EFFECTS OF TRADE COSTS AND CAPITAL CONTROLS ON TRADE IMBALANCES

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Abstract

This dissertation consists of two essays on the determinants of global trade imbalances. In the first essay, I evaluate the effects of declining trade costs and capital controls on global imbalances using a model-based quantitative analysis. I develop a multi-country general equilibrium trade model in which trade imbalances are endogenously determined. Declines in trade costs and capital controls imply that fundamental shocks, such as productivity shocks, propagate more strongly to trade imbalances. I calibrate the model to 25 countries by exploiting data on bilateral trade flows, aggregate prices, net exports and measures of capital controls. I conduct counterfactual exercises where I fix trade costs or capital controls at the 1970's level. The results show that the decline in trade costs accounts for 42 percent of the trade imbalances that occurred between 1970 and 2007, while the decline in capital controls explains 22 percent of the imbalances. I also find the effects are heterogeneous across countries. Finally, my model suggests that welfare implications from lowering trade costs and capital controls are quite different. A reduction in trade costs leads to positive welfare gains for all countries, but a decrease in capital controls does not necessarily bring positive welfare gains.

In the second essay, I address the empirical relationship between trade imbalances, trade costs and capital controls. In particular, the model suggested in the first essay predicts that lower trade costs and capital controls amplify the effects of productivity shocks on trade imbalances. I test this propagation mechanism by taking three empirical approaches; a fixed effects regression with panel data, a 2-country dynamic regression, and a 2-country vector autoregression (VAR). The results of the fixed effects regression show that trade imbalances respond negatively to productivity growth, and a decrease in capital controls makes this effect

more negative. The model's implication for the propagation role of trade costs, however, is not supported by this approach. In the 2-country dynamic regression, trade costs and capital controls amplify the effects of productivity growth on trade imbalances in some countries, but not in others. Finally, the 2-country VAR(1) does not provide any evidence that is consistent with the model's prediction. In sum, there is mixed evidence on the propagation role of trade costs and capital controls.

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to my family

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Chapter 1

Introduction

The world economy experienced a consistent increase in global imbalances during the last several decades. As shown in Figure 2.1 between 1970 and 2007 global trade imbalances - which are measured as a sum of the absolute value of net exports across countries as a share of the world GDP - rose from one percent of world GDP to nearly six percent of world GDP.[1] A consistent rise in global imbalances could be a concern for macroeconomic stability (Blanchard & Milesi-Ferretti, 2012), and it is also considered to be one of the causes of the 2008 financial crisis (Obstfeld & Rogoff, 2009; Bernanke, 2009).

Against this backdrop of rising imbalances is the significant growth in both international trade flows and capital flows across borders. As illustrated in Figure 2.1, gross trade flows doubled between 1970 and 2007 and gross capital flows increased by more than 20 times.[2] These two key aspects of globalization have been mainly attributed to declining costs of such flows; a decrease in trade costs such as tariff reductions or declines in transportation costs contributed to a large increase in world trade while a reduction in capital controls led

[1]Global trade imbalances decreased after 2007 but the imbalances were still considerably higher than they were in the 1970s. The imbalances measure was approximately 4 percent of world GDP in 2017.

[2]In Figure 2.1, gross trade flows are measured as world exports of goods and services as a share of world GDP while gross capital flows are measured as total gross capital flows as a share of world GDP.

to increased international capital flows.[3]

In this dissertation, I explore the relationship between trade costs, capital controls and trade imbalances using both a model-based quantitative analysis and empirical approaches. In the first essay, I develop a dynamic trade model to study the effects of lower costs of trade and capital flows on trade imbalances. I calibrate the model and conduct counterfactual exercises to evaluate the quantitative contribution of declining trade costs and capital controls. I also demonstrate the mechanism of how lower international trade costs and capital controls lead to larger trade imbalances. In the second essay, I address the empirical relationship by testing the mechanism of the model based on three empirical approaches as a complementary work of the model-based findings.

The objective of the first essay is to quantify the relative importance of declining costs of trade flows and capital flows on global imbalances. I develop a dynamic trade model with endogenous trade imbalances that features trade costs and capital controls. I calibrate the model to 25 countries between 1970 and 2007. Then I use the model to quantify how much of an increase in global imbalances observed in the data is accounted for by the decrease in trade costs and capital controls, respectively. The quantitative exercises show that the decline in trade costs accounts for 42 percent of the trade imbalances that occurred between 1970 and 2007, while the decrease in capital controls explains 22 percent of the imbalances.

In my model, I combine a general equilibrium model of international trade with a dynamic household consumption-saving decision. The underlying trade model is a multi-country Ricardian trade model (Eaton & Kortum, 2002). In addition, households have access to international financial market and can buy or sell one-period non-contingent

[3]Costs of international trade capture all the frictions including tariffs, transportation costs and even cultural and language barriers. Baier & Bergstrand (2001) point out that trade liberalization and declines in transportation costs have been important sources of the growth of world trade. In addition, the removal of capital controls in the process of capital market integration lowered the costs of cross-border financial transactions and thus increased the capital flows. Elwell (2001) mentions that the reduced capital controls resulted in the significant growth of international capital flows.

bonds to smooth their consumption. However, international financial market frictions exist; they are explicitly introduced in the form of a tax on interest income from bonds.

