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INTERNATIONAL CAPITAL FLOWS

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International capital flows

by Alba Del Villar Olano

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Abstract

This thesis uses modern macroeconomic modeling techniques and panel data econometrics to quantitatively measure the determinants of financial globalization and its effects on advanced and developing economies. The first two chapters of this thesis provide the starting point for the quantitative analysis of international gross capital flows and valuation effects between two asymmetric countries and it serves policymakers to quantify these matters in an diaphanous manner. In the first chapter, I construct a novel two-country DSGE model with endogenous portfolio choice to study the role of structural asymmetries in explaining the size and composition of capital flows between emerging and advanced economies. In the second chapter, we calibrate an extension to the previous model in order to discuss the potential determinants of the large increase in Canadian Net Foreign Assets with the US observed after 2012. The last two chapters of this thesis provide an econometric analysis which uses empirical data at the world level to quantitatively measure economic integration determinants and its effects. In the third chapter, we examine the link between economic globalization and spatial inequality in a panel of 142 countries over the period 1992-2012 using instrumental variable techniques. In the fourth chapter, I provide results to show how the Lucas Paradox has turned even more pronounced during the Great Recession than in the previous decades.

Preface

"We are all linked together by sharing the same planet. One country's actions can, and do, have large effects on others. The international economy is linked in myriad and very complex ways. Globalization is thus a reality with which we will have to deal. If we deal with it in the right way, the world of the future can be marked by shared prosperity."

— Joseph Stiglitz, Economics Nobel Laureate.

During the last few decades, both gross capital and trade flows across countries have reached unprecedented levels. Furthermore, emerging economies are now net importers of foreign direct investment while being net exporters of financial capital. Advanced economies, such as the US, do exactly the opposite by importing bonds and exporting FDI. That is *two-way*-capital flows. The relevance of portfolio composition in terms of FDI and bonds is directly related to the scale in gross capital flows because the different types of flows provide heterogenous implications for macroeconomic and financial stability. In fact, the combination of large and heterogenous gross capital flows creates wealth transfers, through valuation effects, between advanced and emerging countries whenever exchange rates and stock prices fluctuate.

In the first chapter, I build an open-economy New Keynesian model that incorporates the portfolio choice of FDI-equity and bonds to study the role of structural asymmetries in explaining two-way capital flows between emerging and advanced economies. In a symmetric two-country model, the household optimal position on each foreign assets is equal in both countries, so that net bond and net equity positions are zero. Therefore, the *two-way*-capital flows pattern cannot arise in these models. In fact, there must be some asymmetries that explain the positive (negative) net bond and negative (positive) net equity position in emerging (advanced) economies. Results indicate that a higher volatility on technology and interest rate shocks in emerging economies may be a potential explanation, since it reinforces long positions in local bonds over short positions in foreign bonds, while it reduces foreign equity over local equity positions. *Two-way* capital flows also arise under the presence of higher price stickiness in the emerging economy since nominal rigidities diminish foreign equity positions. Furthermore, we find that a higher home good bias leads to a higher home equity bias.

In the second chapter, which is co-authored with Miguel Casares, we calibrate an extension to the model described in Chapter 1 to discuss the determinants of the increase in Canadian Net Foreign Asset position with the US observed after 2012. We demonstrate that the proposed model performs quite well in explaining the business cycle statistical moments and the high degree of cyclical synchronization between Canada and the US. We find new evidence on a *reversed two-way* capital flows pattern characterizing the Canada-US net foreign investment relationship: Canada has a negative position on bond holdings owned by US investors while a positive balance emerges on equity holdings from US firms. Overall, the model performs quite well in describing the main business cycle statistics. A global technology shock, the US fiscal contraction, an adverse wage-push shock in the US and the unconventional (QE) monetary stimulus provide insights to describe the recent capital flows between Canada and the US.

In the third chapter, which is co-authored with Roberto Ezcurra, we examine the link between economic globalization and spatial inequality in a panel of 142 countries over the period 1992-2012. Our instrumental variables estimates reveal a strong causal effect of the degree of economic integration with the rest of the world on spatial inequality, indicating that the advances in the process of globalization currently underway contribute to significantly increasing regional income disparities. This means that globalization leads to the emergence of losing and winning regions within countries, and that the group of losing (winning) regions tends to be made up of low-(high-)income regions. This result has to do with the regressive spatial impact of actual economic flows, while existing restrictions on trade and capital do not exert a significant effect in this context. Our findings are robust to the inclusion in the analysis of different covariates that may be correlated with both spatial inequality and globalization, and are not driven by a specific group of influential countries. Likewise, the observed relationship between economic integration and spatial inequality does not depend on the measures used to quantify the magnitude of regional income disparities within the various countries.

In the fourth chapter, I examine the Lucas Paradox during the Great Recession.[1] Results show that in the 2008-2015 period, the Paradox might be even more pronounced than in the previous decades. Moreover, our findings suggest that disaggregating capital flows by type of capital is important since trade flows are found to be a key determinant of Foreign Direct Investment (FDI) and credit to private sector mostly explains Portfolio Equity flows.

[1]This chapter contains a research paper that has been already published (See Del Villar, 2018)

Introducción en Castellano

"Todos estamos unidos por compartir el mismo planeta. Las acciones de un país pueden afectar, y de hecho, afectan notablemente al resto. La economía internacional esta unida de formas innumerables y muy complejas. La globalización es una realidad con la que tenemos que lidiar. Si lidiamos con ella de forma correcta, el mundo del futuro puede marcarse por una prosperidad compartida. "

— Joseph Stiglitz, Premio Nobel de Economía.

Durante los últimos años, tanto los flujos de capital como el comercio internacional han alcanzado niveles históricos. Sin embargo, éste crecimiento ha sido heterogéneo a nivel global: Las economías emergentes son importadoras de inversión extranjera directa (IED) y exportadoras de capital financiero (bonos). Por el contrario, las economías avanzadas, como USA, exportan IED para importar bonos. Éste fenómeno, se conoce en la literatura como flujos *bi-direccionales* de capital internacional. La relevancia de investigar la composición de los flujos brutos de capital, en términos de IED y bonos, está directamente relacionada con el volumen de dichos flujos. La IED y el capital financiero generan diferentes implicaciones sobre la macroeconomía y la estabilidad financiera. Hoy en día, la combinación de elevados volúmenes de capital con una composición heterogénea, genera transferencias de riqueza entre los distintos países cada vez que los tipos de cambio o los precios de las acciones fluctúan, generando así ganadores y perdedores de la globalización financiera.

Ésta tesis doctoral utiliza las últimas técnicas de modelaje teórico macroecónomico y de econometría de panel de datos para medir de forma cuantitativa los efectos de la globalización financiera y de la integración económica en países avanzados y en vías de desarrollo. Por un lado, los dos primeros capítulos sirven como punto de partida para el análisis de los flujos brutos de capital y la valoración de activos desde el punto de vista de la teoría macroeconómica y financiera internacional. Por otro lado, en los dos últimos capítulos, análizamos con técnicas econométricas las causas y las consecuencias de la globalización económica, con especial enfásis en la desigualdad regional.

En el primer capítulo, se desarrolla un modelo teórico de dos países con selección de cartera endógena, de IEA y bonos, para estudiar el papel de las asimetrías estructurales en explicar tanto el volumen como la composición de los flujos de capital entre países avanzados y emergentes. En un modelo simétrico, los ciudadanos de cada economía seleccionarían de forma óptima la misma posición extranjera en cada activo, IEA y bonos. Por lo tanto, las posiciones netas tanto en bonos como en IED deben ser cero. Entonces, la evidencia empírica sobre flujos bi-direccionales no se puede explicar con un modelo simétrico. De hecho, debe haber alguna asimetría entre ambas economías que explique porqué las posiciones netas son diferentes de cero. Los resultados de éste estudio arrojan que los principales determinantes son la mayor volatilidad en las innovaciones de los shocks de tecnología y de tipos de interés, así como una mayor rigidez en los precios nominales presente en los países emergentes. Además, encontramos que una mayor apertura comercial genera una mayor diversificación de la cartera de inversión.

En el segundo capítulo, calibramos una extensión del modelo previamente desarrollado en el primer capítulo para explicar los determinantes del aumento de la posición financiera externa (NFA) de Cánada con EEUU observada a partir de 2012. Éste artículo supone la primera vez que se calibra un modelo de dos países DSGE con selección de cartera endógena. Es más, el modelo simula de forma satisfactoria los principales momentos estadísticos para las series de datos trimestrales de EEUU y Canada. Los resultados sugieren que los principales determinantes del incremento de la NFA en Canada, fueron el incremento de la productividad global, la pólitica monetaria del QE llevada a cabo por la Reserva Federal de EEUU, y un shock adverso a los salarios de las empresas localizadas en EEUU.

En el tercer capítulo, examinamos el link entre la globalización económica y la desigualdad espacial en un panel de 142 países para el periódo 1992-2012. Es la primera investigación a nivel global sobre los efectos de la integración económica en la desigualdad regional de los países. Los resultados demuestran que la globalización financiera ha creado regiones ganadoras y regiones perdedoras. Para entender la magnitud de los resultados, los autores muestran un ejemplo. Si Malawi en 2010, hubiera tenido un nivel de globalización similar al de Turquía, es decir un 25% mayor, su grado de desigualdad espacial hubiera incrementado aproximadamente un 17.6%.

Por último, en el cuarto capítulo, estudio cómo la Paradoja de Lucas ha incrementado durante la Gran Recesión. El famoso Puzzle de Lucas (1990) se centra en explicar porqué el capital no fluye de los países ricos hacia los países pobres, donde el rendimiento de éste es mayor. Éste artículo, Del Villar (2018), se centra en analizar los determinantes de los flujos de IED y bonos a nivel internacional, y encuentra que durante la Gran Recesión la paradoja se ha acentuado considerablemente. Es más, las explicaciones tradicionales sobre el papel de la calidad de las instituciones dejan de ser la solución a la Paradoja.

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[2] Also, I would like to thank all the people I have met during my trips and conferences around the world. Further, to the Indonesian earthquake in August 2018, which positively shocked my utility function.

To my best adventure,

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Chapter 1

Gross capital flows between emerging and advanced economies: A two-country portfolio choice model

1.1 Introduction

A heated debate has derived from the contradictions between standard open economy models predictions, empirical evidence on the macroeconomic effects of international capital flows and policy makers' beliefs (Blanchard *et al.*, 2016). Since 1990, the world has experienced an impressive boost in gross cross-border capital flows. As Figure 1.1 shows, average gross external positions are about five times the gross domestic product (GDP) for major industrialized economies (G7 countries) and grew from 1/3 to more than 2/3 of the GDP for emerging economies (BRIC's). Furthermore, Figure 1.2 shows not only large, but also heterogenous external positions across emerging and advanced economies, often referred in the literature as "two-way" capital flows, (Gourichas and Rey, 2014). This heterogenous pattern for both the net Foreign Direct Investment (FDI) and the rest of financial capital starts only after the year 1990, and it explodes after 2000. In fact, emerging and developing economies are net importers of foreign direct investment while being net exporters of financial capital. Furthermore, advanced countries such as the United States (US) do exactly the opposite by importing financial capital and exporting FDI.[1] [2]

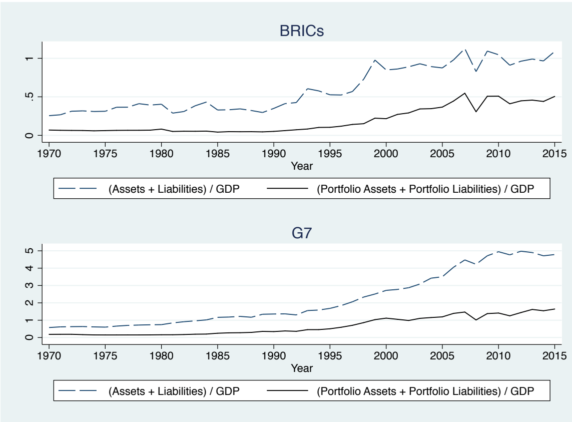

Figure 1.1: Financial global integration

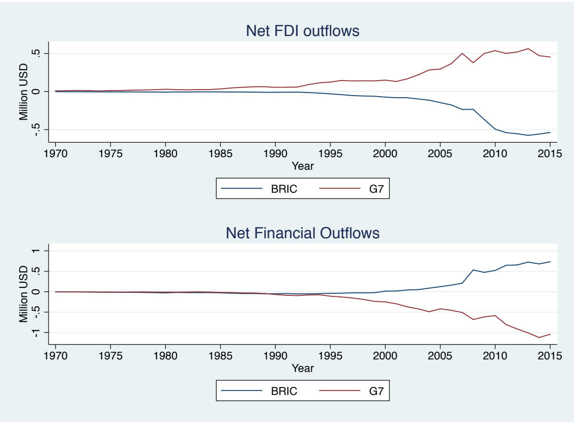

Figure 1.2: "Two-way" capital flows

The exorbitant size of financial markets rises policymakers and investor's concerns on portfolio composition between risky assets (equity and FDI) and safe-assets (bonds). Debt-induced financial integration may have different implications on aggregate macroeconomic outcomes and financial stability, compared to FDI-induced financial integration. More importantly, small variations in the stock market prices and in the exchange rates imply large wealth transfers across financially integrated countries with heterogenous foreign assets (Gourichas and Rey, 2014). Valuation effects account for an increasing part of the dynamics of external positions of many countries.[3] For example, the large accumulated current account deficits in the US

[1] For further reading see Ju and Wei (2010), Ghironi *et al.*, (2005),and Gourichas and Rey (2014)

[2] Data have been borrowed from Lane Milessi and Ferreti (2007) Wealth of Nations Dataset, updated in 2017.

[3] See Benigno (2009), Devereux and Sutherland (2010), Gourichas and Rey (2014) and Rey (2015).

should have been resulted in a deterioration of their net international investment position. However, the US has experienced continuous capital gains on net external positions over the last few decades, out-weighting the current account deficits (see Figure 1.3). In fact, the cumulative current account deficit for the US is about 60% of GDP, while NFA represents 40% of GDP. Thus, valuation effects in the US represent a capital gain of about 20% of GDP. We find similar pattern for other advanced economies such as UK, while the reverse is found for emerging economies like India or China, reflecting negative valuation effects.

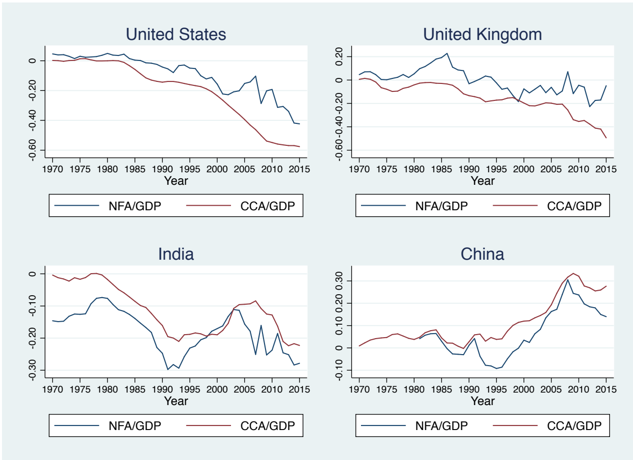

Figure 1.3: The importance of valuation effects.

In relation with these empirical facts, several important questions cannot be fully answered using the standard open-economy New Keynesian model, which abstracts from the crucial transmission mechanisms of gross capital flows and valuation effects. Specifically, what are the effects of large and heterogenous gross external positions for aggregate fluctuations? and, what are the factors behind the size and the composition of portfolio positions in emerging countries? In any symmetric two-country model, the households optimal position on foreign assets is equal in both countries, so that net bond and net equity positions must be zero, and two-way capital flows cannot arise. We particularly describe two-way capital flows as the case in which net asset position are non-zero. Thus, there must be some asymmetries that explain the financial relationships between advanced and emerging market economies, which are clearly non-balanced. This paper tries to give some light to these questions by investigating the role of structural asymmetries in a novel two-country New Keynesian model with endogenous portfolio choice of FDI-equities and bonds. Furthermore, the standard open economy model links NFA dynamics with just current account, since valuation effects can not be measured ($\Delta NFA_t = CA_t$). Hence, does the standard-open economy model under-(over) estimate the NFA dynamics? We provide a comparison between the standard model and our portfolio model, in which the $\Delta NFA_t = CA_t \pm VAL_t$, to show that, in fact, valuation effects are the key component when we quantitatively measure NFA dynamics.

The model builds on the New Keynesian literature related to Woodford (2003), Galí and Monacelli (2005, 2008), Christiano *et al.*, (2010), and its extension to the open economy context of endogenous portfolio choice initiated by Devereux and Sutherland (2009, 2010, 2011) and Tille *et al.*, (2010, 2014). Each country can be described by a medium-scale fully-fledged New Keynesian model in which agents are allowed to consume domestic and foreign goods and optimally purchase financial assets, such as sovereign bonds and FDI-equity. Each economy features home good bias, Calvo (1983)-style pricing mechanisms, incomplete financial markets and a set of real and nominal exogenous shocks. Particularly, the environment in each economy is very close to that of Smets and Wouters (2007), except for some frictions not relevant to this study, like physical capital accumulation, wage rigidities and consumption habits.

The introduction of both home good bias and nominal frictions in the model are key to better understand the trade-off between trade and portfolio diversification.

The intuition relies on the fact that household consumption risks are determined not only from shocks to a country's home production, but also to output of its main trading parters. The weight on the hedging against foreign shocks depends on the degree of trade openness (i.e., home good bias). In order to hedge against a foreign output shock, that reduces the relative price for foreign goods boosting home imports, the loss arisen from the reduction in demand for local goods could be outweighed by the gain on dividends from foreign equity holdings. Therefore, holding foreign assets serves as a hedge to overcome idiosyncratic foreign risks, which are intensified with trade openness. Introducing nominal frictions in the production market would therefore slow down the price adjustment process and the consumption switching effect, affecting directly the optimal choice in portfolio assets.

The contribution of this study is at least threefold; First, we develop a novel theoretical framework to provide the main structural determinants of gross portfolio positions and capital flows behavior in emerging countries. We obtain three key results. First, we find that in the asymmetric case in which the emerging economy faces higher volatility in the technology and interest rate shocks than the advanced economy, two-way capital flows arise. Also, in the case in which the emerging economy fiscal shock is less volatile and the advance economy one. This result goes in line with the empirical evidence about business cycles in advanced economies being approximately half as volatile than those in emerging countries or poor countries (Garcia-Cicco, 2010). Further, adding a higher degree of nominal rigidities in the home economy, increases the two-way capital flows pattern.[4] Second, the model shows an optimal home equity bias, which is close to the empirical evidence for advanced and emerging countries (Coeurdacier and Rey, 2013). Specifically, results suggest that those countries facing higher degree of nominal rigidities, stronger

[4]Gagnon (2009) suggests that emerging countries present less flexible nominal prices than advanced countries, using Mexico-US data.

home good bias and higher business cycle volatilities tend to have a higher degree of home equity bias. Third, our results confirm the existence of a key transmission mechanism between international trade and international portfolio diversification, in which agent consumption preferences over foreign goods directly affect the selection of optimal portfolio choice, since they both represent sources to diversify domestic economy risks. In fact, the more open the goods market preferences, the more diversified the portfolio. We find this result for both parameters governing foreign good markets preferences, the elasticity of substitution between local and foreign goods and the home good bias. These results are also found in Milesi-Ferreti (2008) and Heatcothe and Perri (2013).

Second, this paper provides a theoretical framework that simulates an economically integrated world of two asymmetric countries to study the international business cycle. This setting allows to measure the behavior of gross trade, portfolio flows and valuation effects, along with the rest of the standard macroeconomic variables. We quantitatively analyze business cycles dynamics for these variables to demonstrate how optimal portfolio diversification helps households smooth down income volatility. The overall performance of the financially integrated model is compared with a financial autarky version to show how NFA dynamics differ once we open up international financial markets and valuation channel starts operating. In fact, we show how the NFA is under (over) estimated in the autarky model, and that valuation effects are the key determinant of its dynamics.

Third, our theoretical framework provides an starting point for the analysis of portfolio composition and size between two asymmetric countries. Its empirical application would serve policymakers to quantify these matters in an diaphanous manner. In a near future, it is expected that the share of emerging countries in international capital markets continues to grow at rapid rates. Thus, policy makers in those economies should be aware of the necessity to foresee the prominent role of capital markets in international financial intermediation and to figure out their effects on macroeconomic outcomes. Moreover, we have shown that both trade and portfolio together bring about crucial implications on aggregate macroeconomic fluctuations and financial stability, and they should be embraced as an essential part of the macroeconomist tool box in many emerging economies central banks.

The rest of the paper is organized in seven sections: Section 2 describes related literature. Section 3 lays out a two-country New Keynesian model with international trade in goods, equities and bonds. Section 4 explains the portfolio choice solution method. Section 5 uncovers which asymmetries matter and to what extent they matter to determine portfolio positions in emerging economies. Section 6 analyses business cycles for gross portfolio variables and it compares the portfolio model with a financial autarky version. Section 7 concludes with some remarks on further research.

1.2 Connections to the related literature

Important progress in structural macroeconomic modeling has been achieved since the late 1990s, as reflected in the vast amount of papers on New Keynesian dynamic stochastic general equilibrium (NK DSGE) models. There has also been improvement in generalizing the initially closed-economy NK DSGE models to study the international transmission of shocks and policy design in open economies, giving rise to New Open-Economy Macroeconomics (NOEM, Obstfeld and Rogoff, 1995). Moreover, there is a vast theoretical and empirical literature on net foreign assets and current account balance analysis (Obstfeld and Rogoff (1995), Corsetti and Peseti (2001), Corsetti *et al* (2008, 2014), Kollmann (2002, 2006) Galí and Monacelli (2005, 2008), among others).

The majority of these open-economy models restrict the number of financial assets available in the economy. They mostly rely on financial market structures based on Arrow-Debreu securities, which implies assuming complete asset markets and that households are able to fully hedge against country specific income shocks. More recent literature has begun to analyze open economy models in which financial markets are incomplete, mainly by limiting the number or the type of assets available in the economy or by limiting the functions of the financial market.[5] Ju and Wei (2010) remark that while there is a well-settled literature on horizontal FDI and the gains of multinationals (Helpman *et al.*, (2004)) capital flows across the categories of financial capital and FDI have not received much attention in the literature. Another standard assumption, both in closed and open economy models, is to take the representative household as the owner of the firm.

NOEM and NK DSGE models have become standard elements of the macroeconomists' toolbox, in fact, nowadays they are used in research departments in many central banks. Nonetheless, the powerful spillover channel created by international financial markets has not been routinely incorporated into these models, so that they are not very useful tools to fully analyze the overall macroeconomic effects of heterogenous gross capital flows across countries. Nevertheless, a new strand in the literature has emerged to fill this gap, the open economy financial macroeconomics literature. Coeurdacier and Rey (2013) provide an extended revision on this strand of the literature. In general, the aim of these papers is to explain the factors behind the diversification puzzle (home equity bias) by introducing the portfolio choice of equity assets into the standard open economy model. Gourichas and Coeurdacier (2016) show that many of the earlier results on the determinants of equity bias are not robust to the introduction of domestic

[5] By including more stochastic shocks we ensure that despite the presence of more assets, financial markets are still not complete, so that there is more scope for hedging than in a one-single asset framework.

and foreign bonds, whether nominal or real. In fact, they find that equity home bias arises when non-financial income risk is negatively correlated with equity returns, after controlling for bond returns. Our paper contributes to the open economy financial macroeconomics literature by providing a fully structural open economy DSGE model with endogenous portfolio choice of both FDI-equity and bonds to analyze various interesting questions related with capital flows in emerging economies.

There are a few two-country general equilibrium models which incorporate endogenous portfolio choice of equity and bonds, in an open economy framework (Devereux and Sutherland (2007, 2009, 2010, 2011), Tille *et al.*, (2010, 2014), Engel and Matsumoto, 2009, and Coeurdacier *et al.*, (2010, 2015, 2013)). Until recently, there was no suitable computable method to solve portfolio choice in the context of dynamic stochastic general equilibrium models. However, there has been some developments in macroeconomic modeling to deal with portfolio choice solution and gross capital flows dynamics.

Devereux and Sutherland (2007) solve the equilibrium portfolio choice in a two-country endowment model. They propose a new perturbation based method to solve for constant portfolio choice. Moreover, in 2010 and 2011, they extend their methodology to solve time-varying portfolios under different general equilibrium frameworks. At the same time, a second solution method is proposed in Tille and Wincoop (2010, 2014) to examine how current account and net foreign assets react to changes in savings. Their framework is based on a symmetric two-country general equilibrium model with physical capital accumulation and international trade in equities. Both solution procedures are novel but their mathematical foundations are already established in the literature, in particular the work of Samuelson (1970), Judd (1998), and Judd and Guu (2001). Samuelson (1970), is the first to establish that in order to derive the $\mathcal{N}$-order component of the portfolio, it is necessary to approximate the portfolio problem up to order $\mathcal{N}+2$. The important innovation in Devereux and Sutherland's work is that they find that to derive the $\mathcal{N}$ order accurate solution for portfolio, the portfolio optimality conditions need to be approximated only up to $\mathcal{N}+2$ order. The rest of the non-portfolio optimality and equilibrium conditions need only to be approximated up to $\mathcal{N}+1$, which simplifies the solution considerably.

This model is similar to the one of Engel and Matsumoto (2009), which may be considered a starting point for sticky-price portfolio models in a fully integrated dynamic stochastic general equilibrium framework. They develop a model characterized by complete financial markets to analyze the factors determining portfolio choice in equilibrium. A key difference is that while they solve equilibrium portfolio shares, in the model presented here, we allow portfolio shares to vary over time in response to shocks. Moreover, their model features complete financial markets and they assume two symmetric countries, while I focus on the role of country asymmetries in shaping portfolio choice in the context of incomplete financial markets.[6]

This model is also close to Devereux and Sutherland (2009), in the sense that they incorporate portfolio choice dynamics in a structural general equilibrium model of two asymmetric countries. However, their focus is on risk sharing properties of three different financial market structures, (i.e., autarky, complete markets and asymmetric financial markets). Their framework uses one-single good consumption which price level is determined by a simple money rule characterized by a "velocity shock" to money demand. The model presented in this study, assumes

[6]Another minor differences are that they use one period in advance price setting mechanism, while I use the more standard Calvo(1983)-type pricing mechanism, and that they use money-in-the utility function while this paper takes endogenous monetary policy rules which may play an important role in shaping portfolio choice as shown in Devereux *et al.*, (2014).

differentiated consumption goods which are internationally traded and it provides a richer framework in which price and exchange rate fluctuations have sizable effects on country external positions.

Further, our model is related with Senay and Sutherland (2019). These authors study the link between household portfolio allocation and optimal monetary policy using an incomplete markets model in which multiple financial assets are tradable at the international level. In fact, they show that the presence of multiple assets may imply that optimal monetary polity serves as a stabilization tool for the exchange rate gap obtained in more simplistic theoretical frameworks. While financial market integration is found to have effects on monetary policy, our paper focuses on asymmetries in the monetary policy rules that create different household portfolio allocation across countries.

Our model is also close to Courdacier *et al.*,(2010). They show that a realistic home equity bias arises when capital accumulation, shocks to the efficiency of physical investment, and international trade in stocks and bonds are introduced in the model. Furthermore, these authors also provide a quantitative analysis of the model implications on foreign asset dynamics and international capital flows. While their focus is on exploring the different explanations for the home equity bias, the main objetive of this paper is to understand the role of country asymmetries in explaining capital flows between advanced and emerging countries.

This paper is also related to a number of studies analyzing business cycles in emerging countries. Mainstream research takes into account market failures and monetary policy roles when characterizing economic fluctuations in emerging and developing countries. Nevertheless, there has been a new strand in the literature which argues that emerging market business cycles can be replicated using the neoclassical model with no distortions. Kydland and Zarazaga (2002) argue that the Real Business Cycle model (RBC) can characterize well the lost decade in Argentina in the 1980s. Moreover, Aguiar and Gopinath (2007) suggest that an RBC model driven primarily by permanent shocks to productivity can very well explain the business cycles in developing countries. These authors are aware about the fact that shocks infringing upon emerging countries are quite numerous and of different types but they argue that the combined effect of all different shocks can be modeled as an aggregate shock to total factor productivity with a large non-stationary component. In addition, they show that the neoclassical model is an adequate framework for analyzing the transmission of such shocks in emerging economies.

The theoretical predictions of our model confirm previous empirical and theoretical findings about the positive link between international trade and portfolio choice. Obstfeld and Rogoff (2000) explained how production market frictions decrease portfolio diversification when markets are open to trade, even in the cases in which there is full risk diversification. Lane and Milesi-Ferreti (2008) show a strong positive correlation between bilateral equity holdings and bilateral trade in goods and services, specially evident for emerging-market economies. They further analyze gross variables separately, and find that gross exports effects are larger in some model specifications but gross imports are more significant in the emerging-markets sample. Heathcote and Perri (2013) find similar conclusions in relation with the positive trade effects on portfolio diversification. These authors solve closed-form portfolio choice in an extended version of the seminal model developed by Backus, Kehoe and Kydland (1992). They find qualitatively and quantitatively predictions regarding the level of diversification and trade that are useful to assess cross-country portfolios in developed countries. In their theoretical sensitivity analysis, they find that common values determining the elasticity of substitution across local and foreign goods, predict high values for home equity bias, which is also vaticinated in the present paper. In fact, they offer an empirical analysis that strongly confirms that patterns on portfolio diversification are driven by patters of trade.

1.3 Financial Integration Model

1.3.1 The framework

There are two economies in the model that are referred as home (domestic) economy and foreign economy.[7] There is free international trade in goods and financial capital assets (equity and bonds), where equity assets are claims on firms profitability and bonds are claims on each country currencies. Labour is not mobile across economies. Physical capital accumulation is not modeled. Regarding the exogenous variables, for each economy there are three AR(1) processes for technology, government spending and monetary policy shocks.

Following Coeurdacier and Rey (2013), economies are assumed to have equal size for two reasons. On the one hand, the focus of this paper is on the role played by economic structure asymmetries, neutralizing any effect driven by the size of countries. On the other hand, the focus is not the financial integration of small open economies, but asset flows between advanced and emerging economies, which

[7]Foreign economy is not explicitly displayed here, since it is identical to the one presented in this section, with the specific notation of an asterisk (*). See the Appendix for a detailed description of all variables, parameters and model equations.

account for a large part of the total volume of transaction since 1990.

1.3.2 Households

There is a continuum of households in each economy indexed by j within the unit interval. Representative households maximizes the following lifetime utility function, which is separable in consumption, C_{jt}, and hours worked, N_{jt}

$$\mathbb{E}\sum_{t=0}^{\infty}\beta_t U_t(C_{jt}, N_{jt})$$

where β_t is a time-varying discount factor and the instantaneous utility function takes a constant relative risk averesion (CRRA) form

$$U_t(C_{jt}, N_{jt}) = \left[\frac{C_{jt}^{1-\sigma}}{1-\sigma} - \chi\frac{N_{jt}^{1+\phi}}{1+\phi}\right] \tag{1.3.1}$$

Following Schmitt-Grohe and Uribe (2003), an endogenous discount factor is assumed to ensure a stationary wealth distribution in the linearized approximated dynamic model.[8] In particular, the discount factor is a function of aggregate consumption determined as follows

$$\beta_{t+1} = \beta_t(1 + C_t)^{-\nu} \tag{1.3.2}$$

The rest of structural parameters from household preferences are the risk aversion parameter ($\sigma > 0$) and the inverse of Frisch labor supply elasticity ($\phi > 0$). Let C_t be a CES composite consumption index defined by

$$C_t \equiv \left[(1-\alpha)^{\frac{1}{\theta}}(C_{H,t})^{\frac{\theta-1}{\theta}} + \alpha^{\frac{1}{\theta}}(C_{F,t})^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}} \tag{1.3.3}$$

[8] They propose five different ways to induce stationarity in an open economy model. We choose the endogenous discount factor for simplicity.

where $C_{H,t}$ and $C_{F,t}$ are bundles of consumption of home and foreign goods respectively (i.e., the term $C_{f,t}$ refers to imports)

$$C_{H,t} \equiv \left(\int_0^1 C_{H,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}}, C_{F,t} \equiv \left(\int_0^1 C_{F,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}}$$

Hence, the parameter $\alpha \in [0,1]$ is inversely related to the degree of home bias in preferences.[9] Moreover, parameter $\theta > 1$ denotes the elasticity of substitution between domestic and foreign goods from the viewpoint of domestic consumer, and $\epsilon > 1$, denotes the elasticity of substitution between goods produced within the same economy. Standard open macroeconomics models normally sets $\epsilon > \theta$. The optimal choices of domestic and imported goods are

$$C_{H,t} = (1-\alpha)\left(\frac{P_{H,t}}{P_t}\right)^{-\theta} C_t, \quad C_{F,t} = \alpha\left(\frac{P_{F,t}}{P_t}\right)^{-\theta} C_t \tag{1.3.4}$$

The consumption-based price indices that correspond to the above specifications of preferences are given by the following domestic Consumer Price Index (CPI)

$$P_t = \left[(1-\alpha)P_{H,t}^{1-\theta} + \alpha P_{F,t}^{1-\theta}\right]^{\frac{1}{1-\theta}} \tag{1.3.5}$$

where $P_{H,t}$ is the price index for domestically produced goods also expressed in domestic currency and $P_{F,t}$ is the price index for foreign produced goods expressed in domestic currency. Producer price index inflation is described with π_H for home economy, π_F^* for foreign economy in foreign currency units. While π refers to CPI inflation in the domestic economy, and π^* to CPI inflation in the foreign economy in foreign currency.

[9]If price indexes for domestic and foreign goods are equal (as assumed in the steady state equilibrium), the model parameter α corresponds to the share of domestic consumption allocated to imported goods.

The Household Budget Constraint

Households consume bundles of goods (C_t) which can be domestically produced ($C_{H,t}$) or produced abroad ($C_{F,t}$). They acquire equity shares to decide their participation in either domestic and foreign firms and they may buy or sell either domestic or foreign government bonds.

As suppliers of labor services, they obtain a real wage (w_t) from their hours worked (N_t). As financial capital owners, they obtain total returns from last period equity and bond holdings. The budget constraint of the domestic household, expressed in bundles of consumption goods, is

$$\begin{aligned} w_t N_t + \frac{P_{H,t}}{P_t}(D_t + V_t)S_{H,t-1} + \frac{P^*_{Ft}}{P^*_t} Q_t (D^*_t + V^*_t) S_{F,t-1} \\ + \frac{B_{H,t-1}}{P_t} + E_t \frac{B_{F,t-1}}{P_t} = \\ C_t + \frac{P_{H,t}}{P_t} V_t S_{H,t} + Q_t \frac{P^*_{Ft}}{P^*_t} V^*_t S_{F,t} + (i_t)^{-1} \frac{B_{H,t}}{P_t} + E_t (i^*_t)^{-1} \frac{B_{F,t}}{P_t} \\ + (\bar{g}) e^{G_t} \end{aligned} \tag{1.3.6}$$

for $t = 1, 2, 3, ...,$

where V_t refers to domestic equity value, V^*_t to foreign equity value, D_t refers to domestic firm dividends, D^*_t denotes foreign firm dividends. $S_{H,t}$ refers to the share of domestic equity held by domestic households and $S_{F,t}$ refers to that of foreign equity. Moreover, $B_{H,t}$ and $B_{F,t}$ are, respectively, the amounts of domestic and foreign government bonds purchased by the domestic household in period t to be reimbursed in $t + 1$ and i_t refers to the gross nominal interest rate of domestic bonds, and i^*_t is that of the foreign bonds. Finally, Q_t denotes the real exchange rate defined in terms of domestic bundles that can be purchased with one foreign bundle

$$Q_t = \frac{E_t P_t^*}{P_t} \tag{1.3.7}$$

where E_t is the nominal exchange rate also in foreign currency terms. Note that P_t and P_t^* refer to CPI level of each country.

We shall assume that total government expenditure is exogenous and is subject to an stochastic process. In particular, government purchases are set to 25% of the output in steady state, $\bar{g} = 0.25\bar{Y}$, and itś short-run fluctuations are determined by the AR(1) process

$$G_t = \rho^G G_{t-1} + \epsilon_t^G \tag{1.3.8}$$

where $0 < \rho^G < 1$ and ϵ_t^G is a zero-mean distributed i.i.d shock with $Var[\epsilon_t^G] = \sigma_G^2$

The first order conditions lead to the following expected return of domestic equity and foreign equity[10]

$$r_{EH,t+1} = \frac{\pi_{H,t+1}}{\pi_{t+1}} \frac{(D_{t+1} + V_{t+1})}{V_t}; \tag{1.3.9}$$

$$r_{EF,t+1} = \frac{\pi_{F,t+1}^*}{\pi_{t+1}^*} \frac{Q_{t+1}}{Q_t} \frac{(D_{t+1}^* + V_{t+1}^*)}{V_t^*} \tag{1.3.10}$$

and the following returns for home and foreign bonds

$$r_{BH,t+1} = \frac{i_t}{\pi_{t+1}} \tag{1.3.11}$$

[10]Proof available upon request to the author

$$r_{BF,t+1} = \frac{i_t^*}{\pi_{t+1}^*}\frac{Q_{t+1}}{Q_t} \tag{1.3.12}$$

where π_{t+1} refers to domestic CPI inflation level, $\pi_{H,t+1}$ to domestic producer price inflation level, and the same applies for π_{t+1}^* and $\pi_{F,t+1}^*$. In addition, the Euler equation of domestic consumption is

$$C_t^{-\sigma} = \beta_t \mathbb{E}_t[C_{t+1}^{-\sigma} r_{EH,t+1}] \tag{1.3.13}$$

The optimality condition for equity and bonds are, respectively,

$$\mathbb{E}_t[C_{t+1}^{-\sigma} r_{EF,t+1}] = \mathbb{E}_t[C_{t+1}^{-\sigma} r_{EH,t+1}] \tag{1.3.14}$$

$$\mathbb{E}_t[C_{t+1}^{-\sigma} r_{BF,t+1}] = \mathbb{E}_t[C_{t+1}^{-\sigma} r_{BH,t+1}] \tag{1.3.15}$$

and the labour supply function[11]

$$w_t = \chi C_t^{\sigma} N_t^{\phi} \tag{1.3.16}$$

In order to implement Devereux and Sutherland's solution procedure, the household budget constraint needs to be rewritten in terms of net foreign asset position. Domestic agent portfolio holdings of domestic assets ($\alpha_{H,t}$) and foreign assets ($\alpha_{F,t}$) are written as the product of the asset value in domestic currency units ($q_{a,t}$) and the volume of assets they hold ($S_{H,t}$,$S_{F,t}$ for equities and $B_{H,t}$,$B_{F,t}$ for bonds). Formally,

[11]Where χ is a fixed parameter obtained from the steady-state resolution of the model.

$\alpha_{EH,t}$ refers to domestic agent holdings of domestic equity, $\alpha_{EF,t}$ refers to domestic agent holdings of foreing equity, $\alpha_{BH,t}$ refers to domestic agent holdings of domestic bonds and $\alpha_{BF,t}$ refers to domestic agent holdings of foreign bonds, as follows:

$$\alpha_{EH,t} \equiv q_{EH,t} S_{H,t}$$

$$\alpha_{EF,t} \equiv q_{EF,t} S_{F,t}$$

$$\alpha_{BH,t} \equiv q_{BH,t} \frac{B_{H,t}}{P_t};$$

$$\alpha_{BF,t} \equiv q_{BF,t} \frac{B_{F,t}}{P_t};$$

Thereby, the net foreign asset position becomes

$$NFA_t \equiv [\alpha_{EF,t} + \alpha_{BF,t} - \alpha^*_{EH,t} - \alpha^*_{BH,t}] \tag{1.3.17}$$

where $\alpha^*_{EH,t}$ and $\alpha^*_{BH,t}$ denote foreign agent holdings of domestic equity and domestic bonds respectively.

Moreover, we define the net bond and net equity position as follows,

$$NBA_t \equiv \alpha_{BF,t} + \alpha_{BH,t} \tag{1.3.18}$$

$$NEA_t \equiv \alpha_{EF,t} + \alpha_{EH,t} \tag{1.3.19}$$

As in Devereux and Sutherland (2010), domestic equity is assumed to be the reference asset. Besides, a three-element vector with the excess return on financial assets relative to it is defined

$$r_{x,t} \equiv [r_{BH,t} - r_{EH,t}, r_{BF,t} - r_{EH,t}, r_{EF,t} - r_{EH,t}] \tag{1.3.20}$$

Another vector is introduced to measure real holdings of financial assets

$$\alpha_{t-1} \equiv [\alpha_{BH,t-1}, \alpha_{BF,t-1}, \alpha_{EF,t-1}] \tag{1.3.21}$$

Using (1.3.17), (1.3.18) and (1.3.19), the domestic budget constraint can be rewritten

$$C_t + (\bar{g})e^{G_t} + NFA_t = w_t N_t + D_t + r_{x,t}\alpha_{t-1} + r_{EH,t} NFA_{t-1}; \tag{1.3.22}$$

Valuation Effects

Standard international macroeconomics uses the following country's Balance of Payments (BoP) definition, in which the left-hand side of the equation refers to the current account and the right-hand side to the capital account

$$\Delta NFA_t \equiv CA_t$$

It states that changes in the net foreign asset position (ΔNFA_t) are equivalent to the current account (CA_t). In our portfolio model, these two terms differ in the capital gains and losses from pre-existing asset and liability positions, when stock price and exchange rate fluctuate. Following Devereux *et al.*, (2010), the following approximation is assumed

$$CA_t \approx w_t N_T - C_t - (\bar{g})e^{G_t} + D_t + (r_{EH,t} - 1)NFA_{t-1} \tag{1.3.23}$$

which combined with the budget constraint (3.20) leads to the following re-definition of the change in net foreign assets, including a measure of the valuation effects

$$\Delta NFA_t \equiv CA_t + \underbrace{(r'_{xt}\alpha_{t-1})}_{\text{Valuation Effects}} \tag{1.3.24}$$

Meanwhile, the definition of net exports is

$$NX_t \equiv \underbrace{\alpha^* \left(\frac{RP_t}{Q_t}\right)^{-\theta^*} C_t^*}_{\text{Exports}} - \underbrace{\alpha \left(RP_t^* Q_t\right)^{-\theta} C_t}_{\text{Imports}} \tag{1.3.25}$$

where the first term refers to exports and the second one to imports. Note that RP_t (RP_t^*) refers to the relative domestic and foreign prices,

$$RP_t \equiv \frac{P_{H,t}}{P_t} \tag{1.3.26}$$

$$RP_t^* \equiv \frac{P_{F,t}^*}{P_t^*}; \tag{1.3.27}$$

The Financial Autarky Model

In financial autarky, no financial assets are traded internationally. C_t is the composite index of domestic and foreign bundles of goods, so that international goods trade is still open. The budget constraint for the representative household is given by

$$w_t N_t + D_t + \frac{B_{H,t-1}}{P_t} = C_t + (r_t)^{-1} \frac{B_{H,t}}{P_t} + (\bar{g}) e^{G_t} \tag{1.3.28}$$

for $t = 1, 2, 3, ...,$

Thus, the Balance of Payments is $\Delta NFA_t \equiv CA_t$ and $CA_t = NX_t$

1.3.3 Firms

There is a continuum of intermediate-goods producers indexed over the unit interval. They operate in a monopolistically competitive industry and seek to maximize their profits. In this setup, there is no physical capital. Each firm produces a unique differentiate good and earns some monopoly profit. The amount of output produced of the representative j^{th} firm, $Y_t(j)$, is subject to the Dixit-Stiglitz demand constraint (3.4) and to a technology function with the following form,

$$Y_t(j) = exp(A_t)N_t(j) \tag{1.3.29}$$

where N_t is the amount of labor employed by the representative firm, and A_t follows the AR(1) exogenous process,

$$A_t = \rho^A A_{t-1} + \varepsilon_t^A \tag{1.3.30}$$

with a coefficient of autocorrelation $0 < \rho^A < 1$ and white-noise innovation, ϵ_t^A. It is worth to notice that A_t factor involves any idiosyncratic source that changes marginal product of labour.

