This reveals that foreign aid responds mostly to economic and political shocks, but is insensitive to changes in social conditions.

## 4.7 CONCLUSIONS

This study investigates the consequences of the financial crisis on aid. I model the effect of different crises on aid from the donor's standpoint using banking crisis data from the 23 OECD-DAC donor countries. I build a theoretical framework based on the consumption model and implement it using panel VAR, first in a simple, three variable form and later in an extended model. Simulations are run on the full sample—to capture recession, on crisis data only—to model stronger crises, and on expansion samples—to simulate mild recession, as well as shock variables before and after the crisis and with a variable to capture political influence.

Foreign aid, an important but variable source of income for developing countries, recently became more volatile. I expose financial and political sources of aid volatility originating from donors that might influence recipients' growth prospects. Variations in aid stem

in part from fluctuations in the level of the donor's aid contribution, the share of GDP it decides to allocate to foreign aid.

My main finding is that crises affect aid budgets and their trend. This influence takes place through two channels: *directly* through lower revenues and *indirectly* by increasing fiscal costs through exchange rates and financial volatility.

I find a positive and significant relationship between aid and GDP. GDP and ODA move in the same direction, and prolonged recessions and banking crises have a lasting and negative effect on the behaviour of donors and aid supply. This relationship between aid and the donor economy is not solely economic as the donor's internal political orientation also plays an important role. My results suggest that models using just the donors' economic and international strategic interests as determinants of their aid policy may not be complete. Donor countries' own financial conditions as well as political determinants play important roles in allocating aid budgets, while the social conditions in the donor countries do not. Governments in power are driving aid decisions rather than the needs of people. In particular right-wing and centre governments cut aid in response to economic distress while left-wing governments may not. I also observe that centre parties are more driven by the economic conditions than left and right-wing governments, which tend to make aid budget decisions in accordance with their ideologies.

Results indicate that financial factors matter for aid. Stock market volatility increases aid uncertainty, while exchange rate movements, due to crisis, and the resulting appreciation of the US dollar against other currencies depresses the value of aid. Exchange rate movements have a strong explanatory power of the variation in aid. However, increasing inflation does not contract aid.

The panel VAR approach lets the data speak for itself but fails to offer explanations of the mechanisms beneath the results. Nonetheless, it serves the purpose of deepening our

knowledge of the consequences of crises for the developing world. Economic downturns and financial uncertainty do lower the amount of aid allocated to the developing world, and this effect happens through several channels. But economics is clearly not the most influential factor affecting aid allocation; aid is, to a greater extent, affected by politics.

My findings have some important policy implications. Sustainable and continuous aid is essential for developing countries to achieve their development goals. However, I find that aid is not only sensitive to swings in the economic conditions of the donor countries, but also to their political cycles. One important policy implication is the need gradually reduce the reliance of developing countries on direct aid through diversification, as in cases of global recession this source of financing is not sustainable. Although policies promoting self-sufficiency in generating income, like community development (Minkler et al. 1997, Green and Haines 2007) and bottom-up people-centered systems (Burkey, 1993) may work in countries with sufficient levels of institutional and social development, they may also prove ineffective in the poorest countries. There are also policy implications for the donor countries. As low-income recipients suffer drastic consequences from sudden aid reduction, there is a need to rethink and disconnect aid provision from political influences in the donor countries.

My results add weight to the concerns of many about falling aid. Decreasing aid amounts to the consequences of recessions spilling over to developing countries; this leads to a call for action on the part of the donor countries.

# CHAPTER 5

## Conclusions

### 5.1 SUMMARY OF RESULTS

This dissertation investigates some outcomes of globalization, exploring the effects and transmission of shocks in the economy. Chapters 2 and 3 focus on globalized production markets and volatility linkages, developing a model and calibrating it for an open economy and for Central and Western European data. Chapter 4 examines the interconnection of developing and developed countries through the provision of international aid in the context of global financial crises.

The thesis makes use of two complementary modelling approaches in applied macroeconomics. While both techniques are micro-founded and take interdependencies into account, each approach has its advantages and drawbacks.

The first method consists in building a complex multi-dimensional DSGE model with carefully defined structure: optimizing agents and fully specified preferences, technologies, and constraints. Parameters are used to fit the model to data. DSGE models are extensively used in policymaking, but by design, they impose many restrictions. Consequently, the statistical properties of the data often challenge the consistency of the model. Thus, it is often a challenging interpretative task to use the output of the model to realistically assess real world policy options.

The second approach builds a panel VAR model attempts to capture the static and dynamic interdependencies present in the heterogeneous panels with a minimal set of restrictions. It preserves most of the explicit micro structure present in DSGE modelling. Shocks identification adds structure into the reduced form model, making it recursive, although the structure remains more limited than in DSGE and somehow mechanical. However, impulse response analysis is relatively more straightforward. The results effectively complement DSGE, provide a coherent and credible approach to forecasting and policy analysis, and can improve the realism of rich structural models.