Fundamental shocks in the model - such as changes in productivity or preferences - are the main sources of trade imbalances. The effective interest rates respond to those shocks differently depending on the level of trade costs and capital controls. When trade costs and capital controls are relatively high, fundamental shocks generate relatively large changes in the effective interest rates. This reduces a country's incentive to either borrow or lend. Higher trade costs and capital controls thus reduce the effects of fundamental shocks and result in smaller trade imbalances.

How a shock affects the country's effective interest rate is determined by whether the country is a borrower or a lender. Specifically, with trade costs and capital controls, a borrowing country with a trade deficit will have a higher effective interest rate. A lending country which runs a trade surplus, on the other hand, will have a lower effective interest rate.[4] In other words, trade costs and capital controls introduce a wedge between a borrower's and a lender's effective interest rate. When trade costs and capital controls are relatively high, a country with a negative net foreign asset position borrows less because of an even higher effective interest rate it has to pay; hence it runs a smaller trade deficit. Similarly, a country with a positive net foreign asset position lends less due to an even lower interest rate, thus it runs a smaller trade surplus. Due to the larger wedge, trade imbalances are dampened compared to those generated with relatively low trade costs and capital controls.

For the model calibration, I consider the period from 1970 to 2007 with 24 countries plus the rest of the world. The model parameters are either constructed from data or drawn

[4]Note that the effective interest rate is a function of trade costs and capital controls as well as the real interest rate. When there is a shock, a net lender who runs a trade surplus has a lower price today relative to tomorrow because it pays less trade costs due to fewer imported goods in its consumption basket. In addition, capital controls lower the real returns on bonds for a net lender to discourage capital outflows. This is how trade costs and capital controls lead to a lower effective interest rate for a net lender. By contrast, trade costs and capital controls raise the effective interest rate for a net borrower.

from the literature. I calibrate average productivity, bilateral trade costs and intertemporal preference shifters such that the model-implied prices, bilateral trade shares and net exports match perfectly with the data. In other words, I back out country- and time-varying average productivity, trade costs and intertemporal preference shifters using data on prices, trade shares and net exports. In addition, I construct the measure of capital controls in the form of a tax by using capital account openness indices and converting them into the equivalent tax rates based on six examples of actual capital controls.

I then conduct counterfactual exercises to quantify the effects of declining trade costs and capital controls on trade imbalances and compare their relative contributions. I fix the average trade costs at their 1970 level while allowing all other sources of trade imbalances to follow their original path, and then I solve for the competitive equilibrium again. The contribution of trade costs can be quantitatively assessed by comparing trade imbalances generated under the counterfactual equilibrium with the observed data. Similarly, the consequences of lowering capital controls can be evaluated by solving the model with the magnitude of the tax rates fixed at their 1970 level. Finally, I fix trade costs and capital controls at their initial level to see the effects of both to explain the surge in imbalances.

From the counterfactual exercises, I find 42 percent of trade imbalances that occurred between 1970 and 2007 can be explained by the decline in trade costs, while 22 percent of them can be attributed to lower capital controls. This implies, if trade costs had been fixed from 1970 onwards, the changes in trade imbalances would have been only 58 percent of what the observed data suggests. Similarly, if capital controls had remained at the 1970's level throughout the whole period, the increase in trade imbalances would have been only 78 percent of what we observe from data. In addition, changes in trade costs and capital controls together account for 63 percent of trade imbalances. Both forms of globalization significantly contribute to the increase in global trade imbalances, but trade costs are relatively more important than capital controls.

In addition, the effects are heterogeneous across countries. Trade imbalances in the United States and China were affected more by lower trade costs than by lower capital controls. Other countries such as Japan and the United Kingdom, however, reacted more to changes in capital controls. Finally, the path of trade imbalances for some countries, like Denmark, is barely affected by either trade costs or capital controls.

While lower trade costs and capital controls both increase trade imbalances, their welfare implications are quite different. Every country in my sample shows positive welfare gains from the declining costs of trade. This is mainly because the static gains that come from lower aggregate prices are positive and sizable. Lower capital controls, however, do not necessarily bring positive welfare gains. Less than half of the countries in my sample shows positive welfare gains while the other countries experience welfare losses. In particular, countries that have a positive net foreign asset position in the model tend to have larger welfare losses.

In the second essay, I investigate the empirical relationship between trade imbalances, trade costs and capital controls. The model described in the first essay predicts that trade costs and capital controls affect trade imbalances by interacting with fundamental shocks such as productivity shocks or preference shocks. Lower trade costs or capital controls amplify the effects of those fundamental shocks on trade imbalances. In particular, productivity growth is one of the main sources of trade imbalances, and it affects them more strongly when the level of trade costs or capital controls are relatively low. I refer to it as the propagation role of trade costs and capital controls, and test this propagation mechanism by taking three empirical approaches; a fixed effects regression with panel data, a 2-country dynamic regression and a 2-country vector autoregression (VAR).