Price stickiness is modeled *a la* Calvo (1983). There is a fixed probability of either re-setting the price optimally or maintaining it from last period. In this way, a fraction of $(1-\eta)$ randomly selected firms set optimal prices each period, with an individual firm's probability of re-setting in any given period being completely independent of the time elapsed since it last re-optimized its price. In comparison with the flexible price setting, now adjusting price firms will recognize that the optimal price chosen has a probability of remaining effective for a random number of periods so that they will account for expected future marginal costs, instead of looking at the current level only. Nevertheless, by setting $\eta \to 0$ the model effectively represents the special case of flexible prices. Many portfolio choice models assume flexible price setting. This model features nominal rigidities in order to have a role for monetary policy and shocks in determining gross external positions and dynamics.[12]

Let us assume that the representative domestic firm receives the Calvo signal to set the optimal price in period t. Then, the choice of the price $\bar{P}_{H,t}(j)$ is determined by solving the following maximization problem[13]

$$Max \sum_{i=0}^{\infty} \eta^i \Theta_t \Big[D_{t+i}(j) \Big] \equiv Max \sum_{i=0}^{\infty} \eta^i \Theta_t \left[\left(\frac{\bar{P}_{H,t}(j)}{P_{H,t+i}} \right)^{1-\epsilon} Y_{t+i} - \frac{P_{t+i}}{P_{H,t+i}} \frac{W_{t+i}}{P_{t+i}} N_{t+i}(j) \right] \tag{1.3.31}$$

s.t.

$$exp(A_{t+i}) N_{t+i}(j) - \left(\frac{\bar{P}_{H,t}(j)}{P_{H,t+i}} \right)^{-\epsilon} Y_{t+i} = 0$$

where upper case letters denote nominal variables. Θ is the stochastic discount factor to evaluate its dividend stream. This domestic firm discount factor is not the same as for domestic households because the firm is owned by domestic and foreign

[12] Also, it may be the case that financial globalization influences inflation, which is studied in Devereux, Senay and Sutherland, 2014.

[13] Real magnitudes from the firm-optimization problem are expressed in domestically produced units,(i.e., nominal terms divided by the producer price index $P_{H,t}$). Since the real wage (w_t) and dividends (d_t) are expressed in CPI units in the household problem (i.e., divided by P_t), to be consistent with notation they are now multiplied by $(\frac{P_t}{P_{H,t}})$.

agents. Thus a weighted combination of the home and foreign discount factors is utilized as in Devereux and Sutherland (2010).[14]

The first order condition on labor gives the labour demand function

$$\left(\frac{P_t}{P_{H,t}}\right) w_t = mc_t(j) exp(A_t) \tag{1.3.32}$$

where $mc_t(j)$ is the firm-specific real marginal cost (Lagrange multiplier associated to the constraint), which turns to be equal to aggregate marginal cost.

The first order condition on the price $\bar{P_{H,t}}(j)$, combined with (1.3.30), results in the following optimal price equation

$$\bar{P_{H,t}}(j) = \left(\frac{\epsilon}{\epsilon - 1}\right) \mathbb{E}_t \sum_{k=0}^{\infty} \Theta^k \eta^k \left[\frac{\left(P_{H,t+k}\right)^{\epsilon} Y_{t+k} mc_{t+k}(j)}{\left(P_{H,t+k}\right)^{\epsilon-1} Y_{t+k}}\right] \tag{1.3.33}$$

where $0 < \eta < 1$ is the Calvo probability.

Under the assumed price-setting structure, dynamics of domestic producer price index are described by the equation

$$P_{H,t} = \left[(\eta) P_{H,t-1}^{1-\epsilon} + (1-\eta) \bar{P_{H,t}}(j)^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}} \tag{1.3.34}$$

Aggregating across firms, the average domestic dividend is

$$D_t \equiv \int_0^1 d_t(j) dj = \int_0^1 \left(\frac{\bar{P_{H,t}}(j)}{P_{H,t}}\right)^{-\epsilon} Y_t(j) dj - \left(\frac{W_t}{P_{H,t}}\right) \int_0^1 N_t(j) dj$$

[14]See the Appendix for the full definition

which, using the Dixit-Stiglitz demand constraint, is equivalent to

$$D_t = \int_0^1 \left(\frac{\bar{P}_{H,t}(j)}{P_{H,t}} \right)^{1-\epsilon} Y_t - \left(\frac{W_t}{P_{H,t}} \right) N_t \tag{1.3.35}$$

where we use price dispersion (SS_t) modelled following Schmitt-Grohe-Uribe (2006),

$$SS_t \equiv \int_0^1 \left(\frac{\bar{P}_{H,t}(j)}{P_{H,t}} \right)^{1-\epsilon} dj \tag{1.3.36}$$

Price dispersion is aggregated following Schmitt-Grohe(2006)

$$PD_t \equiv \int_0^1 \left(\frac{\bar{P}_{H,t}(j)}{P_{H,t}} \right)^{-\epsilon} dj \tag{1.3.37}$$

1.3.4 Equilibrium Conditions

The goods market-clearing condition takes the form

$$Y_t = \left(\frac{P_{H,t}}{P_t} \right)^{-\theta} \left[(1-\alpha) C_t + \alpha Q_t^{\theta} C_t^* \right] + (\bar{g} e_t^G)/PD_t \tag{1.3.38}$$

which has been derived from the aggregation across the following market condition for the individual firm

$$Y_t(j) = C_{H,t}(j) + C_{H,t}^*(j) + \bar{g} e_t^G \tag{1.3.39}$$

where $C_{H,t}(j)$ corresponds to domestic demand for domestic goods and $C^*_{H,t}(j)$ foreign demand for domestic goods, which comes from the optimal allocation of home-produced goods for foreign agents.

Asset markets clear at all times according to the following equilibrium conditions for equity,

$$S_{H,t} + S^*_{H,t} = S_{F,t} + S^*_{F,t} = 1 \tag{1.3.40}$$

and bonds[15]

$$b_{H,t} + b^*_{H,t} = b_{F,t} + b^*_{F,t} = 0 \tag{1.3.41}$$

Noticing that $S^*_{H,t}$ refers to the foreign share of domestic equity, and $S^*_{F,t}$ would refer to the foreign share of foreign equity. The same applies to $b^*_{F,t}$ and $b^*_{H,t}$.

1.3.5 Monetary policy rules

The nominal interest rate (i_t) is determined through a reaction function describing monetary policy decisions made by the domestic central bank.[16] In contrast with some open-economy literature, where monetary policy is introduced by assuming that some monetary aggregate follows an exogenous stochastic process, the literature of New Keynesian assume that the short-term interest rate is the instrument of that policy. The size and composition of country portfolios will depend on the structure and stochastic environment of the model, including the properties of the monetary rules. There is therefore an interaction between policy choice and portfolio choice, which has been studied by Senay and Sutherland (2016). In this paper, the authors discuss the effects of different financial market structures, in-

[15]Note that $b_t = \frac{B_t}{P_t}$ and $b^*_t = \frac{B^*_t}{P^*_t}$

[16]A simplified version to that of Fernandez-Villaverde (2006) is used.

cluding autarky, on monetary policy. Formally, the country specific inflation-based Taylor (1993) rule are specified as follows

$$\frac{i_t}{\bar{i}} = \left(\frac{\pi_t}{\bar{\pi}}\right)^{\mu_\pi} exp(R_t) \tag{1.3.42}$$

where $\mu_\pi > 1$ to satisfy the Taylor principle for determinacy. A symmetric inflation targeting is assumed between the two economies. A CPI-inflation targeting rule is selected instead of producer price inflation rule, since the central bank is aimed to stabilize the real interest rate. There are monetary policy shocks generated by the AR(1) process,

$$R_t = \rho^R R_{t-1} + \varepsilon_t^R \tag{1.3.43}$$

with a coefficient of autocorrelation $0 < \rho^R < 1$ and white-noise innovation, ε^R .

1.4 Portfolio choice solution method

The model is a set of 46 equations providing solution paths for all the endogenous variables from both economies.[17] There are 20 endogenous variables $r_{EH,t}, r_{EB,t}, i_t, C_t, \beta_t, \Theta_t, w_t, N_t, C_{H,t}, C_{F,t}, D_t, V_t, mc_t, \tilde{\rho}, RP_t, \pi_t, \pi_{H,t}, SS_t, PD_t, Y_t$ for the domestic economy and other 20 completely analogous from the foreign economy. In addition, there are 6 variables shared for both economies, E_t, Q_t, NX_t, CA_t, NFA_t, VAL_t. Regarding the exogenous variables, for each economy there are three AR(1) processes for technology, government spending and interest rate shocks.

New Keynesian models are typically solved by taking log-linear approximation around a non-stochastic steady state. However, optimal portfolios cannot be

[17]See Appendix for a detailed description of variables, parameters and model equations.

uniquely pinned down in a non-stochastic steady state. As Devereux and Sutherland (2008) state *"The reason is that there is no natural point around which to approximate the model. It is because the steady state is free-risk, there is no uncertainty, so any portfolio allocation would be valid."* Actually, in a non-stochastic world all portfolio allocations are equivalent and can be regarded as valid equilibria. Up to a first-order Taylor approximation, the expected returns on financial assets have no difference, they are perfect substitutes, so portfolio dynamics are not pinned down either. Risk is the only fact that would made assets distinguishable, but neither the non-stochastic steady state nor a first order approximation capture the differences in the risk characteristics of assets.

Devereux and Sutherland (DS)'s methods are limited because they rely on local approximations around the non-stochastic steady state, and they are valid around the point of approximation, which is problematic when there are large deviations away from this point. To avoid this, global solution methods are being increasingly chosen to solve medium-scale models. Rabitsch *et al.* (2015) compare the performance of the DS method with a global solution method. They find that the DS method works very well when focusing on short horizons, especially true when assets returns are similar, whether countries are symmetric or asymmetric. I follow DS solution method for two reasons; First, it is close to standard approximation methods used in New Keynesian and DSGE models. Second, it can be applied to a broad range of environments with complete and incomplete financial markets models that incorporate a potentially large number of shocks and/or financial assets.

In a two-economy model with portfolio choice, there is a set of portfolio optimality conditions and a set of equations defining the rest of the model. The solution of both set of equations will give a vector of the real portfolio holdings solution for each asset traded. For the steady state portfolio to be well defined, also called zero-order portfolio, we need the second-order approximation of the portfolio equations and the first-order approximation of the rest of the model equations. The non-stochastic steady state of the model set of equations determines the approximation point for the non-portfolio variables (see the Appendix for the steady state solution). Then, a combination of the second-order approximation of the portfolio optimal conditions for home and foreign country are used to tie down the zero order component of portfolio,

$$\mathbb{E}_t\left[(\hat{C_{t+1}} - \hat{C^*_{t+1}} - \frac{\hat{Q}_t}{\sigma})\hat{r_{x,t+1}}\right] = 0 + O(\epsilon^3) \tag{1.4.1}$$

$$\mathbb{E}_t\hat{r_{x,t+1}} = -\frac{1}{2}\mathbb{E}_t[\hat{r^2_{H,t+1}} - \hat{r^2_{F,t+1}}] + \rho\frac{1}{2}\mathbb{E}_t\left[(\hat{C_{t+1}} + \hat{C^*_{t+1}} + \frac{\hat{Q}_t}{\sigma})\hat{r_{x,t+1}}\right] + O(\epsilon^3) \tag{1.4.2}$$

Equations (1.4.1) and (1.4.2) together with the first-order approximation of the rest of the model equations will yield the zero-order portfolio holdings solution. DS methods show that to obtain the first-order portfolio solution, in which true portfolios are allowed to move over time, the portfolio equations need to be approximated to the third-order and the non-portfolio equations up to second-order.

1.5 Quantitative results and discussion

The objective of this section is to search for structural asymmetries in our two-economy model, that can be potential explanations for the empirical evidence on positive net bond positions and negative net equity positions in emerging economies. The model solution delivers equal values for each asset holding when the two economies are calibrated symmetrically. Thus, both net equity and net bond position are equal to cero, and two-way capital flows cannot arise. In consequence, there must be some structural asymmetries between the two economies that create non-zero net positions. We test alternative parameter values in the home economy, as we consider it to be a representative emerging economy, while the foreign economy is used as control group and its parameter values are fixed at the benchmark levels which mainly describe advanced economies.

A two-step procedure is followed to isolate those cases in which several asymmetries between the two economies coexist at the same time. First, individual effects of each parameter asymmetry are considered, on both gross and net portfolio positions, to identify which asymmetry alone is able to generate the pattern of two-way capital flows. Second, all the asymmetries are put together into the model to simulate a world-economy with both emerging and advanced countries. In this sense, the overall effect of all asymmetries on portfolio choices can also be measured. We consider potential asymmetries from variations in the parameters characterizing the structural part of the model in the emerging economy. Thus, we test alternative values for the home goods bias (α), nominal price rigidity (η) and the Dixit-Stiglitz demand elasticity for home and imported consumption goods (θ).[18] We also consider variations in the parameter values defining the exogenous component of the model. Particularly, we consider asymmetries from variations in the standard deviations of the innovation of the technology shock, Std(ε^A), fiscal shock, Std(ε^G), and monetary shocks, Std(ε^R), in the emerging economy.

1.5.1 Parameter calibration

Table 1 reports the parameter values for the baseline calibration, where we highlight those parameters subject to asymmetries and their corresponding values for the baseline calibration. Values are set at their standard levels from related literature

[18] All parameters within the model have been tested, such as the degree of market competitiveness (i.e., Dixit-Stiglitz elasticity of substitution between varieties, ϵ) and the weight on inflation from Taylor rule monetary policy, μ_π. They turn out not to have any significant effect on the pattern of equilibrium portfolio. Results are not provided in the paper due to the lack of space, but they are available upon request.

(Devereux and Sutherland, 2009; Smets and Wouters, 2007; Aguiar and Gopinath, 2007; and Galí and Monacelli, 2005).

Table 1.1: Parameter Values

Parameter	Concept	Emerging (Advanced Economy)
β	Steady state discount factor	0.99 (0.99)
σ	Elasticity of consumption marginal utility	1 (1)
ϕ	Elasticity of labor marginal disutility	2(2)
μ_π	Inflation weight in Taylor Rule	1.5 (1.5)
ϵ	Elasticity b/varieties within the same country	6 (6)
ρ^A	Technology shock persistence	0.94 (0.94)
ρ^G	Fiscal shock persistence	0.85 (0.85)
ρ^R	Monetary shock persistence	0.8 (0.8)
$\bar{g}$	Steady-state public spending over output	0.25 (0.25)
		Asymmetric parameter values(*)
α	**Share of domestic consumption to imported varieties**	0.35-**0.4**-*0.41*-0.45 (0.4)
θ	**Elasticity of substitution b/ H and F varieties**	1.3-**1.5**-*1.55*-1.9 (1.5)
η	**Calvo probability of price stickiness**	0.56-**2/3**-*0.72*-0.74 (2/3)
Std(ε^R)	**Monetary shock volatility**	0.2%- **1%**- 2% (1%)
Std(ε^A)	**Technology shock volatility**	0.2%- **1.1%**-*1.13*- 2% (1.1%)
Std(ε^G)	**Fiscal shock volatility**	5%- **10%**- 15% (10%)

(*) Symmetric calibration values for the emerging economy in bold font and asymmetric calibration values in italics.

A period in the model corresponds to one quarter, which is consistent with the literature on business cycles. The discount factor parameter is chosen so that the annualized steady-state real interest rate is 4%. The elasticity of consumption marginal utility is set to have the logarithmic case ($\sigma = 1$) and the elasticity of the marginal disutility of labour is set to 2, for a Frisch labour supply elasticity of 0.5. For the symmetric simulation, home bias parameter is set to 0.4 which is standard in open economy models (Galí and Monacelli, 2005). The elasticity of substitution between home and foreign produced varieties is set at 1.5 as suggested by Backus *et al.* (1992). We vary these two parameters (α, θ) in order to match qualitatively the net bond and net equity position in the emerging economy. Also, following Smets and Wouters (2007), Calvo probability parameter equals 2/3, which implies an average duration of optimal prices at 3 quarters (9 months). For the asymmetric case, we set the Calvo-probability for the home (emerging) economy to a higher value

($\eta = 0.72$), since it is shown that emerging markets (for example, Mexico) tend to have less flexible prices than more advanced countries, (Gagnon, 2009). Also, we chose it because it delivers the two-way capital flow pattern found in emerging economies.

Finally, the parameters for the persistence of the exogenous shocks are set to values found in the literature, in which the technology shocks are clearly more persistent (0.94) than either the fiscal shocks (0.85), or monetary shocks (0.8). The standard deviations of the innovation of the shocks are calibrated to provide a reasonable variance decomposition, in which the total variability of domestic output, is explained by technology shocks (44%), fiscal shocks (36%) and monetary shocks (17%). The remaining 3% variability comes from the effects of foreign economy shocks. We modify the standard deviation of the innovation of the technology shock in the emerging economy. Numerous empirical studies provide values for output volatility that are on average twice as large in emerging markets compared to developed countries (Aguiar and Gopinath, 2007).[19]

1.5.2 Results on equilibrium portfolios and discussion

We solve portfolio equilibrium positions for the emerging economy using the solution procedure outlined in Section 4.[20] These portfolio positions have an impact on the responses of the rest of the endogenous variables to exogenous shocks and also introduce valuation effects. Households select whether to invest more or less in each asset (e.g., portfolio position size), and they also choose whether to hold "long" or "short" positions (e.g., portfolio position sign). In order to diversify risks,

[19] Also, Schmitt-Grohe and Uribe (2017, Chapter 1) provide a detailed description of business cycle facts around the world with special interest in emerging and poor countries.

[20] Devereux and Sutherland (2011) provide an example of closed form solutions of these $\alpha - s$ using a simpler framework. Nevertheless, the relatively large model used in this study cannot deliver analytical solutions, and it is solved using Devereux and Sutherland (2011) solution method for more generalized models.

households choose optimal holdings of assets with the highest relative return in order to smooth down the negative effects in case of a decrease in their relative disposable income.

Particularly, the symmetric calibration leads to the following solution for holdings of domestic and foreign bonds: $\alpha_{B,H} = 0.79$ and $\alpha_{B,F} = -0.79$, respectively. This result makes the net bond asset position, defined in Eq. 3.18 as $NBA \equiv \alpha_{B,H} + \alpha_{B,F}$, be equal to zero. The solution for holdings for domestic and foreign equity are $\alpha_{E,F} = 3.76$, and $\alpha_{E,H} = -3.76$, respectively. Again, the net equity position, defined in Eq. 3.19 as $NEA \equiv \alpha_{E,H} + \alpha_{E,F}$, is zero. It is worth recalling that portfolio choice is measured in terms of output, so bond holdings represent around 80% of output and equity holdings are 3 and 3/4 times larger than output. Thus, two-way capital flows cannot arise in the symmetric setting because it delivers the same value for each portfolio holding with opposite signs. In consequence, there must be some structural asymmetries between the two economies that create two-way capital flows (i.e., $NEA < 0$ and $NBA > 0$).

In the asymmetric calibration, the size of each asset position is heterogenous across the two countries giving rise to non-zero net asset positions, while the "long-short" position choice on asset composition remains unchanged. We focus on those asymmetries with larger effects on portfolio holdings (see Figure 1.5) and we compute both the NBA and NEA in Figure 1.4. In general, our results indicate that households in the emerging economy go 'long' ('short') in domestic (foreign) bonds since its respective excess return co-moves negatively (positively) with relative disposable income. On the equity side, households optimally choose to hold a positive (negative) position in foreign (domestic) equity, since its return co-moves negatively (positively) with disposable income, conditional on the rest of the assets returns.

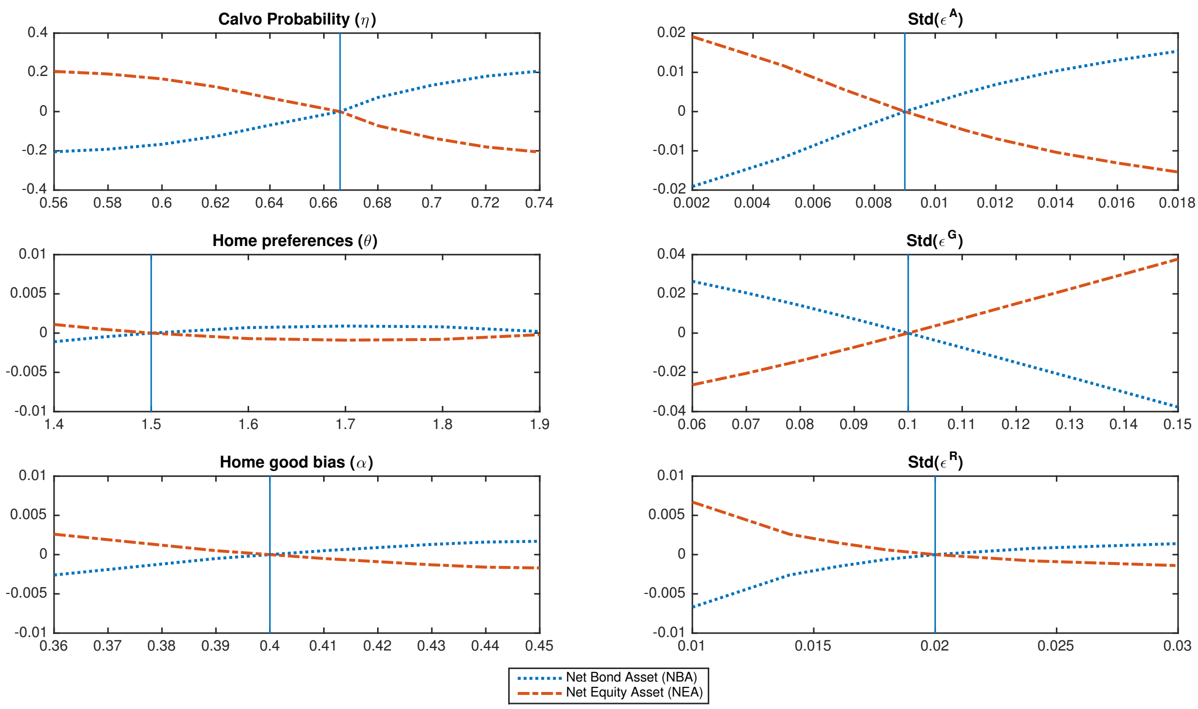

Figure 1.4: Net bond asset position and net equity position in the emerging economy under alternative parameter calibrations.

Nominal price rigidities

First, equilibrium asset holdings are illustrated for distinct grades of price stickiness in the emerging economy. As Obstfeld and Rogoff (2000) highlight, the presence of frictions in the production markets directly affects the portfolio choice. Figure 1.4 —upper left diagram–, demonstrates that two-way capital flows arise when the emerging economy suffers from higher nominal rigidities than the advanced economy. In fact, a 0.05 basis points gap between the domestic and the foreign price stickiness ($\eta - \eta^* = 0.05$), causes a 20% change in net asset positions over output. This result goes in line with the empirical evidence of emerging countries with positive net bond positions and negative equity positions, assuming that emerging countries face a higher degree of nominal rigidities.

To better understand this result, let us take a look at the relationship between each asset position and price rigidities in Figure 1.5 —upper panel–. Particularly, the maximum level in domestic bond holdings is higher, in absolute value, than that of foreign bond holdings, when local prices are only a bit more rigid than those in the foreign country. The size in assets (domestic bonds) surpasses the size in liabilities (foreign bonds), making the net bond position positive in the emerging economy. Domestic bond returns co-move negatively with relative income, thus higher nominal price rigidities in the emerging economy make domestic bonds to be a relatively better hedge than the rest of the financial assets. Furthermore, price rigidities in the emerging economy reduce equity holdings from advanced economies since the correlation between disposable income and foreign equity returns is diminished. We find that an economy with greater price stickiness reduces considerably foreign equity long positions, making net equity position to be negative, and increases domestic bond long positions, making net bond position to be positive.[21], [22]

Household consumption preferences

Second, there is an essential positive relationship between trade and portfolio diversification (Heatcothe and Perri, 2013). Thus, we are interested in testing this empirical prediction in a more complex and realistic model. For this reason, we compute gross and net portfolio positions for different values of the parameters controlling agent preferences over foreign markets. Particularly, the elasticity of substitution between local and foreign goods and the home good bias parameter.

[21]Price rigidities issues in the context of macroeconomic modeling are key part of the vast DSGE literature (Smets and Wouters, 2007; Fernandez-Villaverde, 2006). Nevertheless, studies assessing the empirical validity of such hypothesis using micro-data are scarce. The majority of these few papers have been focused in developed economies. Hence, analyses on emerging and/or developing countries are rare and country-based. As one representative example, Gagnon (2009) focuses on the relationship between inflation and consumer price setting by examining a large data set of Mexican consumer prices. He finds that overall, the Mexican prices appear less flexible than the U.S. ones for comparable inflation rates.

[22]We compute the escenario in which interest rate shocks are cancelled out in both economies in order to isolate nominal rigidities effects from those coming from the iteration of nominal rigidities and monetary policy functions (Devereux *et al.*, 2014). Under this situation, domestic bond holdings and foreign bond holdings present the exact same pattern with opposite sign, so that NBA and NEA positions do not vary when nominal price rigidities change. Equity holdings are not sensitive to variations in η-parameter under this very specific case.

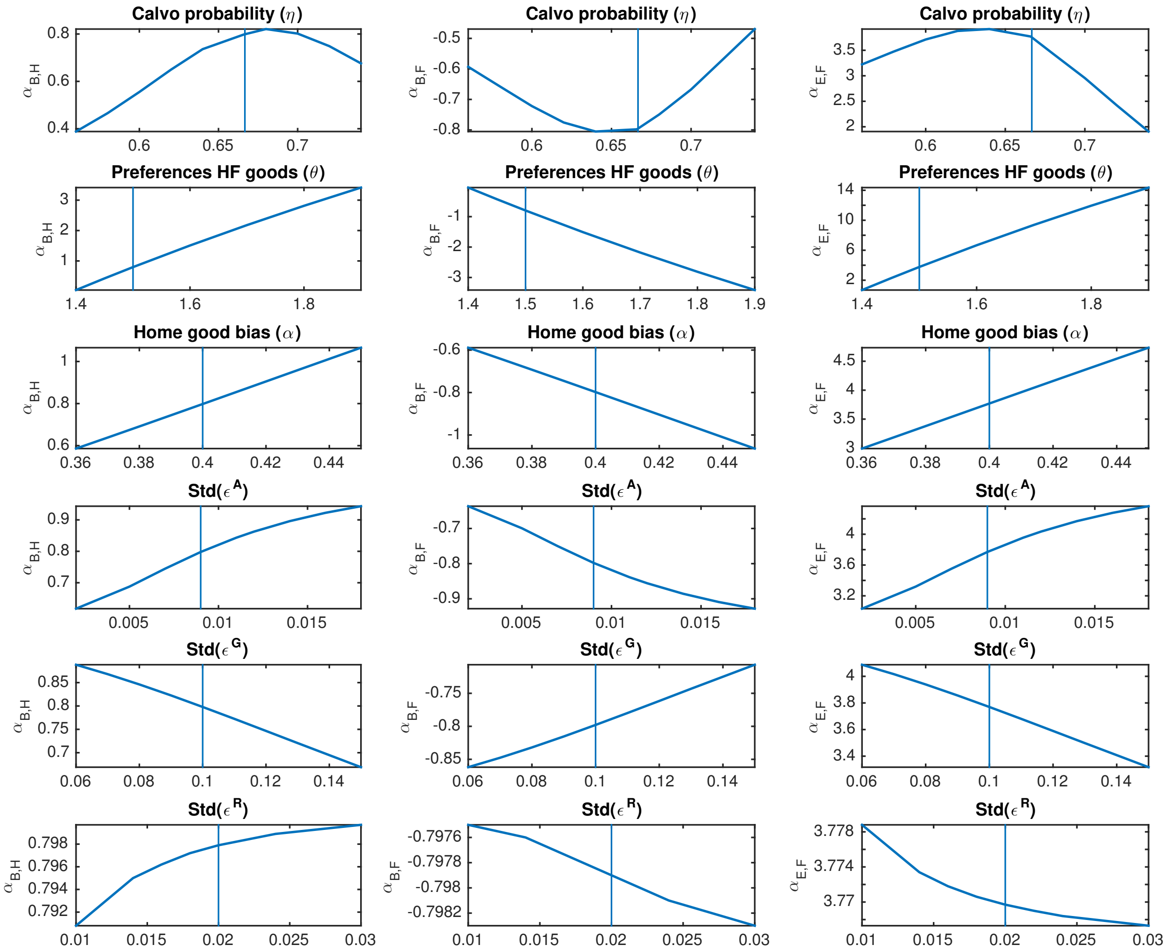

Figure 1.5: Equilibrium asset positions in the emerging economy under alternative parameter calibration.

On the one hand, Figure 1.4–central left diagram– shows that two-way capital flows emerge when consumption good bias in the emerging economy is smaller than that in the advanced economy, particularly for $\alpha > 0.4$ and $\alpha^* = 0.4$. In fact, the higher the home consumption bias (lower α), the smaller the overall portfolio position (see Figure 1.5). On the other hand, positive net bond position and negative net equity position appear in the case in which households demand over foreign goods is more elastic in the emerging economy than the advanced economy (see Figure 1.4 —lower left panel–). Figure 1.5 displays a positive relationship between each portfolio position and θ, reflecting the fact that a more elastic consumption of domestic goods relative to foreign goods, increases the overall size of the economy portfolio position. These results indicate that in those cases in which household preferences are biased towards domestically produced goods, external portfolio positions are smaller than their foreign counterparts. Our results confirm the key transmission mechanism between international trade and international financial markets, found in Heatcothe and Perri (2013). Consumption preferences over foreign goods directly affect the selection of optimal portfolio choice, since they both represent sources to diversify domestic economy risks. In fact, the higher the home good bias, the higher the equity bias.

Business cycle volatility

Third, business cycle volatility in emerging and in advanced markets is found to be relatively different.[23] Thus, we compute the portfolio equilibrium effects of introducing asymmetries in the standard deviations of the innovation of the exogenous shocks in the emerging economy, Std(ε^A), Std(ε^G), Std(ϵ^R). Figure 1.5 illustrate a positive relationship between bond holdings and higher standard deviation of technology and monetary policy shocks, while a negative relation with higher fiscal shocks volatility. Moreover, domestic households choose a larger position in foreign equity holdings for higher volatility of supply shocks, while a smaller position for higher volatility in demand and monetary shocks. The fact that emerging economy volatility of the technology shock is higher than the advanced country one, makes disposable income to be more correlated with returns on domestic equity than on foreign equity. Thus, the increase in domestic equity liabilities surpasses the

[23]Kydland and Zarazaga (2002), Aguiar and Gopinath (2007) and Schmitt-Grohe (2017, Chapter 1) present examples for business cycle facts in emerging markets to be at least double than those in advanced countries.

increase in foreign equity assets, so that net equity position turns negative. In fact, Figure 1.4– right panel–, exhibits that in those cases in which the emerging economy faces more volatility in the technology shock than the advanced economy, two-way capital flows arise. Further, we find that two-capital flows arise also under the situation in which the volatility of fiscal shocks is higher in the advanced economy.

Home equity Bias

Fourth, regardless of the tremendous growth in cross-border financial transactions, international portfolios remain biased towards domestic assets.[24] We utilize our framework to understand the effects of each asymmetry on the home equity bias, which can be solved using Devereux and Sutherland solution method. In fact, we confirm the empirical evidence suggesting that emerging markets have less diversified portfolios than advanced countries, and that they present more stable home equity bias, 0.9 and 0.67, respectively.[25] Although the aim of our paper is not to obtain asset positions that match exactly these empirical findings, it does provide some key insights in order to analyze the role of asymmetries in the degree of home equity bias. Figure 1.6 provides the solution for home equity bias across different values for the selected parameters and the standard deviations of the innovation of the shocks in the emerging economy. There are three principal results. First, there is positive relationship between price rigidities and home equity bias. This result goes in line with the empirical evidence on emerging countries having higher home equity bias and higher degree of nominal price rigidities (Gagnon, 2009). Second, the more restricted the international goods preferences are, the higher the home equity bias. In addition, these results suggest that home good bias and less elastic demand for imported goods lead to a stronger home equity bias. Third, the home

[24]This feature is known in the literature as the equity home bias. Heathcote and Perri (2002), Coeurdacier *et al*, Coeurdacier and Rey (2013) and Gourichas and Coeurdacier (2016) review various explanations of this international macroeconomic puzzle that range from hedging motives in frictionless financial markets to the role of transaction costs and informational asymmetries.

[25]Coeurdacier and Rey (2013)

equity bias in the emerging economy remains fairly stable around 0.77, in all cases, and it is shown to increase with the business cycle volatility.

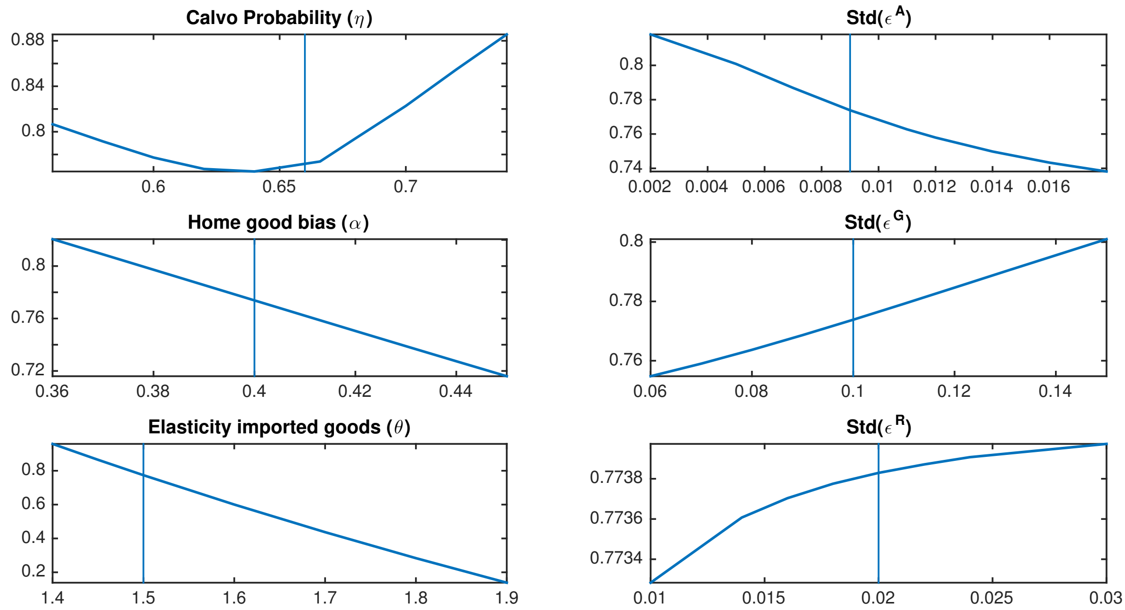

Figure 1.6: Home equity bias in the emerging economy under alternative parameter calibration.

Overall effect of asymmetries on portfolio allocation

Finally, once the effect of each relevant asymmetry on the pattern of portfolio position has been examined, the focus now is on the overall effect of all asymmetries together in order to understand which asymmetries are the most powerful in explaining portfolio allocation. The choices of asymmetric parameter values are the following: Calvo probability ($\eta = 0.72$ and $\eta^* = 2/3$), home good bias ($\alpha = 0.41$ and $\alpha^* = 0.4$), and household preferences over foreign goods ($\theta = 1.55$ and $\theta^* = 1.5$). Let us pay particular attention to the more realistic case in which the emerging economy volatility is set at a higher level than that of the advanced economy (σ_A^2=1.13%, and σ_A^{*2}=1.1%). In this situation, the emerging economy buys home bonds to the amount of 1.26 (over output) and sells advanced economy bonds to the amount of 0.95 (over output), which results in a positive net position in bonds of 30% of output

($NBA = \alpha_B + \alpha_B^* > 0$). On the equity side, the emerging economy sells domestic equity to the amount of 4.07 times output, and buys 3.77 times output in advanced economy equity, which results in a negative net position in equity of 30% of output ($NEA = \alpha_E + \alpha_E^* < 0$). Under this scenario, two-way capital flows emerge. This result goes in line with the empirical evidence showed in the introduction about FDI-equity inflows from advanced to emerging economies surpass bond-inflows from emerging economies to advanced economies (Rey, 2015).

1.6 Business cycle analysis with gross capital flows

In this section, business cycle dynamics of the gross portfolio variables are studied in the asymmetric calibration that simulates the interaction between emerging and advanced countries.[26] The aim of this section is to analyze the business cycle of two asymmetric countries in which gross capital flows are endogenous and international asset markets are incomplete. The dynamic behavior of gross portfolio variables is related with their steady-state equilibrium position. Actually, both the size and the sign of equilibrium portfolio choice play an important role in shaping gross portfolio short-term dynamics. The γ-vector describes the first-order movements (absolute deviation with respect to their steady-state values) in the emerging economy holdings following Devereux and Sutherland (2010),

$$\hat{\alpha}_{a,t} = \alpha_{a,t} - \bar{\alpha}_a \tag{1.6.1}$$

[26]The choices of asymmetric parameter values are the following: Calvo probability ($\eta = 0.72$ and $\eta^* = 2/3$), home good bias ($\alpha = 0.41$ and $\alpha^* = 0.4$), agent preferences ($\theta = 1.55$ and $\theta^* = 1.5$). and standard deviation of the technology shocks (σ_A^2=1.13%, and σ_A^{*2}=1.1%)

$$\alpha_{a,t} - \bar{\alpha}_a \approx \gamma_1 NFA_t + \gamma_2 \hat{A}_t + \gamma_3 \hat{G}_t + \gamma_4 \hat{R}_t + \gamma_5 \hat{NR}_t + \gamma_6 \hat{V}_t + \gamma_7 \hat{RP}_t + \gamma_{8-13} \bar{\Theta} \quad (1.6.2)$$

where a-subscripts may refer to domestic equity, domestic bonds, foreign equity and foreign bonds. $\bar{\Theta}$ contains those purely predetermined variables with insignificant effects on gross asset dynamics. While the number of rows in the gamma vector describes financial assets, the number of columns depends on the number of purely predetermined variables. Conclusively, this section provides a comparison between the financial integrated model and the financial autarky case. Furthermore, we provide a description of the decomposition of portfolio flows into volume and prices in the Appendix.

1.6.1 Impulse-response functions for portfolio variables

Figure 1.7 illustrates the impulse-response functions of portfolio-related variables to a 1% standard deviation technology shock in the emerging economy. As productivity rises and marginal cost decreases in the emerging economy, optimizing firms reset their prices to a lower level, and there is a real depreciation that boosts net exports. The central bank reduces the policy rate in response to lower inflation. Hence, the real interest rate falls, and consumption increases. Thus, firms produce more in response to higher demand, and output increases. In this situation, the realized return on the emerging economy bond increases less than that of the advanced economy, subplot (2), and the return on equity rises more relative to that of the advanced economy, subplot (4). Nevertheless, the shock is persistent and the realized returns are equalized after one period.

Emerging economy households experience an overall capital loss due to their pre-existing bond position (i.e., long in domestic bonds and short in foreign bonds).