In both the DSGE and the recursive panel VAR approaches, a one standard deviation shock models the effect of a 1% change in that variable. As errors – and therefore innovations – are uncorrelated across all equations in my models, the interpretation of impulse responses is unambiguous: they measure the effects of a 1% change in a shocked variable on current and future values of the concerned variables. The response to a shock appears in the short-run, and is followed by a damped absorption, gradually returning to equilibrium in the long run. In the panel VAR model, I apply a novel method that allows various scenarios to be modeled (e.g. recessions or expansions) by selecting the corresponding subsets of data. The shocks are still one standard deviation, but naturally vary following the statistical properties of the selected subset. In DSGE models, I use the benchmark one standard deviation magnitude for all shocks, making the results easily comparable between demand and supply shocks and across models.

There are six main contributions in this dissertation. First, I build a Dynamic Stochastic General Equilibrium (DSGE) model to address the impact of demand and supply shocks in an economy with offshoring. The model is based on the research of Bergin et al. (2011) who use calibration but do not generate IRFs through stochastic simulation. The difficulty in extending such a DSGE model lies in adding new variables and allowing for simulation. Dynamic models of offshoring are scarce in the current literature. The DSGE analysis overcomes the drawbacks of

the more commonly used static or partial equilibrium setup, which lie in the ineffectiveness to analyze dynamic adjustments in highly non-linear models. I solve the model for its stationary state, perform stochastic simulations, and conduct a sensitivity analysis by individually varying the offshoring level and preference parameters. I find that *offshoring has generally positive consequences* for the home country relocating production to the foreign country, and these effects are amplified by the ‘*export*’ of shocks that happens through the offshoring link. The foreign country is only positively affected in terms of labor market. However, if the follow-up inshoring happens, the situation becomes favorable for the foreign country, while the home country is adversely affected, and the magnitude of this effect is greater than the initial advantage. I also discover an *offshoring threshold* beyond which offshoring becomes detrimental for the domestic economy. I find supportive evidence on sectoral *labor complementarity* and *substitutability* between the home and foreign countries when engaging in offshoring.

Second, this DSGE study fills a gap in the theoretical literature examining the relationship between offshoring, volatility and shocks transmission. As suggested by Bergin et al. (2011) and Tesar (2008), offshoring has an impact on volatility and acts as a *shocks transmission channel*. In the thesis, I confirm the pro-cyclical pattern of offshoring and the extensive and intensive offshoring margins dynamics. My results are relevant to the study of persistent wage differences between regions, such as the US and Mexico or the original and new EU member countries. I find that offshoring contributes to maintaining the core-periphery wage gap.

Third, I establish a new *interest rates transmission channel* of offshoring. Offshoring is found to affect interest rates through two mechanisms. It amplifies the effects of productivity on domestic sector prices and consumption through changes in supply capacity, which in turn affects the interest rates; it also directly influences interest rates through multinational sector consumption.



Fourth, I examine offshoring in the context of Western and Central Europe. In three statistical studies on employment, export and import between these two regions of the European Union, I find that offshoring is a channel of adjustment to shocks. To better assess its dynamics, I calibrate the DSGE model to the European data and run simulations. The results confirm my earlier findings on shocks transmission, volatility and the interest rates link, and reveal European market specificities. I determine the existence of an *optimal level of offshoring* for which volatility is minimal. I also find that the substitutability of labor is smaller and that offshoring creates jobs at home, even in the multinational assembly sector.

Fifth, I design a theoretical framework of international aid provision based on a consumption model where donors consume international aid indirectly. The analysis is conducted from the donor's standpoint, unexplored in the literature. I use the panel VAR method to evaluate it empirically, modeling different types of crises including mild recession, recession, and severe crisis to better understand the dynamics of the responses. I expose the financial sources of aid volatility in the context of crises. My main finding is that *crises affect aid budgets and their trends*. This influence takes place through two channels: *directly* through lower revenues and *indirectly* by increasing fiscal costs through exchange rates and financial volatility.

Sixth, I find evidence that *aid decisions are not purely economic and that they are driven by political considerations* as well. The influence of internal politics of the donor country on aid fits as a new perspective in the literature. I identify that donor countries' political determinants play important roles in allocating aid budgets. As determinants of aid allocation, internal politics is complementary to financial conditions. In particular, right-wing and centre governments cut aid in response to economic distress while left-wing governments may not. I also observe that centre parties are more driven by the economic conditions than left and right-wing governments, which tend to make aid budget decisions in accordance with their

ideologies. An important implication is that models solely using the donors' economic and international strategic interests as determinants of their aid policy may not be complete.

## 5.2 FURTHER RESEARCH

It is worthwhile suggesting further avenues of research which could benefit from the framework of this thesis.

There are two direct extensions to the DSGE model developed in Chapter 2. First, a rigorous welfare analysis of the effects of offshoring could explain whether global production and the changes in volatility that it entails are beneficial or not for the participating countries. Second, the DSGE model could be modified to allow for two-way offshoring, as globalization is made of reciprocal relationships. For instance the OECD data shows that Central European countries have generally higher offshoring than Western European countries. This direction of research would render the model more complete by accounting for the net effect of jobs substitution and complementarity.

A direct extension of my research on aid provision and crises could consist in investigating the long-run relationships from dynamic heterogeneous panels. Panel VAR analysis yields short-run responses only. Hence, as the long-run implications are particularly important in the topic of development aid, this direction of research seems appropriate.



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