I start with panel data on macroeconomic variables for 24 countries which includes each country's trade imbalances, productivity growth, trade costs and capital controls. As a baseline case, I consider a fixed effects model with the panel data to explore the relationship among those variables. In particular, I look at how productivity growth, trade costs (or capital controls) and interaction between the two variables affect trade imbalances. If the model's prediction holds true, the estimation results would show the following two expected signs of coefficients; the estimated coefficient for productivity growth would be negative which is consistent with the counter-cyclicality of net exports (Backus et al., 1992; Glick & Rogoff, 1995), and the estimated coefficient for the interaction term would be positive, implying that the negative impact of productivity growth on trade imbalances is mitigated as trade costs or capital controls increase. The propagation role of capital control is supported by the fixed effects regression because all signs are as expected, but the propagation role of trade costs is not supported by this approach.

I then turn to a 2-country dynamic regression that allows me to capture the dynamic effects as well as other relevant information in order to test the propagation mechanism. I construct country-specific rest of the world (ROW), as opposed to exploring every country's information from the panel data, and consider only two countries in each estimation. I include the ROW's productivity growth, the ROW's trade costs (or capital controls) and the lag values of trade imbalances as additional determinants of trade imbalances. To be consistent with the model's prediction, the estimated coefficients are expected to have the same signs as before, but those for the ROW are expected to have the exact opposite signs. The results suggest that trade costs and capital controls amplify the effects of productivity growth in some countries but not in others.

I finally consider a 2-country vector autoregression (VAR). In particular, I estimate a VAR(1) with two countries' net exports and productivity growth in two different time periods where one has, on average, higher trade costs or capital controls than the other. I would expect to see a stronger relationship between trade imbalances and productivity growth in a time period where trade costs or capital controls are relatively low. In each of the 2-country VAR estimation, the signs of coefficients do not match with the expected signs. These results indicate that the VAR approach does not provide any evidence that is consistent with the model's implication.

Related Literature This paper is related to studies that explore the determinants of observed global imbalances. Gourinchas & Rey (2014) provides a comprehensive summary on several models of global imbalances.[5] Caballero et al. (2008), Mendoza et al. (2009) and Angeletos & Panousi (2011) attribute asymmetries in financial and economic development across countries to fundamental causes of the imbalances.[6] Papers such as Antras & Caballero (2009) and Jin (2012) consider the interaction between trade flows and capital flows.[7] Most of other papers in this literature rely on financial frictions as a fundamental determinant of global imbalances.[8] One exception is Chang et al. (2013) that accounts for the global dispersion of current accounts with intertemporal consumption and investment responses to productivity shocks while allowing for frictions in both goods and financial markets.

The most closely related paper is Reyes-Heroles (2016) which explains the observed trade imbalances with structural residuals induced by various frictions in the model, rather than focusing only on specific driving forces of the imbalances. In particular, he emphasizes the role of declining trade costs from other sources of the global imbalances. I follow his approach, but I explicitly introduce financial market frictions. I allow both types of

[5]Many studies in the literature focus on explaining the observed patterns of current account imbalances. Most of theories incorporate the feature of capital flows from emerging market economies to advanced economies - particularly to the U.S.

[6]Caballero et al. (2008) focuses on the heterogeneity in the ability to supply financial assets across different regions of the world. Developing countries' inability to supply sufficient financial assets along with their rapid growth is the key feature that generates a rise in global imbalances. In contrast, Mendoza et al. (2009) and Angeletos & Panousi (2011) emphasize the differences in the degree of risk sharing.

[7]Trade specialization pattern which is derived from the differences in financial development across countries or sectors is the main driving force of imbalances.

[8]Bernanke (2005) argues a global saving glut to explain the increase in global imbalances; Lane & Milesi-Ferretti (2001), Ferrero (2010) and Coeurdacier et al. (2015) look at the impact of demographic characteristics; Buera et al. (2011) and Song et al. (2011) emphasize the interaction between financial frictions and productivity growth.

frictions in the model and evaluate their relative importance in explaining the surge of global imbalances quantitatively.

The paper is also linked to the literature on trade costs and capital controls. Backus et al. (1992), Obstfeld & Rogoff (2000), Kose & Yi (2006), Fitzgerald (2008), Fitzgerald (2012) and others examine the role of trade costs in explaining macroeconomic variables or phenomena.[9] Regarding capital controls, a majority of the literature studies either the impact of capital controls or their desirability.[10] One challenge that remains in this literature is the limited availability of comprehensive capital control measures and the lack of a unified theoretical framework to analyze the effects of controls.[11] I rely on the index of financial openness calculated by Chinn & Ito (2006) to construct capital control measures and I assume a simple form of capital controls in the model.[12] I contribute to the literature by isolating and quantifying the effects of declining trade costs and capital controls on trade imbalances.