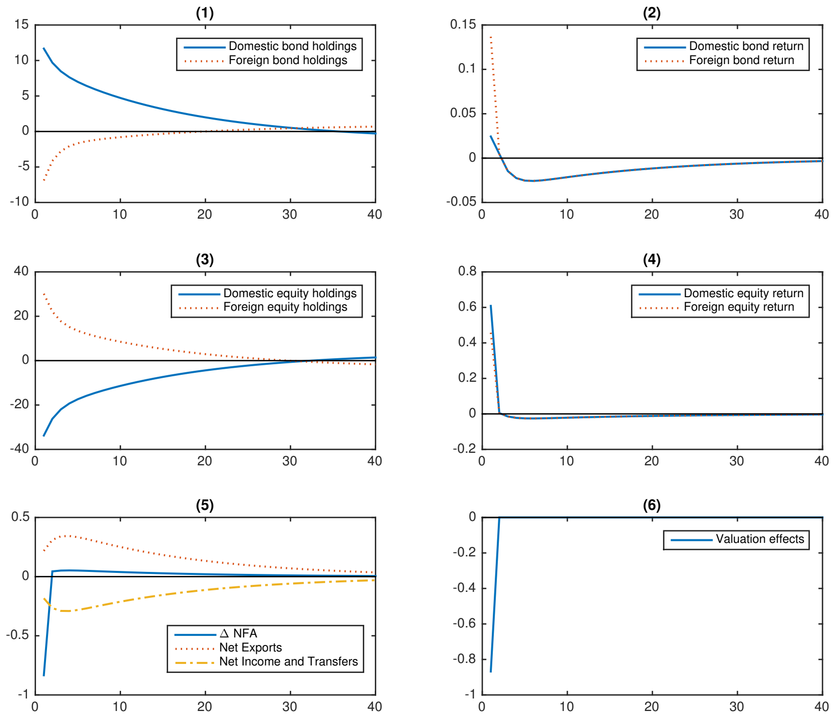

Figure 1.7: Impulse-response function following a technology shock in the emerging economy.

Since both bond returns increase, agents face a rise in the value of home bond assets, but also a rise in the value of their liabilities on foreign bonds, subplot (1). In this case, the small capital gain on domestic bonds is out-weighted by the loss produced in foreign bonds. At the same time, households also address a capital loss due to their pre-existing equity position (i.e., short in domestic equity and long in foreign equity). The increase in foreign equity assets value is out-weighted by the increase in domestic equity liability value. Consequently, the change in NFA drops abruptly in the first period, even-though net exports are positive, as it is shown in subplot (5), which displays the main components of the NFA.[27] This decrease in NFA is reflected in large negative valuation effects coming from pre-existing portfolio positions and from the negative net income transfers. Households in the emerging economy adjust on each portfolio position by increasing their position in those assets providing cap-

[27]Note that $\Delta NFA_t - CA_t = VAL_t$ and $CA_t = NX_t + NIR_t$ (NetIncomeReceived)

ital gains, such as local bonds and foreign equity, while decreasing their position in those assets providing capital losses, such as foreign bonds and local equity, subplots (1) and (3). Nevertheless, the emerging economy still pays higher dividends to the advanced economy households, so than net income received is negative.

We conduct an exercise by comparing the symmetric and the asymmetric model parameterizations to see the effect of the most relevant asymmetries (Calvo probability and the Std(ϵ^A)) in shaping business cycle dynamics of portfolio flows between emerging and advanced economies. There are two interesting results when analyzing the impulse-response functions following a technology shock in the emerging economy.[28] First, households in the emerging economy would receive a higher capital gain on their domestic bond position in those countries facing more nominal prices rigidities ($\eta = 0.72$ and $\eta^* = 2/3$), just because they optimally chose a larger positive position (see Figure 1.6). Nonetheless, domestic bond returns are expected to be smaller in the presence of higher nominal rigidities, which reduces the potential gain. In general, it is shown that a higher degree of nominal rigidities increases portfolio positions, and thus, capital flows are more dynamic. Second, results show that in those cases in which the emerging economy faces a higher volatility on the technology shocks than the advanced economy, (Std(ϵ^A) = 2% and Std(ϵ^A*) = 0.09%), capital flow dynamics are smoother than in the opposite case, in which the emerging economy faces a lower volatility (Std(ϵ^A) = 0.04% and Std(ϵ^A*) = 0.09%). This is mainly due to the fact that, when the volatility of the technology shock moves to a higher level, the effect on portfolio dynamics of model predetermined variables is lower. Further, this results suggest that the higher volatility in emerging countries business cycles may explain why they are less financially integrated. [29]

[28]Quantitative results on the IRF-comparison between the symmetric and the asymmetric setting are available upon request.

[29]Similar understanding can be used to analyze portfolio variables responses to the fiscal and monetary shock under alternative calibration for the Calvo probability and the standard deviation of the innovation of exogenous shocks in the emerging economy.

Figure 1.8 describes the impulse-response functions following a 1% standard deviation fiscal shock in the emerging economy. As government purchases increase in the emerging economy, optimizing firms reset their prices to a higher level in respond to a higher demand. There is a real appreciation in the emerging economy that decreases domestic consumption and net exports. Because CPI inflation increases, the central bank in the emerging economy sets nominal interest rate to a higher level, making the return on the emerging economy bond fall less relative to that of the advanced economy, subplot (2). Therefore, the realized return on both domestic and foreign equity also fall.

Households in the emerging economy have a long position in domestic bonds and

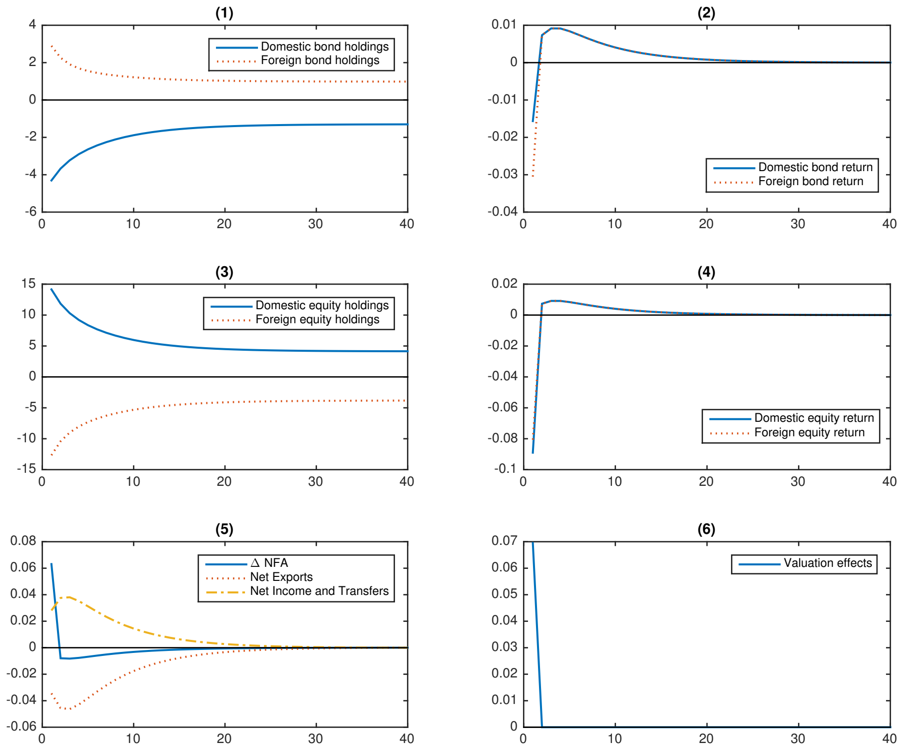

Figure 1.8: Impulse-response function following a fiscal shock in the emerging economy.

they lose value on these assets. Since they go short on foreign bonds they receive a financial gain through the reduction of their liabilities which out-weights previous loss. Thereby, they receive an overall capital gain on their bond position. On the equity side, the capital gain coming from their short domestic equity position is almost entirely out-weighted by the capital loss coming from their long position in foreign equity. Overall, emerging economy households experience a capital gain due to their pre-existing portfolio choice which leads to an initial improvement in the NFA position, subplot(8). Nonetheless, all financial asset returns are expected to increase in the following period, which produces a small capital loss followed by an overall capital gain, due to the adjustment of capital flows, subplots (1) and (3). The responses of ΔNFA and the current account differ due to this valuation effect on the pre-existing portfolio, which it is shown to be positive. Optimal portfolio choice helps to smooth down consumption, since the negative effects produced after a positive demand shock are balanced out with the positive valuation effects coming from their optimal position in foreign assets.

Next, we discuss the effects of a monetary shock in the emerging economy. Figure 1.9 provides the impulse-response functions to a 1% standard deviation monetary policy shock in the Taylor-type monetary policy rule of the central bank from the emerging economy. Higher nominal interest rates push domestic households to postpone their consumption since expected inflation responds slowly due to price rigidities and the real interest rate goes up. The increase in the nominal interest rates also appreciates the nominal currency in the emerging economy making goods less competitive for the advanced economy, leading to a decrease in exports. There are two opposing forces which affect the foreign economy. The advanced economy experiences an increase in its competitiveness relative to the emerging economy due to the real appreciation of their currency, their overall consumption should increase and so their demand for domestic goods. The decrease in aggregate consumption in the emerging economy affects the demand of foreign goods, which leads to a decrease in foreign output. Realized return on domestic bond increases, thus domestic

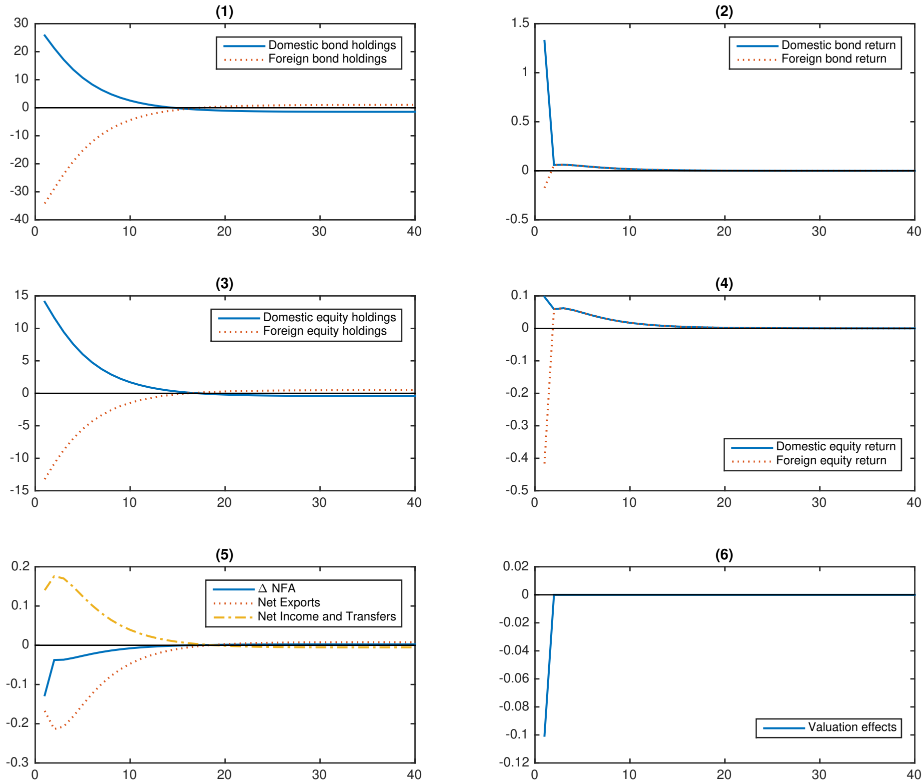

Figure 1.9: Impulse-response function following a interest rate shock in the emerging economy.

agents asset holdings value increase, as reflected in subplots (1) and (2). Foreign bond return drops in response to a decrease in the foreign CPI-level.

Households in the emerging economy holding negative pre-existing positions in foreign bonds, experience a capital gain. Domestic agents face a reduction on their foreign equity assets value, since its realized return drops. Again, emerging economy households experience an increase on their domestic equity liabilities, due to their short position. Despite the small capital gain on the bond equity side, these households experience an overall capital loss on their pre-existing equity position. The drop in NFA is out-weighted by the positive effects on their net income received from the equity side. In this case, portfolio deteriorates even more the external position after an interest rate shock in the emerging economy.

1.6.2 A comparison to financial autarky

This subsection compares the portfolio choice model with the case of financial autarky. The autarky case may be seen as the standard open economy model in which households are allowed to trade internationally in domestic and foreign goods markets, but international financial markets are closed and there are no possible valuation effects (see Eq. 1.3.28).[30] It is clear to see how the external position of a country may be under(over)-estimated in the standard open-economy model in which the valuation channel is closed and NFA is determined only by current account dynamics. Thus, $\Delta NFA_t = NX_t$. In the portfolio model, valuation effects are a key component of NFA dynamics and they emerge when stock prices and exchange rate fluctuate. Whether these effects are positive or negative depends on the gross external position in each financial asset, which has been calculated in previous section. Furthermore, net dividends received are also part of the NFA dynamics, and can be calculated in the portfolio model, so that $\Delta NFA_t = NX_t \pm NIR \pm VAL_t$. Figure 1.10 presents the impulse-response functions for key open-economy variables to a 1% standard deviation technology, fiscal and interest rate shock in the emerging economy, respectively in each row.

First row analyses the case of a positive technology shock in the emerging economy. Both models predict an increase in the emerging economy net exports due to the real exchange depreciation. In the standard model, the change in NFA is directly linked to the current account dynamics and it does not capture valuation effects nor net income received. Thus, it predicts an increase in the NFA as a response to a positive innovation to the technology shock in the emerging economy. However, the portfolio model shows that stock price fluctuations create a negative valuation effect derived

[30] We use the asymmetric calibration for the emerging and the advanced economy described in previous subsection. Results for the symmetric case-comparison are available upon request.

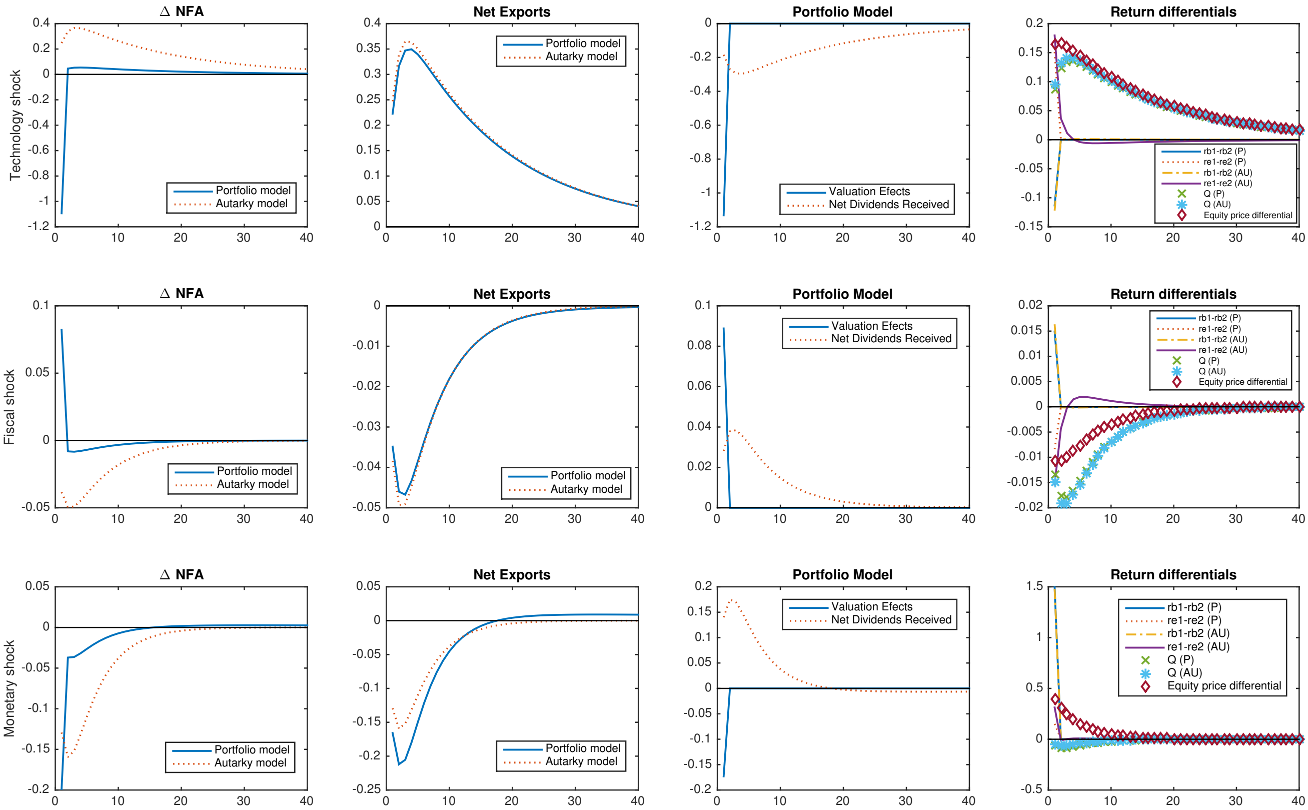

Figure 1.10: Impulse-reponse functions for the emerging and advanced economies with either international portfolio choice (P) or financial autarky (AU).

from the net external position in the emerging economy, which is positive in bonds and negative in equity. Also, exchange rate fluctuation creates positive valuation effects (Column 4, Figure 10). In fact, the negative position in equity implies also negative net income received, decreasing even more the NFA in the portfolio model. In this way, the standard open-economy model overestimates the external position of the emerging country in relation with the portfolio model which includes the valuation channel. Moreover, in the opposite case in which the emerging economy would have a negative net bond position and a positive net equity position, the valuation effect would be positive, and NFA would increase even more than in the autarky model. Thus, it is key to take into account gross capital positions on each asset since they determine whether a country gains or loses on its external position with its main financial partners.

Second row analyses the case of a positive fiscal shock in the emerging economy. Real exchange rate appreciation leads to a decrease in the emerging economy net exports. Thus, the autarky model predicts negative NFA. However, the exchange rate fluctuation creates a positive wealth transfer from the advanced economy to the emerging economy due to their net external position on bonds and equity. Moreover, net dividends received are positive. Dividends of the advanced economy firms are larger than those of the emerging firms due to stock and goods price differentials. The emerging economy external position in equity is larger than that of the advanced economy, so that that the dividends' value received surpasses the value paid to the advanced economy. Overall, the portfolio model shows positive NFA suggesting that the autarky model under-estimates the external position in the emerging economy.

Finally, the lower-panel analyzes the case of an interest rate shock in the emerging economy. Again, the difference between the two models lies in the valuation effects derived from pre-existing portfolio holdings. Net exports decrease in both models due to real exchange rate appreciation in the emerging economy. Equity price differentials create negative valuation effects on the net equity position of the emerging economy, making the NFA drop even more in the portfolio model than in the autarky case. However, the portfolio model shows a faster NFA recovery due to the positive net income received. While the instant negative effect of an interest rate shock in the NFA is worse in the portfolio model, it recovers faster than in the autarky case.

We have shown how NFA dynamics differ from standard open-economy model predictions once we open up international financial markets and valuation channel starts operating. These results confirm the relevance and reinforce our motivation to study gross capital flows instead of aggregate NFA in general equilibrium models when the research focus is on international economic integration and open-economy issues.

1.7 Conclusions

The relevance of portfolio composition in terms of FDI and bonds is directly related to the scale in gross capital flows because the different types of flows provide heterogenous implications for macroeconomic and financial stability. This paper shows that introducing endogenous portfolio choice in an otherwise standard model is quite important since the external position of a country may be under(over)-estimated in the standard open-economy model in which the NFA is determined only by current account dynamics (net exports). Our model solves for gross asset positions in FDI and bonds, and quantitatively measures the valuation effects. In fact, we show that valuation effects are a key part of NFA dynamics, and emerge when exchange rate and stock prices fluctuate ($\Delta NFA_t = CA_t \pm VAL_t$). Furthermore, we deeply analyze the structural determinants of non-zero equity and bond positions which ultimately determine the sign of valuation effects. We show that structural asymmetries in the nominal price rigidities and trade openness maybe a potential explanation of the two-way capital flows pattern in emerging countries. Moreover, we find that higher volatility in the innovations of the technological and the interest rate shocks, and lower volatility in the innovation of fiscal shocks, also creates positive net bond positions and negative equity position in the emerging economy. The empirical application of this theoretical model is the next step in our research agenda. In fact, Casares and Del Villar (2018) extend the benchmark theoretical model by including nominal frictions in the wage adjustment processes and consumption habits. Their focus is to study the NFA position between Canada and the US over the last few decades.

There are many venues to extend the baseline model and analyze other portfolio related issues. The increasing role for emerging economies in global financial markets, suggests that emerging markets financial institutions should be prepared to compete at the global level. Particularly, should emerging economies develop a better local capital markets in order to absorb the expected increase in the demand for credit access and the demand for a wider variety of financial assets?. In fact, there could many implications for monetary policy and financial stability programs. The more capital flows to emerging countries, the larger the spill-over effects. Under this scenario, there is a need to better understand the actual complexity of international financial market transmission mechanisms and their implications on international monetary coordination. Heterogeneity across households in their access to financial assets is ignored through this paper and it could be an interesting path to follow in order to analyze wealth and income effects of financial integration across countries. Furthermore, the analysis of global imbalances in an environment of endogenous portfolio choice is also left out for future research.

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Appendix

A. Description of model variables and parameters

Those variables in capital letters are measured in nominal terms while lower case letters represent variables measured in consumption bundles.

Model variables

α_t vector of financial assets real holdings.

$\alpha_{EH,t}$ home agent domestic equity holdings, $\alpha^*_{EH,t}$ foreign agent holdings.

$\alpha_{EF,t}$ home agent foreign equity holdings, $\alpha^*_{EF,t}$ foreign agent holdings.

$\alpha_{BH,t}$ home agent domestic bond holdings , $\alpha^*_{BH,t}$ foreign agent holdings.

$\alpha_{BF,t}$ home agent foreign bond holdings , $\alpha^*_{BF,t}$ foreign agent holdings.

$S_{H,t}$ home agent domestic firm ownership, $S^*_{H,t}$ foreign agent domestic firm ownership.

$S_{F,t}$ home agent foreign firm ownership, $S^*_{F,t}$ foreign agent foreign firm ownership.

$B_{H,t}$ home agent domestic bonds volume, $B^*_{H,t}$ foreign agent domestic bonds volume.

$B_{F,t}$ home agent foreign bonds volume, $B^*_{F,t}$ foreign agent foreign bonds volume.

$r_{x,t}$ vector of excess returns on financial assets.

$r_{EH,t}$ is the return on domestic equity in domestic consumption bundles.

$r_{EF,t}$ is the return on foreign equity in domestic consumption bundles.

$r_{BH,t}$ is the return on domestic bond in domestic consumption bundles.

$r_{BF,t}$ is the return on foreign bond in domestic consumption bundles.

NX_t are net exports.

CA_t is the current account.

VAL_t are valuation effects.

NFA_t are net foreign assets.

E_t is the nominal exchange rate.

Q_t is the real exchange rate.

i_t is the nominal interest rate and i_t^* the foreign country one.

r_t is the real interest rate and r_t^* the foreign country one.

Y_t is the aggregate output and Y_t^* the foreign country one.

C_t is the aggregate consumption and C_t^* the foreign country one.

$C_{H,t}$ is the domestic consumption of domestically produced goods.

$C_{F,t}$ is the domestic consumption of foreign produced goods.

$C_{H,t}^*$ is the foreign consumption of domestically produced goods.

$C_{F,t}^*$ is the foreign consumption of foreign produced goods.

β_t is the agent discount factor and β_t^* the foreign country one.

Θ_t is the firm discount factor and Θ_t^* the foreign country one.

w_t is the real wage and w_t^* the foreign country one.

N_t are labour hours and N_t^* the foreign country one.

D_t are dividends and D_t^* the foreign country one.

V_t is the value of domestic equity and V_t^* the foreign country one.

mc_t is the marginal cost and mc_t^* the foreign country one.

P_t is the home CPI price level in domestic currency units.

$P_{H,t}$ is the home producer price level in domestic currency units.

$P_{H,t}^*$ is the home producer price level in foreign currency units.

P_t^* is the foreign CPI price level in foreign currency units.

$P_{F,t}^*$ is the foreign producer price level in foreign currency units.

$P_{F,t}$ is the foreign producer price level in domestic currency units.

π_t is the home CPI inflation level in domestic currency units.

π_t^* is the foreign CPI inflation level in foreign currency units.

$\pi_{H,t}$ is the producer price inflation level in domestic currency units.

$\pi_{H,t}^*$ is the home producer price inflation level in foreign currency units.

$\pi_{F,t}^*$ is the foreign producer price inflation level in foreign currency units.

$\pi_{F,t}$ is the foreign producer price inflation level in domestic currency units.

$\bar{P_{H,t}}(j)$ is the home optimal price level in domestic currency units.

$\tilde{\rho}$ is the optimal price and PPI price level ratio.

RP_t are relative prices $(\frac{P_{H,t}}{P_t})$ and RP_t^* the foreign country ones $(\frac{P_{F,t}^*}{P_t^*})$.

SS_t is a price dispersion term and SS_t^* the foreign country one.

PD_t is another price dispersion term and PD_t^* the foreign country one.

cg_t is consumption growth.

cd_t is consumption differential.

ε_G fiscal shock, ε_G^* foreign country one.

ε_A technology shock, ε_A^* foreign country one.

ε_R interest rate shock,ε_R^* foreign country one.

Model parameters

σ Elasticity of marginal utility of consumption

ϕ Frisch Labour supply elasticity.

χ Labour supply function steady state parameter.

ν Discount factor steady state parameter.

ϵ Elasticity between varieties within the same country.

α Share of domestic consumption to imported goods.

α^{equity} Steady state share of foreign firm ownership allocated to domestic agents.

θ Elasticity of substitution between varieties produced at home and foreign.

η Calvo probability of price stickiness.

μ_π Inflation weight Taylor Rule.

$\bar{g}$ Public spending % over output in steady state.

ρ^A Productivity shock persistance.

ρ^G Government shock persistence.

ρ^R Monetary shock persistence.

ϵ^r Monetary shock volatility.

ϵ^A Productivity shock volatility.

ϵ^G Government shock volatility.

B. The model equations

The model is a set of 48 equations providing solution paths for the domestic and foreign variables. There are 20 domestic endogenous variables $r_{EH,t}, r_{EB,t}, i_t, C_t, \beta_t, \Theta_t, w_t, N_t, C_H, C_F, D_t, V_t, mc_t, \tilde{\rho}, RP_t, \pi_t, \pi_{H,t}, SS_t, PD_t, Y_t$ and foreign endogenous variables are completely analogous. There are 8 common variables in both economies, $dER_t, Q_t, NX_t, CA_t, NFA_t, VAL_t, cg_t, cd_t$. Regarding the exogenous variables; for each economy there are three AR(1) processes for technology, government spending and monetary policy shocks.

The following [10] functions are unique in the model,

Portfolio equations

$$C_t^{-\sigma} = \beta_t \mathbb{E}_t[C_{t+1}^{-\sigma} r_{EH,t+1}] \tag{EQ1}$$

$$C_t^{-\sigma} = \beta_t \mathbb{E}_t[C_{t+1}^{-\sigma} r_{EF,t+1}] \tag{EQ2}$$

$$C_t^{-\sigma} = \beta_t \mathbb{E}_t[C_{t+1}^{-\sigma} r_{BH,t+1}] \tag{EQ3}$$

$$C_t^{-\sigma} = \beta_t \mathbb{E}_t[C_{t+1}^{-\sigma} r_{BF,t+1}] \tag{EQ4}$$

$$\frac{1}{Q_t}C_t^{-\sigma} = \beta_t \mathbb{E}_t[C_{t+1}^{-\sigma} r_{EH,t+1}]\frac{1}{Q_{t+1}} \tag{EQ5}$$

Domestic economy equity asset demand (returns in domestic consumption units)

$$r_{EH,t+1} = \frac{\pi_{H,t+1}}{\pi_{t+1}} \frac{(D_{t+1} + V_{t+1})}{V_t} \tag{EQ6}$$

Foreign economy equity asset demand (returns in domestic consumption units)

$$r_{EF,t+1} = \frac{\pi^*_{F,t+1}}{\pi^*_{t+1}} \frac{Q_{t+1}}{Q_t} \frac{(D^*_{t+1} + V^*_{t+1})}{V^*_t} \tag{EQ7}$$

Domestic economy bond asset demand (returns in domestic consumption units)

$$r_{EB,t+1} = \frac{i_t}{\pi_{t+1}} \tag{EQ8}$$

Foreign economy bond asset demand (returns in domestic consumption units)

$$r_{EF,t+1} = \frac{i^*_t}{\pi^*_{t+1}} \frac{Q_{t+1}}{Q_t} \tag{EQ9}$$

Real Exchange Rate

$$\frac{Q_t}{Q_{t-1}} = \frac{E_t}{E_{t-1}} \frac{\pi^*_t}{\pi_t} \tag{EQ10}$$

The following [16] equations describe domestic economy, and the foreign economy is described with the corresponding analogous functions [16x2]

Endogenous discount factor

$$\beta_t = (1 + C_t)^{-\nu} \tag{EQ11}$$

Firm's discount factor

$$\Theta_t = (1-\alpha^{equity})\beta_t + \alpha^{equity}\beta_t^* \tag{EQ12}$$

where α^{equity} is the domestic agent ownership of foreign firm.

Labour Supply Function

$$w_t = \chi C_t^{\sigma} N_t^{\phi}; \tag{EQ13}$$

Relationship between CPI-inflation and Producer Price-inflation

$$\pi_{H,t} = \frac{RP_t}{RP_{t-1}}\pi_t \tag{EQ14}$$

CPI index

$$1 = \left[(1-\alpha)RP_t^{1-\theta} + \alpha\Big(RP_t^* Q_t\Big)^{1-\theta}\right]^{\frac{1}{1-\theta}} \tag{EQ15}$$

Optimal Price Function

$$\bar{P}_{H,t}(j) = \left(\frac{\epsilon}{\epsilon-1}\right)\mathbb{E}_t\sum_{k=0}^{\infty}\Theta_{t+k}\eta^k\left[\frac{\big(P_{H,t+k}\big)^{\epsilon}Y_{t+k}mc_{t+k}(j)}{\big(P_{H,t+k}\big)^{\epsilon-1}Y_{t+k}}\right] \tag{EQ16}$$

Domestic produced goods Price index ($\pi_{h,t}$) using Dixit-Stiglitz aggregator

$$P_{H,t} = \left[(\eta)P_{H,t-1}^{1-\epsilon} + (1-\eta)\bar{P}_{H,t}(j)^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}} \tag{EQ17}$$

Real Marginal Cost (Labour demand function)

$$mc_t = \left(\frac{P_t}{P_{H,t}}\right)\frac{w_t}{exp(A_t)} \tag{EQ18}$$

Aggregate Production Function

$$Y_t(PD_t) = exp(A_t)N_t \tag{EQ19}$$

where A_t follows AR(1) exogenous process and PD_t is price dispersion

$$PD_t \equiv \int_0^1 \left(\frac{\bar{P}_{H,t}(j)}{P_{H,t}} \right)^{-\epsilon} dj$$

$$PD_t = (1-\eta)\left(\frac{\bar{P}_{H,t}(j)}{P_{H,t}} \right)^{-\epsilon} + \pi_{H,t}^{\epsilon} \eta PD_{t-1} \tag{EQ20}$$

Aggregate Dividends Function

$$D_t = (SS_t)Y_t - \frac{w_t N_t}{RP_t} \tag{EQ21}$$

where price dispersion is defined as follows

$$SS_t \equiv \int_0^1 \left(\frac{\bar{P}_{H,t}(j)}{P_{H,t}} \right)^{1-\epsilon} dj$$

$$SS_t = (1-\eta)\left(\frac{\bar{P}_{H,t}(j)}{P_{H,t}} \right)^{1-\epsilon} + \pi_{H,t}^{\epsilon-1} \eta SS_{t-1} \tag{EQ22}$$

Resources constraint equilibrium condition

$$Y_t = \left(\frac{P_{h,t}}{P_t} \right)^{-\theta} \left[(1-\alpha)C_t + \alpha Q_t^{\theta} C_t^* \right] + \frac{(\bar{g} e_t^G)}{PD_t} \tag{EQ23}$$

Domestic Imports equilibrium condition

$$IM_t = \alpha \left(RP_t^* Q_t \right)^{-\theta} C_t \tag{EQ24}$$

Domestic Exports equilibrium condition

$$EX_t = \alpha^* \left(\frac{RP_t}{Q_t} \right)^{-\theta^*} C_t^* \tag{EQ25}$$

Monetary Taylor Rule

$$\frac{i_t}{\bar{i}} = \left(\frac{\pi^{CPI_t}}{\bar{\pi}}\right)^{\mu_\pi} exp(R_t) \tag{EQ26}$$

The following [6] unique equations describe the Balance of Payments (Foreign economy uses the same variables with opposite sign)

Budget constraint in terms of NFA

$$C_t + (\bar{g})e^{G_t} + NFA_t = w_t N_t + D_t + r_{X,t}\alpha_{t-1} + r_{EH,t}NFA_{t-1}; \tag{EQ27}$$

Net Exports

$$NX_t = \alpha^* \left(\frac{RP_t}{Q_t}\right)^{-\theta^*} C_t^* - \alpha\left(RP_t^* Q_t\right)^{-\theta} C_t \tag{EQ28}$$

Current Account Approximation

$$CA_t \approx w_t N_T - C_t - (\bar{g})e^{G_t} + D_t + (r_{EH,t} - 1)NFA_{t-1} \tag{EQ29}$$

Valuation effects

$$VAL = \Delta NFA_t - CA_t \equiv (r'_{xt}\alpha_{t-1}) \tag{EQ30}$$

where the vector of excess return is the following

$$r_{X,t} \equiv [r_{BH,t} - r_{EH,t}, r_{BF,t} - r_{EH,t}, r_{EF,t} - r_{EH,t}]$$

and the vector with the real holdings of financial assets is;

$$\alpha_{t-1} \equiv [\alpha_{BH,t-1}, \alpha_{BF,t-1}, \alpha_{EF,t-1}]$$

Consumption differential

$$cd_t = C_t - C_t^* - \frac{Q_t}{\sigma} \tag{EQ31}$$

$$cg_t = \frac{1}{2}(C_t + C_t^* + \frac{Q_t}{\sigma}) \tag{EQ32}$$

C.The steady state

The system of steady state functions that solves the following steady state variables $mc, i, r, \beta, \Theta, Y, C, C_H, C_F, w, N, V, D, NX$ is the following. Note that the foreign country system of equations and variables is analogous. Assuming steady-state rate of inflation at 0;

Marginal cost

$$mc = \frac{\epsilon - 1}{\epsilon} \tag{SSB1}$$

Nominal interest rate

$$i = 1 - \beta \tag{SSB2}$$

Real interest rate

$$r = i \tag{SSB3}$$

Parameter from endogenous discount factor

$$\mu = -\frac{log(\beta)}{log(1 + C)} \tag{SSB4}$$

Firm endogenous discount factor

$$\Theta = (1 - \alpha^{equity})\beta + \alpha^{equity}\beta^* \tag{SSB5}$$

Production function

$$Y = N; \tag{SSB6}$$

Goods market clearing

$$C = Y - NX - \bar{g}Y \tag{SSB7}$$

Net exports

$$NX \equiv 0 \tag{SSB8}$$

Domestic consumption of domestically produced goods

$$C_H = (1 - \alpha)C \tag{SSB9}$$

Domestic consumption of foreign produced goods

$$C_F = (\alpha)C \tag{SSB10}$$

Real Wage

$$w = mc \tag{SSB11}$$

Labour supply

$$wC^{\sigma} = \chi N^{\phi} \tag{SSB12}$$

Domestic equity

$$V = \frac{\beta}{1 - \beta} D \tag{SSB13}$$

Aggregated dividends domestic firms

$$D = Y - wN \tag{SSB14}$$

D. Decomposition of gross assets and liabilities movements

The introduction of endogenous portfolio choice not only permits a detailed investigation about gross dynamics of each financial asset available (e.g., $\widehat{\alpha}_{EF,t}$, $\widehat{\alpha}_{EH,t}$,$\widehat{\alpha}_{BH,t}$ and $\widehat{\alpha}_{BF,t}$), but it also allows the decomposition of gross assets and liabilities movements into price and volume movements. In order to do so, it is worth to mention that up to a first-order Taylor approximation, the following relationships hold

$$\widehat{\alpha}_{EF,t} = \overline{q_{EF,t}S_F} \times \hat{q}_{EF,t} + \hat{S}_{F,t} \tag{1.7.1}$$

$$\widehat{\alpha}_{EH,t} = \overline{q_{EH,t}S_H} \times \hat{q}_{EH,t} + \hat{S}_{H,t} \tag{1.7.2}$$

$$\widehat{\alpha}_{BH,t} = \overline{q_{BH,t}b_H} \times \hat{q}_{BH,t} + \hat{b}_{H,t} \tag{1.7.3}$$

$$\widehat{\alpha}_{BF,t} = \overline{q_{BF,t}b_F} \times \hat{q}_{BF,t} + \hat{b}_{F,t} \tag{1.7.4}$$

where $q_{EF,t} = \frac{P^*_{Ft}}{P^*_t} Q_t V^*_t$ is the value of foreign equity, $q_{EH,t} = \frac{P_{Ht}}{P_t} V_t$ that of domestic equity, $q_{BH,t} = (r_t)^{-1}$ is the value of the domestic bonds and $q_{BF,t} = Q_t(r^*_t)^{-1}$ is the value of the foreign bonds. All values are measured in domestic consumption bundles. $S_{F,t}$ describes the the foreign firm share allocated to domestic households, and $S_{H,t}$ that of domestic firm (i.e., $0 < S_t < 1$). $b_{H,t}$ and $b_{F,t}$ describe holdings of domestic and foreign bonds.Those variables denoted with a hat (e.g., $\hat{X}$) describe their first-order dynamics and those with an overline (e.g., $\overline{X}$) represent their steady-state values. Figure 1.11 shows the impulse-response functions for asset prices and volume following a technology, government spending and interest rate shock in the emerging economy. Foreign equity portfolio variation not only comes from the increase in foreign equity price but also on the adjustment through the increase in foreign equity volume as shown in Plot 1 and 2. The impulse-response functions to a government spending shock in the emerging economy are displayed in subplot (2). The decrease in foreign equity asset not only comes from the reduction on equity price but also from the drop in foreign equity volume, as it is shown in Plot 3 and 4. Same logic applies to the interest rate shock.

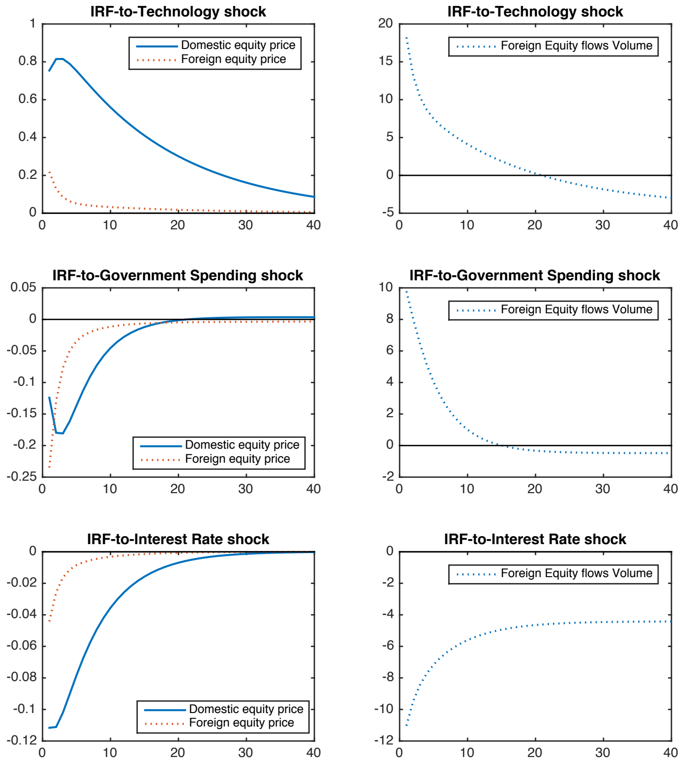

Figure 1.11: Impulse-response functions for asset prices and volumes.

Chapter 2

A portfolio-choice macro model to analyze the recent gross capital flows between Canada and the US

with **Miguel Casares Polo**

2.1 Introduction

During the last few decades, both gross capital and trade flows across countries have reached unprecedented levels. Canada and the US are known to have the world's largest bilateral trade relationship.[1] This link is generally characterized by a high Canadian net trade surplus, which reached a peak value of 7.8 billions of US dollars in 2008. After the 2008 financial crisis, trade surplus in Canada has been gradually reduced and it has punctually become even negative in 2016.

[1]Policymakers of OCDE countries (especially, the US, the UK and EU countries) and emerging countries (especially, China) are nowadays merged into controversial debates on the global economy's uncertain trajectory, increasingly protectionist trade policies and a need for strengthened global institutions. Thus, Canada and the US economies provide natural examples that are vital to understand how economic integration thorough trade and foreign capital affects macroeconomic aggregates, financial stability and business cycle synchronization.

Regarding financial transactions, Canadian overall Net Foreign Asset (NFA) position has been traditionally negative until 2015, when it turned positive for the first time in decades (see Figure 2.1). The evolution of Canadian NFA is vastly dominated by the capital flows with the US because it accounts for the largest share in total position. Moreover, the negative US position outweights all positive positions with the rest of the world. As net exports have declined while the variations in NFA have been typically positive, there have been significant valuation effects on Canadian assets and liabilities that explain the upwards trend in the NFA position of Canada with the US.

Both net Foreign Direct Investment (FDI) and Portfolio Equity (PE) account for the largest shares in the contributions for Canadian NFA. Their overall sizes have increased dramatically since 1990.[2] We have built a quarterly time series that results from adding up net FDI and net PE of Canada with respect to the US, which it has shown an upwards trend to reached almost 1.25 times Canadian GDP in 2017 (see Figure 2.1). Meanwhile, the quarterly balance of Canadian net Portfolio Bonds (PB) with the US has been always negative, since Canada bond liabilities are way larger than Canada bond assets held in the US. Thus, the Canada-US foreign asset relationships present a "reversed two-way" capital flows pattern. Generally, a "two-way pattern" refers to the case in which emerging economies net bonds positions are positive and their net equity positions are negative with respect to advanced economies. After 2011, the gap between net equity and net bond position starts increasing in Canada, as Figure 2.1 clearly shows. This means that US investors buy equity from emerging countries while they sell US-equity to other advanced countries, such as Canada. In addition, US investors sell domestic US-bonds to

[2] Canadian holdings of FDI and PE in US firms have increased from representing 50% and 20% of Canadian GDP, respectively, in 1990 to almost 180% and 200%, respectively, in 2018.

emerging countries while they buy bonds from other advanced countries, such as Canada.[3]

With the motivation of studying these empirical findings, we propose a two-economy optimizing model with endogenous gross trade and financial assets. The model is going to be calibrated to reproduce fluctuations macroeconomic variables from Canada and the US over the period between 1990 and 2018. Our approach is based on the open-economy New Keynesian literature related to seminal papers such as Smets and Wouters (2002) and Galí and Monacelli (2005), and its extension to incorporate endogenous portfolio choice initiated by Devereux and Sutherland (2009, 2010 and 2011) and Tille *et al.* (2008 and 2010). In general, models that incorporate portfolio choice into two-country general equilibrium frameworks, are highly theoretical and small in size. Hence, they do not contain enough elements, such as nominal and real frictions both at the local and at the international level, to provide realistic business cycle fluctuations for macroeconomic variables that are related in an open economy environment. Another important advantage of our model is that variations in the NFA position are pinned down not only by current account fluctuations but also due to valuation effects, which we have found to be key in explaining the increase in Canadian NFA.

Therefore, the first contribution of our paper on the modeling side is to introduce a wide set of nominal and real frictions into a medium-scale fully-fledged two-country New Keynesian model with endogenous gross trade and portfolio variables. This paper builds on Del Villar (2018), who provides a two-country New Keynesian model with portfolio choice of equity and bonds, nominal price rigidities following Calvo (1983)'s fixed probabilities, home good bias, and incomplete financial markets to study the factors behind heterogenous capital flows across emerging and advanced countries. We extend her benchmark model by including nominal wage rigidities *á*

[3] We left out for future research the analysis of "reverse" international capital flows between US and other advanced countries.

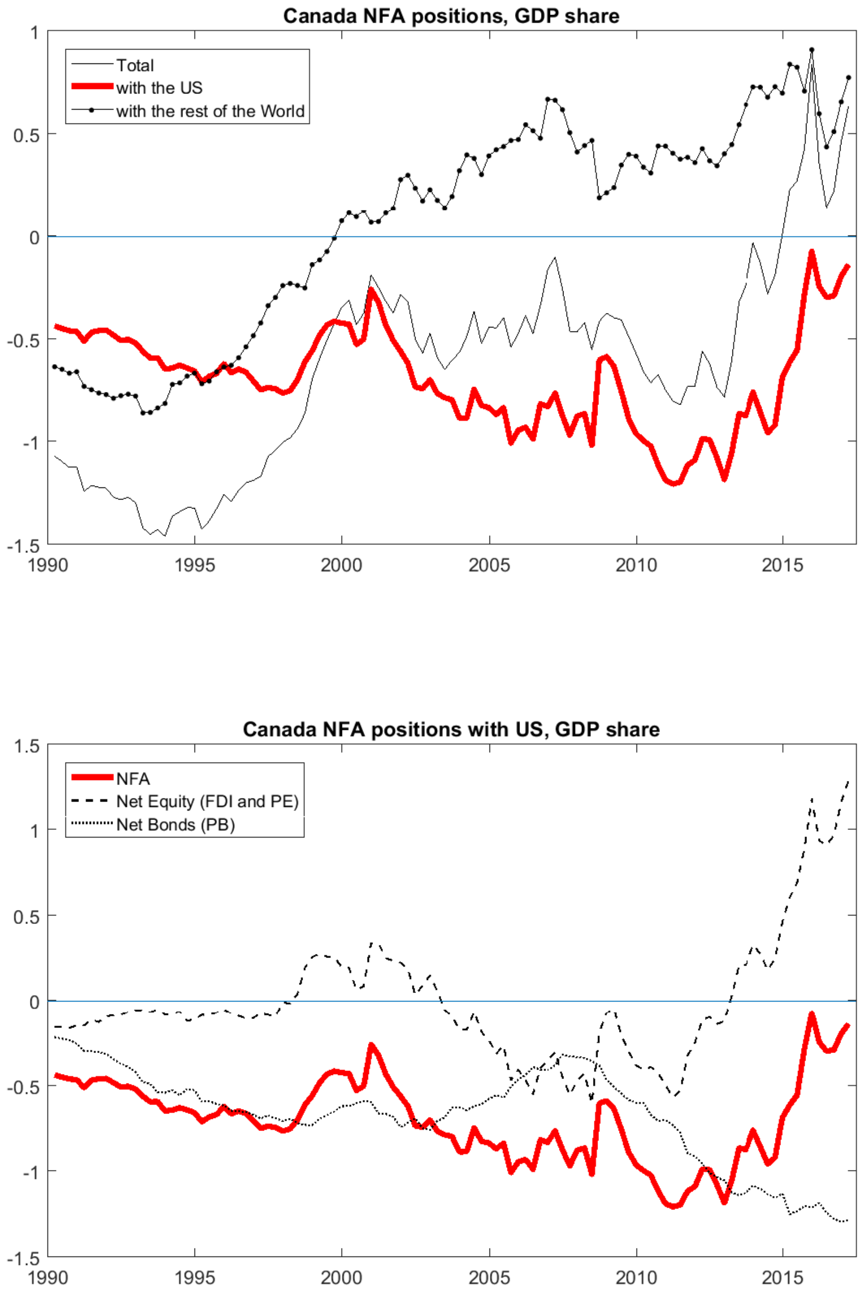

Figure 2.1: Net Foreign Asset positions for Canada (1990-2018)

la Calvo (1983), price and wages indexation rules, consumption habits on household preferences, and additional exogenous processes to account for the business cycle synchronization across Canada and the US.

The second contribution of our paper is to provide a quantitative analysis on the overall model performance and on its ability to explain the highlighted empirical facts for the recent evolution of the Canada NFA position. This paper is the first that calibrates the parameters of the model with actual data from Canada and the US. Furthermore, we demonstrate that the proposed model performs reasonably well in explaining business cycle statistical moments of Canada, the US and their degree of cyclical synchronization.[4] Besides, our model allows for valuation effects channel through portfolio choices that significantly affect the dynamics of the NFA balances.

The organization of the rest of the paper is as follows. Section 2 reviews selection of related literature. Section 3 provides an overview of the two-country New Keynesian model describing the optimizing programs of domestic households and firms. Section 4 brings the parameter calibration. Section 5 presents the business cycle analysis of impulse response functions to evaluate the propagation channels of the shocks of the model and their international effects. Section 6 searches for the determinants of the increase in the NFA position of Canada with the US and their reversed two-way capital flows. Section 7 concludes with a summary of the main results of the paper.

2.2 Selective literature review

Since the late 1990s, there have been additional elements included to the New Keynesian model to introduce the behavior of the exchange rate and the interna-

[4]Schmitt-Grohé (1998) highlighted that the positive responses of Canadian output, employment, investment, exports, imports and terms of trade to positive shocks in the US cannot be explained using the standard international business cycle model.

tional transmission of shocks in open economies. After the the seminal paper by Obstfeld and Rogoff (1995), this framework coined the name New Open-Economy Macroeconomics (NOEM). These models generally focus the attention on net foreign assets and current account dynamics and not on the gross asset flows.[5] The main extensions derived in the literature aim at characterizing the price of exported and imported goods by implementing producer (or local) currency pricing, homogenous pricing (or pricing to market) and sticky (or flexible) prices. Other extensions focus the attention on the international risk sharing properties to discuss optimal monetary policy and economic policy coordination. Nonetheless, there is a growing empirical literature that studies the increasing significance of the valuation effects channel created by large and heterogenous gross capital flow movements across countries (Gourichas and Rey, 2007 and 2014). Still standard NOEM models abstract from gross capital flows which ultimately help to understand NFA dynamics and the international transmission of shocks through financial markets. There are just a few general equilibrium models which incorporate endogenous portfolio choice in an open economy framework because, until recently, there was no suitable computable method to solve portfolio choice in the context of DSGE models. In this regard, both Devereux and Sutherland (2008, 2010 and 2011), and Tille *et al.* (2008 and 2010) have developed novel methods to facilitate portfolio model solution within general equilibrium frameworks.[6]

The bulk of research within the NOEM literature has been highly theoretical and based on small-stylized models such as Ghironi (1999) or Justiniano and Preston (2004). The small size of these models at the local and the international dimensions of the economy, does not permit an empirical test of the main implications of these

[5]Other important contributions to the NOEM literature are Corsetti and Peseti (2001), Kollmann (2002) and Galí and Monacelli (2005).

[6]See Coeurdacier and Rey (2013) for an extended literature revision on Open Economy Financial Macroeconomics. Also, for portfolio choice studies see Engel and Matsumoto (2009), and Coeurdacier *et al.* (2010 and 2013).

models for a relatively wide range of macro-aggregates. Nowadays, many Central Bankers in industrialized economies use extensions to the NOEM model that include more realistic features to facilitate the empirical check, such as nominal rigidities, capital accumulation with adjustment cost and traded and non-traded sectors, although most of them still lack of endogenous portfolio choice.[7] Given the empirical evidence on the increasing size of international financial markets (Lane and Milesi-Ferretti, 2008), it is quite important to incorporate not only trade but also gross capital flows within the open-economy setting of our model.

Finally, our model is also fed with the vast literature on cross-country business cycle synchronization. Generally, output and other macroeconomic variables are found to be positively correlated across industrialized countries. Kose, Prasad, and Terrones (2003) provided evidence that trade and financial market integration increase the output correlation pattern across countries. Schmitt-Grohe (1998) suggests that the majority of international real-business-cycle models cannot account for the synchronized fluctuations observed in the data and international trade alone does not explain the well-evidenced cross-country co-movements of the macroeconomic variables at business cycle frequency. In particular, she highlights that the positive responses of Canadian output, employment, investment, exports, imports and terms of trade to positive shocks in the US cannot be explained using the standard international business cycle model. To overcome this difficulty, our calibrated model delivers a positive cross correlation (+0.56) between the quarterly growth of GDP in the home (Canada) and foreign (US) economies. Miranda-Agrippino and Rey (2015) find that US monetary policy is a main driver for global business cyles and we replicate the same monetary policy rule for the US and Canada. Mumtaz

[7] Examples of two (or multi-country) models at monetary and financial institutions are Laxton and Pesenti (GEM-Global Economy Model at the IMF, 2003), Erceg, Guerrieri and Gust (SIGMA at the Federal Reserve Board, 2003), Benigno and Thoenissen (Bank of England, 2003), Murchison, Rennison and Zhu (Bank of Canada, 2004), Adolfson *et al.* (Riksbank, 2005), and Kortelainen (Bank of Finland, 2002).

et al. (2011) indicate that international co-movements within regions account for most aggregate fluctuations, which justifies assuming simultaneous technology or monetary shocks for both the US and Canada.

Our model addresses some of the limitations of previous theoretical and empirical literature by providing a medium-scale fully-fledged open economy New Keynesian model with endogenous gross trade and gross capital flows, to empirically analyze Canada and US bilateral economic relationships during the last few decades.

2.3 Two-country New Keynesian model

The model incorporates two economies that are referred as either the home or the foreign economy.[8] Free international trading among them takes place in markets for consumption goods and financial assets. There are domestic markets for labor services. Financial assets are of two types: equity issued by either domestic or foreign firms with a variable return determined by the dividend and bonds issued by either the domestic or the foreign governments that yield a risk-free interest rate. There is a flexible exchange rate toe equalize purchasing power and central banks operate their monetary policy by implementing a Taylor (1993)-type monetary policy rule. Both sticky prices and sticky wages introduce nominal rigidities to capture real effects of demand-side shocks.

2.3.1 Households

Let each economy contain a continuum of households indexed by j $\in [0,1]$. The preferences of a representative infinitely-lived j household at time t are expressed in an intertemporal utility function whose arguments are a consumption index $c_t(j)$

[8]The foreign economy will not be explicitly displayed here because it is structurally identical to the one presented in this section. See the Appendix for a complete description of all the model variables, parameters and equations.

and labour hours worked, $n_t(j)$. External consumption habits are determined by the parameter $0 < h < 1$ which measures the influence of lagged aggregate consumption, c_{t-1}, on smoothing household-level consumption. The instantaneous utility function in period t takes the following form

$$U(c_t(j), n_t(j)) = \frac{(c_t(j) - hc_{t-1})^{1-\sigma}}{1-\sigma} - \psi \frac{n_t(j)^{1+\gamma}}{1+\gamma} \tag{2.3.1}$$

where $\sigma > 0$ is the risk aversion parameter, $\gamma > 0$ is the inverse of Frisch labor supply elasticity, and $\psi > 0$ is a scale parameter that weighs labor disutility with respect to total utility.

Following Schmitt-Grohe and Uribe (2003), β_t is an endogenous discount factor to ensure a stationary wealth distribution in the linearized approximated dynamic model.[9] In particular, the discount factor is a function of aggregate consumption determined as follows

$$\beta_{t+1} = \beta_t (1 + c_t)^{-\varsigma} \tag{2.3.2}$$

where $\varsigma > 0$ is a discount rate parameter. Due to identical preferences and symmetric equilibrium, household-level and aggregate consumption are equal, $c_t(j) = c_t$. The consumption bundle, $c_t(j)$, is represented by a Dixit and Stiglitz (1977)'s consumption index composed by baskets of home consumption goods, $c_{H,t}$, i.e. produced by home (H) firms, and foreign consumption goods, $c_{F,t}$, i.e. produced by foreign (F) firms and purchased (imported) by domestic households

$$c_t \equiv \left[(1-\alpha)^{\frac{1}{\theta}} (c_{H,t})^{\frac{\theta-1}{\theta}} + \alpha^{\frac{1}{\theta}} (c_{F,t})^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}} \tag{2.3.3}$$

where $\theta > 1$ denotes the elasticity of substitution between domestic and foreign goods from the viewpoint of a domestic household and $0 < \alpha < 1$ is inversely related

[9] They propose five different ways to induce stationarity in an open economy model. We choose the endogenous discount factor for simplicity.

to the degree of home bias in preferences.[10] For simplicity, we assume identical Dixit-Stiglitz aggregation schemes for $c_{H,t}$ and $c_{F,t}$

$$c_{H,t} \equiv \left(\int_0^1 c_{H,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}}, \; c_{F,t} \equiv \left(\int_0^1 c_{F,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}}$$

with $\epsilon > 1$ denoting the elasticity of substitution between goods produced within the same economy. The optimal choices of domestic and imported goods imply the standard demand functions

$$c_{H,t} = (1-\alpha) \left(\frac{P_{H,t}}{P_t} \right)^{-\theta} c_t, \quad c_{F,t} = \alpha \left(\frac{P_{F,t}}{P_t} \right)^{-\theta} c_t, \tag{2.3.4}$$

where $P_{H,t}$ is the price for domestically produced goods expressed in domestic currency (Producer Pride Index, PPI) and $P_{F,t}$ is the price for foreign produced goods expressed also in domestic currency. The consumption-based price aggregation that corresponds to the Dixit-Stiglitz scheme gives the following Consumer Price Index (CPI)

$$P_t = \left[(1-\alpha) P_{H,t}^{1-\theta} + \alpha P_{F,t}^{1-\theta} \right]^{\frac{1}{1-\theta}}, \tag{2.3.5}$$

and the rate of inflation from the CPI in period t therefore is $\pi_{t-1}^{CPI} = P_t/P_{t-1} - 1$.

The model allows for household heterogeneity on the labor services provided to firms and sticky wages, following Erceg *et al.* (2000). Thus, the representative j-type household faces the following Dixit-Stiglitz labour demand constraint that determines the amount of specific labour supply inversely depending on the relative wage.

$$n_t(j) = \left(\frac{W_t(j)}{W_t} \right)^{-\theta_w} n_t \tag{2.3.6}$$

[10] If price indices for domestic and foreign goods are equal (as assumed in the steady state equilibrium), the model parameter α corresponds to the share of domestic consumption allocated to imported goods.

where $W_t(j)$ is the nominal wage earned by the type of labor supplied by household j, W_t and n_t are the Dixit-Stiglitz aggregate nominal wage and labor, respectively, and $\theta_w > 1$ is the elasticity of substitution between differentiated labor services.

Income is obtained from selling labour services in the market and from last-period portfolio holdings payments. There is a lump-sum tax charged by the government to the household. The uses of household income are purchases of consumption goods, net purchases of equity shares from home and foreign incumbents, and net purchases of domestic and foreign government bonds held during next period. The budget constraint imposed in period t for a representative household expressed in nominal terms

$$W_t(j)n_t(j) + (D_t + V_t)\, S_{H,t-1} + e_t\,(D_t^* + V_t^*)\, S_{F,t-1} + B_{H,t-1} + e_t B_{F,t-1} - Tax_t =$$
$$P_t c_t + V_t S_{H,t} + e_t V_t^* S_{F,t} + (1 + R_t)^{-1} B_{H,t} + (1 + R_t^*)^{-1} e_t B_{F,t},$$

where V_t refers to domestic equity value, V_t^* to foreign equity value, D_t and D_t^* refer, respectively, to domestic and foreign firm dividends, $S_{H,t}$ refers to the share of domestic equity held by domestic households and $S_{F,t}$ refers to that of foreign equity. $B_{H,t}$ and $B_{F,t}$ are the amount of domestic and foreign government bonds purchased by the domestic household in period t to be reimbursed in $t+1$. R_t refers to nominal interest rate set by the central bank in the domestic economy, R_t^* that of the foreign economy and e_t is the nominal exchange rate expressed in foreign currency. Using (2.3.6) in the labor income and introducing the aggregate nominal wage gives

$$\left(\frac{W_t(j)}{W_t}\right)^{1-\theta_w} W_t n_t + (D_t + V_t)\, S_{H,t} + e_t\,(D_t^* + V_t^*)\, S_{F,t} + B_{H,t} + e_t B_{F,t} - Tax_t =$$
$$P_t c_t + V_t S_{H,t+1} + e_t V_t^* S_{F,t+1} + (1 + R_t)^{-1} B_{H,t+1} + (1 + R_t^*)^{-1} e_t B_{F,t+1}$$

Dividing both sides by the CPI, P_t, introducing the real exchange rate, $q_t = \frac{e_t P_t^*}{P_t}$, and the aggregate real wage, $w_t = \frac{W_t}{P_t}$, in the previous expression brings the budget constraint in real terms

$$\left(\frac{W_t(j)}{W_t}\right)^{1-\theta_w} w_t n_t + \frac{1}{P_t}\left(D_t + V_t\right) S_{H,t} + \frac{1}{P_t^*} q_t \left(D_t^* + V_t^*\right) S_{F,t} + \frac{B_{H,t}}{P_t} + q_t \frac{B_{F,t}}{P_t^*} - \frac{Tax_t}{P_t} = \tag{2.3.7}$$

$$c_t + \frac{1}{P_t} V_t S_{H,t+1} + \frac{1}{P_t^*} q_t V_t^* S_{F,t+1} + \left(1 + R_t\right)^{-1} \mathbb{E}_t \frac{P_{t+1}}{P_{t+1}} \frac{B_{H,t+1}}{P_t} + \left(1 + R_t^*\right)^{-1} e_t \frac{P_t^*}{P_t^*} \mathbb{E}_t \frac{P_{t+1}^*}{P_{t+1}^*} \frac{B_{F,t+1}}{P_t}$$

measured in terms of domestic bundles of consumption goods. Using the definition of the expected CPI inflation, $\mathbb{E}_t \frac{P_{t+1}}{P_t} = \mathbb{E}_t \left(1 + \pi_{t+1}^{CPI}\right)$, with the rational expectation operator evaluated in period t, $\mathbb{E}_t$, and the Fisher relation that introduces the *ex ante* real interest rate, $1 + r_t = \frac{1+R_t}{\mathbb{E}_t\left(1+\pi_{t+1}^{CPI}\right)}$, for both the domestic and foreign economies, transforms (2.3.7) as follows

$$\begin{aligned} &\left(\frac{W_t(j)}{W_t}\right)^{1-\theta_w} w_t n_t + \frac{1}{P_t}\left(D_t + V_t\right) S_{H,t} + \frac{1}{P_t^*} q_t \left(D_t^* + V_t^*\right) S_{F,t} + \frac{B_{H,t}}{P_t} + q_t \frac{B_{F,t}}{P_t^*} - \frac{Tax_t}{P_t} = \\ &\quad c_t + \frac{1}{P_t} V_t S_{H,t+1} + \frac{1}{P_t^*} q_t V_t^* S_{F,t+1} + \left(1 + r_t\right)^{-1} \frac{B_{H,t+1}}{P_{t+1}} + \left(1 + r_t^*\right)^{-1} q_t \frac{B_{F,t+1}}{P_{t+1}^*} \end{aligned} \tag{2.3.8}$$

To simplify notation, we suggest taking variables on lower-case letters to refer to the real value of those variables in upper case letters measured as units of the domestic consumption bundle. For example, $d_t = \frac{D_t}{P_t}$. Applying such notation rule through the expression (2.3.8) yields

$$\begin{aligned} &\left(\frac{W_t(j)}{W_t}\right)^{1-\theta_w} w_t n_t + \left(d_t + v_t\right) S_{H,t} + q_t \left(d_t^* + v_t^*\right) S_{F,t} + b_{H,t} + q_t b_{F,t} - tax_t = \\ &\quad c_t + v_t S_{H,t+1} + q_t v_t^* S_{F,t+1} + \left(1 + r_t\right)^{-1} b_{H,t+1} + \left(1 + r_t^*\right)^{-1} q_t b_{F,t+1} \end{aligned} \tag{2.3.9}$$

The representative household will maximize intertemporal utility subject to budget constraints as the one in period t, (2.3.9), and labor supply constraints as the one in period t, (2.3.6). Hence, the household will compute first order conditions to determine the optimal choices of consumption, c_t, the specific nominal wage, $W_t(j)$, the ownership shares of both domestic equity, $S_{H,t+1}$, and foreign equity, $S_{F,t+1}$, the purchases of both domestic bonds, $b_{H,t+1}$, and foreign bonds, $b_{F,t+1}$.

Sticky wages are introduced also as in Erceg *et al.* (2000), assuming that there is only a proportion $1-\eta_w$ of households who can set optimally the nominal wages according to the Calvo (1983)-type fixed probability scheme. The remaining η_w share of the households will have to follow a weighted-indexation rule on lagged CPI inflation and steady-state CPI inflation. For an adjustment to take place in period t, the indexation factor is

$$(1+idx_t^w) = (1+\pi_{t-1}^{CPI})^{\kappa_w}(1+\pi+\varepsilon_t^W)^{1-\kappa_w}$$

which includes the weight parameter $0<\kappa_w<1$ and a wage-push AR(1) shock, $\varepsilon_t^W = \rho_W \varepsilon_{t-1}^W + u_t^W$ with white-noise innovations $u_t^W \sim N(0,\sigma_{u^W})$. The first order condition on the optimal choice of the nominal wage brings a relative wage as a mark-up on the ratio between the marginal rate of substitution and the real wage

$$\widetilde{W}_t(j) = \frac{W_t(j)}{W_t} = \left(\frac{\theta_w}{\theta_w-1}\right)\mathbb{E}_t\sum_{k=0}^{\infty}\eta_w^k\frac{\beta_{t+k+1}}{\beta_{t+k}}\frac{\xi_{t+k}n_{t+k}\Pi_{s=1}^k\left(\frac{1+\pi_{t+s}^w}{1+idx_{t+s}^w}\right)^{\theta_w}}{\lambda_{t+k}w_{t+k}n_t\Pi_{s=1}^k\left(\frac{1+\pi_{t+s}^w}{1+idx_{t+s}^w}\right)^{\theta_w-1}}$$

where π^w gives the quarterly rate of nominal wage inflation and both λ and ξ, respectively, denote the marginal utility of consumption and the marginal disutility of labour for the households that can set the optimal wage in period t. From the Dixit-Stiglitz aggregator of nominal wages,

$$W_t = \left[(1-\eta_w)\,W_t(j)^{1-\theta_w} + \eta_w\left(\left(1+idx_t^w\right)W_{t-1}\right)^{1-\theta_w}\right]^{1/(1-\theta_w)},$$

we can obtain the following expression for the relative wage

$$\widetilde{W}_t(j)^{(\theta_w-1)} = (1-\eta_w)+\eta_w \left[(1+\pi_{t-1}^{CPI})^{\kappa_w}(1+\pi_{ss}^{CPI}+\varepsilon_t^W)^{1-\kappa_w}\right]^{(1-\theta_w)}(1+\pi_t^w)^{\theta_w-1}\widetilde{W}_t(j)^{(\theta_w-1)}$$

2.3.2 Firms

There is a continuum of producers of differentiated consumption goods that operate under monopolistic competition and seek to maximize their profits. They are indexed in the unit interval, so as to have the representative i firm where $i \in [0,1]$. In this setup, there is no physical capital and the amount of output produce depends on labor employed and a technology shock. Let us denote $P_{H,t}(i)$ as the price set by the representative domestic (home) firm i in period t, and $P_{H,t}$ as the home producer price index. Firm dividend obtained by the representative firm is

$$d_t(i) = \frac{P_{H,t}(i)}{P_{H,t}}y_t(i) - \frac{P_t}{P_{H,t}}\frac{W_t}{P_t}n_t(i)$$

which faces a Dixit-Stiglitz demand constraint

$$y_t(i) = \left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\epsilon} y_t$$

that implies

$$d_t(i) = \left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{1-\epsilon} y_t - \frac{P_t}{P_{H,t}}\frac{W_t}{P_t}n_t(i)$$

It should be noticed that firm dividend is measured in real terms as bundles of the consumption goods produced by all domestic firms. This is a different unit of measure from the bundle of all consumption goods for domestic households (which would also include imported goods produced by foreign firms). Therefore, it is convinient to introduce the relative prices as the ratio of the price index of domestically produced goods (Producer Price Index, PPI), denoted as $P_{H,t}$, and price of bundles of all consumption goods (CPI)

$$RP_t \equiv \frac{P_{H,t}}{P_t}; \tag{2.3.10}$$

which for the foreign economy would be $RP_t^* \equiv P_{F,t}^*/P_t^*$. The aggregation across the continuum of firms and the relative price definition, (2.3.10), result in the following real aggregate dividend, in terms of the household consumption bundle,

$$d_t \equiv \frac{P_{H,t}}{P_t}\int_0^1 d_t(i)di = RP_t\left(\int_0^1\left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{1-\epsilon}di\right)y_t - w_t\int_0^1 n_t(i)di$$

The production technology is linear on labor

$$y_t(i) = e^{\varepsilon_t^A}An_t(i)$$

and incorporates an AR(1) productivity shock, $\varepsilon_t^A = \rho_A\varepsilon_{t-1}^A + u_t^A$ with white-noise innovations $u_t^A \sim N(0, \sigma_{u^A})$. Using this production function and the Dixit-Stiglitz demand constraint in the labor cots of the aggregate dividend gives

$$d_t = y_t\left[RP_t\left(\int_0^1\left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{1-\epsilon}di\right) - \left(\frac{w_t}{e^{\varepsilon_t^A}A}\right)\int_0^1\left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\epsilon}di\right] \tag{2.3.11}$$

Following Schmitt-Grohe and Uribe (2006), we define the price dispersion indicators

$$PD_t \equiv \int_0^1\left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{1-\epsilon}di \quad ; \quad PDD_t \equiv \int_0^1\left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\epsilon}di$$

which can be plugged in (2.3.11) to reach the final expression for the aggregate dividend (measured in terms of domestically-produced bundles of consumption goods)

$$d_t = y_t\left[RP_tPD_t - \left(\frac{w_t}{e^{\varepsilon_t^A}A}\right)PDD_t\right] \tag{2.3.12}$$

Each firm sets the price of a unique differentiate good and earns some monopoly profit. We include price stickiness following Calvo (1983)-type rigidity for price adjustments. In this way, a fraction of $(1-\eta_p)$ randomly selected firms set optimal prices each period, with an individual firm's probability of re-setting in any given period being completely independent of the time elapsed since it last re-optimized its price. For cases when the firm cannot setthe optimal price, the price indexation factor takes this specific form

$$(1+idx_{t+k}^{p}) = (1+\pi_{t+k-1}^{PPI})^{\kappa_p}(1+\pi+\varepsilon_{t+k}^{P})^{1-\kappa_p}$$

that combines adjustments to lagged producer price inflation, $\pi_t^{PPI} = P_{H,t}/P_{H,t-1} - 1$, the steady-state price inflation, π, and the AR(1) price-push shock, $\varepsilon_t^p = \rho_p \varepsilon_{t-1}^p + u_t^p$ with white-noise innovations $u_t^p \sim N(0, \sigma_{u^p})$.

Assuming that the Calvo signal allows optimal pricing, the representative firm would choose $P_{H,t}(i)$ by solving the following maximization problem

$$Max \sum_{k=0}^{\infty} \mathbb{E}_t \left[\frac{\Theta_{t+k+1}}{\Theta_{t+k}} \eta_p^k y_{t+k} \left(\int_0^1 \left(\frac{RP_{t+k}(1+idx_{t+k}^{p})P_{H,t}(i)}{P_{H,t+k}} \right)^{1-\epsilon} di \; - \left(\frac{w_{t+k}}{e^{\varepsilon_{t+k}^{A}} A} \right) \int_0^1 \left(\frac{(1+idx_{t+k}^{p})P_{H,t}(i)}{P_{H,t+k}} \right)^{-\epsilon} di \right) \right.$$

where $\frac{\Theta_{t+k+1}}{\Theta_{t+k}}$ is the stochastic discount factor between period $t+k$ and period $t+k+1$.[11] The (relative) optimal price obtained from the firm's maximization problem is

$$\widetilde{P_{H,t}}(i) = \frac{P_{H,t}(i)}{P_{H,t}} = \left(\frac{\epsilon}{\epsilon - 1} \right) \mathbb{E}_t \sum_{k=0}^{\infty} \frac{\Theta_{t+k+1}}{\Theta_{t+k}} \eta_p^k \frac{(mc_{t+k})\, y_{t+k} \Pi_{s=1}^{k} \left(\frac{1+\pi_{t+s}^{p}}{1+idx_{t+s}^{p}} \right)^{\epsilon}}{y_{t+k} \Pi_{s=1}^{k} \left(\frac{1+\pi_{t+s}^{p}}{1+idx_{t+s}^{p}} \right)^{\epsilon-1}} \tag{2.3.13}$$

[11] The domestic firm discount factor is not the household's inter-temporal marginal rate of substitution since the firm is owned by domestic and foreign agents, thus a weighted combination of the home and foreign discount factors is utilized as in Devereux and Sutherland (2010)

where $0 < \eta_p < 1$ is the Calvo probability and $mc_{t+k} = \frac{w_{t+k}}{RP_{t+k}\left(e^{\varepsilon^A_{t+k}}A\right)}$ is the real marginal cost in period $t+j$. From the Dixit-Stiglitz aggregator, we define the PPI of domestic firms,

$$P_{H,t} = \left[(1-\eta_p)\, P_{H,t}(i)^{1-\epsilon} + \eta_p \left((1+idx^p_t)\, P_{H,t-1} \right)^{1-\epsilon} \right]^{1/(1-\epsilon)},$$

which implies this dynamic equation for the relative price of the representative firm

$$\widetilde{P_{H,t}}(i)^{(\epsilon-1)} = (1-\eta_p)+\eta_p \left[(1+\pi^{PPI}_{t-1})^{\kappa_p} (1+\pi+\varepsilon^P_t)^{1-\kappa_p} \right]^{(1-\epsilon)} (1+\pi^{PPI}_t)^{\epsilon-1} \widetilde{P_{H,t}}(i)^{(\epsilon-1)} \tag{2.3.14}$$

2.3.3 Central bank

Nominal interest rate (R_t) is determined through a reaction function describing Taylor (1993)-type monetary policy decisions made by the the central bank

$$1+R_t = \left((1+r)\,(1+\pi)^{(1-\mu_\pi)} \right)^{(1-\mu_R)} (1+R_{t-1})^{\mu_R} \left(1+\pi^{CPI}_t\right)^{(1-\mu_R)\mu_\pi} \left(\frac{y_t}{y_{t-1}}\right)^{(1-\mu_R)\mu_y} exp(\varepsilon^R_t) \tag{2.3.15}$$

where $\mu_\pi > 1$ is the policy coefficient for responses to CPI inflation, $\mu_y > 0$ is the policy coefficient for response to output growth, $0 < \mu_R < 1$ is the smoothing coefficient for gradual adjustments of the nominal interest rate and there is also an AR(1) monetary policy shock $\varepsilon^R_t = \rho_R \varepsilon^R_{t-1} + u^R_t$ with white-noise innovations $u^R_t \sim N(0, \sigma_{u^R})$. The constant term serves to pin down the steady-state rate relationship between nominal interest rate, real interest rate and inflation, $1+R = (1+r)\,(1+\pi)$.

A similar rule, with specific policy coefficients, is assumed for the monetary policy of the foreign economy.

2.3.4 Government

Finally, lump-sum transfers of the government are financed by selling bonds to local and foreign households. In turn, the government budget constraint becomes in aggregate output terms. Note that r_t refers to real interest rate.

$$g_t = tax_t + \frac{b_{H,t+1}}{1+r_t} - b_{H,t} + \frac{b^*_{H,t+1}}{1+r_t} - b^*_{H,t} \tag{2.3.16}$$

where public spending g_t is exogenously determined. Particularly, deviations from the steady-state level of government purchases are determined as follows

$$g_t = e^{\varepsilon^g_t} g_{ss}$$

and the exogenous component ε^g_t is generated by an AR(1) time series $\varepsilon^g_t = \rho_g \varepsilon^g_{t-1} + \rho_{gA} u^A_t + u^g_t$ with white-noise innovations $u^g_t \sim N(0, \sigma_{u^g})$ and, following Smets and Wouters (2007), a cross effect coming from the innovations of the technology shock.[12]

2.3.5 Equilibrium conditions and the balance of payments

For a representative j good produced in the domestic economy, the market clearing condition is

$$y_t\,(i) = c_{H,t}\,(i) + c^*_{H,t}\,(i) + g_t\,(i)$$

The optimal choices of the home differentiated consumption good, decided by domestic and foreign households are, respectively,

$$c_{H,t}\,(i) = \left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\epsilon} c_{H,t} \text{ and } c^*_{H,t}\,(i) = \left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\epsilon^*} c^*_{H,t}$$

[12] A innovation to the technology shock would result in a higher autonomous spending through either capital accumulation or net exports from the rest of the world excluding the foreign economy. Both elements are ignored in the model setup and could be captured by the cross correlation between technology innovations and variations in the exogenous component of aggregate spending.

Meanwhile the government purchases the same amount of all domestically produced goods. Implementing the aggregation across domestically-produced goods, we obtain the aggregate goods market clearing condition

$$PD_t y_t = PD_t c_{H,t} + PD_t^* c_{H,t}^* + g_t \tag{2.3.17}$$

where $c_{H,t}$ corresponds to domestic demand for domestic goods and $c_{H,t}^*$ foreign demand for domestic goods (domestic exports), g_t is the amount of government purchases of domestic bundles, PD_t is the price dispersion defined above, and PD_t^* is the following price dispersion indicator that takes the foreign elasticity of substitution

$$PD_t^* \equiv \int_0^1 \left(\frac{P_{H,t}(i)}{P_{H,t}} \right)^{1-\epsilon^*} di$$

Asset markets clear at all times according to the following equilibrium conditions

$$S_{H,t} + S_{H,t}^* = S_{F,t} + S_{F,t}^* = 1; \tag{2.3.18}$$

$$b_{H,t} + b_{H,t}^* = b_{F,t} + b_{F,t}^* = 0 \tag{2.3.19}$$

Noticing that $S_{H,t}^*$ refers to the foreign share of domestic equity, and $S_{F,t}^*$ would refer to the foreign share of foreign equity. The same applies to $b_{F,t}^*$ and $b_{H,t}^*$.

In the labor market, the equilibrium condition is

$$\int_0^1 n_t(i) di = n_t$$

which combined with the production function, $y_t(i) = e^{\varepsilon_t^A} n_t(i)$, and the Dixit-Stiglitz demand constraint, $y_t(i) = \left(P_{H,t}(i)/P_{H,t}\right)^{-\epsilon} y_t$, result in the following aggregate production function

$$y_t \int_0^1 \left(P_{H,t}(i)/P_{H,t}\right)^{-\epsilon} di = e^{\varepsilon_t^A} n_t$$

or

$$PDD_t y_t = e^{\varepsilon_t^A} n_t$$

Finally, let us discuss the key ingredients of the balance of payments for the domestic economy: the net exports from trading in the goods market and the net foreign assets position from trading in the financial markets. Exports for domestic firms are decided by foreign households. Recalling the choice of foreign goods, (2.3.4), and applying it to the decision of foreign households, exports of domestic firms would be

$$ex_t = \alpha^* \left(\frac{P_{H,t}}{e_t P_t^*} \right)^{-\theta^*} c_t^*$$

where using the definition of the real exchange rate, $q_t = e_t P_t^* / P_t$, and relative prices, (2.3.10), we get

$$ex_t = \alpha^* \left(\frac{RP_t}{q_t} \right)^{-\theta^*} c_t^*$$

Imports are decided by domestic households as an inverse function of its relative price, (see $c_{F,t}$ in (2.3.4)), which means

$$im_t = \alpha \left(RP_t^* q_t \right)^{-\theta} c_t,$$

The trade balance of consumption goods determines net exports

$$NX_t = ex_t - im_t$$

For the trading of financial assets, we define the net foreign asset holdings in period t from the joint contribution of equity and bonds,

$$NFA_t \equiv [\alpha_{EF,t} + \alpha_{BF,t} - \alpha_{EH,t}^* - \alpha_{BH,t}^*]$$

where $\alpha_{EF,t} = q_t v_t^* S_{F,t+1}$ is the foreign equity holdings of the domestic households (expressed in domestic bundles through the real exchange rate), $\alpha_{BF,t} = (1+r_t^*)^{-1} q_t b_{F,t+1}$ is the amount of foreign bond holdings of the domestic households (also expressed in domestic bundles), $\alpha^*_{EH,t} = v_t S^*_{H,t+1}$ is the amount of domestic equity purchased by foreign households and $\alpha^*_{BH,t} = (1+r_t)^{-1} b^*_{H,t+1}$ is the amount of domestic bonds owned by foreign households. The reference asset will be domestic equity and the asset holdings of domestic households at the end of period $t-1$ are allocated in the column vector

$$\alpha_{t-1} = \begin{bmatrix} \alpha_{EF,t-1} \\ \alpha_{BH,t-1} \\ \alpha_{BF,t-1} \end{bmatrix} = \begin{bmatrix} q_{t-1} v^*_{t-1} S_{F,t} \\ (1+r_{t-1})^{-1} b_{H,t} \\ \left(1+r^*_{t-1}\right)^{-1} q_{t-1} b_{F,t} \end{bmatrix}$$

Moreover, the return differentials with respect to domestic equity used to determine the valuation effects and the NFA position are

$$r_{x,t-1} = \begin{bmatrix} \frac{q_t}{q_{t-1}} (1+r_{EF,t-1}) - 1 - r_{EH,t-1} \\ r_{BH,t-1} - r_{EH,t-1} \\ \frac{q_t}{q_{t-1}} (1+r_{BF,t-1}) - 1 - r_{EH,t-1} \end{bmatrix} = \begin{bmatrix} \frac{q_t}{q_{t-1}} \left(\frac{d_t^* + v_t^*}{v^*_{t-1}}\right) - \left(\frac{d_t + v_t}{v_{t-1}}\right) \\ r_{t-1} - \left(\left(\frac{d_t + v_t}{v_{t-1}}\right) - 1\right) \\ \frac{q_t}{q_{t-1}} \left(1 + r^*_{t-1}\right) - \left(\frac{d_t + v_t}{v_{t-1}}\right) \end{bmatrix}$$

which includes the differential, with respect to the domestic equity return, of returns from foreign equity (first row), domestic bonds (second row) and foreign bonds (third row). As carefully proved in the technical appendix, we could combine the household budget constraint, the government budget constraint, equilibrium conditions of the asset markets and the definitions of $r_{x,t-1}$ and α_{t-1} to obtain the following dynamic equation for the NFA position of the domestic economy

$$NFA_t - \left(\frac{d_t + v_t}{v_{t-1}}\right) NFA_{t-1} = w_t n_t \int_0^1 \left(\frac{W_t(j)}{W_t}\right)^{1-\theta_w} dj + d_t - g_t - c_t + r'_{x,t} \alpha_{t-1}$$

Moreover, the valuation effects can be defined from the return differentials and the gain in the market value of lagged NFA

$$VAL_t = r'_{x,t}\alpha_{t-1} + \left(\frac{v_t}{v_{t-1}} - 1\right) NFA_{t-1}$$

in a way to extracted from the expression of NFA above to have the link between the change in NFA and valuation effects

$$\triangle NFA_t = w_t n_t \int_0^1 \left(\frac{W_t(j)}{W_t}\right)^{1-\theta_w} dj + d_t + \left(\frac{d_t}{v_{t-1}}\right) NFA_{t-1} - (g_t + c_t) + VAL_t$$

The variation of NFA can be explained from two sources:

i) the difference between total domestic income, $w_t n_t \int_0^1 \left(\frac{W_t(j)}{W_t}\right)^{1-\theta_w} dj + d_t + \left(\frac{d_t}{v_{t-1}}\right) NFA_{t-1}$, and total domestic expenditures both from the public and the private sectors, $g_t + c_t$ which in national accounting terms would proxy for net exports, and

ii) the valuation effects that results from changes in the value of net asset holdings expressed in domestic currency.

The complete set of dynamic equations of the model and can be reviewed in the technical appendix. The model can be solved numerically using the *stoch_simul* routine in Dynare. Even though the model is introduced in its original (non-linear) form, the numerical methods taken for obtaining the solution form use first-order approximations. The calibration of the model parameters is discussed next.

2.4 Calibration

The two-economy model is calibrated to represent Canada as the home economy and the US as the foreign economy. One time period in the model corresponds to one quarter, which is consistent with the short-run analysis of business cycle fluctuations.

A symmetric calibration is initially assumed for both economies due to their high degree of economic integration and the similarities in the institutional framework and market regulation. Nevertheless, some of the parameters take country-specific values in order to accommodate differences in economic outcomes. The selection criteria for the asymmetric parameter calibration is twofold. First, we calibrate a subset of parameters to match long-run data properties individually observed in either US or Canada data. Second, the parameters that shape the stochastic elements of the model are specified at values that fairly replicate some of the business cycle patterns documented from either the US or Canada. In particular, we will look at second-moment statistics of real GDP growth, price inflation, wage inflation and the nominal interest rate. The data considered correspond to quarterly observations for the period 1990:1 to 2018:2, expressed in per capita terms of the population older than 16 years and seasonally adjusted. The values for the baseline model calibration are reported in Tables 2.1 and 2.2.