This paper relates to a recent literature on quantitative general equilibrium models of international trade that builds on Eaton & Kortum (2002) and features trade imbalances. Dekle et al. (2007, 2008), Ossa (2014), Caliendo & Parro (2015), Caliendo et al. (2017) and others incorporate trade imbalances into the static Eaton-Kortum model for the quantitative analysis, but the imbalances are assumed to be exogenous.[13] In contrast, Eaton, Kortum,

[9] The main focus in each paper is business cycles [Backus et al. (1992) and Kose & Yi (2006)]; international macroeconomic puzzles [Obstfeld & Rogoff (2000)]; the relation between exchange rate volatility and inflation [Fitzgerald (2008)]; and asset market frictions and risk sharing [Fitzgerald (2012)].

[10] Ostry et al. (2010) and Ostry et al. (2011) focus on the effectiveness of controls on capital inflows as a country's "policy toolkit" perspective. Some papers specifically consider the experience of individual countries; Chile [De Gregorio et al. (2000),K. J. Forbes (2007), Andreasen et al. (2018)], Malaysia [Kaplan & Rodrik (2002), Johnson & Mitton (2003)], Brazil [Alfaro et al. (2017), K. Forbes et al. (2016)]. There is a growing body of theoretical research on evaluating capital controls; Farhi & Werning (2012), Costinot et al. (2014), Heathcote & Perri (2016).

[11] Chinn-Ito index is computed based on dummy variables that codify the restrictions on cross border financial transactions reported in the IMF's *Annual Report on Exchange Arrangements and Exchange Restrictions* (AREAER). It captures the degree of capital account openness, but it is too coarse, enough to provide rich information on heterogeneity in capital control measures across countries and time. Schindler (2009) and Fernández et al. (2016) provide and update a new dataset with finer granularity, but the time coverage is shorter.

[12] I use Chinn-Ito index mainly because it is the only index which goes back to the 1970s and covers for multiple countries.

[13] Dekle et al. (2007, 2008) evaluate quantitative implications of eliminating the current account

Neiman, & Romalis (2016) develop a dynamic general equilibrium model of international trade in which trade imbalances emerge endogenously. They embed the trade model into a dynamic model of real business cycle to investigate the sources of the recent global recession. The paper, however, focuses on the forces that determine trade flows at the business-cycle frequency rather than those affecting the long-term evolution of trade imbalances.[14] My model builds on Reyes-Heroles (2016) that proposes a dynamic trade model with endogenous trade imbalances which arise from economic agents' intertemporal decisions. It is also closely related to the model with trade imbalances and capital accumulation suggested by Ravikumar et al. (2019).[15]

Empirical Studies This paper is related to empirical literature on the determinants of global imbalances. Debelle & Faruqee (1996), Chinn & Prasad (2003), Gruber & Kamin (2007), Chinn & Ito (2007) and others study current account determination based on cross-section and panel data analysis focusing on a saving-investment perspective.[16] Other

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imbalances. Trade imbalances, however, do not arise endogenously in the model and their quantitative exercise is comparative statics. Ossa (2014) provides an extended Eaton-Kortum framework that is suitable for analyzing noncooperative and cooperative trade policy. Their counterfactual exercise is similar to Dekle et al. (2007). Caliendo & Parro (2015) study the welfare effects of tariff reduction - particularly considers the case of NAFTA - based on the extended Eaton-Kortum model that features multiple sectors and input-output linkages. Finally Caliendo et al. (2017) focus on trade imbalances across different regions in the U.S. as opposed to trade imbalances across countries.

[14] Eaton, Kortum, Neiman, & Romalis (2016) solve a planner's problem to determine the equilibrium market allocation, but I solve for the competitive equilibrium following Reyes-Heroles (2016). In addition, my model doesn't not have endogenous capital accumulation while Eaton, Kortum, Neiman, & Romalis (2016) consider both saving and investment decisions in determining the trade imbalances.

[15] Ravikumar et al. (2019) calculate welfare gains from trade based on a dynamic trade model with both trade imbalances and capital accumulation.

[16] Debelle & Faruqee (1996) explain the factors that determine the long-term current account and also consider short-run dynamics of current account based on cross-section and panel data models. They find that the relative income and demographics play an important role in determining long-term current accounts. Chinn & Prasad (2003) investigate the medium-term determinants of current accounts using both cross-section and panel regression approach. The findings suggest that government budget balances and initial stocks of net foreign assets are positively and significantly associated with current account balances. In addition, current account balances respond positively to measures of financial deepening while negatively to indicators of openness to international trade for developing countries. Gruber & Kamin (2007) and Chinn & Ito (2007) extend the work of Chinn & Prasad (2003) by analyzing the impact of financial crisis and by incorporating the effects of legal and institutional development, respectively.

studies such as Lee & Chinn (2006), Karadimitropoulou & León-Ledesma (2009) and Bracke & Fidora (2008) test different theories that explain the emergence of global imbalances with a structural VAR (SVAR) approach.[17] In contrast, Bettendorf (2017) investigates the sources of global imbalances by taking a Global VAR (GVAR) approach.[18] In the empirical analyses, trade costs are not taken into account even though the trade-openness indicator, which is closely related to trade costs, is included in some of the studies. Capital controls are taken into account, but they turn out to have an insignificant impact on the imbalances. My contribution to the literature is that I evaluate the effects of trade costs and capital controls by considering their interaction with fundamental shocks that generate trade imbalances.