The parameters that characterize household preferences have been set identically for both economies. Thus, we use the values of the elasticities on consumption marginal utility, σ, and hours marginal disutility, γ, found for the US in the estimated DSGE model of Smets and Wouters (2007) for both the US and Canada. Likewise, the consumption habits parameter, h, takes the value reported by Smets and Wouters (2007). The weight of the hours disutility contribution to the overall utility takes the value that results in a normalized labor $n = 1$ in the steady state solution of the model for Canada.

The discount factor parameter ς has a substantial impact on the steady-state real interest rate, r. Thus, it also plays a crucial role on the steady state value of firm equity ($\nu = d/r$, where v is equity and d is firm dividend in steady state) and the net foreign asset position. Since the historical average of net foreign assets of Canada with respect to the US is negative, we have decided to calibrate ς at different values for Canada and the US. Our target has been the average net foreign assets over GDP for Canada in its trading with the US from 1990 to 2018. We make it correspond to the steady-state ratio NFA/y in the model. After the calibration, $\varsigma = 0.0075$ and $\varsigma^* = 0.0059$, the model delivers $NFA/y = -0.65$ close enough to the mean value of -0.63 observed in the data displayed in Figure 2.1. The steady-state real interest rate in the model is common for both economies at $r = r^* = 0.0033$, an annualized rate of 1.32%.

Table 2.1. Parameter calibration. Non-stochastic elements.

	Canada	US
Elasticity of consumption marginal utility	$\sigma = 1.39$	$\sigma^* = 1.39$
Consumption habits	$h = 0.71$	$h^* = 0.71$
Elasticity of hours marginal disutility	$\gamma = 1.92$	$\gamma^* = 1.92$
Weight of hours disutility	$\psi = 6.78$	$\psi^* = 6.78$
Discount rate parameter	$\varsigma = 0.0075$	$\varsigma^* = 0.0059$
Labor productivity	$A = 1.0$	$A^* = 1.26$
Elasticity of substitution across domestic goods	$\epsilon = 6.0$	$\epsilon^* = 6.0$
Elasticity of substitution across labor services	$\theta_w = 3.0$	$\theta_w^* = 3.0$
Elasticity of substitution between domestic and foreign goods	$\theta = 1.5$	$\theta^* = 1.5$
Home good bias	$\alpha = 0.36$	$\alpha^* = 0.26$
Steady-state ratio of autonomous spending over GDP	$g_{ss}/y_{ss} = 0.41$	$g_{ss}^*/y_{ss}^* = 0.38$
Calvo probability for price stickiness	$\eta_p = 2/3$	$\eta_p^* = 0.85$
Calvo probability for wage stickiness	$\eta_w = 0.75$	$\eta_w^* = 0.5$
Weight of price indexation on lagged inflation	$\kappa_p = 0.2$	$\kappa_p^* = 0.2$
Weight of wage indexation on lagged inflation	$\kappa_w = 0.2$	$\kappa_w^* = 0.2$
Inflation coefficient in monetary policy rule	$\mu_\pi = 1.5$	$\mu_\pi^* = 1.5$
Output coefficient in monetary policy rule	$\mu_y = 0.5/4$	$\mu_y^* = 0.5/4$
Smoothing coefficient in monetary policy rule	$\mu_R = 0.9$	$\mu_R^* = 0.9$

The production technology ignores capital accumulation and a linear function relates employment to output produced. Since the average per capita real GDP has been 18% higher in the US than Canada, we have decided to set labor productivity A as a country-specific value that matches the average Canada/US ratio in the steady-state solution of the model. Setting $A = 1.0$ and $A^* = 1.26$, the steady-state solution of the model implies $y/y^* = 0.85$, which is precisely the inverse value of 1.18.

The internal elasticities of substitution in the goods market (demand for consumption goods, ϵ) and in the labor market (supply for labor services, θ_w) are set are standard values from the DSGE literature for both the US and Canada. Thus, we fix $\epsilon = \epsilon^* = 6.0$ to imply a 20% steady-state mark-up of prices over the marginal cost, and $\theta_w = \theta_w^* = 3$ to have a wedge between the real wage and the marginal rate of substitution of 50%. It is known that the estimation of the intra-temporal elasticity of substitution between domestic and foreign goods, θ, is quite controversial (Justiniano and Preston, 2004; Adolfson *et al.,* 2004). Most of the existing theoretical papers use a value of 1.5, as suggested by Backus *et al.* (1992). We follow this criterion for both Canada and the US and give $\theta = \theta^* = 1.5$.

The home goods bias parameter is set at $\alpha = 0.36$ in Canada and at a lower value $\alpha^* = 0.26$ in the US. It should be noticed that a lower α implies a stronger preference for domestic good relative to foreign goods. We have introduced this asymmetry to render a positive net exports for Canada with the US. The data show a mean value of Canadian net exports to the US equivalent to 3% of Canadian GDP over the sample period 1990-2018. Our steady-state solution gives $nx/y = 0.03$. The mean value of Canadian exports to the US and Canadian imports from the US over Canadian GDP are also replicated in the steady state solution of the model with $ex/y = 0.22$ and $im/y = 0.19$.

The steady state share of government expenditures over GDP is calibrated at $g/y = 0.41$ in Canada and, slightly lower in the US, $g^*/y^* = 0.38$. Our model abstracts from capital accumulation and net exports with the rest of the world. Thus, g/y and g^*/y^* take higher value than the empirical average values for Canada and the US, since the numerator captures all factors determining output that are model-exogenous, including investment and net exports with the rest of the world. The steady-state solution of the model brings $c/y = 0.56$ and $c^*/y^* = 0.65$ which provides a good matching to the actual ratios observed in Canada and the US, and brings a higher share over GDP in the US than in Canada (67% versus 56% on average from 1990 to 2018).

The monetary policy parameters are set at identical values for the US and Canada. Both the inflation and output coefficients are the ones recommended in the original Taylor (1993) rule, $\mu_\pi = \mu_\pi^* = 1.5$ and $\mu_y = \mu_y^* = 0.5/4$, whereas the smoothing parameter is at $\mu_R = \mu_R^* = 0.9$ to reproduce the long inertia and slow adjustments of policy rates set by the Fed and the Bank of Canada. This assumes a high degree of monetary coordination and it is consistent with the leading role for monetary actions and global fluctuations that has been found empirically by Miranda-Agrippino and Rey (2015).

The remaining parameters have been calibrated looking at the characteristics of the quarterly fluctuations observed in the data. In particular, we have paid attention to the series of (per capita) real GDP growth, producer price inflation (from the GDP implicit price deflator), nominal wage inflation and the nominal interest rates displayed in Figure 2.2 and with second-moment statistics reported in Table 2.3.[13] The numbers displayed in Table 2.3 indicate that price inflation is less volatile (lower standard deviation) and more persistent (higher autocorrelation) in the US than in Canada. Thus, we have assumed more price rigidities in the US and set a Calvo probability for the foreign economy at $\eta_p^* = 0.85$, whereas the domestic economy (Canada) takes a substantial lower value $\eta_p = 2/3$. No autocorrelation is assumed for the price-push shocks of both economies to keep the inflation autocorrelation low. The lagged inflation component of the price indexation rule is fixed at a small value for both economies $\kappa_p = \kappa_p^* = 0.2$ also to avoid excessive inflation inertia in the model. On the comparison shown at Table 2.3, it can be observed that model simulations provide a good fit of Canadian inflation volatility (standard deviation)

[13]The time series of the US nominal interest rate correspond to the shadow interest rate elaborated by Wu and Xia (2016) to bring the effects of unconventional monetary policy in the quarters of the zero lower bound constraint. A detailed description of the time series taken from the data is available in the technical appendix.

but US inflation volatility is significantly lower in the data (both from PPI and CPI inflation). Moreover, the model overestimates the inflation inertia, as it embeds a price rigidity structure that inherently results in high autocorrelation for inflation. Similar comments can be mentioned for the US inflation.

Regarding wage inflation, we introduce asymmetric behavior on wage setting. The Calvo probability for wage stickiness is set at the standard value $\eta_w = 0.75$ in Canada (average duration of wage contract at one year) and at a lower value in the US, $\eta_w^* = 0.5$ (average duration of wage contract at half a year). Such differentiated calibration is motivated by the empirical evidence reported in Table 2.3, where wage inflation in Canada is less volatile (lower standard deviation) and more persistent (higher coefficient of autocorrelation) than in the US.[14] Wage indexation on lagged inflation is weak both in Canada ($\kappa_w = 0.2$) and in the US ($\kappa_w^* = 0.2$) to generate low wage inflation inertia but still accommodate for the effects of wage-push shocks entering the wage indexation rule.

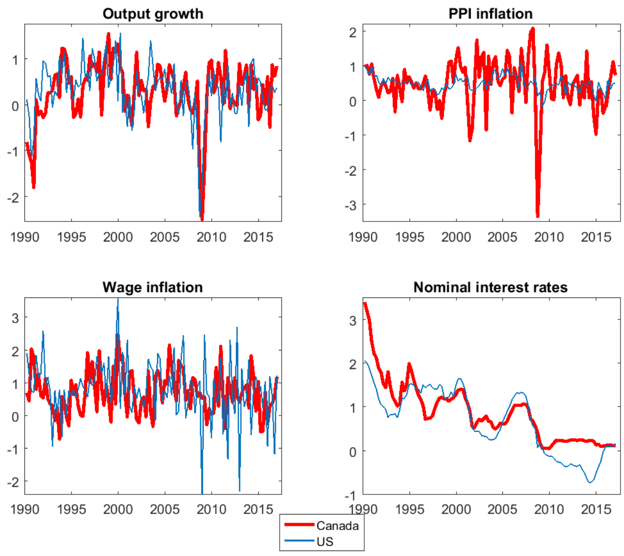

Figure 2.2: Quarterly macroeconomic fluctuations in Canada and the US, 1990-2018

[14]Our sticky-wage model cannot replicate the negative autocorrelation of US wage inflation, which comes explained by the erratic fluctuations observed after 2008 (see Figure 2.3).

Regarding the calibration of the generating processes for the exogenous variables (see Table 2.2), the technology shock and the monetary policy shock are common for both economies (global shocks). This helps to obtain a business cycle synchronization and it gives a positive correlation between output growth of both the domestic economy (Canada) and the foreign economy (US) in the model at 0.52, close to the number found in the data, 0.56. The coefficient of autocorrelation of the technology shock is the usual value, 0.95 and the autocorrelation of the monetary policy shock is low at 0.35, close to the estimated number reported by Smets and Wouters (2007). The standard deviation of the innovations to technology and monetary shocks are decided to match the variability of output growth observed in the data and also to obtain reasonable shares of the impact of these shocks on the long-run output growth variance decomposition.[15]

Table 2.1: Parameter Values. Stochastic elements

	Canada	US
Technology shock, standard deviation of the innovation, %	$\sigma_{u^A} = 0.89$	
Technology shock, coefficient of autocorrelation	$\rho_A = 0.95$	
Monetary policy shock, standard deviation of the innovation, %	$\sigma_{u^R} = 0.17$	
Monetary policy shock, coefficient of autocorrelation	$\rho_R = 0.35$	
Public spending shock, standard deviation of the innovation, %	$\sigma_{u^g} = 1.05$	$\sigma^*_{u^g} = 1.41$
Public spending shock, coefficient of autocorrelation	$\rho_g = 0.9$	$\rho^*_g = 0.9$
Public spending shock, cross correlation with tech. innovations	$\rho_{gA} = 0.6$	$\rho^*_{gA} = 0.6$
Price-push shock, standard deviation of the innovation, %	$\sigma_{u^p} = 0.3$	$\sigma^*_{u^p} = 0.09$
Price-push shock, coefficient of autocorrelation	$\rho_p = 0.0$	$\rho^*_p = 0.0$
Wage-push shock, standard deviation of the innovation, %	$\sigma_{u^W} = 0.67$	$\sigma^*_{u^W} = 1.10$
Wage-push shock, coefficient of autocorrelation	$\rho_W = 0.0$	$\rho^*_W = 0.0$

The public spending shock features long inertia for both Canada and the US (coefficient of autocorrelation at 0.9 in both cases), and a higher volatility on the

[15] In the calibrated model, technology shocks explain 40% of output growth variability for Canada and 14% for the US. Monetary policy shocks take a share of 23% of Canadian output growth variance decomposition and 24% of that of the US output growth.

innovations for the US in order to match the standard deviation of output growth observed in the data. The price-push shocks have no serial correlation to prevent the price inflation autocorrelation from rising. The standard deviation of the price-push innovations are calibrated at the values that give a good fit to the price inflation volatility observed in Canadian data. The standard deviation of US price shocks is just 30% of that set for Canada in order to replicate the relative observed variability of Canada and US inflation. As the wage-push shocks, they are not serially correlated because of the lack of persistence of wage inflation in the data and the innovations volatility is greater in the US also to approximately match the observed relative standard deviations.

Table 2.2: US-Canada descriptive statistics and their model-based values with baseline calibration

	Canada		US	
	Data	Model	Data	Model
Second-moment statistics				
Standard deviation of GDP rate of growth, %	0.68	0.67	0.60	0.59
Standard deviation of PPI inflation, %	0.74	0.61	0.22	0.53
Standard deviation of CPI inflation, %	0.64	0.56	0.62	0.54
Standard deviation of wage inflation, %	0.66	0.65	0.94	1.05
Standard deviation of the interest rate, %	0.94	0.30	0.69	0.31
Cross correlation across output growth	0.56	0.52	0.56	0.52
Cross correlation between PPI inflation and output growth	0.26	-0.41	-0.03	-0.06
Cross correlation between CPI inflation and output growth	-0.26	-0.34	0.16	-0.11
Cross correlation between wage inflation and output growth	-0.01	-0.02	-0.09	0.14
Cross correlation between the interest rate and output growth	-0.24	-0.23	0.11	-0.16
Autocorrelation of output growth	0.56	0.33	0.40	0.14
Autocorrelation of PPI inflation	0.36	0.74	0.52	0.89
Autocorrelation of CPI inflation	0.25	0.79	0.20	0.87
Autocorrelation of wage inflation	0.19	0.35	-0.23	0.34
Autocorrelation of interest rates	0.98	0.88	0.98	0.89

Finally, let us discuss the calibration of the asset holdings that enter the NFA equation to account for the valuation effects. The standard solution method, based on first-order approximations, cannot pin down a unique solution path for each portfolio asset holdings (e.g., $\alpha_{EH,t}$, $\alpha_{EF,t}$, $\alpha_{BH,t}$ and $\alpha_{BF,t}$ for the domestic economy).[16] The focus of this paper is to understand the factors behind a large increase in the Canadian NFA, given the specific position of Canada in each financial asset with the US. In fact, in the data (taking the period 1990-2018), the average US bond holdings owned by Canadian investors represent 17% of Canadian GDP, the average Canadian bond holdings owned by US investors is 83% of Canadian GDP and US equity holdings owned by Canadian investors account for 145% of Canadian GDP. These facts are used to fix the values of asset holdings as the following proportions to steady-state domestic output: $\alpha_{EF} = 1.45 y_{ss}$, $\alpha_{BH} = -0.83 y_{ss}$, and $\alpha_{BF} = 0.17 y_{ss}$.

2.5 Impulse-response functions

Next, we are going to discuss the propagation channels from changes in the exogenous variables to their effects over the endogenous variables. The calibrated model incorporates eight shocks and, due to space restrictions, we will analyze here the dynamic effects of five of them: a technology shock (Figure 2.3), a monetary policy shock (Figure 2.4), a public spending shock (Figure 2.5), a price-push shock (Figure 2.6), and a wage-push shock (Figure 2.7). In the case of the technology and monetary shock, the exogenous variation would be simultaneously affecting both the home (Canada) and foreign (US) economies as examples of global shocks. The other three cases (fiscal, price and wage shocks) represent innovations that initially enter the home (Canada) economies. The specific shocks to the foreign economy (US) are not discussed here but the effects for the domestic economy (Canada) can somehow be anticipated by the responses of the foreign economy to domestic shocks in Figures 2.5, 2.6 and 2.7. Furthermore, the contribution of the non-displayed shocks to the variance decomposition of Canadian variables is very small (lower

[16] See the Appendix for a more detailed explanation.

than 5% for output growth, price inflation, wage inflation and the nominal interest rate).

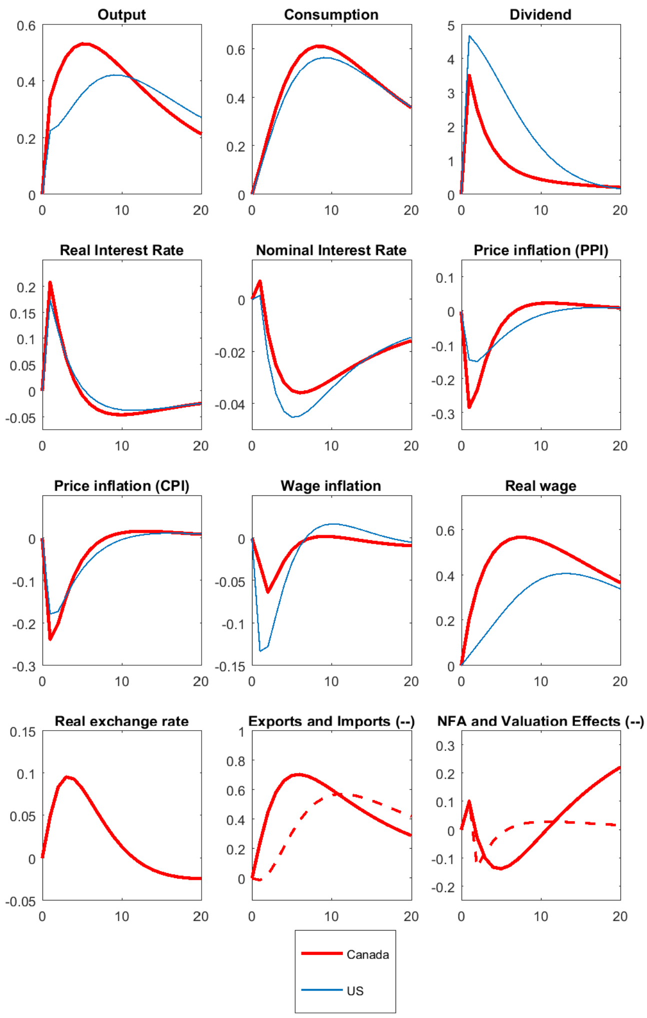

Figure 2.3: Impulse-response functions following a (global) technology shock

Figure 2.3 plots the responses to a one standard deviation technology shock, which would increase labor productivity by 0.89% simultaneously in the home economy (Canada) and the foreign economy (US). The fraction of firms that receive the Calvo signal to set the optimal prices will decide a lower price and they will observe a higher demand for consumption goods. As more fractions adjust optimally the price in Canada than in the US, the PPI inflation rate falls further in Canada. The rates of CPI inflation report more similar declines across the two economies because they incorporate the prices of foreign goods (imports). The central banks will reduce the nominal interest rate in reaction to lower CPI inflation falls (and despite the output growth). The real interest rate increases as the expected inflation slides down below the steady state rate. Exports and imports increase for both economies because international trading rises with higher household income and the taste for both domestic and foreign goods. Canadian net exports turn positive: taking advantage of the real exchange rate depreciating due to lower inflation in Canada than in the US. Wage inflation falls in both cases because of the decline in the marginal rate of substitution between hours and consumption. The fraction of households that can set their optimal wage will prefer a lower wage that increases their labor supply. As there are more firms setting a lower wage in the US than Canada (lower Calvo probability assumed in the calibration), wages fall more sharply in Canada. In turn, the real wage will be higher in Canada than in the US, while firm dividends will be higher in the US than in Canada.

The effects of a global monetary policy shock are displayed in Figure 2.4. An interest-rate shock that identically enters the monetary policy rule (2.3.15) for the home economy (Canada) and the analogous rule for the foreign economy (US) can represent the scenario of a higher cost of borrowing that emerged in the advance economies during the financial crisis of 2008. The shock results in a an increase of the nominal interest rate of 12.5 basis points (0.5% increase of the annualized nominal interest rate). The real interest rate reports a larger increase (close to 30 basis points) due to the expected deflation that the contractionary shock generates. As household demand for consumption goods falls, firms demand less labor and cut production downwards. Thus, the real wage falls and the fraction of firms that can optimize on price setting would decide to charge a lower price. Nominal interest rates, consumption and real interest rates report similar responses for both Canada

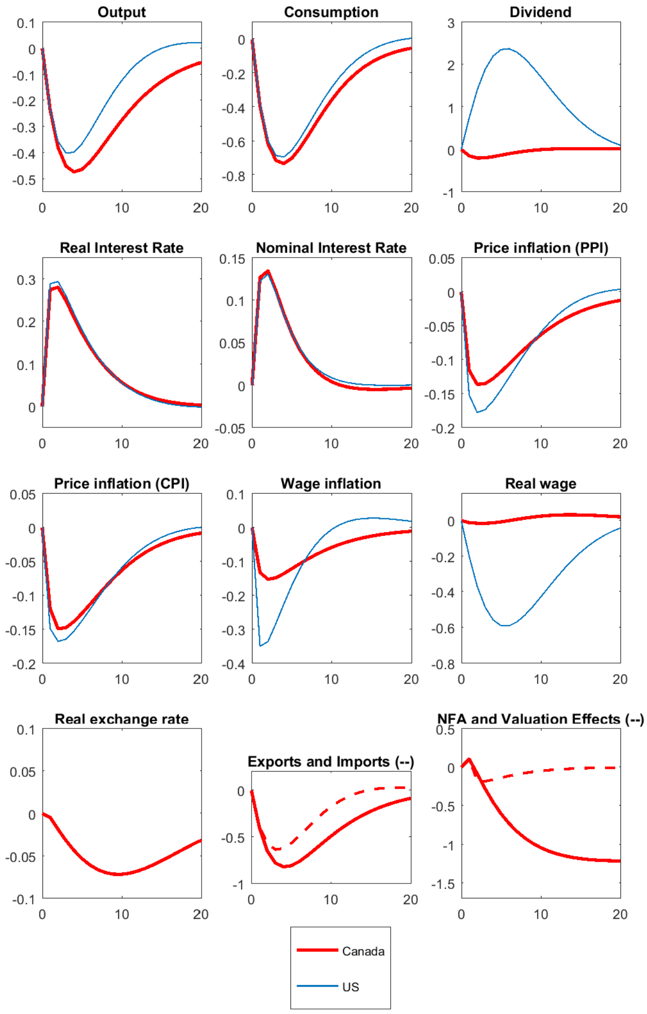

Figure 2.4: Impulse-response functions following a (global) interest rate shock

and the US. However, wage inflation and the real wage would have a more severe adjustment downwards in the US than in Canada. With a lower Calvo probability for wage rigidity, there will be a larger fraction of US households that would set a lower wage as they wish to supply more labor in response to a decrease in the marginal disutility from labor. The differences in the response of wage inflation makes the real wage fall significantly in the US whereas it barely moves down in Canada. The dividends of US firms become higher taking advantage of the lower cost of production, whereas Canadian firms see initially small profit reduction.

Firms price inflation (PPI) report similar declining patterns in US and Canada, with a more severe fall in the US due to the larger reduction in the marginal cost of production (and despite having less firms adjusting prices optimally). In turn, CPI inflation gets reduced slightly further in the US than in Canada. Regarding international trade, both Canadian exports and imports fall with the global recession. Moreover, Canadian net exports are negative because exports fall deeper than the reduction of imports. The reason for the negative current account effect in Canada is its real exchange rate appreciation (lower value) which comes along from the higher relative CPI prices in Canada. As a consequence, the US takes advantage of the external Canadian demand to reduce the negative impact of the monetary shock. The recession is milder in the US than in Canada as it is showed in the comparison of the output responses displayed in Figure 2.4.

The effects of a country-specific public spending shock in Canada can be seen in Figure 2.5. As the autonomous component of aggregate demand rises firms increase their sales and demand more labor. The cost of production increases in Canada and the fraction of firms that can set the optimal price will move it upwards. The rate of PPI inflation rises. The increase of home prices make Canadian households substitute domestic goods for US goods. Subsequently, the CPI inflation reports an initial drop at the time of the shock that is quickly corrected with the effect of higher prices of domestic goods.

The public spending shock has crowding-out effects on both domestic consumption and net exports. As the real interest rate increases, consumption reports a fall with a trough value observed five quarters after the shock of size equivalent to 1/6 of the impact on aggregate output. Meanwhile, the real exchange rate appreciates and net exports are negative jointly caused by the fall in exports and the increase of imports.

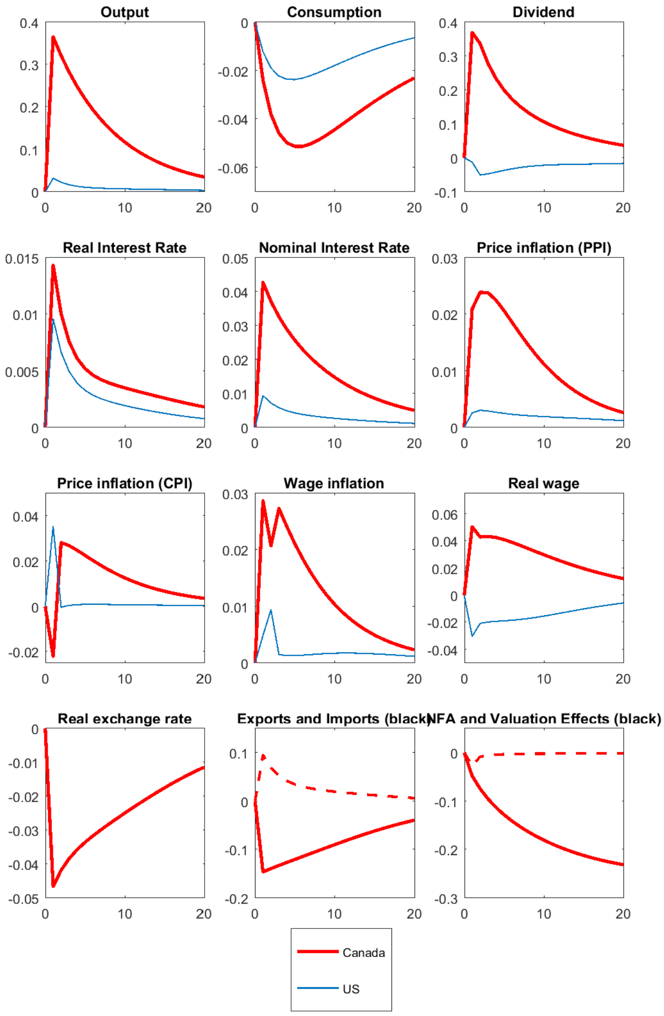

Figure 2.5: Impulse-response functions following a Canadian spending shock

The effects transmitted to the foreign (US) economy are mildly expansionary through external demand. Canadian imports are US exports that increase the demand for US goods. In turn, the responses observed in the US are higher output produced by firms, some price and wage inflation, higher nominal and real interest rates, and some crowding-out effect on consumption. All the responses have a significantly smaller size than the ones found for Canada.

Figure 2.6 provides the responses of a price-push shock that only hits the home economy. The fraction of Canadian firms that cannot set the optimal price will

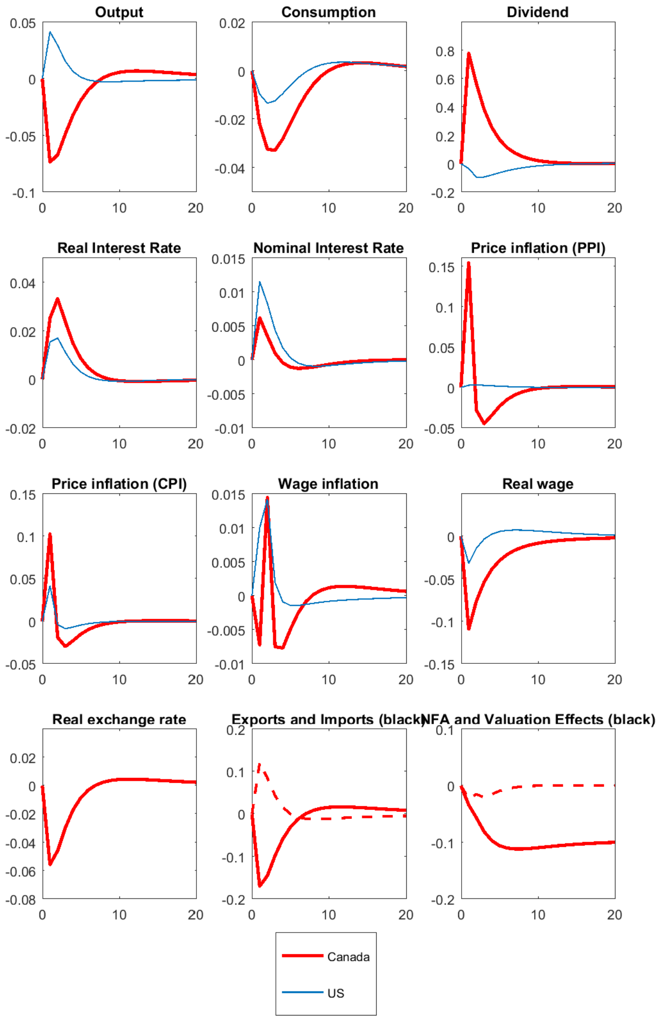

Figure 2.6: Impulse-response functions following a Canadian price-push shock

charge a higher selling price as they apply the indexation rule. The effects of the inflation shock on aggregate output are of reversed sign between the home economy (Canadian output falls) and the foreign economy (US output rises). As prices of Canadian producers increase the two endogenous components of aggregate demand (consumption and net exports) react with falls. The drop in domestic consumption is due to the preference for future consumption (savings) as households see the higher interest rates set by the central bank in reaction to the inflationary episode. Meanwhile, the real exchange rate appreciates with higher producer prices in Canada than in the US and net exports move downwards. Since households of both economies substitute between domestic and foreign goods, Canadian exports fall and their imported goods from the US increase.

The effect on wage inflation is very little. Following the impact of less labor employed in their marginal disutility, Canadian households decide to set lower wages while US households prefer higher wages. In both economies, the real wage falls because of higher inflation, especially in Canada where the impact of the inflation shock is primarily received. Firm dividends in Canada increase substantially because of higher firm revenues (higher selling prices) and lower costs of production (lower real wage).

Finally, the propagation of a Canada wage-push shock can be examined in Figure 2.7. Those Canadian households who cannot decide the optimal nominal wage adjust it upwards in the implementation of the wage indexation rule. Wage inflation rises and both the real wage and the cost of production move up. The pool of Canadian firms that can revise the price optimally respond to the higher cost of production charging higher prices. Producer inflation rises and the central bank announces a higher nominal interest rate as prescribed by the Taylor (1993)-type rule (2.3.15). The Canadian real wage goes up and firm dividends suffer a significant decline as a consequence of the larger cost of labor.

The real exchange rate appreciates due to the relative increase of Canadian CPI, and consumers substitute Canadian goods for US goods. As exports fall and imports rise, Canadian net exports move down and the aggregate demand drops. Moreover, consumption of domestic goods describes a u-shape downwards pattern in reaction to higher expected real interest rates (from the initial decline). The overall effect on output is also characterized by a u-shape plot. As for the foreign (US) economy, there is some price inflation and output growth caused by the Canadian wage shock. The boost of external demand (imports of Canadian households from

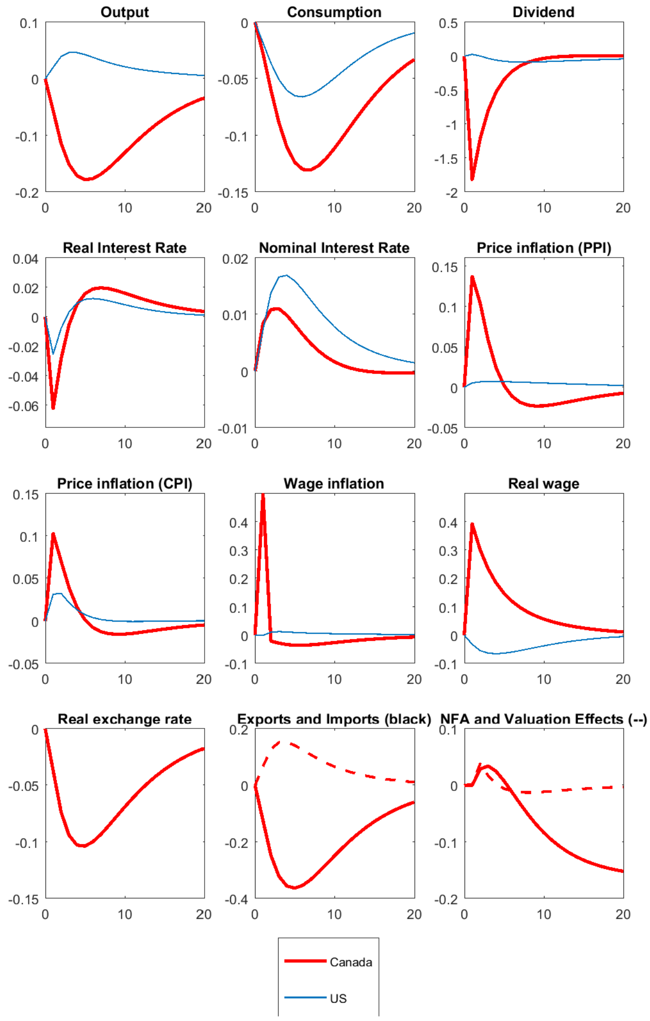

Figure 2.7: Impulse-response functions following a Canadian wage-push shock

US firms increase) explains that US output rises. As for inflation, there is a pass-through effect from the price of Canadian imported goods to the US price index (CPI). This effect eventually rises the nominal and real interest rates, which bring a fall of US consumption in a similar pattern to that of Canadian consumption.

2.6 The reversed two-way capital flows

This section takes the model to discuss the determinants, specifically, of the recent evolution in the Net Foreign Asset (NFA) position of Canada with respect to the US. As documented above (see Figure 2.1), there have been "reversed two-way" capital flows between Canada and the US from 2012 to 2018:

- FDI and the net Portfolio Equity position of Canada with respect of the US describes an upwards trend that moves the initial -50% of GDP in 2012 to more than 100% of GDP in 2018.

- The net Portfolio Bonds position remains on the negative sign and the unbalance keeps growing over the 2012-2018 period to reach the size of Canadian GDP

Since the quantitative implications for NFA are larger in the upwards move of net equity holdings than the downwards move of net bond holdings, the NFA position of Canada with respect to the US switches from being markedly negative upwards to close to the zero level. These capital flows took place along a significant reduction of Canadian net exports with the US, which started after the financial crisis of 2008.[17] Therefore, valuation effects should explain the variations observed in the position of the Canadian NFA with the US.

As the model cannot directly show fluctuations of gross capital flows due to the identification issues on asset holdings, we will analyze the return differentials for the international multi-asset portfolio to discuss the determinants of the reversed two-way phenomenon. Hence, let us introduce the *effective* rates of return obtained in the four assets available for the home/foreign households. These will be different from the *ex ante* expected returns that show up in the first order conditions. Obviously, the no arbitrage condition requires that *ex ante* all the returns get equalized in the portfolio choice. The evolution *ex post* may determine strategic decisions on how to reallocate asset holdings. Such effective returns on Canadian bonds, US bonds, Canadian equity and US equity (all of them expressed in terms of Canadian currency

[17]Between 1998 and 2007, Canadian net exports with the US represented on average 5.2% of Canadian GDP. From 2008 to 2017, this number has fallen to 1.7%. In the second quarter of 2016, there was even a current account deficit for Canada with the US equivalent to -0.28% of its GDP.

and evaluated in percentage annualized terms) are

$$\begin{aligned} r_{B,t}^{CAN} &= 400\left[(1+r_{t-1})\frac{1+E_{t-1}\pi_t^{CPI}}{1+\pi_t^{CPI}}-1\right] \\ r_{B,t}^{US} &= 400\left[(1+r_{t-1}^{*})\frac{1+E_{t-1}\pi_t^{CPI,*}}{1+\pi_t^{CPI,*}}\frac{q_t}{q_{t-1}}-1\right] \\ r_{E,t}^{CAN} &= 400\left[\left(\frac{d_t+v_t}{v_{t-1}}\right)-1\right], \text{ and} \\ r_{E,t}^{US} &= 400\left[\left(\frac{d_t^*+v_t^*}{v_{t-1}^*}\right)\frac{q_t}{q_{t-1}}-1\right]. \end{aligned}$$

The differences between *ex ante* and *ex post* returns emerge from the wedge created between expected inflation and actual inflation and from the evolution of the real exchange rate that would imply some gains or losses when conducting international transactions. Our conjecture to explain the portfolio asset substitutions that would bring reversed two-way capital flows is

$$\begin{aligned} r_{B,t}^{CAN} &> r_{B,t}^{US}, \text{ and} \\ r_{E,t}^{US} &> r_{E,t}^{CAN}, \end{aligned} \tag{2.6.1}$$

together with an increase in the overall NFA position of Canada with the US

$$\triangle NFA_t = w_t n_t \int_0^1 \left(\frac{W_t(j)}{W_t}\right)^{1-\theta_w} dj + d_t + \left(\frac{d_t}{v_{t-1}}\right) NFA_{t-1} - (g_t + c_t) + VAL_t > 0 \tag{2.6.2}$$

where the valuation effects, VAL_t, are determined by return differentials and gains/losses from the lagged NFA position

$$VAL_t = r'_{x,t}\alpha_{t-1} + \left(\frac{v_t}{v_{t-1}} - 1\right) NFA_{t-1} \tag{2.6.3}$$

Figure 2.8 provides the plots of the returns of r_B^{CAN}, r_B^{US}, r_E^{CAN} and r_E^{US} following each one of the eight shocks of the model, and Table 2.4a reports the values obtained in the responses of these returns. Meanwhile, the responses of both NFA and valuation effects for the home economy (Canada) had been plotted in the corresponding last boxes of Figures 2.3 through 2.7 and numerically documented, for all shocks, in Table 2.4b.[18]

The global technology shock brings an economic expansion and pushes up the annualized returns on both equity (around 3.5%) and bonds (around 2.25%) above the steady-state real rate of return (1.32%). The equity return rises because firm dividends are boosted by a lower marginal cost of production. The real return of bonds also rises in this case due to the household consumption smoothing that increases saving through the demand for bonds. In the comparison across asset types, Figure 2.8 displays and Table 2.4a reports that equity investments turn more profitable than purchasing bonds both in the US and Canada. Such equity premium is 1.06% in Canada and 1.34% in the US. The return differentials across countries are barely noticeable at first eyesight on Figure 2.8. As Table 2.4a documents, numbers are small, slightly favorable to Canadian bonds (4 basis points) and US equity (23 basis points), but their order of magnitude would not probably justify the massive capital flows observed in the data. The NFA position plotted in Figure 2.3 indicates that there are initially net losses on Canadian asset holdings which are reversed towards net gains five quarters after the shock and even move onto the positive side from the tenth quarter after the shock onwards. Valuation effects are positive at the quarter of the shock because the bond returns fall below the equity return and Canadian bonds are owned by US citizens. One quarter after the shock, the valuation effects turn negative because the return differentials vanish and the market value of Canadian foreign debt with the US rises. After four quarters, Canadian NFA

[18]It should be noticed that the valuation effects are obtained in the calibrated model for fixed asset holdings at $\alpha_{EF} = 1.45y$, $\alpha_{BH} = -0.83y$, and $\alpha_{BF} = 0.17y$, which implies a negative effects from the excess return of home (Canada) bonds. As Canadian bonds are owned by US households, an increase in the interest rate of Canadian bonds would bring negative valuation effects for the Canadian NFA position.

starts rising because valuation effects disappear and there are positive net exports. The response of Canadian NFA twelve quarters after the shock is positive (+0.067) as Table 2.4b reports.

Hence, it could be argued that a positive global shock brings the conditions for two-reversed capital flows with two limitations: the return differentials are quantitatively small and the positive response of NFA is found with lag of approximately 2.5 years.

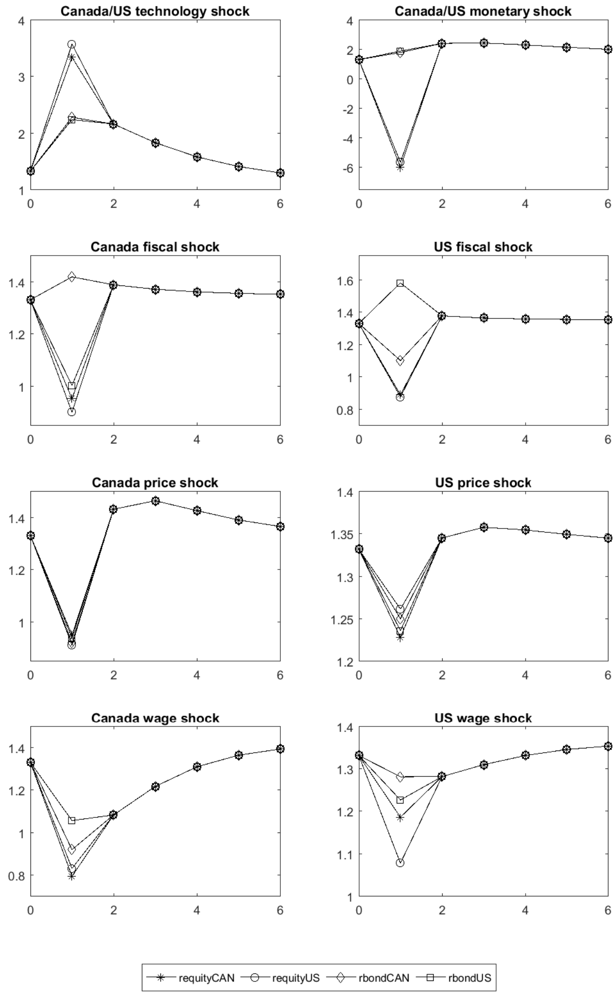

Figure 2.8: Responses of the rates of return, annualized

As displayed in Figure 2.8, the global monetary (interest-rate) shock, that simultaneously occurs in Canada and the US, has a positive impact on the return of bonds and a severe and negative effect on the equity return. Both firm dividends and equity value fall as interest rates increase. The rates of return are similar for Canada and the US with little differences in bond premia (see Table 4a). The interest rate of the Canadian bond rises to 1.81% but falls 9.8 basis points below that of the US bond. Equity returns turn clearly negative in both economies (near -6%), and the fall of Canadian equity is 34 basis points deeper than US equity. The equity return differentials may explain the Canadian purchases of US equity observed in the data, but the US purchases of Canadian bonds is not supported by the return differential favorable to the US bond. Thus, we cannot conclude that a global monetary shock explains the reversed two way capital flows observed from 2012 to 2018.