Saadaoui (2015) focuses on the role of financial openness in explaining the rise of global imbalances. He estimates panel regression models and finds that the relative financial openness has a significant impact on global imbalances.[19] One of his measures of relative financial openness is based on the Chinn-Ito index, which my measure of capital controls also relies on. I evaluate the role of capital controls, but I use the *level* of capital controls instead of the *relative* measure. As stated earlier, I also consider the interaction of capital controls with productivity growth as well as the level of capital controls itself to assess their contribution to global imbalances.

This paper also relates to the existing literature on three methodological approaches

[17] Lee & Chinn (2006) and Karadimitropoulou & León-Ledesma (2009) test the prediction of intertemporal open-economy macroeconomic model. The former finds that monetary shocks play an important role in capturing the largest variations in current account while the latter suggest that preference shocks and external supply shocks are important. Bracke & Fidora (2008) also apply a SVAR model to test for a *excess liquidity*, a *savings glut* and a *investment drought* hypothesis. Their findings show that monetary policy shocks are more important than savings shocks or investments shocks in explaining the variations in global imbalances.

[18] A GVAR model (Pesaran et al., 2004) allows to incorporate international linkages of variables across countries, which is an essential aspect of global imbalances. Bettendorf (2017) applies a GVAR framework to study main drivers of trade imbalances, and the results support a hypothesis of global savings glut and international wealth effects.

[19] Saadaoui (2015) finds that the relative financial openness is positively associated with the current account for industrialized countries while the relationship is negative for the emerging economies. Hence a decline in the relative financial openness over time has a negative and positive impact on current account balance for industrialized countries and emerging economies, respectively.

presented in the second essay. Panel data analysis has been widely used in the literature to identify the drivers of global imbalances.[20] I rely on a fixed effects model to analyze panel data which includes both entity fixed effects and time fixed effects.[21] Then I depart from the panel regression analysis in order to incorporate dynamic effects and use a dynamic regression model. In particular, I consider an autoregressive distributed lag (ADL) model which allows for the inclusion of past observation of dependent variables as well as other relevant variables and their lags. Hendry et al. (1984), Wickens & Breusch (1988) and Pesaran & Shin (1998) provide a comprehensive review of the ADL models. Finally I consider a simple vector autoregression model (VAR) (Sims, 1980) because it is a relatively flexible and easy way of analyzing the relationship among the relevant economic variables. It also allows me to capture feedback effects among them. Hamilton (1994) and Lütkepohl (2005) describe details about the VAR models.

Road Map The rest of the paper is organized as follows; Section 2.1 describes the model and illustrates the mechanism through which trade costs and capital controls affect trade imbalances, where the equilibrium of the model is also defined. In Section 2.2, I take the model to data and recover the structural residuals. Section 2.3 presents three counterfactual exercises which answer the main question of the paper. I conclude the first essay in Section 2.4. For the empirical analysis, Section 3.1 describes the sources of data and defines variables of interests. Section 3.2 - 3.4 present a fixed effects regression, a dynamic regression and a vector autoregression, respectively, summarize the empirical results and evaluate whether they are consistent with the model's prediction. Finally, Section 3.5 concludes the chapter.

[20]Papers such as Debelle & Faruqee (1996) and Chinn & Prasad (2003) and many other papers explore panel data to investigate the factors that determine current account balances.

[21]This approach allows me to control for time-invariant variables that differ across countries and for variables that change over time not but across countries. See Baltagi (2008) for further information on advantages and disadvantage of exploring panel data.

Chapter 2

Effects of Trade Costs and Capital Controls on Trade Imbalances

2.1 The Model

Section 2.1 describes the model that allows me to evaluate the effects of trade costs and capital controls on trade imbalances quantitatively. I extend a static model of international trade to the dynamic setting by incorporating a representative households' optimal consumption-saving decisions. The underlying trade model is a multi-country, general equilibrium model of international trade based on Ricardian comparative advantage. It is closest to the Eaton & Kortum (2002) framework. Households have access to international financial market to buy or sell one-period bonds to smooth their consumption. This non-contingent bond is denominated in a world currency, and it is the only asset traded internationally. However, there is a tax on interest income from bonds which discourages bond transactions. In this model, trade imbalances are endogenously determined through the households' intertemporal consumption-saving decisions.

The world consists of N countries which is indexed by either i or n. Time is discrete and it is indexed by t = 1, 2, ... ∞. Each country is populated by a representative household that is endowed with labor and capital stock.