The valuation effects after a global interest-rate shock are displayed in Figure 2.4 and reported in Table 2.4b. The immediate effect is positive because the market value of the existing debt with the US falls (and despite the higher cost of the interest service of Canadian debt owned by US households). One quarter after the shock NFA begins to fall substantially and continuously over the next fifteen quarters of so. The reasons for this net borrowing to the US is the trade deficit (negative Canadian net exports) and the negative valuation effects caused by the recovery of the market value of US debt. Twelve quarters after the shock, the Canadian NFA position accumulates a decline of -1.15% units relative to the steady-state level of output.

A specific public spending shock in Canada results in a interest rate spread for the Canadian bond respect to the US bond (see Figure 2.8). In annualized percent terms, the gap $r_B^{CAN} - r_B^{US}$ is close to 0.42%. This might explain net purchases of Canadian bonds out of sales of US bonds. This is one way of the capital flows

Table 2.3: Responses of asset returns to shocks,

Table 2.4a. Responses of asset returns to shocks,

	Canada		US		Differentials	
$r_{ss} = 1.32\%$	Bonds, r_B^{CAN}	Equity, r_E^{CAN}	Bonds, r_B^{US}	Equity, r_E^{US}	$r_B^{CAN} - r_B^{US}$	$r_E^{US} - r_E^{CAN}$
Canada/US tech. shock	2.283	3.345	2.242	3.578	0.041	0.233
Canada/US mon. shock	1.810	-5.973	1.908	-5.629	-0.098	0.344
Canada fiscal shock	1.420	0.954	1.004	0.902	0.416	-0.052
US fiscal shock	1.103	0.891	1.583	0.878	-0.480	-0.013
Canada price shock	0.920	0.951	0.941	0.912	-0.021	-0.039
US price shock	1.250	1.228	1.236	1.262	0.014	0.032
Canada wage shock	0.921	0.795	1.058	0.832	-0.137	0.037
US wage shock	1.282	1.187	1.227	1.079	0.055	-0.108

Table 2.4: Responses of Canadian NFA to shocks,

Table 2.4b. Responses of Canadian NFA to shocks, % of output

	Quarter of the shock	4 quarters after the shock	12 quarters after the shock
Canada/US tech. shock	0.099	-0.138	0.067
Canada/US monetary shock	0.107	-0.601	-1.148
Canada fiscal shock	-0.048	-0.128	-0.201
US fiscal shock	0.014	0.013	0.004
Canada price shock	-0.034	-0.106	-0.105
US price shock	0.019	0.011	0.003
Canada wage shock	-0.000	0.001	-0.118
US wage shock	-0.043	-0.012	-0.034

documented in this paper. The other way –net purchases of US equity– cannot be anticipated by the return differential of this Canadian public spending shock. Equity returns fall both in Canada and in the US, with a little gap favorable to Canadian equity (3.9 basis points). The extra payoffs of Canadian bond returns to US owners explains the valuation effects that make Canada NFA move downwards at the time of the shock. In the following quarters, the Canadian net borrowing position continues because of its current account deficit with the US. The persistence of such negative next exports accumulates an overall negative effect of -0.2% of steady-state output twelve quarters after the shock.

If the public spending (fiscal) shock takes place in the US economy, the results bring return differentials favorable to the US bond and the Canadian equity (see Table 2.4a). Therefore, if the shock took a negative realization (fiscal contraction), the return differentials would satisfy (2.6.1) for the empirical test of the Canada/US capital flows. As displayed in Figure 8, the gap between bond returns is significant (0.48%), but the distance between equity return is tiny (as Table 2.4a informs it is just 1.3 basis points). So, although we could argue that (2.6.1) holds for a US fiscal contraction the Canada/US equity flows that generates would not be large because of the small return differential. The response of the Canadian NFA is quantitatively small (see numbers in Table 2.4b) and of positive sign due to the lending capacity that emerges from the increase of Canadian net exports with the US. Thus, in the case of a US fiscal contraction shock the Canada NFA position would take the opposite downwards direction which cannot meet the movement observed during the reversed two-way capital flows, implied by (2.6.2).

An inflation shock introduced in the price indexation scheme of Canadian firms reduces the rates of return of the four available assets. As Figure 2.8 shows and Table 2.4a informs, there is a simultaneous cut of about 0.4% in the return of bonds and equity, both from Canada and the US. In Canada, there is a little domestic equity premium over the domestic bond, whereas the opposite occurs in the US. Anyway, the shock does not provide significant interest rate differentials neither across assets nor across economies. It could be mentioned that Canadian equity yields a lower return than US equity as firms from Canada suffer the adverse effects of the shock originated in Canada more than US firms. Meanwhile, the Canadian bond provides 2 basis points of higher return than the US bond. If the shock were deflationary (negative realization), the simulated return differentials would satisfy (2.6.1). When we re-examine the response of Canada NFA position (Figure 2.6), the negative net exports motivate a fall over four quarters after the shock (valuation effects are small in this case). Accordingly, if the shock were deflationary on Canadian goods, the current account would register positive values and the NFA position had increased. We could, thus, argue that a deflationary price push-shock in Canada could explain the reversed two-way capital flows. However, there are two limitations to this argument. First, the quantitative effects found, in terms of either return differentials or NFA variations, are small. And secondly, actual data on Canada and US producer price inflation between 2012 and 2018 do not show any signal of price shocks in Canada relative to the US (see Figure 2.2 for the plots of the inflation rates and Table 2.5 for their average values).

If the price-push shock hits the US economy, the four asset returns also drop, but they do it at a lower extent to what they did after a Canada price shock because the size of shock is smaller.[19] The effects are symmetrically reversed from the Canadian price-push shock. Hence, the return differentials are favorable to Canadian bonds and US equity (see Table 2.4a). But these numbers are really little. 1.4 basis points and 3.2 points, respectively, which does not justify the massive capital flows found in the data. Besides, we have already mentioned that the rates of inflation in Canada and the US have not been significantly different over the period. The Canadian NFA improves due to its increase in net exports and the lack of significant valuation effects. Numbers reported in Table 4b are again very small and there should be a huge US price-push shock (e.g., 100 times its calibrated standard deviation) to explain an increase in NFA of similar size to the one observed in the data.

Moving to wage-push shocks, Figure 2.8 shows a more apparent differentiation of asset returns. As expected, a wage-push shock reduces the rates of return on all the assets. The effects are larger after a Canadian wage-push shock because of the higher wage stickiness calibrated for the Canadian (home) economy. As documented in Table 2.4a, equity returns fall deeper than bond returns and home assets report a larger effect than foreign assets. Regarding the return differentials for testing (2.6.1), Table 2.4a reports $r_B^{CAN} - r_B^{US} < 0$ and $r_E^{US} - r_E^{CAN} > 0$ after a Canada wage-push shock and switched signs after a US wage-push shock. Therefore,

[19]It may be recalled that the shocks have a size equivalent to one calibrated standard deviation and the baseline calibration assumes that the price-push shock is less volatile in the US than in Canada to be consistent with the empirical evidence on their relative inflation volatility.

neither shock satisfies (2.6.1). The effects of wage-push shocks on the Canadian NFA position are rather small (see last two rows of Table 2.4b). Figure 2.7 plots the response of Canadian NFA to a Canada wage-push shock. The fall in net exports brings borrowing needs and explains a decreasing pattern in the NFA position of Canada with the US. Valuation effects are little. When the wage-push shock hits the (foreign) US economy, the Canadian net exports rise but there are some negative valuation effects that dominate. Canada NFA slides downwards to the negative values reported in Table 2.4b. The negative valuation effects come from the extra interest-rate payments of Canadian bonds owned by US households and also in the lower return of US equity held by Canadian households (see last row of Table 2.4a).

Summarizing, we can say that only price-push shocks can be explanatory factors to the reversed two-way capital flows between the US and Canada that characterized the rise of the Canada NFA position with the US from 2012 to 2018. All the remaining shocks fail to jointly satisfy (2.6.1) and (2.6.2). A combination of shocks may still explain the reversed two-way capital flows. Thus, we twist our strategy to define the sources of exogenous variability from a prospective look at the data. The type and size of the shocks are going to be specified from the economic facts that characterized the US and Canada in the period between 2012 and 2018. This opens the next subsection.

Replicating the scenario of 2012

The price-push shocks emerge as the candidates to explain the excess returns and NFA sign observed in the US/Canada capital flows. Are they found in the data? Looking at Figure 2.2, no substantial change is found in the fluctuations of either US or Canada producer price inflation. Table 2.5 reports the average values and, again, numbers are quite homogeneous across samples. Both US and Canada had some disinflation in the 2012-2018 period compared to the full sample, but the

Table 2.5: Mean values of selected variables (quarterly, percentage)

Table 2.5. Mean values of selected variables (quarterly,percentage)

	Canada	US	Difference
Full sample, 1990-2018			
Output growth	0.30	0.32	-0.02
Price inflation (PPI)	0.49	0.50	-0.01
Wage inflation	0.72	0.82	-0.10
Nominal interest rate	0.88	0.68	0.20
Subsample of increasing Canadian NFA, 2012-2018			
Output growth	0.37	0.25	0.12
Price inflation (PPI)	0.36	0.40	-0.04
Wage inflation	0.63	0.53	0.10
Nominal interest rate	0.19	-0.29	-0.48

extent of the disinflation is similar and the difference between Canada and US price inflation remains small. Since individual shocks cannot account for the stylized facts that characterize Canada/US capital flows after 2012 (because of either theoretical or empirical flaws), we have reviewed the circumstances of that time and built a combination of shocks that may represent the state of the economies at that time:

i) A positive global technology shock: both economies experienced an increase in total factor productivity in the years after the financial crisis (which might have been the consequence of a creative destruction that results from the process of business churning). Cao and Kozicki (2015) from the Bank of Canada and Fernald (2014) from the Federal Reserve of San Francisco obtain estimates of increasing total factor productivity after 2009 for, respectively, Canada and the US. A positive technology shock on both economies of size equivalent to one calibrated standard deviation (0.89%) is set to capture the global increase in total factor productivity.

ii) Looking at the time series of the nominal interest rate (Figure 2.1), the subperiod of the sample that runs from 2012 to 2018 coincides with massive balance sheet purchases of the Fed, commonly referred as the Quantitative Easing (QE) policies.[20] Actually, the third round of Quantitative Easing (QE3) was implemented

[20]The Wu and Xia (2013)'s shadow policy rate capture the impact of asset purchases on the nominal interest rate below the zero lower bound. It allows for the negative US nominal interest rates displayed in Figure 2.2.

during the sample period of upwards trend in the NFA position of Canada with the US.[21] Meanwhile, the Bank of Canada also increased significantly the size of its balance sheet, with the official policy rate at an annualized 1%. We replicate these monetary expansions with a negative shock entering the Taylor-type policy rule of value equivalent to one calibrated standard deviation for the US and half of it for Canada.

iii) Adverse (negative) wage-push shock in the US: the rates of growth of nominal wages in the US are, on average, lower after 2012 than in the years before and they also come smaller than the ones observed in Canada. Figure 2 shows two observations after 2012 with clearly negative values for US wage inflation (one of them at -2.30% quarterly). Table 5 reports a swap in the average wage inflation difference from -0.10% in the full sample (favorable to the US) to +0.10% in the period 2012-2018 (favorable to Canada). Average wage inflation falls in almost 20 basis points in the period 2012-2018 in comparison to the complete period. These are indications for the existence of an adverse wage push shock in the US. Hence, we introduce a single negative wage-push shock for the US equivalent to 3 times its calibrated standard deviation.

iv) The US government ran a fiscal consolidation program in response to the dramatic increase in public debt after the financial crisis (fiscal cliff). Thus, public deficit over GDP got reduced from -6.7% in 2012 to -2.4% in 2016. We introduce an adverse fiscal shock for the US of size equivalent to two calibrated standard deviations.

Arguably, the combination of shocks i) to iv) could have been designed in a more rigorous way. Moreover, there could have been other sources of fluctuations (e.g., external demand shocks or risk premium shocks) that have a significant influence on Canada/US macroeconomic fluctuations. We have taken the list i) to iv) based

[21] The period of purchases under Q3 is typically considered from September of 2012 to October of 2014. In December of 2015, the Fed decided to raise the official interest rate since 2006.

on some empirical grounds and our own retrospective intuition about the facts that took place during the Great Recession.

Figure 2.9 plots the impulse-response functions following a simultaneous combination of the four shocks defined above. Let us describe what we see and discuss why we see it. Both economies report a fall in output produced at the time of the combined shocks, but it quickly goes up to the positive size. In the US, the economic expansion peaks four quarters after the shocks when output is almost 1% higher than its steady-state level. In Canada, the effects are much smaller. Such difference is due to the origin of the shocks: the fiscal (contractionary) shock only takes place in the US economy, the (QE) monetary shock in the US is twice the size of it in Canada, and the wage-push shock only enters the US wage indexation norm. The nominal interest rate moves down from the QE shocks, with a higher cut implemented by the Fed compared to the Bank of Canada. Wage inflation and the real wage fall by around 2% in the US (the wage-push shock cuts nominal wages down) whereas Canadian wages barely change. The lower cost of labor in the US has a significant implication for the comparison of firm dividends. Although both Canadian and US firms take advantage of lower interest rates and increasing sales, the US dividend displays a much higher increase than the Canadian one (14% *versus* 4%) because the US real wage drops significantly while the Canadian one reports a moderate increase. The combined shocks result in a real exchange rate appreciation and a trade deficit for Canada, where imports rise up to 1.5% while exports falls around 0.5%. As Figure 2.9 also shows, the NFA position of Canada rises persistently due to the valuation effects (and despite the negative net exports). The positive valuation effects come from two main sources: the Canadian ownership of US equity that yields a higher return and the reduction in the interest rate payments of Canadian bonds to US households. These valuation effects determine the upwards trend in the Canadian NFA position with the US.

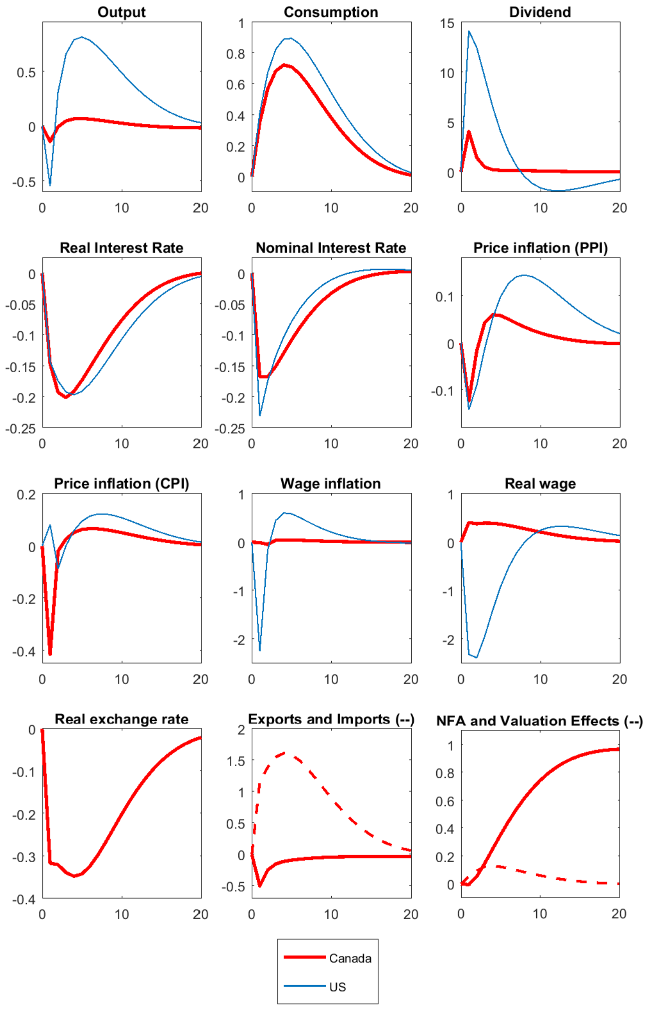

Figure 2.9: Impulse-response functions following a combination of shocks describing the 2012 scenario for Canada and the US

Table 2.6a provides the asset returns. The combined shocks reduces the US bond interest rate to a negative value, -0.27%, while the Canadian real interest rate rises to almost 3%. Hence, the bond return differential is 3.26%. Most of this spread is due to the impact of unanticipated inflation, which lowers significantly the *ex post* real interest rate of the US bond (and it is not captured in the *ex ante* real interest rates plotted in Figure 9). This spread can motivate sales of US bonds to purchase Canadian bonds as actually occurred in the period of the quantitative expansion in the US (Canada bond outflows to the US). Regarding equity returns, the combined shocks bring a positive impact on firm profitability both in the US and Canada. Both equity returns rise to rates around 8%. The spread in equity returns is small (0.24%) and favorable to the US. Meanwhile, firm dividends rise significantly more in the US than Canada (see Figure 2.9). The equity gain is higher for US firms, because they take advantage of the lower cost of labor that comes with the negative wage-push shock. Such dividend gap can also explain the purchases of US equity by Canadian investors (US equity inflows to Canada).

Table 2.6a. Asset returns following shocks in the 2012-18 scenario

	Canada		US		Differentials	
$r_{ss} = 1.32\%$	Bonds, r_B^{CAN}	Equity, r_E^{CAN}	Bonds, r_B^{US}	Equity, r_E^{US}	$r_B^{CAN} - r_B^{US}$	$r_E^{US} - r_E^{CAN}$
Four shocks	2.993	7.928	-0.267	8.168	3.260	0.240
eliminating technology shock	2.529	7.321	-0.720	7.493	3.249	0.172
eliminating QE shocks	2.161	2.871	2.218	3.527	-0.057	0.657
eliminating US wage-push shock	2.761	7.158	-0.807	6.868	3.568	-0.290
eliminating US fiscal shock	2.859	7.766	-0.160	7.946	3.019	0.180

Table 2.6: Responses of Canadian NFA following shocks in the 2012-18 scenario, percentage of output

Table 2.6b. Responses of Canadian NFA following shocks in the 2012-18 scenario, % of output

	Quarter of the shock	4 quarters after the shock	12 quarters after the shock
Four shocks	-0.005	0.352	0.870
eliminating technology shock	-0.043	0.274	0.743
eliminating QE shocks	0.224	0.137	0.278
eliminating US wage-push shock	-0.182	0.328	0.749
eliminating US fiscal shock	-0.015	0.317	0.841

As for the Canadian NFA position with the US, Table 2.6b reports a initial tiny drop followed by a persistent and substantial increase that becomes 0.87% of output twelve quarters after the shock. Since net exports are negative, the positive variation of NFA must be accounted for gains in the value of existing assets. The relative position of bonds and equity determines this positive valuation effects: Canadian households own US equity and the Canadian government is being financed by US households. Since equity returns are higher than bond returns, the valuation effects have been positive for Canada. Therefore, the combined shocks described above can explain: i) Canadian capital outflows to purchase US equity, ii) US capital inflows to buy Canadian bonds and iii) a persistent increase in the NFA position of Canada with the US. These effects correspond to the stylized facts that describe the Canada/US capital flows from 2012 to 2018 and jointly satisfy (2.6.1) and (2.6.2).

Finally, let us carry out some robustness checks to distinguish which individual shocks play a major role in the reversed two-way capital flows. Tables 2.6a and 2.6b collect, respectively, the return differentials and the NFA variations when one of the contributing shocks is eliminated. The absence of a technology shock would reduce the returns of all assets and also the spreads would be smaller, but the conditions stated in (2.6.1) are met. The response of NFA without the technology shock is qualitatively similar but also small. Hence, the combined shocks without the technology shock still can explain the reversed two-way capital flows at a smaller magnitude. If the monetary shocks are eliminated the picture changes dramatically. The bond return differential would switch from $r_B^{CAN} - r_B^{US} > 0$ to $r_B^{CAN} - r_B^{US} < 0$, and equity returns would be much lower. These changes would reduce significantly the valuation effects and the NFA position of Canada with the US would only rise by 0.28% after twelve periods. Hence, monetary shocks are necessary to explain the reversed two-way capital flows as they play a major role to explain US purchases of Canadian bonds and a significant increase in the Canada NFA position. The adverse US wage-push shocks turns also a necessary contributor. If the negative US wage shock is dropped, the US equity premium vanishes as $r_E^{US} - r_E^{CAN} = -0.29\%$. The valuation effects and the variation of the NFA would also be significantly diminished. Without the contractionary US fiscal shock, the signs of the return differentials (2.6.1) are satisfied and the evolution of the NFA position is similar to the all-shock case. The absence of the US fiscal contraction just reduces, in a minor way, the quantitative implications of the shocks.

In summary, monetary (QE) shocks and adverse wage-push shocks in the US are the major contributors to the model-based explanation of the capital flows and the NFA position of Canada with the US.

2.7 Conclusions

This paper comes motivated by some interesting empirical facts observed in the asset trading between Canada and the US. There is a reversed two-way capital flows that characterize the evolution of net foreign assets positions between these two countries from 2012 to the present time. The US is a net creditor for Canadian risk-free bonds while Canada has increased significantly the purchases of US equity.

We have built a two-economy structural model with international portfolio choice and nominal rigidities. The model introduces both sticky prices and sticky wages for the real effects of monetary and demand shocks. In addition the role of international trading is crucial for aggregate fluctuations through the impact of net exports on the determination of the aggregate demand. The portfolio choice setup describes the household decision of international purchases and sales of bonds and equity. The general equilibrium model brings a dynamic equation that determines the evolution of the Net Foreign Asset position across the two economies where valuation effects matter.

The calibration of the model has initially assumed a symmetric institutional framework and similar preferences and technology for households and firms. Then, some asymmetric patterns were introduces to replicate long-run properties and business cycle patterns observed empirically in the relationships between Canada and the US. The paper finds a reasonably good fit between the model and actual data, both in terms of long-run ratios and second-moment statistics.

The analysis of impulse-response functions has included both global and country-specific shocks. A global technology shock turns more expansionary to Canada than to the US due to its lower inflation and a positive trade balance for Canadian goods. Likewise, a global monetary (interest-rate) shock brings a larger and more persistent recession in Canada than in the US due to its higher wage rigidities and the reduction of Canadian net exports. We have also discussed the implication of country-specific shocks. A positive shock on government spending results in a exchange rate appreciation that increases the external demand and aggregate output of the foreign economy. Either price-push or wage-push shocks originate changes in relative prices and a substitution between domestic and foreign goods. Aggregate output falls in the economy hit by the inflationary shock whereas the other economy observes higher external demand and output produced.

The variability of asset returns has been examined following either global or individual shocks. The only exogenous perturbation that can explain both the increase in the NFA position of Canada with the US and the two-way reversed capital flows is a producer price shock (either a negative shock on Canadian inflation or a positive shock on US inflation). However, there is no apparent evidence of actual price inflation shocks in the corresponding period from 2012 to 2018.

So, we have design a combination of shocks that may describe some of the stylized facts of the 2012-2018 period: a positive global technology shock that raises total factor productivity after the financial crisis, monetary shocks that capture the QE stimulus, a contractionary fiscal shock that reflects the US fiscal cliff and a negative shock on US wage inflation consistent with the lower relative wages observed in the data. It turns out that the effective real interest rate of US bonds turns negative and creates a substantial spread between the returns of the Canadian bond and the US bond. Moreover, equity value rises in the US more than in Canada. These responses are a correct characterization of the two-way reversed capital flows between the US and Canada documented after 2012. Furthermore, the model simulation indicates that the NFA position of Canada with the US rises steadily in the quarters after the US monetary expansion. Both the monetary shock and the adverse US wage inflation shock are crucial to key ingredients the two-way reversed capital flows.

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Appendix (for online publication)

I. A detailed description of the equations of the model

The model comprises a set of behavioral equations providing solution paths for the 58 endogenous variables. Each economy is described with 26 endogenous variables which for the domestic economy would be c_t, $c_{H,t}$, $c_{F,t}$, β_{t+1}/β_t, n_t, $\widetilde{W}_t(j)$, w_t, π_t^w, $A_{W,t}$, $B_{W,t}$, $\widetilde{P_{H,t}}(j)$, $A_{P,t}$, $B_{P,t}$, π_t^{PPI}, π_t^{CPI}, RP_t, Θ_{t+1}/Θ_t, d_t, v_t, mc_t, PD_t, PDD_t, PD_t^*, y_t, R_t, and r_t. Foreign endogenous variables are completely analogous. There are 6 variables that simultaneously relate or affect to both economies, e_t, q_t, NX_t, NFA_t, WD_t and VAL_t. Finally, there are 8 exogenous variables: 3 country-specific AR(1) processes to autonomous (government) spending, price and wage indexation rules, along with 2 global (common) shocks to technology and monetary policy.

The following 26 equations describe only the home economy (foreign-economy equations are totally analogous):

Intertemporal consumption (Euler) equation

$$\frac{(c_t - hc_{t-1})^{-\sigma}}{(1+r_t)} = \frac{\beta_{t+1}}{\beta_t}\mathbb{E}_t[(c_{t+1} - hc_t)^{-\sigma}]$$

Equilibrium condition for home equity assets

$$v_t = \mathbb{E}_t\left[\frac{d_{t+1} + v_{t+1}}{1+r_t}\right]$$

Fisher equation

$$1 + r_t = \frac{1 + R_t}{\mathbb{E}_t\left(1 + \pi_{t+1}^{CPI}\right)}$$

Endogenous discount factor

$$\frac{\beta_{t+1}}{\beta_t} = (1 + c_t)^{-\varsigma}$$

Domestic consumption of domestically produced goods

$$c_{H,t} = (1-\alpha)\, RP_t^{-\theta} c_t$$

Domestic consumption of foreign produced goods (imports)

$$c_{F,t} = \alpha \left(RP_t^* q_t\right)^{-\theta} c_t$$

Plugging the optimal allocation of both domestic and foreign consumption, $c_{H,t}$ and $c_{F,t}$, in the aggregate consumption definition, $c_t \equiv \left[(1-\alpha)^{\frac{1}{\theta}} (c_{H,t})^{\frac{\theta-1}{\theta}} + \alpha^{\frac{1}{\theta}} (c_{F,t})^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}$, it is obtained

$$1 = (1-\alpha)\left(RP_t\right)^{1-\theta} + \alpha \left(RP_t^* q_t\right)^{1-\theta}$$

Optimal wage setting. We use $A_{W,t}$ and $B_{W,t}$ variables to solve the infinite sum

$$\widetilde{W}_t(j) B_{W,t} = \left(\frac{\theta_w}{\theta_w - 1}\right) A_{W,t}$$

with

$$A_{W,t} = \psi \left(\left(\widetilde{W}_t(j)\right)^{-\theta_w} n_t\right)^{\gamma} n_t + \eta_w \frac{\beta_{t+1}}{\beta_t} \mathbb{E}_t \left[A_{W,t+1} \left(\frac{(1+\pi_{t+1}^w)}{(1+\pi_t^{CPI})^{\kappa_w} (1+\pi+\varepsilon_{t+1}^W)^{1-\kappa_w}}\right)^{\theta_w}\right]$$

and

$$B_{W,t} = (c_t - hc_{t-1})^{-\sigma} w_t n_t + \eta_w \frac{\beta_{t+1}}{\beta_t} \mathbb{E}_t \left[B_{W,t+1} \left(\frac{(1+\pi_{t+1}^w)}{(1+\pi_t^{CPI})^{\kappa_w} (1+\pi+\varepsilon_{t+1}^W)^{1-\kappa_w}}\right)^{\theta_w - 1}\right]$$

Dixit-Stiglitz aggregator for relative wages

$$\widetilde{W_t}(j)^{(\theta_w-1)} = (1-\eta_w)+\eta_w \left[(1+\pi^{CPI}_{t+k-1})^{\kappa_w}(1+\pi^{CPI}_{ss}+\varepsilon^W_t)^{1-\kappa_w}\right]^{(1-\theta_w)}(1+\pi^w_t)^{\theta_w-1}\widetilde{W_t}(j)^{(\theta_w-1)}$$

Nominal wage inflation from the definition of the real wage ($w_t = W_t/P_t$)

$$(1+\pi^w_t) = \frac{w_t}{w_{t-1}}(1+\pi^{CPI}_t)$$

Firm's discount factor (α^{equity} is the home agent ownership of foreign firm)

$$\frac{\Theta_{t+1}}{\Theta_t} = (1-\alpha^{equity})\frac{\beta_{t+1}}{\beta_t} + \alpha^{equity}\frac{\beta^*_{t+1}}{\beta^*_t}$$

Optimal price function for which we use $A_{P,t}$ and $B_{P,t}$ variables to solve the infinite sum.

$$\widetilde{P_{H,t}}(j)B_{P,t} = \left(\frac{\epsilon}{\epsilon-1}\right)A_{P,t}$$

with

$$A_{P,t} = y_t mc_t + \frac{\Theta_{t+1}}{\Theta_t}\eta_P \mathbb{E}_t\left[A_{P,t+1}\left(\frac{(1+\pi^{PPI}_{t+1})}{(1+\pi^{PPI}_t)^{\kappa_p}(1+\pi+\varepsilon^P_{t+1})^{1-\kappa_p}}\right)^{\epsilon}\right]$$

and

$$B_{P,t} = y_t + \frac{\Theta_{t+1}}{\Theta_t}\eta_P \mathbb{E}_t\left[B_{P,t+1}\left(\frac{(1+\pi^{PPI}_{t+1})}{(1+\pi^{PPI}_t)^{\kappa_p}(1+\pi+\varepsilon^P_{t+1})^{1-\kappa_p}}\right)^{\epsilon-1}\right]$$

Dixit-Stiglitz price aggregator

$$\widetilde{P_{H,t}}(j)^{(\epsilon-1)} = (1-\eta_p)+\eta_p\left[(1+\pi^{PPI}_{t-1})^{\kappa_p}(1+\pi^{PPI}_{ss}+\varepsilon^P_t)^{1-\kappa_p}\right]^{(1-\epsilon)}(1+\pi^{PPI}_t)^{\epsilon-1}\widetilde{P_{H,t}}(j)^{(\epsilon-1)}$$

Relationship between CPI-inflation, π^{CPI}_t, and producer price-inflation, π^{PPI}_t, through relative prices, RP_t,

$$\frac{(1+\pi_t^{PPI})}{(1+\pi_t^{CPI})} = \frac{RP_t}{RP_{t-1}}$$

Real marginal cost (labour demand function)

$$mc_t = \left(\frac{P_t}{P_{H,t}}\right)\frac{w_t}{e^{\varepsilon_t^A}A}$$

Average dividend

$$d_t = y_t\left[RP_tPD_t - \left(\frac{w_t}{e^{\varepsilon_t^A}A}\right)PDD_t\right]$$

with these price dispersion measures

$$PD_t = (1-\eta_p)\left(\widetilde{P_{H,t}}(j)\right)^{1-\epsilon} + \eta_p\left(\widetilde{P_{H,t-1}}(j)(1+idx_t^p)\right)^{1-\epsilon}PD_{t-1}$$

and

$$PDD_t = (1-\eta_p)\left(\widetilde{P_{H,t}}(j)\right)^{-\epsilon} + \eta_p\left(\widetilde{P_{H,t-1}}(j)(1+idx_t^p)\right)^{-\epsilon}PDD_{t-1}$$

Aggregate production function

$$PDD_ty_t = e^{\varepsilon_t^A}n_t$$

Resources constraint equilibrium condition

$$PD_ty_t = PD_tc_{H,t} + PD_t^*c_{H,t}^* + g_t$$

with another price dispersion indicator

$$PD_t^* = (1-\eta_p)\left(\widetilde{P_{H,t}(j)}\right)^{1-\epsilon^*} + \eta_p\left(\widetilde{P_{H,t-1}(j)(1+idx_t^p)}\right)^{1-\epsilon^*} PD_{t-1}$$

Monetary policy rule *a la* Taylor (1993)

$$1+R_t = \left((1+r)\,(1+\pi)^{(1-\mu_\pi)}\right)^{(1-\mu_R)} (1+R_{t-1})^{\mu_R} \left(1+\pi_t^{CPI}\right)^{(1-\mu_R)\mu_\pi} \left(\frac{y_t}{y_{t-1}}\right)^{(1-\mu_R)\mu_y} exp(\varepsilon_t^R)$$

The following 6 equations are related to both economies

Real exchange rate

$$\frac{q_t}{q_{t-1}} = \frac{e_t}{e_{t-1}} \frac{1+\pi_t^{CPI,*}}{1+\pi_t^{CPI}}$$

Uncover interest rate parity condition

$$(1+r_t) = (1+r_t^*)\mathbb{E}_t\left[\frac{q_{t+1}}{q_t}\right]$$

Net Exports

$$NX_t = \alpha^*\left(\frac{RP_t}{q_t}\right)^{-\theta^*} c_t^* - \alpha\,(RP_t^* q_t)^{-\theta}\,c_t$$

Net Foreign Assets

$$NFA_t - \left(\frac{d_t+v_t}{v_{t-1}}\right) NFA_{t-1} = w_t n_t \int_0^1 \left(\frac{W_t(j)}{W_t}\right)^{1-\theta_w} dj + d_t + r'_{x,t}\alpha_{t-1} - g_t - c_t$$

with wage dispersion computed as follows

$$\int_0^1 \left(\frac{W_t(j)}{W_t}\right)^{1-\theta_w} dj \equiv WD_t = (1-\eta_w)\left(\frac{W_t(j)}{W_t}\right)^{1-\theta_w} + \eta_w\left(\frac{W_{t-1}(j)}{W_{t-1}}(1+idx_t^w)\right)^{1-\theta_w} WD_{t-1}$$

Valuation effects

$$VAL_t = r'_{x,t}\alpha_{t-1} + \left(\frac{v_t}{v_{t-1}} - 1\right) NFA_{t-1}$$

where $r'_{x,t}\alpha_{t-1}$ is defined as a function of asset holdings and return differentials.

II. Derivation of Net Foreign Assets (NFA) dynamic equation

Let us introduce the variable α for asset holdings where the time subscript is identified with two letters: either E or B refers to equity and bond assets respectively, while either H or F refers to origin (issuing) from either the home or foreign agents. Recalling the household budget constraint

$$\left(\frac{W_t(j)}{W_t}\right)^{1-\theta_w} w_t n_t + (d_t + v_t) S_{H,t} + q_t (d_t^* + v_t^*) S_{F,t} + b_{H,t} + q_t b_{F,t} - tax_t =$$
$$c_t + v_t S_{H,t+1} + q_t v_t^* S_{F,t+1} + (1 + r_t)^{-1} b_{H,t+1} + (1 + r_t^*)^{-1} q_t b_{F,t+1}, \quad \text{(A0)}$$

the following definitions bring the domestic household asset holdings in period t

$$\alpha_{BH,t} \equiv \frac{b_{H,t+1}}{(1 + r_t)} \quad \text{(A1)}$$

$$\alpha_{BF,t} \equiv \frac{q_t b_{F,t+1}}{(1 + r_t^*)} \quad \text{(A2)}$$

$$\alpha_{EH,t} \equiv v_t S_{H,t+1} \quad \text{(A3)}$$

$$\alpha_{EF,t} \equiv q_t v_t^* S_{F,t+1} \quad \text{(A4)}$$

Meanwhile, the definition of Net Foreign Assets (NFA) implies

$$NFA_t = [\alpha_{EF,t} + \alpha_{BF,t} - \alpha^*_{EH,t} - \alpha^*_{BH,t}] \tag{A5}$$

where it should be noticed that the foreign holdings of home assets, $\alpha^*_{EH,t}$ and $\alpha^*_{BH,t}$, are expressed in terms of the domestic bundle of consumption goods

$$\alpha^*_{EH,t} \equiv v_t S^*_{H,t+1} \text{ and } \alpha^*_{BH,t} \equiv \frac{B^*_{H,t+1}/P_{t+1}}{(1+r_t)} = \frac{b^*_{H,t+1}}{(1+r_t)}.$$

The financial market clearing conditions are, for the equity markets,

$$S_{H,t+1} + S^*_{H,t+1} = S_{F,t+1} + S^*_{F,t+1} = 1 \tag{A6}$$

whereas for the government bond markets

$$b_{H,t+1} + b^*_{H,t+1} = b_{F,t+1} + b^*_{F,t+1} = 0 \tag{A7}$$

So, that the following conditions hold

$$\alpha^*_{EH,t} = v_t(S^*_{H,t+1}) = v_t(1 - S_{H,t+1}) = v_t - v_t S_{H,t+1} = v_t - \alpha_{EH,t} \tag{A8}$$

and

$$\alpha^*_{BH,t} = \frac{b^*_{H,t+1}}{(1+r_t)} = \frac{-b_{H,t+1}}{(1+r_t)} = -\alpha_{BH,t} \tag{A9}$$

and inserting both (A8) and (A9) in (A5) gives

$$NFA_t = [\alpha_{EF,t} + \alpha_{BF,t} - v_t + \alpha_{EH,t} + \alpha_{BH,t}]$$

or, alternatively

$$NFA_t + v_t = \alpha_{EF,t} + \alpha_{BF,t} + \alpha_{EH,t} + \alpha_{BH,t} \tag{A10}$$

Next, let us define the returns in domestic consumption bundles

$$1 + r_{BH,t} \equiv 1 + r_t \tag{A11}$$

$$1 + r_{BF,t} \equiv 1 + r_t^* \tag{A12}$$

$$1 + r_{EH,t} \equiv \left(\frac{d_{t+1} + v_{t+1}}{v_t}\right) \tag{A13}$$

$$1 + r_{EF,t} \equiv \left(\frac{d_{t+1}^* + v_{t+1}^*}{v_t^*}\right) \tag{A14}$$

Both the definitions of the holdings, (A1)-(A4), and the returns, (A11)-(A14), can be combined to find the following key relationships for terms that belong to the left hand side of the household budget constraint

$$\alpha_{BH,t-1}\left(1 + r_{BH,t-1}\right) = b_{H,t} \tag{A16}$$

$$\alpha_{BF,t-1}\left(1 + r_{BF,t-1}\right) = \frac{q_{t-1}}{q_t} q_t b_{F,t} \tag{A17}$$

$$\alpha_{EH,t-1}\left(1 + r_{EH,t-1}\right) = \left(d_t + v_t\right) S_{H,t} \tag{A18}$$

$$\alpha_{EF,t-1}\left(1 + r_{EF,t-1}\right) = \frac{q_{t-1}}{q_t} q_t \left(d_t^* + v_t^*\right) S_{F,t} \tag{A19}$$

Hence, inserting (A16) to (A19) on the left side of the household budget constraint (A0) gives

$$\left(\frac{W_t(j)}{W_t}\right)^{1-\theta_w} w_t n_t + \alpha_{EH,t-1}\left(1+r_{EH,t-1}\right) + \frac{q_t}{q_{t-1}}\alpha_{EF,t-1}\left(1+r_{EF,t-1}\right) + \alpha_{BH,t-1}\left(1+r_{BH,t-1}\right)$$
$$+\frac{q_t}{q_{t-1}}\alpha_{BF,t-1}\left(1+r_{BF,t-1}\right) - tax_t =$$
$$c_t + v_t S_{H,t+1} + q_t v_t^* S_{F,t+1} + \left(1+r_t\right)^{-1} b_{H,t+1} + \left(1+r_t^*\right)^{-1} q_t b_{F,t+1},$$

and, furthermore, plugging (A1)-(A4) on the right side of the resulting expression brings

$$\left(\frac{W_t(j)}{W_t}\right)^{1-\theta_w} w_t n_t + \alpha_{EH,t-1}\left(1+r_{EH,t-1}\right) + \frac{q_t}{q_{t-1}}\alpha_{EF,t-1}\left(1+r_{EF,t-1}\right) + \alpha_{BH,t-1}\left(1+r_{BH,t-1}\right)$$
$$+\frac{q_t}{q_{t-1}}\alpha_{BF,t-1}\left(1+r_{BF,t-1}\right) - tax_t = c_t + \alpha_{EH,t} + \alpha_{EF,t} + \alpha_{BH,t} + \alpha_{BF,t}, \tag{A20}$$

Using (A10) and a lagged version of it in (A20) introduces both current and lagged NFA

$$\left(\frac{W_t(j)}{W_t}\right)^{1-\theta_w} w_t n_t + NFA_{t-1} + v_{t-1} + r_{EH,t-1}\alpha_{EH,t-1} + \left(\frac{q_t}{q_{t-1}}\left(1+r_{EF,t-1}\right)-1\right)\alpha_{EF,t-1} + r_{BH,t-1}$$
$$+\left(\frac{q_t}{q_{t-1}}\left(1+r_{BF,t-1}\right)-1\right)\alpha_{BF,t-1} - tax_t = c_t + NFA_t + v_t, \tag{A21}$$

or, alternatively

$$NFA_t - NFA_{t-1} + \left(v_t - v_{t-1}\right) = \left(\frac{W_t(j)}{W_t}\right)^{1-\theta_w} w_t n_t - c_t - tax_t$$
$$+r_{EH,t-1}\alpha_{EH,t-1} + \left(\frac{q_t}{q_{t-1}}\left(1+r_{EF,t-1}\right)-1\right)\alpha_{EF,t-1} + r_{BH,t-1}\alpha_{BH,t-1} + \left(\frac{q_t}{q_{t-1}}\left(1+r_{BF,t-1}\right)-1\right)\alpha$$