2.1.1 Technologies, Prices, and Trade shares

Tradeable Goods There is a continuum of intermediate goods $\omega \in$[0,1], and its production in each country i at period t is given by

$$q_{i,t}(\omega) = z_{i,t}(\omega)[L_{i,t}(\omega)^{1-\varphi_i} K_{i,t}(\omega)^{\varphi_i}]^{\beta_{i,t}}[M_{i,t}(\omega)]^{1-\beta_{i,t}} \tag{2.1}$$

where $L_{i,t}(\omega)$ and $K_{i,t}(\omega)$ is the labor endowment and capital stock allocated in the production of intermediate good in country i at time t, $M_{i,t}(\omega)$ is the composite intermediate good demanded by the producer of ω in country i at time t. The parameter $\beta_{i,t}$ and φ_i are the share of value-added, and capital share in value-added, in country i, respectively.

The productivity of producing ω, $z_{i,t}(\omega)$, is the realization of a random variable z that follows a Fréchet distribution conditional on all the information known at time t.

$$F_{i,t}(z|t) = Pr(z_{i,t} \leq z) = e^{-T_{i,t}z^{-\theta}} \tag{2.2}$$

where $T_{i,t}$ corresponds to the mean of the distribution of productivity in country i at time t and θ is the variance of the distribution. In the context of international trade literature, $T_{i,t}$ refers a notion of absolute advantage while θ represents that of comparative advantage. As the level of $T_{i,t}$ gets higher, country i at time t produces ω more efficiently in absolute terms. In the case of θ, the lower θ is, the more dispersed the distribution is. Hence the relative efficiency of producing each good ω varies more with a smaller value of θ. The average productivity $T_{i,t}$ varies across countries and changes over time, and this is one of the main driving force of trade imbalances. The variance θ, however, is assumed to be a time-invariant constant.

Nontradeable Goods A final good is given by an aggregate of a continuum of intermediate goods in a CES form.

$$Q_{i,t} = \left[\int_0^1 \mathit{\Gamma}_{i,t}(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right]^{\frac{\sigma}{\sigma-1}} \tag{2.3}$$

where $\Gamma_{i,t}(\omega)$ is the demand for intermediate good ω from the country who produces it at the lowest cost that is available for country i at time t, and σ is the elasticity of substitution between goods, $\sigma>0$. The final output is either used for final consumption or as an input for the composite intermediate good $M_{i,t}$. Note that, unlike the intermediate goods, a final good is not tradeable.

Trade costs and Firm's optimal decisions The intermediate good ω is tradeable across countries, but there are iceberg transport costs to ship it from country n to country i at time t, which is denoted as $d_{in,t}$. In order for the destination country(i) to receive one unit of ω, the source country(n) should send $d_{in,t}\geq 1$. I assume that $d_{ii,t}=1$ for $\forall$i and t, implying that there are no trade costs within a country.

The producers of intermediate goods in each country face a problem of cost minimization under perfect competition. Then the free-on-board price is equal to the cost of input-bundles over its productivity, $\left(\frac{cost_{i,t}}{z_{i,t}(\omega)}\right)$, which is the cost of producing one unit of intermediate good ω in country i at time t. The cost of an input-bundle is expressed as a Cobb-Douglas function of input prices. $w_{i,t}$ and $r_{i,t}$ refer to the labor income and capital income in country i at time t, and $P_{i,t}$ is the price of country-specific final good. $\chi_{i,t}$ is a constant that is a function of parameter $\beta_{i,t}$ and φ_i.

$$cost_{i,t} = \chi_{i,t}[(w_{i,t})^{1-\varphi_i}(r_{i,t})^{\varphi_i}]^{\beta_{i,t}}(P_{i,t})^{1-\beta_{i,t}} \tag{2.4}$$

where $\chi_{i,t} = [\beta_{i,t}\varphi_i^{\varphi_i}(1-\varphi_i)^{(1-\varphi_i)}]^{-\beta_{i,t}}(1-\beta_{i,t})^{-(1-\beta_{i,t})}$

The producers of a final good also face a cost minimization problem. Given the price of each intermediate good, which is denoted as $p_{i,t}(\omega)$, the producers of a final good minimize their costs. Each country's demand for intermediate good ω is denoted as $\Gamma_{i,t}(\omega)$. Note that the price of intermediate good ω that country i pays at time t is the minimum of all the intermediate prices (inclusive of trade costs) that are offered by country i's trading partners including country i itself. The price of a final good in country i at time t, $P_{i,t}$, is an aggregate of a continuum of intermediate prices.

$$\Gamma_{i,t}(\omega) = \left(\frac{p_{i,t}(\omega)}{P_{i,t}}\right)^{-\sigma} Q_{i,t} \tag{2.5}$$

where

$$p_{i,t}(\omega) = min_n \left[p_{in,t}(\omega)\right] = min_n \left[\frac{cost_{n,t} \cdot d_{in,t}}{z_{n,t}(\omega)}\right] \tag{2.6}$$

$$P_{i,t} \equiv \left[\int_0^1 p_{i,t}(\omega)^{1-\sigma} d\omega\right]^{\frac{1}{1-\sigma}} \tag{2.7}$$

Prices and Trade Shares The assumption of Fréchet distribution on productivity z allows simple expression for each country's aggregate price index. Country i's price at time t depends on all its trading partners' average productivity level and their factor prices as well as trade costs. According to Eaton & Kortum (2002), prices are given by

$$P_{i,t} = \gamma \left[\Phi_{i,t}\right]^{-\frac{1}{\theta}} \tag{2.8}$$

$$\Phi_{i,t} = \textstyle\sum_{n=1}^{N} T_{n,t}(cost_{n,t} d_{in,t})^{-\theta}$$

where γ is a constant from Gamma distribution.[1] Note that the aggregate prices differ across

[1] $\gamma = \left(\Gamma(\frac{\theta+1-\sigma}{\theta})\right)^{\frac{1}{1-\sigma}}$ where $\Gamma(\cdot)$ is the Gamma function.

countries due to trade costs ($d_{ni,t}\neq 1$). Under free trade ($d_{ni,t}$=1), prices will be equalized across countries.

Trade shares are also expressed in a simple closed form as a function of parameters from productivity distribution, factor prices and trade costs. Let $X_{i,t}$ denote total expenditure of country i at time t and $X_{in,t}$ total expenditure by country i on goods imported from country n at time t. Country i's total expenditure at a given point time t is the sum of $X_{in,t}$ for all possible trading partners, $X_{i,t} = \sum_{n=1}^{N} T_{n,t}(cost_{n,t}d_{in,t})^{-\theta}$. Then, the trade share $\pi_{in,t}$, which is the share of country i's total expenditure on goods from country n at time t is given by:

$$\pi_{in,t} = \frac{X_{in,t}}{X_{i,t}} = \frac{T_{n,t}(cost_{n,t}d_{in,t})^{-\theta}}{\Phi_{i,t}} = T_{n,t}\left(\frac{\gamma cost_{n,t}d_{in,t}}{P_{i,t}}\right)^{-\theta} \tag{2.9}$$

Note that $\sum_{n=1}^{N} \pi_{in,t} = 1$ for $\forall$ i,t. Firms' optimal decisions are completely reflected in the expression of prices and trade shares which determine the static part of equilibrium.

2.1.2 Households

Household's Optimal Decisions Households' preferences are given by log utility in each country, u(c) = ln(c). The lifetime utility for a representative household at time t in country i is:

$$U_i = \max \sum_{t=1}^{\infty} \delta^{t-1}\phi_{i,t}u(C_{i,t}) \tag{2.10}$$

where $C_{i,t}$ refers to the aggregate level of consumption in country i at time t, $\delta\in(0,1)$ is the discount factor and $\phi_{i,t}$ is an intertemporal preference shifter.

Let $B_{i,t+1}$ be bond holdings of country i that are chosen at the end of the period t and q_t be the price of bond at time t that returns 1 in the next period t+1. q_t is the reciprocal of the gross rate of return, which is denominated in world common good, between t and t+1,

$q_t = \frac{1}{R_{t+1}}$. In order to maximize the discounted lifetime utility, the representative household either buys or sells one-period bonds in the international financial market.

I introduce capital controls in the form of a tax on interest income from bonds. A tax can be imposed both on capital inflows and outflows.[2] The magnitude of the tax rates is exogenously given while their signs are determined by each country's net foreign asset position, i.e., the tax rate, $\tau_{i,t}$, is assumed to be positive when country i is a net foreign lender at the beginning of time t ($B_{i,t}$>0). In contrast, it is assumed to be negative when country i is a net foreign borrower ($B_{i,t}$<0).[3] The government collects taxes and the revenue is redistributed to the public in the form of lump-sum transfer, $H_{i,t}$. Then the household's budget constraint can be expressed as follows:

$$P_{i,t}C_{i,t} + q_t B_{i,t+1} = w_{i,t}L_{i,t} + r_{i,t}K_{i,t} + B_{i,t} - \tau_{i,t}(1 - q_{t-1})B_{i,t} + H_{i,t} \tag{2.11}$$

Equation (2.11) holds for ∀ i,t. The initial period's bond holdings are given for each country i. The initial period's bond price, q_0, is also given. As stated earlier, there is no endogenous capital accumulation. Capital stocks, $K_{i,t}$, are considered as an exogenous endowment for each country in every time period.

Note that all economic agents are assumed to have perfect foresight. In addition, I set world GDP as a numeraire: $\sum_{i \in N}(w_{i,t}L_{i,t} + r_{i,t}K_{i,t}) = 1$ for ∀t. Thus the amount of bonds held by each country is denominated in terms of world GDP.

The optimality condition that maximizes the lifetime utility subject to the budget constraint (2.11) yields the Euler equation, which determines household's optimal

[2] Heathcote & Perri (2016) introduce capital controls as a government's tax on interest income from internationally traded bonds. They assume that the tax rate is proportional to the aggregate net foreign asset position and also dependent on a country-specific capital control policy parameter. I follow the way they model capital controls, but I simply assume that the sign of a tax is consistent with the net foreign asset position.