Without a loss of generalization, we take the return of domestic equity, $r_{EH,t-1}$, as the reference one and both add it and subtract it, multiplied by $(\alpha_{EH,t-1} + \alpha_{EF,t-1} + \alpha_{BH,t-1} + \alpha_{BF,t-1})$, in the previous expression to obtain

$$NFA_t - NFA_{t-1} + (v_t - v_{t-1}) = \left(\frac{W_t(j)}{W_t}\right)^{1-\theta_w} w_t n_t - c_t - tax_t$$

$$+(\alpha_{EH,t-1} + \alpha_{EF,t-1} + \alpha_{BH,t-1} + \alpha_{BF,t-1})\, r_{EH,t-1} - (\alpha_{EH,t-1} + \alpha_{EF,t-1} + \alpha_{BH,t-1} + \alpha_{BF,t-1})\, r_{EH,t}$$

$$+r_{EH,t-1}\alpha_{EH,t-1} + \left(\frac{q_t}{q_{t-1}}(1 + r_{EF,t-1}) - 1\right)\alpha_{EF,t-1} + r_{BH,t-1}\alpha_{BH,t-1} + \left(\frac{q_t}{q_{t-1}}(1 + r_{BF,t-1}) - 1\right)\alpha$$

Using the lagged expression from (A10), and cancelling terms on $\alpha_{EH,t-1} r_{EH,t-1}$, and grouping terms on $\alpha_{EF,t-1}$, $\alpha_{BH,t-1}$, and $\alpha_{BF,t-1}$, we reach

$$\begin{aligned} NFA_t - NFA_{t-1} + (v_t - v_{t-1}) &= \left(\frac{W_t(j)}{W_t}\right)^{1-\theta_w} w_t n_t - c_t - tax_t \\ &+ (NFA_{t-1} + v_{t-1})\, r_{EH,t-1} + \left(\frac{q_t}{q_{t-1}}(1 + r_{EF,t-1}) - 1 - r_{EH,t-1}\right)\alpha_{EF,t-1} \\ &+ (r_{BH,t-1} - r_{EH,t-1})\,\alpha_{BH,t-1} + \left(\frac{q_t}{q_{t-1}}(1 + r_{BF,t-1}) - 1 - r_{EH,t-1}\right)\alpha_{BF,t-1} \end{aligned} \tag{A22}$$

To save some space, let us putting together the return differentials as

$$\begin{aligned} r'_{x,t-1}\alpha_{t-1} &= \alpha_{EF,t-1}\left(\frac{q_t}{q_{t-1}}(1 + r_{EF,t-1}) - 1 - r_{EH,t-1}\right) + \alpha_{BH,t-1}(r_{BH,t-1} - r_{EH,t-1}) \\ &+ \alpha_{BF,t-1}\left(\frac{q_t}{q_{t-1}}(1 + r_{BF,t-1}) - 1 - r_{EH,t-1}\right) \end{aligned}$$

which requires that $r_{x,t-1}$ is the column vector

$$r_{x,t-1} = \begin{bmatrix} \frac{q_t}{q_{t-1}}(1 + r_{EF,t-1}) - 1 - r_{EH,t-1} \\ r_{BH,t-1} - r_{EH,t-1} \\ \frac{q_t}{q_{t-1}}(1 + r_{BF,t-1}) - 1 - r_{EH,t-1} \end{bmatrix} = \begin{bmatrix} \frac{q_t}{q_{t-1}}\left(\frac{d_t^* + v_t^*}{v_{t-1}^*}\right) - \left(\frac{d_t + v_t}{v_{t-1}}\right) \\ r_{t-1} - \left(\left(\frac{d_t + v_t}{v_{t-1}}\right) - 1\right) \\ \frac{q_t}{q_{t-1}}(1 + r_{t-1}^*) - \left(\frac{d_t + v_t}{v_{t-1}}\right) \end{bmatrix}$$

while α_{t-1} is also a column vector

$$\alpha_{t-1} = \begin{bmatrix} \alpha_{EF,t-1} \\ \alpha_{BH,t-1} \\ \alpha_{BF,t-1} \end{bmatrix} = \begin{bmatrix} q_{t-1} v_{t-1}^{*} S_{F,t} \\ (1+r_{t-1})^{-1} b_{H,t} \\ (1+r_{t-1}^{*})^{-1} q_{t-1} b_{F,t} \end{bmatrix}$$

Replacing $r'_{x,t-1}\alpha_{t-1}$ in the (A22) and connecting terms on both NFA_{t-1} and v_{t-1} yield

$$NFA_t - (1+r_{EH,t-1})\,NFA_{t-1} + v_t - (1+r_{EH,t-1})\,v_{t-1} = \left(\frac{W_t(j)}{W_t}\right)^{1-\theta_w} w_t n_t - c_t - tax_t + r'_{x,t-1}\alpha_{t-1} \tag{A22}$$

Finally, reinserting the definition of the domestic equity return $(1+r_{EH,t-1}) = \left(\frac{d_t+v_t}{v_{t-1}}\right)$ implies

$$NFA_t - \left(\frac{d_t+v_t}{v_{t-1}}\right) NFA_{t-1} + v_t - \left(\frac{d_t+v_t}{v_{t-1}}\right) v_{t-1} = \left(\frac{W_t(j)}{W_t}\right)^{1-\theta_w} w_t n_t - c_t - tax_t + r'_{x,t-1}\alpha_{t-1}$$

which simplifies to

$$NFA_t - \left(\frac{d_t+v_t}{v_{t-1}}\right) NFA_{t-1} = \left(\frac{W_t(j)}{W_t}\right)^{1-\theta_w} w_t n_t + d_t - c_t - tax_t + r'_{x,t-1}\alpha_{t-1} \tag{A24}$$

The government budget constraint is

$$g_t = tax_t + \frac{b_{H,t+1}}{1+r_t} - b_{H,t} + \frac{b_{H,t+1}^{*}}{1+r_t} - b_{H,t}^{*}$$

where inserting the bonds market-clearing conditions, $b_{H,t+1} = -b_{H,t+1}^{*}$ and $b_{H,t} = -b_{H,t}^{*}$, we have

$$g_t = tax_t \tag{A25}$$

Using (A25) in (A24) yields

$$NFA_t - \left(\frac{d_t + v_t}{v_{t-1}}\right) NFA_{t-1} = \left(\frac{W_t(j)}{W_t}\right)^{1-\theta_w} w_t n_t + d_t - c_t - g_t + r'_{x,t-1}\alpha_{t-1} \tag{A26}$$

Finally, the aggregation of (A26) across households implies

$$NFA_t - \left(\frac{d_t + v_t}{v_{t-1}}\right) NFA_{t-1} = w_t n_t \int_0^1 \left(\frac{W_t(j)}{W_t}\right)^{1-\theta_w} dj + d_t - c_t - g_t + r'_{x,t-1}\alpha_{t-1}$$

Let us find the change in net foreign assets, $\triangle NFA_t = NFA_t - NFA_{t-1}$, implied by the last expression

$$\triangle NFA_t = \left(\frac{d_t + v_t}{v_{t-1}}\right) NFA_{t-1} - NFA_{t-1} + w_t n_t \int_0^1 \left(\frac{W_t(j)}{W_t}\right)^{1-\theta_w} dj + d_t - g_t - c_t + r'_{x,t}\alpha_{t-1}$$

which slightly simplifies to

$$\triangle NFA_t = w_t n_t \int_0^1 \left(\frac{W_t(j)}{W_t}\right)^{1-\theta_w} dj + d_t + \left(\frac{d_t + v_t}{v_{t-1}} - 1\right) NFA_{t-1} - g_t - c_t + r'_{x,t}\alpha_{t-1}$$

Valuation effects, VAL_t, correspond to the sum of the return differentials and the gains in value of previous NFA holdings

$$VAL_t = r'_{x,t}\alpha_{t-1} + \left(\frac{v_t}{v_{t-1}} - 1\right) NFA_{t-1}$$

which comprises the excess returns that domestic households get of foreign equity holdings, domestic bond holdings and foreign bond holdings, (adjusted with real exchange rate variations). Having valuation effects recognized, the dynamic equation for Net Foreign Assets becomes

$$\triangle NFA_t = w_t n_t \int_0^1 \left(\frac{W_t(j)}{W_t}\right)^{1-\theta_w} dj + d_t + \left(\frac{d_t}{v_{t-1}}\right) NFA_{t-1} - (g_t + c_t) + VAL_t$$

III. Data sources

Canada

Data series are retrieved from FRED, Federal Reserve Bank of St. Louis and main source is OCDE "Main Economic Indicators - complete database". Otherwise it is stated.

Y is real GDP obtained as the ratio between the *Current Price Gross Domestic Product* (Series ID: CANGDPNQDSMEI) and the GDP implicit price deflator with base year in 2010 (Code CANGDPDEFQISMEI). Original series presented at annual rates are transformed into quarterly rates. Presented in per capita terms using *Pop* is *working age population, Aged 15-64,* (Series ID: LFWA64TTCAM647S). Quarters from 1990-1995 are missing from original source, and they are computed using the linear trend.

W are *monthly earnings in manufacturing*. Data are presented at monthly rates and transform into quarterly rate. (Series ID: LCEAMN01CAM189S).

R is the *Interest Rates, Government Securities, Treasury Bills*. Original data are presented in percent per annum, monthly and not seasonally adjusted, and transform into percent per quarter.

π is the quarterly rate of producer price inflation measured as the rate of growth of the GDP implicit price deflator (P).

G are *governments final consumption expenditures*. (Series ID: CANGFCE-QDSMEI).

NT, EXP and IMP are *net exports, exports and imports of goods and services.* Data are taken from Statistics Canada: Table CANSIM 380-0070). Ratio over Canadian GDP.

$IMP(US)$ are in theory equal to $EXP(CA)$ see United States data for source. This data series is converted into Canadian dollars by using the Canadian Nominal Exchange Rate with the United States. We compute $NX(US)$ using these two variables.

NFA refers to *International investment position in Canada* in market values, expressed in quarterly millions of Canadian dollars. We compute Canadian NFA for the US and for the rest of the world. NFA data are provided by assets-liabilities basis, and we make use of its main components: Foreign Direct Investment, Portfolio equity and Portfolio Debt. Data series comes from STACAN Table: 36-10-0485-01 (formerly CANSIM 376-0142).

US

Data series are retrieved from FRED, Federal Reserve Bank of St. Louis and main source is U.S. Bureau of Economic Analysis. Otherwise it is stated.

Y^* is the *real gross domestic product* (Series ID GDPC1). These data series are computed in per capita terms using working age population: Monthly Ratio of Civilian Labor Force (in thousands of persons 16 years of age and older (Series ID CLF16OV)) and civilian labor force participation rate in percentage (Series ID CIVPARTT, it comes from the 'Current Population Survey (Household Survey))

W^* are *Average Hourly Earnings of Production and Nonsupervisory Employees for Total Private* in Dollars per Hour. (Series ID AHETPI. The series comes from the Current Employment Statistics (Establishment Survey)). Also, we have computed Median usual weekly real earnings for those employed full time. Workers 16 years and over. 1982-84 CPI Adjusted Dollars. (Series ID LES1252881600Q)

π^* is the quarterly rate of producer price inflation measured as the rate of growth of the GDP implicit price deflator (P^*), Series ID: GDPDEF.

G^* are *Government total expenditures.* (Series ID, W068RCQ027SBEA).

R^* is the *Wu-Xia Shadow Federal Funds Rate* obtained as described in Wu and Xia (2016). Unlike the observed short-term interest rate, the shadow rate is not bounded below by 0 percent.

NX^*, EXT^*, and IMP^* are *US total net exports, exports and imports of goods and services.* (Series ID NETEXP, EXPGS and IMPGS)

$EXP(CA)$ are monthly *US Exports of Goods by free Along side Ship Basis to Canada* (Not Seasonally Adjusted in millions of US dollars, Series ID EXPCA). This data series is converted to quarterly basis to be consistent with the model.

$IMP(CA)$ are monthly *US Imports of Goods by Customs Basis from Canada* (Not Seasonally Adjusted in millions of US dollars, Series ID IMPCA).

IV. The dynamics for portfolio holdings for valuation effects

We have endogenously incorporated the portfolio choice for asset holdings. A first step in the process would be to recall the home economy budget constraint in terms of the net foreign asset position

$$NFA_t - \left(\frac{d_t + v_t}{v_{t-1}}\right) NFA_{t-1} = w_t n_t \int_0^1 \left(\frac{W_t(j)}{W_t}\right)^{1-\theta_w} dj + d_t - g_t - c_t + r'_{x,t}\alpha_{t-1}$$

where

$$r_{x,t-1} = \begin{bmatrix} \frac{q_t}{q_{t-1}}(1 + r_{EF,t-1}) - 1 - r_{EH,t-1} \\ r_{BH,t-1} - r_{EH,t-1} \\ \frac{q_t}{q_{t-1}}(1 + r_{BF,t-1}) - 1 - r_{EH,t-1} \end{bmatrix}$$

and

$$\alpha_{t-1} = \begin{bmatrix} \alpha_{EF,t-1} \\ \alpha_{BH,t-1} \\ \alpha_{BF,t-1} \end{bmatrix}$$

Following Devereux and Sutherland (2009,2011) we need to solve a first order Taylor-approximation of our model, so that the term $r'_{x,t-1}\alpha_{t-1}$ rests as follows,

$$r_{x,\hat{t-1}}{}'\bar{\alpha} + \bar{r_x}{}'\alpha_{\hat{t-1}}$$

in which the bar refers to steady state value and the hat to first order deviation with respect to the value in the steady state solution. Since there is no risk in steady state, the differential in the rates of return are 0, that is $\bar{r_x} = 0$. Thus, the second term disappears $\bar{r_x}{}'\alpha_{\hat{t-1}}$. Then, up to first order, the only way portfolio holdings affect the overall performance of the model is through its steady state value in the first term, $\bar{\alpha}$. Moreover, the solution for the steady state portfolio holding vector, can take any value because there is no unique solution for this term in the steady state. Since there is no risk in equilibrium, any asset allocation would be valid. Furthermore, since we are empirically testing our theoretical model to the case of Canada and the US, we already have the values for the $\bar{\alpha}$-vector from the historical rations observed in the data. Those are described in the Calibration Section.

Chapter 3

Globalization and spatial inequality: Does economic integration affect regional disparities?

with **Roberto Ezcurra Orayen**

3.1 Introduction

Although globalization is by no means a new phenomenon, during the last few decades its importance has reached unprecedented levels. This explains why the consequences of globalization have attracted so much attention in recent years (Rodrik, 2011; Stiglitz, 2018). While economic integration is considered to improve aggregate economic growth both at the world and at national level (Frankel and Romer, 1999; Alcalá and Ciccone, 2004; Dreher, 2006), the focus of the current debate is on the distributional effects of globalization. In order to shed light on this point, numerous studies have examined the impact of economic integration on interpersonal inequality (e.g. Dollar and Kraay, 2004; Wade, 2004; Milanovic, 2005; Dreher and Gaston, 2008). Less is known about how globalization affects spatial inequality, defined as income inequality across regions within a country. Nevertheless, this issue is potentially relevant, as it is likely that globalization will shape the spatial distribution of income within countries, leading to the emergence of winning and losing regions.

Most existing empirical analyses on the connection between globalization and spatial inequality are based on single-country case studies (e.g. Zhang and Zhang, 2003; Chiquiar, 2005; Kanbur and Zhang, 2005; Rivas, 2007), which has probably to do with the scarcity of regional comparable data across countries. However, there are also several contributions that consider the spatial impact of globalization in various countries. The vast majority of these cross-country studies investigate the relationship between globalization and spatial inequality using measures of the degree of trade openness (Rodríguez-Pose, 2012; Ezcurra and Rodríguez-Pose, 2014; Hirte et al., 2017) or FDI (Lessmann, 2013). From a policy perspective, the link between these variables and spatial inequality is clearly important, as it provides information on the role that these dimensions of economic integration play in this context. Nevertheless, the degree of trade openness or the amount of FDI do not allow one to capture the spatial impact of other aspects of economic integration such as the extent of capital controls or changes in portfolio investment. Accordingly, the effect of the degree of economic integration observed in earlier contributions may be affected by the omission from the analysis of these other components of economic globalization. Bearing this in mind, and in a quest for empirically well-founded stylized facts, the present paper aims to provide a comprehensive study of the relationship between economic globalization and spatial inequality. To that end, we adopt a broader perspective than in previous analyses on this topic and examine in a systematic way the consequences that actual economic flows and existing restrictions have on spatial inequality.

To the best of our knowledge, only Ezcurra and Rodríguez-Pose (2013) have thus far considered the multidimensional nature of the process of economic globalization in this context. Using data for 47 countries, these authors find a positive association between an aggregate index capturing different aspects of economic globalization and spatial inequality. This result is potentially important. Nevertheless, Ezcurra and Rodríguez-Pose (2013) do not adequately address the possible endogeneity of globalization, which is particularly important to establish a causal link between the degree of integration with the rest of the world and spatial inequality. In the present paper we employ two strategies to tackle this issue. The first strategy is to include in the analysis country fixed effects in order to control for those time-invariant factors affecting both spatial inequality and globalization, such as geographical features. This is the first important difference between our paper and Ezcurra and Rodríguez-Pose (2013). While fixed effects estimation is useful in removing the influence of long-run determinants of both spatial inequality and globalization, it does not necessarily estimate the causal effect of the degree of integration with the rest of the world on spatial inequality. For this motive, unlike Ezcurra and Rodríguez-Pose (2013), our second strategy to address potential endogeneity problems is to use an instrumental variables approach. To this end, we construct an instrument for economic globalization based on the degree of integration in neighbouring countries.

Furthermore, the 47 countries considered by Ezcurra and Rodríguez-Pose (2013) are mainly middle- and high-income countries, which means that their study does not take into account the impact of globalization on low-income countries. In order to dismiss the possibility that the results of the analysis could be affected by selection bias, in this paper we use a new dataset on spatial inequality recently constructed by Lessmann and Seidel (2017) and based on the information provided by satellite images of nigh-time luminosity. The employment of this novel dataset allows us to examine the connection between regional income disparities and economic globalization in a sample of 142 countries over the period 1992-2012.

Our results reveal a strong causal effect of the degree of economic integration with the rest of the world on spatial inequality, indicating that the advances in the process of globalization currently underway contribute to significantly increasing regional income disparities. This confirms that globalization leads to the emergence of losing and winning regions within countries, and that the group of losing (winning) regions tends to be made up of low-(high-)income regions. This finding has to do with the regressive spatial impact of actual economic flows, while existing restrictions on trade and capital do not exert a significant effect in this context. Our findings are robust to the inclusion in the analysis of different covariates that may be correlated with both spatial inequality and globalization, and are not driven by a specific group of influential countries. Likewise, the observed relationship between economic integration and spatial inequality does not depend on the measures used to quantify the magnitude of regional income disparities within the various countries.

The remainder of the paper is organized as follows. After this introduction, section 2 provides the theoretical framework on the link between economic globalization and spatial inequality. Section 3 presents the measures used to quantify the incidence of economic integration and spatial inequality in the sample countries. In section 4 we describe the results of the empirical analysis.

The robustness of our findings is checked in section 5. Section 6 offers the main conclusions from the paper.

3.2 Theoretical framework

There is a vast literature devoted to examining from a theoretical perspective what happens within countries when trade barriers are removed between countries. Most of this literature focusses on the impact of international trade on the reallocation of resources and production factors across industries and on the distribution of firm types within countries (Brülhart, 2011). Nevertheless, the last three decades have seen the appearance of numerous theoretical contributions that seek to shed light on what occurs with the spatial distribution of economic activity within countries when trade with the rest of the world becomes less costly. This increasing interest on the spatial dimension of trade liberalization is closely related to the development of the so-called "new economic geography" (NEG). Previously, only the neoclassical urban systems models had attempted to incorporate into international trade theory the within-country spatial dimension (e.g. Henderson, 1982; Rauch, 1991). The urban systems models are based on the assumption of perfectly competitive markets with exogenous scale economies at the regional level, but in these contributions the changing internal geographies are not related to any welfare-relevant dimension of spatial inequality (Brülhart, 2011; Ezcurra and Rodríguez-Pose, 2013). Unlike the urban systems models, the NEG school allows for monopolistically competitive markets and endogenous regional scale economies. Within this framework, the NEG conceptualizes the effect of economic integration on the spatial distribution of income in terms of changes in cross-border access to markets that affect the interactions between agglomeration and dispersion forces, which ultimately contributes to determining the dynamics of the location of economic activity across the different regions within a country.

Nevertheless, the numerous NEG studies published since the appearance of the seminal paper by Krugman (1991) often provide contradictory and ambiguous conclusions regarding the impact of trade liberalization on spatial inequality (Rodríguez-Pose, 2012). Depending on the assumptions adopted on the dispersion forces, international trade can either increase or decrease regional income disparities. For example, Krugman and Livas Elizondo (1996) propose a model where trade liberalization, with unchanged internal transport costs, leads to regional convergence due to the existence of urban congestion costs. The same conclusion is obtained by Behrens et al. (2007) using the model of monopolistic competition developed by Ottaviano et al. (2002) in which the increasing intensity of local competition acts as a dispersion force. However, other papers closer to the original Krugman (1991) model such as Monfort and Nicolini (2000) or Paluzie (2001) achieve the opposite result. In these studies the dispersion force generated by the immobility of some workers ("farmers") across regions ultimately implies that trade openness favours spatial divergence. In turn, Fujita et al. (1999, chap. 18) find that trade liberalization gives rise to the spatial concentration of individual sectors in a model assuming the existence of sector-level agglomeration forces but no sector-level dispersion forces. In fact, the uncertainty on the impact of international trade on spatial inequality remains in those papers that consider an heterogeneous intra-national space in which some places offer cheaper access to foreign markets than others (e.g. Alonso Villar, 1999; Brülhart et al., 2004) or have better factor endowments (e.g. Haaparanta, 1998).

So far we have focussed on the spatial implications of trade liberalization. Nevertheless, as pointed out in the introduction, the degree of trade openness is not the only dimension of economic globalization relevant for spatial inequality. In particular, international capital flows may also affect the spatial distribution of income across the regions within a country. In fact, the standard neoclassical theory predicts that capital should flow to poorer regions where the marginal return of the investment is higher. According to this argument, international capital flows may contribute to reducing regional income disparities. In practice, however, there are numerous examples showing that international capital flows tend to benefit mainly the most prosperous regions, which often have better institutions and better access to foreign markets (e.g. Zhang and Zhang, 2003; Nunnenkamp and Stracke, 2008; Wei et al., 2009). Therefore, it is difficult to determine a priori the impact of international capital flows on regional income disparities.

The previous discussion reveals that the theoretical literature does not provide a conclusive result on the spatial implications of economic globalization. As shown above, this is a complex relationship and attempting to explain how economic integration affects the spatial distribution of economic activity within countries implies to take into account multiple factors and mechanisms that often work in opposite directions. In these circumstances, empirical research is key to shedding light on the nature of the link between economic globalization and spatial inequality. For this reason, the rest of the paper is devoted to investigating this issue in a cross-section of countries with different levels of economic development.

3.3 Measuring spatial inequality and economic globalization

The analysis of the link between globalization and spatial inequality requires to quantify the degree of economic integration in the various countries. To do this, most previous studies on this topic have resorted to various measures of trade openness and FDI as proxies for the incidence of economic globalization (Rodríguez-Pose, 2012; Lessmann, 2013; Ezcurra and Rodríguez-Pose, 2014; Hirte et al., 2017). As discussed above, this approach is useful to examine the impact of changes in trade and/or FDI flows on regional income disparities, but it ignores the spatial implications of other aspects of economic integration potentially important in this context, such as the extent of capital controls or variations in the amount of portfolio investment. This leads to a partial and incomplete view of economic globalization. In order to overcome this problem, in the present paper we follow the approach adopted by Ezcurra and Rodríguez-Pose (2013) and use as our measure of globalization the 2017 version of the KOF index of economic integration constructed by Dreher (2006) and updated by Dreher et al. (2008). This index is one of the components of the KOF index of globalization which also includes information about the social and political dimensions of integration. The KOF index has been widely used in the literature on international economics to capture different aspects of the consequences of the process of globalization.[1]

The KOF index of economic globalization is a composite indicator that takes into account the multidimensional nature of economic integration. The index is constructed by means of a principal component analysis using the eight variables

[1]A comprehensive list of papers using the KOF index of globalization can be found at http://globalization.kof.ethz.ch/. See also the survey paper by Potrafke (2015).

displayed in Table 3.1.[2] These variables, which capture different features of economic globalization, are employed to obtain two subindices. The first one measures the relevance of actual economic flows from the information provided by trade openness, FDI and portfolio investment across countries, expressed in all cases as a percentage of national GDP. This subindex also considers income payments to foreign nationals and capital to proxy for the extent that a country employs foreign labour force and capital in its production processes. The second subindex includes existing restrictions on trade and capital using hidden import barriers, mean tariff rates, taxes on international trade (as a share of current revenue), and a measure of capital controls based on data drawn from Gwartney et al. (2016). The overall index of economic globalization, which is our proxy for the degree of economic integration throughout the paper, results from aggregating the data on actual economic flows and restrictions (Table 3.1).

Table 3.1: Components of the KOF index of economic globalization.

Indices and variables	Weights
Actual economic flows	[50%]
Trade (percent of GDP)	(21%)
Foreign direct investment, stocks (percent of GDP)	(28%)
Portfolio investment (percent of GDP)	(24%)
Income payments to foreign nationals (percent of GDP)	(27%)
Restrictions	[50%]
Hidden import barriers	(22%)
Mean tariff rate	(28%)
Taxes on international trade (percent of current revenue)	(26%)
Capital account restrictions	(24%)

Source: http://globalization.kof.ethz.ch/

In order to estimate the relevance of spatial inequality within the various countries, we need regional data on income and population. Although national sta-

[2]For further details on the method of calculation used to obtain the index, see http://globalization.kof.ethz.ch/.

tistical offices, the OECD or Eurostat provide this kind of data for the majority of developed countries, lack of regional information in middle- and, especially, low-income countries represents an important barrier for the analysis. This limitation is particularly relevant if, as in our case, one aims to examine the spatial effect of economic integration at the global level, since during the last two decades numerous developing countries have implemented important reforms to open their economies to world markets (Ezcurra and Rodríguez-Pose, 2014). In order to overcome this problem of data availability, in the present paper we use a new dataset on spatial inequality recently constructed by Lessmann and Seidel (2017). These authors employ satellite night-time lights data to predict regional income per capita for 180 countries over the period 1992-2012. The method used by Lessmann and Seidel (2017) is based on estimating the relationship between night-time lights and income using existing regional income data. The results obtained are employed in a second step to calculate income predictions at the regional level using for each country the highest administrative division defined by the GADM project.[3] The employment of this dataset is particularly useful in our setting, as it allows us to include in the analysis a considerably higher number of countries than in Ezcurra and Rodríguez-Pose (2013), the only earlier study that has so far considered a comprehensive definition of economic globalization in this context (see the introduction for further details).

We use the dataset constructed by Lessmann and Seidel (2017) to compute the magnitude of spatial inequality within the various countries. To that end, we

[3]The reliability of the regional income predictions based on luminosity data is confirmed by various robustness tests performed by Lessmann and Seidel (2017, pp. 128-131). Interestingly, the results of these authors suggest that their predictions are more appropriate for an analysis of real income differentials within countries than observed income data, which are usually based on nominal values.

employ the population-weighted Gini index, which adopts the following form:

$$GINI_{it} = \frac{1}{2\mu_{it}} \sum_{j=1}^{J} \sum_{k=1}^{J} p_{jt} p_{kt} |y_{jt} - y_{kt}| \tag{3.3.1}$$

where y_{jt} and p_{jt} are respectively the (predicted) income per capita and population share of region j in country i during year t, and $\mu_{it} = \sum_{j=1}^{J} p_{jt} y_{jt}$. The Gini index is a measure of dispersion widely used in the literature on income inequality. Its advantage over other potential alternative measures is that it is independent of scale, and it satisfies the population principle and Pigou-Dalton transfer principle (Cowell, 1995; Lessmann and Seidel, 2017). Furthermore, this inequality measure takes into account the differences in population size across the regions in a country, which is particularly important in the present context. This issue has traditionally been overlooked by the literature on regional convergence, despite the fact that omitting population size significantly biases our perceptions of spatial inequality (Ezcurra and Rodríguez-Pose, 2013; Lessmann, 2014).

3.4 Empirical analysis: Does economic globalization affect spatial inequality?

3.4.1 The model

In this section we examine the relationship between economic globalization and spatial inequality in 142 countries over the period 1992-2012.[4] To that end, we

[4]The list of countries included in the analysis is ultimately determined by data availability to calculate the KOF index of economic globalization. In particular, in order to facilitate comparison, countries with missing data for some of the two subindices of economic integration mentioned in the prior section were removed from the analysis. See the Appendix for further details.

estimate the following model:

$$I_{it} = \alpha_i + \beta \log G_{it} + \gamma' X_{it} + \lambda_t + \varepsilon_{it} \quad (3.4.1)$$

where I_{it} is the measure of spatial inequality in country i and year t, G_{it} is the KOF index of economic globalization described in section 3.3, and X_{it} denotes a set of variables that control for additional factors that are assumed to have an influence on regional income disparities. In turn, α_i stands for country-specific effects, while λ_t are year dummies common to all countries. Finally, ε_{it} is the corresponding error term. The coefficient of interest throughout the paper is β, which measures the effect of economic integration on spatial inequality.[5]

At this point it is important to note that the inclusion of country fixed effects represents an important difference between this model and that considered by Ezcurra and Rodríguez-Pose (2013) in their previous study on the link between economic globalization and spatial inequality. Country fixed effects allow us to control for those time-invariant factors relevant in this context, removing from the analysis any potential bias emerging from the heterogeneity in territorial levels across countries (Lessmann and Seidel, 2017). Furthermore, country fixed effects also account for different geographical features which may be related to spatial inequality. This is the case, for example, of a country's total area. Larger countries are often characterized by greater spatial heterogeneity than smaller countries, which tend to be more homogeneous and compact (Williamson,

[5]Taking into account that the study period is relatively short, our empirical approach exploits the variation in annually repeated cross-country data in order to maximize the number of observations, thus thus reducing the collinearity among explanatory variables and improving the efficiency of the estimates (Baltagi, 2001). An alternative strategy would be to divide the time span under analysis into five-year periods (Lessmann and Seidel, 2017; Hirte et al., 2017). Although this latter approach may be preferable to minimize the potential effects of the business cycle (Lessmann, 2014), the employment of five-year periods comes at the cost of ignoring valuable information on changes in both spatial inequality and economic globalization within any given five-year interval. In any case, Table A1 in the Appendix shows that the main results of the paper remain qualitatively unaltered when we divide the study period into five-year periods to estimate model (3.4.1).

1965; Ezcurra and Rodríguez-Pose, 2017). Likewise, within-country geographical heterogeneity may affect the spatial distribution of income. In fact, spatial inequality has often to do with the existence of physical constraints to mobility, as more topographically uneven countries tend to experience a greater spatial concentration of economic activity (Ramcharan, 2009). Importantly, many of these geographical factors are also likely to be correlated with globalization (Frankel and Romer, 1999; Hirte et al., 2017), which implies that removing the country fixed effects from model (3.4.1) may lead to biased and inconsistent estimates.

3.4.2 Baseline results

The first three columns in panel A of Table 3.2 show the results obtained when various versions of model (3.4.1) are estimated by OLS using heteroskedastic and autocorrelation consistent standard errors. Column 1 considers a parsimonious specification in which our measure of spatial inequality, the population-weighted Gini index, is regressed on the indicator of economic globalization and country and time fixed effects. In column 2 we also include the level of GDP per capita as an additional control, since spatial inequality and economic globalization may both be related to the level of economic development (Frankel and Romer, 1999; Alesina et al., 2016).[6] In fact, adopting the Kuznets' (1955) approach to a spatial framework, some studies suggest that the link between regional income disparities and economic development may be non-linear (Williamson, 1965; Lessmann, 2014). That is, as progress in economic development takes place, spatial inequality first increases, before systematically decreasing in the ensuing stages of development. Nevertheless, this process of

[6] The sources and definitions of all the control variables used throughout the paper are presented in the Appendix.

regional convergence does not continue indefinitely and spatial inequality may again increase at very high levels of economic development (Lessmann, 2014; Lessmann and Seidel, 2017). The result would be a N-shaped trend in spatial inequality. Bearing this in mind, in column 3 we consider a cubic functional relationship between spatial inequality and GDP per capita.

Table 3.2: Economic globalization and spatial inequality: Baseline results.

	OLS (1)	OLS (2)	OLS (3)	2SLS (4)	2SLS (5)	2SLS (6)
Panel A			*Dependent variable is Spatial inequality*			
Economic globalization	0.003**	0.003***	0.003***	0.029**	0.030**	0.041**
	(0.001)	(0.001)	(0.001)	(0.012)	(0.012)	(0.017)
GDP per capita		-0.002	0.160***		-0.005**	0.342***
		(0.001)	(0.042)		(0.002)	(0.093)
(GDP per capita)^2			-0.017***			-0.041***
			(0.005)			(0.012)
(GDP per capita)^3			0.001***			0.002***
			(0.000)			(0.000)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.141	0.142	0.163			
Countries	142	142	142	142	142	142
Observations	2,918	2,918	2,918	2,918	2,918	2,918
Panel B			*First stage for Economic globalization*			
Economic globalization				0.944***	0.905***	0.709***
in neighbouring countries				(0.171)	(0.162)	(0.147)
GDP per capita					0.125***	-4.018***
					(0.025)	(1.007)
(GDP per capita)^2						0.516***
						(0.114)
(GDP per capita)^3						-0.021***
						(0.004)
Country fixed effects				Yes	Yes	Yes
Time fixed effects				Yes	Yes	Yes
Kleibergen-Paap rk LM stat.				62.96***	51.01***	34.09***
F statistic excluded instrum.				30.43***	31.12***	23.40***
R-squared				0.459	0.471	0.485
Countries				142	142	142
Observations				2,918	2,918	2,918

Notes: The dependent variable in Panel A is the population-weighted Gini index. Heteroskedasticity and autocorrelation consistent standard errors in parentheses. * Significant at 10% level, ** significant at 5% level, *** significant at 1% level.

The results displayed in the first three columns in panel A of Table 3.2 show that the coefficient of the KOF index of economic globalization is in all cases positive and statistically significant. This suggests that those countries whose economies are more integrated with the rest of the world tend to experience greater levels of spatial inequality, which is in line with the findings obtained by Ezcurra and Rodríguez-Pose (2013) for a considerably smaller number of countries than that considered in the present paper. It is important to note that the inclusion of GDP per capita in the list of regressors of model (3.4.1) does not reduce the effect of economic globalization on regional income disparities –in terms of coefficient size and its statistical significance (columns 2 and 3). This seems to indicate that the degree of economic integration affects spatial inequality beyond its potential impact through the level of economic development. Furthermore, our estimates do not support the existence of a linear relationship between GDP per capita and regional income disparities (column 2), but are consistent with the presence of a N-shaped trend (column 3), confirming the results of Lessmann (2014) and Lessmann and Seidel (2017).

As mentioned in the introduction, fixed effects regressions do not necessarily identify the causal effect of economic globalization on spatial inequality. Indeed, it is possible that $Cov(\log G_{it}, \varepsilon_{it}) \neq 0$ because of the potential reverse impact of spatial inequality on the spread of globalization. The existence of differences in development terms across the regions of a country may foster the adoption of public policies designed to improve the relative situation of lagging regions, including infrastructure projects, regional transfers or formal fiscal equalization schemes. As well as affecting the spatial distribution of income within national borders, this kind of policies may also have an influence on the intensity of economic flows between the country in question and the rest of the world (Hirte et al., 2017). Moreover, high levels of spatial inequality may contribute to increasing the risk of political instability and internal conflict (Deiwiks et al., 2012;

Ezcurra and Palacios, 2016), which may in turn affect the spread of globalization (Martin et al., 2008). In addition to this reverse causality problem, there may be time-varying omitted determinants of spatial inequality correlated with the degree of economic integration. Finally, the values of the KOF index of economic globalization may be affected by measurement errors.

All of these problems could be solved if we had a suitable instrument for globalization. Such an instrument must not be correlated with the error term in model (3.4.1), but account for the cross-country variation in the incidence of globalization. Due to the nature of the KOF index of globalization, finding an exogenous source of variation is not an easy task. Fortunately, we can follow the strategy adopted by Ezcurra and Manotas (2017) and use as instrument the (weighted) average of the incidence of globalization in neighbouring countries. To calculate this average, the values of the globalization index are weighted by a spatial weights matrix, W, which describes the spatial interdependences among the sample countries. In particular, W is defined as follows:

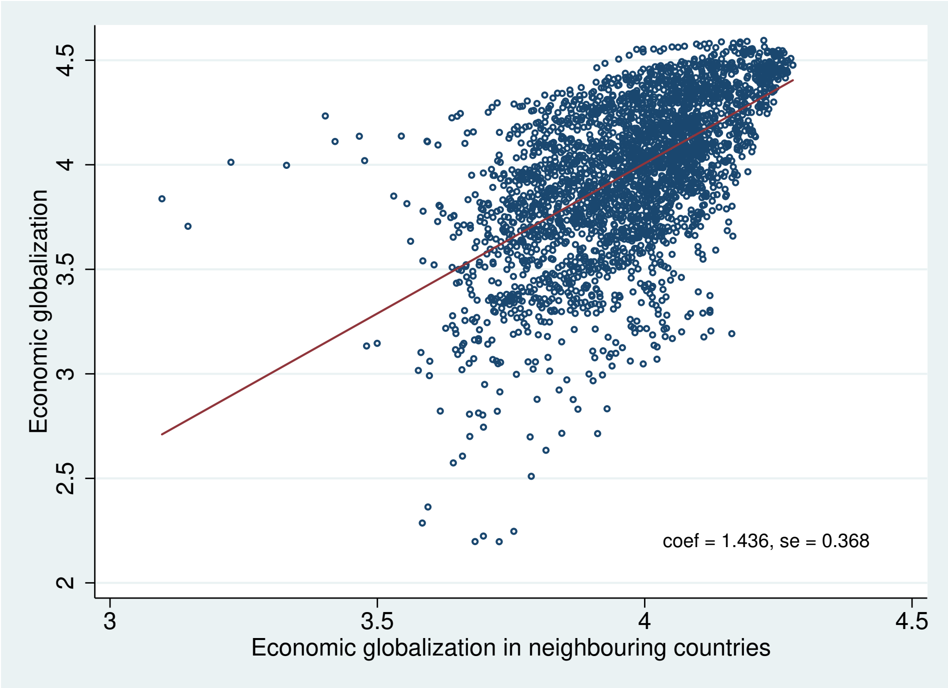
$$W = \begin{cases} w_{ij} = 0 \quad \text{if} \quad \mathrm{i} = \mathrm{j} \\ w_{ij} = \frac{1/d_{ij}}{\sum\limits_{j} 1/d_{ij}} \quad \text{if} \quad \mathrm{i} \neq \mathrm{j} \end{cases} \tag{3.4.2}$$

where d_{ij} is the geographical distance between countries i and j, which in itself is strictly exogenous. As can be checked, W is row standardized, so that it is relative and not absolute distance which matters. As discussed in Ezcurra and Manotas (2017, p. 2599), the rationale for using this instrument is based on the idea that geography and spatial interdependence are important factors for the spread of globalization, which is consistent, for example, with many theoretical models proposed in the context of the NEG school (e.g. Krugman, 1998; Fujita and Thisse, 2002). In fact, numerous studies find that economic flows are more likely between neighbouring countries, as transport costs increase with geographical distance and neighbouring countries are in general culturally similar (Anderson and Van Wincoop, 2004; Disdier and Head, 2008; Klasing, 2013).

The various arguments discussed above suggest that a country's level of economic globalization should be higher (lower), the higher (lower) the degree of integration of its neighbouring countries with the rest of the world. This is confirmed by the scatter plot displayed in Figure 3.1. In fact, the instrument alone explains around 34% of the cross-country variation in the incidence of globalization. The relevance of the instrument is corroborated by the first stage regressions included in panel B of Table 3.2. The coefficient of the degree of economic integration in neighbouring countries is in all cases positive and statistically significant at the 1% level, which is consistent with the information provided by Figure 3.1. Furthermore, the estimated Kleibergen and Paap's (2006) rk LM statistics allow us to reject the null hypothesis that the instrument is uncorrelated with the endogenous regressor and that the model is not identified. Finally, the values of the F statistics for the excluded instrument lies well above 10 in the various specifications, which indicates that there is no reason to believe that our estimates are biased by a weak instrument.

To be a valid instrument, however, the degree of globalization in neighbouring countries should not have influence on spatial inequality in any given country beyond its effect on the level of globalization in that country. This exclusion restriction cannot be tested formally in the absence of other instruments, but we consider that it is a plausible assumption. Nevertheless, one may argue that the degree of economic integration in neighbouring countries might affect the dependent variable in model (3.4.1) through its impact on the level of economic development in neighbouring countries. In order to address this potential con-

Figure 3.1: Economic globalization and degree of integration in neighbouring countries.



cern, we control for the (weighted) average GDP per capita in neighbouring countries. As can be checked in section 3.5, the observed relationship between economic globalization and spatial inequality survives this test.

Columns 4-6 in panel A of Table 3.2 present the results of the second stage regressions. As in the OLS regressions discussed above, the 2SLS estimates show that the coefficient of the index of economic integration is in all cases positive and statistically significant. It is worth noting, however, that its size is larger than in the OLS estimates, which may have to do with a potential attenuation bias generated by measurement error in the index of economic globalization. To get a more accurate idea of the dimension of the impact of economic globalization on spatial inequality, let us consider for example the case of Malawi. In 2010 Malawi had a relatively low degree of integration with the rest of the world ($G = 42.1$), while the value of the population-weighted Gini index in that country was around the sample mean ($GINI = 0.074$). According to our estimates, if Malawi had had a level of globalization similar to that of Turkey ($G = 55.7$), its degree of spatial inequality would have increased by around 17.6%. These figures suggest that economic globalization exerts a quantitatively relevant impact on regional income disparities.

So far we have examined the overall effect of economic globalization on spatial inequality. In order to complement our previous findings, we now use the information provided by the KOF index to investigate the role played in this context by its two components: actual economic flows and existing restrictions on trade and capital (see section 3.3 for further details). This is especially interesting, as it is not evident a priori that these two aspects of economic integration affect spatial inequality in the same way. Accordingly, model (3.4.1) is estimated again using the subindices of actual economic flows and restrictions as regressors, instead of the overall index employed so far. The results presented in Table 3.3 indicate that the subindex of actual economic flows has a positive and significant effect on spatial inequality, which implies that countries with higher values in this dimension of globalization tend to experience greater regional income disparities. Regarding the second component of the KOF index, the information provided by Table 3.3 reveals that existing restrictions on trade and capital do not have any significant influence on spatial inequality.[7]

[7]Following the same strategy described above, the 2SLS regressions in columns 4-6 of Table 3.3 use the (weighted) average of actual economic flows and restrictions in neighboring countries as instruments for the two components of the KOF index of economic globalization.

Table 3.3: Actual economic flows, restrictions and spatial inequality.

	OLS (1)	OLS (2)	OLS (3)	2SLS (4)	2SLS (5)	2SLS (6)
Actual economic flows	0.002**		0.002**	0.030***		0.032***
	(0.001)		(0.001)	(0.010)		(0.010)
Restrictions		0.001	0.001		0.005	0.008
		(0.001)	(0.001)		(0.006)	(0.007)
GDP per capita	0.148***	0.154***	0.157***	0.209***	0.186***	0.278***
	(0.042)	(0.043)	(0.043)	(0.058)	(0.060)	(0.083)
(GDP per capita)^2	-0.016***	-0.017***	-0.017***	-0.023***	-0.021***	-0.032***
	(0.005)	(0.005)	(0.005)	(0.007)	(0.007)	(0.010)
(GDP per capita)^3	0.001***	0.001***	0.001***	0.001***	0.001**	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap rk LM stat.				41.86***	34.93***	33.57***
F statistic Actual economic flows				14.96***		7.60***
F statistic Restrictions					42.77***	21.36***
Countries	142	142	142	142	142	142
Observations	2,918	2,918	2,918	2,918	2,918	2,918

Notes: The dependent variable is in all cases the population-weighted Gini index. Heteroskedasticity and autocorrelation consistent standard errors in parentheses. * Significant at 10% level, ** significant at 5% level, *** significant at 1% level.

3.5 Robustness checks

The analysis carried out thus far indicates that the degree of economic integration with the rest of the world exerts a positive and significant effect on spatial inequality. This is due to the impact of actual economic flows on regional income disparities, whereas existing restrictions on trade and capital do not appear to have influence in this context. In this section we investigate the robustness of these findings.

3.5.1 Influential countries

As a first robustness test, we examine the impact of influential countries on the above results. To do this, we begin by removing from the sample the ten countries with the lowest and highest average values of the index of economic globalization throughout the study period. The estimates in columns 1-4 of Table 3.4 reveal that the coefficients of the aggregate index of economic globalization and the subindex of actual flows continue to be positive and statistically significant in all cases, which means that our results are not driven by the least and most globalized countries. Analogously, columns 5-8 of Table 3.4 show that our findings also hold when we exclude from the analysis the ten countries with the lowest and highest levels of spatial inequality during the study period.

[INSERT TABLE 3.4 AROUND HERE]

We now examine whether the level of economic development matters in this context. To investigate this issue, we remove from the sample the groups of low-income countries and high-income countries according to the World Bank classification. Despite the reduction in the sample size, the results in columns 9-12 of Table 3.4 reveal that our main findings remain qualitatively unaltered. That said, it is interesting to note that the size of the coefficients suggests that the spatial impact of economic globalization seems to be greater in low- and middle-income countries, which is consistent with the empirical evidence provided by Ezcurra and Rodríguez-Pose (2013).

3.5.2 Alternative measures of spatial inequality

The results of our analysis may be sensitive to the choice of the measure used to quantify the degree of spatial inequality within the various countries. Different inequality measures may provide different orderings of the distribution one wishes to compare, as each index has a different way of aggregating the information contained in the distribution under study (Ezcurra and Rodríguez-Pose, 2017). For this motive, and in order to complement the information provided by the population-weighted Gini index employed so far, we now use other alternative measures of spatial inequality. Specifically, we resort to various members of the generalized entropy family of inequality measures ($GE(\delta)$), and the population-weighted coefficient of variation (CV). These measures can be expressed as follows:

$$GE(\delta)_{i,t} = \frac{1}{\delta^2 - \delta}\left[\sum_{j=1}^{J} p_{j,t}\left[\left(\frac{y_{j,t}}{\mu_{i,t}}\right)^{\delta} - 1\right]\right] \quad (3.5.1)$$

$$CV_{it} = \frac{1}{\mu_{it}}\left[\sum_{j=1}^{J} p_{jt}\left(y_{jt} - \mu_{it}\right)^2\right]^{0.5} \quad (3.5.2)$$

where δ is the weight attached to income differences between different parts of the distribution. In our analysis, $\delta = -1, 0, 1$.[8] $GE(0)$ coincides with the population-weighted mean logarithmic deviation, whereas $GE(1)$ is equal to the population-weighted Theil index. In turn, CV has been widely used in the literature on regional disparities (Williamson, 1965; Lessmann, 2014; Ezcurra and Rodríguez-Pose, 2017). As in the case of the population-weighted Gini index, these measures are independent of scale and satisfy the population principle, and Pigou-Dalton transfer principle.

[INSERT TABLE 3.5 AROUND HERE]

Table 3.5 provides the results obtained when the estimation of the baseline model is repeated using as regressors $GE(-1)$, $GE(0)$, $GE(1)$ and CV. The coefficients of the aggregate index of economic globalization and the subindex

[8] Note that $GE(\delta)$ can be transformed into a subclass of the widely employed Atkinson index with $\varphi = 1 - \delta$ for $0 \leq \delta < 1$, where φ is the (relative) inequality aversion parameter (Lessmann and Seidel, 2017).

of actual flows are in all cases positive and statistically significant, indicating that the observed connection between the degree of economic integration and regional income disparities holds regardless of the specific measure employed to calculate the magnitude of spatial inequality within the various countries.

3.5.3 Additional controls

As an additional sensitivity check, we examine the possibility that our results are driven by an omitted variable. This requires controlling for different covariates that may be correlated with spatial inequality, economic globalization or the instrument used in the analysis, and checking whether the inclusion of these covariates affects our estimates.

We begin by considering the role played by natural resources in this context. Some natural resources, such as minerals and fuels, tend to be spatially concentrated, thus affecting industry location and, therefore, the regional distribution of income within countries (Henderson et al., 2012; Lessmann and Seidel, 2017). In fact, the presence of natural resources is also likely to have influence on the degree of openness to world markets. In view of this, we investigate whether the observed link between economic globalization and spatial inequality still holds when we control for natural resources. To do this, we use two variables: total natural resources rents and oil rents, expressed in both cases as a share of national GDP. Following Lessmann (2014), we also include in the list of regressors of model (3.4.1) the share of population living in urban areas as a proxy for potential agglomeration effects, which may affect regional income disparities. At this point it is important to note that there are numerous studies showing the existence of a relationship between urban concentration and trade openness (Frankel and Romer, 1999; Krugman and Livas Elizondo, 1996; Nitsch, 2006).

Moreover, economic globalization may be associated with the incidence of civil conflicts (Barbieri and Reuveny, 2005; Martin et al., 2008). Given the possibility that political instability and internal conflict may also affect the spatial distribution of income within a country (Abadie and Gardeazabal, 2003), we also include in the baseline model a dummy variable indicating if the country in question has experienced a civil conflict in each year of the study period. Furthermore, the existence of more or less developed redistributive policies is likely to be related to spatial inequality and globalization (Ezcurra and Rodríguez-Pose, 2013). Accordingly, any observed connection between economic globalization and spatial inequality may be spurious if existing differences in the capacity of the state to redistribute financial resources across regions are ignored. For this reason, we follow Rodríguez-Pose and Ezcurra (2010) and control for government size, measured as the share of government expenditure in GDP, as a proxy for the redistributive capacity of the state in the sample countries.

The exclusion restriction implied by our 2SLS regressions is that, conditional on the set of controls, the instrument has no effect on spatial inequality, other than its impact through the degree of economic integration with the rest of the world. As pointed out above, we consider that this is a plausible assumption. Nevertheless, one might argue that the intensity of globalization in neighbouring countries could have influence on their level of economic development, which may in turn give rise to population movements between the various countries. These migratory flows may eventually modify the regional distribution of population within the different countries, thus affecting their levels of spatial inequality. In order to address empirically this potential concern, we also control for the (weighted) average GDP per capita in neighbouring countries.

The results of estimating model (3.4.1) including these additional controls are presented in Table 3.6. The majority of the newly-added controls are not statistically significant at conventional levels and, more importantly, have little impact on the main results of the paper. The new controls do not affect the estimates of the impact of the degree of economic integration with the rest of the world on spatial inequality. The coefficients of the aggregate index of economic globalization and the subindex of actual flows remain positive and statistically significant in all cases, confirming, once again, the robustness of our findings.

[INSERT TABLE 3.6 AROUND HERE]

3.6 Conclusions

With the aim of improving our understanding of the factors behind spatial inequality, this paper has examined the relationship between economic globalization and regional income disparities in a panel of 142 countries over the period 1992-2012. Unlike most of existing studies on this topic, our analysis uses a comprehensive notion of globalization which takes into account different aspects associated with the opening of national economies to world markets. The instrumental variables estimates presented in the paper reveal a strong causal effect of the degree of economic integration with the rest of the world on spatial inequality, indicating that the advances in the process of globalization currently underway contribute to significantly increasing regional income disparities. This means that globalization leads to the emergence of losing and winning regions within countries, and that the group of losing (winning) regions tend to be made up of low-(high-)income regions. This result has to do with the regressive spatial impact of actual economic flows, whereas existing restrictions on trade and capital do not exert a significant effect in this context. Our findings are robust to the inclusion in the analysis of different covariates that may be correlated with both spatial inequality and globalization such as the level of development, geographical factors, the degree of urban concentration or natural resources abundance. We have also checked that the results are not driven by a specific group of influential countries and neither do they depend on the measure used to quantify the degree of spatial inequality within the various countries.

Our research raises some potentially interesting implications. Thus, the observed relationship between economic globalization and spatial inequality should not be overlooked by policy makers and international organizations because of the negative consequences derived from high levels of spatial inequality. Regional income disparities may spark social unrest and grievances, which may contribute to the rise of populism (Rodríguez-Pose, 2018). At the same time, the existence of high levels of spatial inequality may lead to redistributive struggles across regions, thus undermining political stability and making civil conflict more likely (Sambanis and Milanovic, 2014). Indeed, the risk is particularly relevant in the developing world, since the degree of economic integration with the rest of the world in many developing countries still has a large potential to grow. In the view of this, the opening of national borders to world markets should be accompanied by active public policies designed to improve the conditions for the development of economic activity in lagging regions.

The present paper has documented the unconditional effect of globalization on spatial inequality. Nevertheless, the impact of globalization on regional income disparities may be contingent on factors such as the quality of government, industry mix or the devolution of fiscal and political power from central to subnational governments. Further research should explore the empirical relevance of these potential interaction effects in order to complete our results and attain a more detailed picture about how economic globalization affects spatial inequality. Future studies should also examine the transmission channels which ultimately explain the observed effect of globalization on spacial inequality.

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Appendix (for online publication)

List of countries

Albania
Algeria
Angola
Argentina
Armenia
Australia
Austria
Azerbaijan
Bahamas
Bahrain
Bangladesh
Barbados
Belgium
Belize
Benin
Bhutan
Bolivia
Bosnia Herzegovina
Botswana
Brazil
Brunei
Bulgaria
Burkina Faso
Burundi
Cambodia
Cameroon
Canada
Central African Rep.
Chad
Chile
China
Colombia
Congo
Congo (Dem. Rep.)
Costa Rica
Cote d'Ivoire
Croatia
Cyprus
Czech Republic
Denmark
Dominican Republic
Ecuador
Egypt
El Salvador
Estonia
Ethiopia
Finland
France
Gabon
Gambia
Georgia
Germany
Ghana
Greece
Guatemala
Guinea
Guyana
Haiti
Honduras
Hungary
Iceland
India
Indonesia
Iran
Ireland
Israel
Italy
Jamaica
Japan
Jordan
Kazakhstan
Kenya

Kyrgyzstan
Latvia
Lesotho
Lithuania
Luxembourg
Macedonia
Madagascar
Malawi
Malaysia
Mali
Mauritania
Mauritius
Mexico
Moldova
Mongolia
Montenegro
Morocco
Mozambique
Myanmar
Namibia
Nepal
Netherlands
New Zealand
Nicaragua
Niger
Nigeria
Norway
Oman
Pakistan
Panama
Papua New Guinea
Paraguay
Peru
Philippines
Poland
Portugal
Qatar
Romania
Russian Federation
Rwanda
Saudi Arabia
Senegal
Serbia
Sierra Leone
Slovakia
Slovenia
South Africa
Spain
Sri Lanka
Suriname
Swaziland
Sweden
Switzerland
Tajikistan
Tanzania
Thailand
Togo
Trinidad and Tobago
Tunisia
Turkey
Uganda
Ukraine
United Kingdom
United States
Uruguay
Venezuela
Vietnam
Yemen
Zambia
Zimbabwe

Definitions and sources of control variables

GDP per capita: Log of GDP per capita based on purchasing power parity and expressed in constant 2011 international dollars. Source: World Development Indicators.

Natural resources rents: Total natural resources rents expressed as a share of GDP. Source: World Development Indicators.

Oil rents: Oil rents expressed as a share of GDP. Source: World Development Indicators.

Urban population: Fraction of the total population living in urban areas. Source: World Development Indicators.

Civil conflict: Dummy variable that takes the value one if the country has experienced a civil armed conflict in the year in question, and zero otherwise. A country is recorded as having experienced a civil armed conflict in a given year if a threshold of 25 or more battle-related deaths has been met. Source: UCDP/PRIO.

Government size: Government expenditure expressed as a share of GDP. Source: International Monetary Fund.

Additional Tables

[INSERT TABLE A1 AROUND HERE]

Tables and Figures

Table 3.4: Robustness analysis: Influential countries.

	2SLS (1)	2SLS (2)	2SLS (3)	2SLS (4)	2SLS (5)	2SLS (6)	2SLS (7)	2SLS (8)	2SLS (9)	2SLS (10)	2SLS (11)	2SLS (12)
Economic globalization	0.041**		0.050**		0.048**		0.037**		0.046**		0.056**	
	(0.018)		(0.020)		(0.019)		(0.017)		(0.021)		(0.026)	
Actual economic flows		0.031***		0.033***		0.036***		0.029***		0.037***		0.038**
		(0.010)		(0.010)		(0.012)		(0.009)		(0.011)		(0.016)
Restrictions		0.008		0.015*		0.010		0.006		0.006		0.008
		(0.008)		(0.009)		(0.008)		(0.007)		(0.009)		(0.017)
GDP per capita	0.400***	0.346***	0.318***	0.247***	0.375***	0.276***	0.348***	0.278***	0.506	0.444*	0.368***	0.246
	(0.099)	(0.097)	(0.094)	(0.095)	(0.110)	(0.100)	(0.100)	(0.086)	(0.309)	(0.265)	(0.117)	(0.176)
(GDP per capita)^2	-0.047***	-0.039***	-0.038***	-0.029**	-0.045***	-0.032***	-0.041***	-0.032***	-0.059*	-0.050*	-0.044***	-0.029
	(0.012)	(0.012)	(0.012)	(0.012)	(0.014)	(0.012)	(0.012)	(0.010)	(0.035)	(0.030)	(0.015)	(0.023)
(GDP per capita)^3	0.002***	0.001***	0.001***	0.001**	0.002***	0.001**	0.002***	0.001***	0.002*	0.002	0.002***	0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Omitted countries	Least globalized	Least globalized	Most globalized	Most globalized	Least unequal	Least unequal	Most unequal	Most unequal	Low income	Low income	High income	High income
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap rk LM stat.	31.39***	23.37***	24.82***	19.23***	26.29***	30.85***	34.01***	30.02***	24.72***	20.48***	17.18***	6.242**
F stat. Economic globaliz.	21.34***		18.84***		20.15***		22.20***		19.30***		12.72***	
F stat. Actual economic flows		8.93***		7.40***		6.72***		7.76***		11.91***		4.96***
F stat. Restrictions		18.11***		14.87***		18.80***		20.68***		11.17***		4.88***
Countries	132	132	132	132	132	132	132	132	114	114	98	98
Observations	2,708	2,708	2,711	2,711	2,713	2,713	2,708	2,708	2,343	2,343	2,019	2,019

Notes: The dependent variable is in all cases the population-weighted Gini index. Heteroskedasticity and autocorrelation consistent standard errors in parentheses. * Significant at 10% level, ** significant at 5% level, *** significant at 1% level.

Table 3.5: Robustness analysis: Alternative measures of spatial inequality.

	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	$GE(-1)$	$GE(-1)$	$GE(0)$	$GE(0)$	$GE(1)$	$GE(1)$	CV	CV
Economic globalization	0.011**		0.011**		0.011**		0.066**	
	(0.004)		(0.004)		(0.005)		(0.028)	
Actual economic flows		0.008***		0.008***		0.008***		0.057***
		(0.003)		(0.003)		(0.003)		(0.020)
Restrictions		0.001		0.000		-0.001		-0.007
		(0.002)		(0.002)		(0.002)		(0.013)
GDP per capita	0.081***	0.054**	0.079***	0.046*	0.078***	0.038	0.486***	0.235
	(0.026)	(0.024)	(0.026)	(0.024)	(0.026)	(0.026)	(0.160)	(0.167)
(GDP per capita)^2	-0.010***	-0.006**	-0.010***	-0.005*	-0.010***	-0.004	-0.059***	-0.026
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.020)	(0.020)
(GDP per capita)^3	0.000***	0.000**	0.000***	0.000*	0.000***	0.000	0.002***	0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap rk LM stat.	34.09***	33.57***	34.09***	33.57***	34.09***	33.57***	34.09***	33.57***
F stat. Economic globaliz.	23.40***		23.40***		23.40***		23.40***	
F stat. Actual economic flows		7.60***		7.60***		7.60***		7.60***
F stat. Restrictions		21.36***		21.36***		21.36***		21.36***
Countries	142	142	142	142	142	142	142	142
Observations	2,918	2,918	2,918	2,918	2,918	2,918	2,918	2,918

Notes: Heteroskedasticity and autocorrelation consistent standard errors in parentheses. * Significant at 10% level, ** significant at 5% level, *** significant at 1% level.

Table 3.6: Robustness analysis: Additional controls.

	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Economic globalization	0.041**		0.039**		0.039**		0.042**		0.042**		0.042**	
	(0.017)		(0.018)		(0.016)		(0.016)		(0.020)		(0.017)	
Actual economic flows		0.032***		0.033***		0.032***		0.031***		0.082**		0.032***
		(0.010)		(0.012)		(0.011)		(0.009)		(0.039)		(0.010)
Restrictions		0.007		0.009		0.008		0.009		-0.002		0.008
		(0.007)		(0.008)		(0.008)		(0.007)		(0.013)		(0.008)
GDP per capita	0.347***	0.263***	0.279***	0.241***	0.288***	0.272***	0.345***	0.289***	0.245***	0.072	0.347***	0.277***
	(0.086)	(0.082)	(0.081)	(0.087)	(0.077)	(0.078)	(0.092)	(0.081)	(0.080)	(0.165)	(0.097)	(0.086)
(GDP per capita)^2	-0.041***	-0.030***	-0.034***	-0.029***	-0.034***	-0.032***	-0.041***	-0.034***	-0.029***	-0.007	-0.041***	-0.032***
	(0.011)	(0.010)	(0.010)	(0.011)	(0.009)	(0.010)	(0.011)	(0.010)	(0.010)	(0.020)	(0.012)	(0.011)
(GDP per capita)^3	0.002***	0.001***	0.001***	0.001**	0.001***	0.001***	0.002***	0.001***	0.001***	0.000	0.002***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Natural resources rents	0.001	-0.008										
	(0.008)	(0.010)										
Oil rents			0.001	-0.009								
			(0.006)	(0.009)								
Urban population					-0.016	0.002						
					(0.014)	(0.015)						
Civil conflict							-0.002**	-0.003***				
							(0.001)	(0.001)				
Government size									-0.008*	-0.009		
									(0.005)	(0.011)		
GDP per capita in											0.005	-0.001
neighbouring countries											(0.006)	(0.008)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap rk LM statistic	36.78***	37.32***	34.35***	38.49***	34.98***	28.01***	34.09***	31.22***	26.41***	11.47***	37.25***	32.60***
F stat. Economic globaliz.	23.44***		21.41***		22.51***		24.03***		21.81***		21.89***	
F stat. Actual economic flows		7.11***		6.51***		7.17***		8.03***		3.26**		7.51***
F stat. Restrictions		21.08***		19.59***		18.97***		21.01***		17.67***		18.40***
Countries	142	142	139	139	140	140	142	142	140	140	142	142
Observations	2,915	2,915	2,834	2,834	2,872	2,872	2,918	2,918	2,359	2,359	2,918	2,918

Notes: The dependent variable is in all cases the population-weighted Gini index. Heteroskedasticity and autocorrelation consistent standard errors in parentheses. * Significant at 10% level, ** significant at 5% level, *** significant at 1% level.

Table A1: Robustness analysis: Five-year periods.

	2SLS (1)	2SLS (2)	2SLS (3)	2SLS (4)	2SLS (5)	2SLS (6)
Economic globalization	0.037**	0.039**	0.054**			
	(0.017)	(0.017)	(0.024)			
Actual economic flows				0.035**		0.037**
				(0.018)		(0.016)
Restrictions					0.008	0.007
					(0.010)	(0.013)
GDP per capita		-0.006*	0.369**	0.169*	0.206*	0.238*
		(0.004)	(0.153)	(0.091)	(0.108)	(0.143)
$(\text{GDP per capita})^2$			-0.045**	-0.019*	-0.023*	-0.027
			(0.019)	(0.011)	(0.013)	(0.018)
$(\text{GDP per capita})^3$			0.002**	0.001	0.001	0.001
			(0.001)	(0.000)	(0.001)	(0.001)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap rk LM statistic	29.49***	24.20***	15.25***	13.66***	14.42***	7.978***
F stat. Economic globaliz.	10.23***	11.45***	8.48***			
F stat. Actual economic flows				5.01**		2.55*
F stat. Restrictions					14.71***	7.59***
Countries	142	142	142	142	142	142
Observations	696	696	696	696	696	696

Notes: The dependent variable is in all cases the population-weighted Gini index. Heteroskedasticity and autocorrelation consistent standard errors in parentheses. * Significant at 10% level, ** significant at 5% level, *** significant at 1% level.

Table A2: Descriptive statistics.

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
Spatial inequality: $GINI$	2918	0.066	0.032	0.002	0.163
Spatial inequality: $GE(-1)$	2918	0.010	0.009	0.000	0.046
Spatial inequality: $GE(0)$	2918	0.010	0.009	0.000	0.046
Spatial inequality: $GE(1)$	2918	0.010	0.010	0.000	0.053
Spatial inequality: CV	2918	0.131	0.067	0.003	0.356
Economic globalization	2918	3.973	0.363	2.197	4.595
Actual economic flows	2918	3.967	0.425	2.062	4.605
Restrictions	2918	3.927	0.481	1.656	4.590
Ec. Glob. neighb. countries	2918	3.976	0.148	3.097	4.277
Actual econ. flows neighb. countries	2918	3.987	0.157	2.819	4.413
Restrictions neighb. countries	2918	3.955	0.178	2.980	4.290
GDP per capita	2918	8.928	1.251	5.870	11.770
(GDP per capita)^2	2918	81.3	22.2	34.5	138.5
(GDP per capita)^3	2918	753.3	300.3	202.3	1630.6
Natural resources rents	2915	0.075	0.107	0.000	0.635
Oil rents	2836	0.048	0.112	0.000	0.733
Urban population	2873	0.540	0.227	0.063	0.989
Civil conflict	2918	0.163	0.369	0.000	1.000
Government size	2360	0.312	0.117	0.000	0.710
GDP per capita neighb. countries	2918	8.966	0.439	6.907	9.927

Chapter 4

The Lucas Paradox in the Great Recession: Does the type of capital matter?

Published paper:

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4.1 Introduction

Why doesn't capital flow from rich to poor countries? is a key economic question, raised in Lucas (1990) seminal paper. More than three decades later, even though there has been a substantial number of empirical studies trying to provide an explanation to the Lucas Paradox, it remains relevant, and arguably, unresolved. The Paradox is clear, capital should flow from countries with low marginal returns of capital (i.e., rich economies) into countries where marginal returns are higher (i.e., poor economies). The surge of financial globalisation in the late 90s along with the recent financial crisis provide natural examples of the lack of flows from rich to poor countries. It has been argued that institutions explain the paradox by affecting ex-ante capital returns and hence capital inflows. Alfaro, Kalemli-Ozcan, and Volosovych (2008) (henceforth, AKV) found that institutional quality, not only is a strong determinant of capital inflows, but also accounts as a robust solution for the Lucas Paradox, since it removes the positive and significant relationship between the log of initial income per capita and aggregate capital inflows per capita. However, the validity of AKV results has been questioned by Azémar and Desbordes (2013) and Athtaruzzaman (2017), who claim that their model is missespecified. On the contrary, Göktan (2015) uses cross-banking statistics of the Bank of International Settlements (BIS) to argue that institutions solve the Paradox once country heterogeneity is controlled.

These empirical papers treat capital inflows as the sum of FDI and Portfolio Equity liabilities (PE, hereafter) for the period previous to the financial crisis. The contribution of this paper is twofold. First, the Lucas Paradox is evaluated in the Great Recession (2008-2015) using the latest available data for capital stock and institutional quality (Lane and Milessi-Ferreti 2017). Second, I check whether the Lucas puzzle still holds once we disaggregate data on capital inflows, studying separately FDI and PE. AKV argue that the reason for aggregating capital is data availability for PE flows. However, assuming that a country does not receive capital when in reality it is unknown or not reported, is a strong hypothesis. Empirical evidence shows heterogeneous patterns for FDI and PE flows across countries, which suggests that they might have different determinants.

Section 2 describes the data. Section 3 presents the empirical results and Section 4 concludes.

4.2 Data

The dependent variable is the average yearly change in foreign claims on domestic assets per capita over the 1970-2007 and 2008-2015 periods, reported in Lane and Milesi-Ferreti (2017). In line with Azémar and Desbordes (2013) and Akhtaruzzaman (2017), I take the log of the dependent variable to narrow its range. I examine FDI and PE data separately, as well as the aggregate sum. I employ the log of initial level of GDP per capita to account for the Lucas Paradox (measured in constant USD of year 2000). Following Rodrik *et al* (2002), institutional quality is measured using the Rule of Law Indicator included in the World Governance Indicators compiled in Kaufmann *et al* (2009).

Table I shows the descriptive statistics for 143 countries with available data for main variables, excluding financial centers[1] and countries with less than half million population, as in AKV.

Table I: Summary Statistics

	1970-2007		2008-2015	
	Mean	St.Dev	Mean	St.Dev
Average Rule of Law index	-0.112	0.94	-0.13	0.91
Log Income per capita initial year	8.30	1.20	8.76	1.32
Average Capital inflows per capita	584.86	1,775.31	900.57	2107.3
Average FDI inflows per capita	339.72	1,033.42	483.49	1,347.6
Average PE inflows per capita	242.22	1,057.78	417.08	1,104.58

[1] Belgium, Hong Kong, Ireland, Luxemburg, Netherlands, Singapure, Switzerland, UK, Mauritius, Panama and Bermuda, as characterised in Lane and Milesi-Ferreti (2017).

On average per capita capital inflows have increased 53% during the Great Recession period. Per capita FDI inflows have increased by 42% and average portfolio equity by 72%. Also, there has been a decline in the average quality of institutions, measured by the Rule of Law index. Figure 1 provides some light

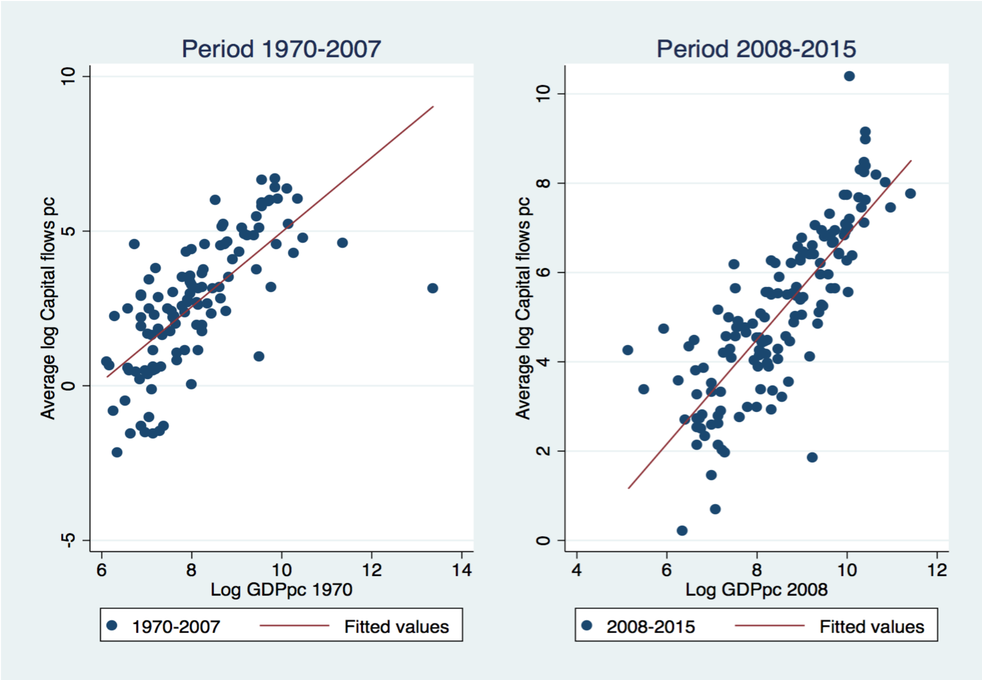

Figure 4.1: The Lucas Paradox in the Great Recession

supporting the lack of capital flows from rich to poor countries, both in the period (1970-2007) and in the Great Recession (2008-2015). It uses the average of the log of aggregate capital inflows, measured in per capita terms on the initial level of GDP (also in per capita terms). These positive slopes suggest that capital goes where capital is, and that during the Great Recession Period this pattern is even more pronounced.

4.3 Empirical results and discussion

OLS regressions are carried out through the estimation of several variants of the AKV model using two dependent variables (FDI and PE). Table II shows results for the 1970-2007 period taking FDI and PE as dependent variables in Columns 1-4, and 5-8, respectively. Column 1 demonstrates that there is a lack of FDI flows from rich to poor countries. The log of the initial GDP per capita is significant at the 1% level and has positive sign. In Columns 2 and 6 institutional quality is included. It enters with 1% level of statistical significance and a positive sign. This result suggests that institutional quality has a positive impact on both types of capital inflows but it is not enough to clear out the Lucas puzzle, since the log of initial GDP per capita remains statistically significant. I control for potential endogeneity of the institutions measure using an instrumental variable (IV) estimator. In line with Alcalá and Ciccone (2004) and Göktan (2015), I instrument institutional quality with distance from the equator.[2] F-statistic indicates for the excluded instrument, the rejection of weak instruments hypothesis in both model specifications, Columns 3 and 7. Results are similar to those found in Columns 2 and 6. Hence, IV exercise suggests that endogeneity is unlikely to be a problem.

In Columns 4 and 8, I include a set of additional variables examined in AKV to test the robustness of results. Human capital is measured as the percentage of enrolment in secondary school. Trade openness is the sum of imports and exports over GDP. Financial development is obtained as the ratio of domestic credit to private sector as percentage of GDP. Macroeconomic stability is measured as the average rate of inflation, and capital openness indicator, Kaopen,

[2] Data is taken from Dollar and Kraay (2003). Also, the exercise has been conducted using log of European settler mortality rate as instrument following Acemoglu et al (2001), results are available upon request.

Table II: The Lucas Paradox during the 1970-2007 period

	(1) FDI	(2) FDI	(3) FDI(IV)	(4) FDI	(5) PE	(6) PE	(7) PE(IV)	(8) PE	(9) Capital
Log(GDP)pc 1970	1.130***	0.699**	0.528*	0.557*	1.517***	0.831***	0.922**	0.797**	0.570**
	(0.205)	(0.213)	(0.222)	(0.224)	(0.235)	(0.212)	(0.298)	(0.269)	(0.217)
Rule of Law		0.904***	1.263***	0.895***		1.496***	1.296**	1.303***	0.910***
		(0.176)	(0.279)	(0.199)		(0.205)	(0.415)	(0.225)	(0.194)
Sch.Enroll (%)				0.002				0.003	0.001
				(0.005)				(0.009)	(0.004)
Trade/GDP				0.019***				0.013*	0.017***
				(0.004)				(0.006)	(0.004)
Credit/GDP				0.004				0.016***	0.008*
				(0.004)				(0.004)	(0.003)
Inflation				0.001				0.000	0.001
				(0.001)				(0.001)	(0.001)
Kaopen				0.136				-0.998	0.239
				(0.518)				(1.052)	(0.503)
Observations	115	115	115	111	106	106	106	103	111
R^2	0.470	0.591	0.571	0.676	0.474	0.650	0.646	0.686	0.718
$Fstat$	30.41	83.84	62.021	31.93	41.73	117.9	57.30	41.36	48.63

Dependent variable is the average of the log of FDI inflows per capita in Column 1-4, same for PE in Columns 5-8, and total capital in Column 9.
All regressions include a constant and are estimated by OLS, except Column 3 and 7 which are estimated by 2SLS.
F stat for 2SLS Columns 3 and 7, provides the F-statistic for the excluded instrument, with a p-value equal to 0.000.
Robust Standard errors in parentheses.
* , **, and *** denote statistical significance at 10%, 5% and 1% levels.

is taken from Chinn and Ito (2008). Column 4 shows that among all other potential factors only trade seems to contribute, in statistical and economic terms, to the explanation of the lack of FDI from rich to poor countries, along with institutional quality, which remains significant at 1% level. The log initial income per capita is still statistically significant at 10% level, so the paradox is not fully solved. Column 8 reports results for the PE model and presents evidence on the importance of separating types of capital. Credit provided by the financial sector is a key factor for PE with 1% of statistical significance but it is not statistically significant in the FDI model. Also, Rule of Law remains significant at 1% level with a positive sign. The significance of the log of initial income has been reduced to 5% level, so it explains better the flows of PE than those of FDI. Column 9 reports results using the aggregation of FDI and PE as dependent variable as it is typically done in the related literature. Institutional quality and trade openness are statistically significant at 1% level, along with the log of initial GDP at 10% level. Results are robust to employing other measures for institutions (ICRG-PRS index), and human capital (total years of schooling and mortality rate at birth).[3]

Table III: The Lucas Paradox in the Great Recession (2008-2015)

	(1) Capital	(2) Capital	(3) Capital(IV)	(4) Capital	(5) FDI	(6) FDI	(7) FDI	(8) PE	(9) PE	(10) PE
Log(GDP)pc 2008	1.170***	0.840***	0.5162***	0.742***	1.061***	0.839***	0.733***	1.839***	1.017***	0.922***
	(0.087)	(0.122)	(0.1413)	(0.127)	(0.086)	(0.122)	(0.125)	(0.135)	(0.208)	(0.236)
Rule of Law		0.637***	1.366***	0.439*		0.429**	0.333		1.529***	1.252***
		(0.147)	(0.2523)	(0.179)		(0.148)	(0.187)		(0.264)	(0.339)
Sch. Enroll (%)				0.006			0.009			-0.001
				(0.005)			(0.005)			(0.011)
Trade/GDP				0.010***			0.011***			-0.001
				(0.003)			(0.002)			(0.005)
Credit/GDP				0.007***			0.003			0.011***
				(0.002)			(0.003)			(0.003)
Inflation				0.010			0.017			0.012
				(0.018)			(0.017)			(0.047)
Kaopen				0.343			0.498			0.012
				(0.319)			(0.306)			(0.606)
Observations	143	143	139	124	143	143	124	124	124	112
R^2	0.655	0.704	0.678	0.779	0.613	0.639	0.721	0.586	0.688	0.740
$F stat$	179.6	162.3	43.98	55.6	152.8	107.3	38.8	186.8	167.0	51.3

Dependent variable is the average of log capital inflows per capita in Column 1-4, same for FDI in Columns 5-7, and PE in Columns 8-10.
All regressions include a constant and are estimated by OLS, except Column 3 which is estimated by 2SLS.
F stat for 2SLS Column 3, provides the F-statistic for the excluded instrument with a 0.000 pvalue.
Robust Standard errors in parentheses.
* , **, and *** denote statistical significance at 10%, 5% and 1% levels.

Table III reports the OLS regressions for the 2008-2015 period. Column 1 confirms the Lucas Paradox during the Great Recession. The log of the initial GDP per capita is significant at the 1%, using aggregate capital as dependent variable. The coefficient on the log of the initial GDP per capita is greater than for the previous period. This is a preliminary result suggesting that the Lucas puzzle has become much more pronounced during the Great Recession. Institutions have strong explanatory power but they do not eliminate the positive significance of the log of initial income per capita as shown in Column 2. Column 3 suggests that this result is not subject to endogeneity issues, following the same procedure as in Table II. Column 4 shows that trade openness and credit to private sector, along with the log of the initial income per capita, seem to

[3]These variables for the robustness checks have been taken from World Bank Open Data Base and The Quality of Governance Database.

be the main drivers of international capital flows and that the statistical significance of institutional quality is reduced from 1% to 10% level (compare across Column 9 in Table II). This result is better understood once capital flows are decomposed. Columns 5 to 7 do the same exercise taking FDI as dependent variable, while Columns 8-10 take PE. In fact, institutions are no longer statistically significant in the FDI model. Trade and the log of the initial GDP per capita are the most influential variables for FDI as Column 7 indicates. On the contrary, institutions remain an important factor in determining PE inflows (Column 9 and 10) along with the degree of financial development measured by credit over GDP. In both tables, school enrolment, inflation and capital openness present expected signs but have no explanatory power. The importance of disaggregating capital inflows is key to understand the true determinants of international capital flows across countries, specially when analysing the Great Recession period.

4.4 Conclusion

This paper is the first to show the importance of disaggregating capital inflows by the type of capital when analyzing the Lucas Paradox. It shows that total trade flows are a key driver for FDI inflows, while total credit to private sector mostly determines PE inflows. Moreover, this result holds in the Great Recession Period and in the previous periods. Institutions, though still important, cannot solve the Lucas puzzle on their own. Hence, it seems rational to argue that foreign investors actually reward structural policies that improve the institutional atmosphere through increased investment. However, which structural reforms improve the quality of institutions goes beyond the scope of this study and it is left out for future research.

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Appendix

Data Description

To capture fundamentals, we use a measure for institutional quality. Data for institutional variables used by Alfaro et al (2008) are taken from International Country Risk Guide?s (ICRG) from the Political Risk Services Group. However, this data is not public. Therefore, we use similar data from Worldwide Governance Indicators Online Database (WGI), which reports aggregate and individual governance indicators for six dimensions of governance. A common feature of both indicators is its low variance across years. These aggregate indicators combine the views of a large number of agents. They are based on 30 individual data sources which are rescaled and combined to create six aggregate indicators; Voice and accountability, Political stability and absence of violence, government effectiveness, regulatory quality, rule of law and control of corruption. These variables are originally reported in standard units, ranging approx. from -2.5 to 2.5, where a higher score means higher quality. In particular, we use the "Rule of law" index which captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence. From PRS uses Law and Order.

Conclusion

“ The Renaissance brought a crescendo of new ideas in the full range of human endeavor, and with them a century of transformational change. It also brought interdependence, risk, instability, confusion and fear. The present age feels similar. ”

— Michael Spence, Nobel Laureate in Economics

This doctoral thesis brings together the results of four research papers on the causes and on the effects of international capital flows. The timing of this thesis goes in line with an uncertain global scenario in which both Globalization 4.0 and the future evolution of globalization are being debated in international forums such as World Economic Forum in Davos (January, 2019). Nevertheless, we still need to better understand the complexity of the international macroeconomic panorama in order to delineate the future evolution of globalization, both at the trade, at the financial and at the services levels. There are many global challenges that require some sort of global coordination since countries can not address them individualy, such as global climate change and increasing inequalities. Thus, this thesis provides a small step in order to understand the benefits and the costs of international economic integration using quantitative methods. The emphasis is on the gross capital flows composition across differentiated economies as a source of wealth transfers across countries, in an scenario of large volumes of cross-border flows.

Conclusiones

"El Renacimiento trajo consigo un incremento de la creación de nuevas ideas en todas las dimensiones humanas, y con él vino un siglo de cambio transformacional. También trajo interdependencia, riesgo, inestabilidad, confusión y miedo. Los tiempos presentes son similares."

— Michael Spence, Premio Nobel en Economía

Esta tesis doctoral reúne el desarrollo de cuatro artículos de investigación sobre las causas y las consecuencias de la globalización financiera. El momento de la publicación de ésta tésis va ligado a un escenario político y económico global marcado por la incertidumbre sobre la evolución de la integración económica. Hoy, se está debatiendo como lidiar con la globalización 4.0, en foros como World Economic Forum en Davos. Sin embargo, necesitamos entender mejor el complejo panorama macroeconómico internacional para poder delinear la futura evolución de la globalización, tanto a nivel de comercio, como de mercados financieros y de servicios. Hoy en día, hay muchos retos globales, como el cambio climático y el incremento de las desigualdades, que no pueden resolver los países de forma aislada. Por eso, ésta tésis doctoral es un pequeño paso hacia el mejor entendimiento de los beneficios y de los costes de la integración económica global mediante la utilización de métodos cuantitativos. El énfasis es en la composición de los flujos brutos de capital internacional entre economías asimétricas como fuente de tranferencia de riqueza entre países, en un escenario con elevados volúmenes de flujos de capital entre países.