[3] The sign of $\tau_{i,t}$ is determined by the sign of $B_{i,t}$. $\tau_{i,t}$ and $B_{i,t}$ have the same sign, and thus $\tau_{i,t}(1 - q_{t-1})B_{i,t}$ is always positive. This indicates that a country always pays taxes regardless of its net foreign asset position.

intertemporal consumption-saving behavior. Note that $\hat{\phi}_{i,t+1} = \frac{\phi_{i,t+1}}{\phi_{i,t}}$ represents the relative change in country i's intertemporal preferences between t and t+1.

$$u'(C_{i,t}) = \delta\hat{\phi}_{i,t+1}\left(\frac{1}{q_t}\right)\left(\frac{P_{i,t}}{P_{i,t+1}}\right)[1-\tau_{i,t+1}(1-q_t)]u'(C_{i,t+1}) \qquad (2.12)$$

Denote the effective gross rate of return (ER) in country i between time t and time t+1 as $ER_{i,t+1} = \frac{1}{q_t}\left(\frac{P_{i,t}}{P_{i,t+1}}\right)[1-\tau_{i,t+1}(1-q_t)]$. The price of bond, q_t, is the same across all countries, because there is only one international financial market in which one-period bonds are transacted. The price of bond is determined so that the net supply of bonds is zero. The effective gross rate of return, however, differs across countries because of trade costs and capital controls. A country's price level depends on trade costs, and the price today relative to tomorrow matters for that country's real returns on bonds. In the case of capital controls, the tax on interest income from bonds directly raises or lowers the real interest rates on bonds.

Note that the channel through which trade imbalances occur in this model is household's optimal intertemporal consumption-saving decisions. These dynamic decisions are affected by the changes in effective interest rates. In particular, the effective interest rates respond differently to a shock that generates trade imbalances, depending on the level of trade costs and capital controls. Relatively lower trade costs and capital controls lead to smaller changes in effective interest rates and thus result in larger trade imbalances. That is a key mechanism of how lower trade costs and capital controls ultimately contribute to trade imbalances. More details about this mechanism are described in Section 2.1.5.

2.1.3 Market Clearing

Let $Y_{i,t}$ denote the gross production in country i at period t. Recall that $X_{i,t}$ is total expenditure in country i at time t. Then by its definition, country i's net exports at time t are the difference between the two, $NX_{i,t} = Y_{i,t} - X_{i,t}$. There are six market clearing conditions: for each country, market clearing for nontradeable goods and tradeable goods, a country-specific resource constraint, government's budget constraint, and a labor market and a capital market equilibrium condition. In addition, there is global bond market clearing condition.

First, the market for the nontradeable goods must clear in each country, every period; equation (2.13) refers the market clearing for the nontradeable goods. The supply of a final good should equal its demand, which is the sum of final consumption and its use for composite intermediate goods. This condition can be re-written in terms of total expenditure, implying that it is the product of the aggregate price and the final output.

$$Q_{i,t} = C_{i,t} + M_{i,t} \tag{2.13}$$

$$X_{i,t} = P_{i,t}C_{i,t} + P_{i,t}M_{i,t} \tag{2.14}$$

Second, the market for the tradeable goods (intermediate goods) must clear in every country and period. The sum of expenditure of every country on goods that come from country i should equal gross production of country i each period.

$$Y_{i,t} = \sum_{n=1}^{N} \pi_{ni} X_{n,t} \tag{2.15}$$

Third, the resource constraint indicates that net exports in each country must equal the changes in the net asset position every period. Put differently, the amount of net exports has to be consistent with household's optimal saving decisions.

$$q_t B_{i,t+1} - B_{i,t} = Y_{i,t} - X_{i,t} \tag{2.16}$$

Fourth, the government's budget constraint implies that the amount of tax collected from bond holdings should equal the lump-sum transfers provided.

$$H_{i,t} = \tau_{i,t}(1 - q_{t-1})B_{i,t} \tag{2.17}$$

Fifth, the amount of labor and capital used to produce intermediate goods should sum up to the total labor endowment and capital stock in each country every period.

$$L_{i,t} = \int_0^1 l_{i,t}(\omega)d\omega \tag{2.18}$$

$$K_{i,t} = \int_0^1 k_{i,t}(\omega)d\omega \tag{2.19}$$

Sixth, the global bond market must clear in each period. The sum of every country's bond holding across countries should sum up to zero in each period.

$$\sum_i B_{i,t} = 0 \tag{2.20}$$

2.1.4 Equilibrium

The economy's initial conditions are each country's bond holdings in period zero and the price of those bonds in period zero. The labor endowment and capital stock are exogenously given for each country in every period. The sequence of disturbances is defined by $\{S_t\}_{t=1}^T$ where $S_t \equiv \{d_{ni,t}, T_{i,t}, \hat{\phi}_{i,t+1}\}$.

Definition *Given the initial conditions, exogenous variables and the sequence of* $\{S_t\}$, *an equilibrium is sequences of each country's wages, rental rates, prices, price of bonds and bond holdings* $\{\{w_{n,t}\}_{n=1}^N, \{r_{n,t}\}_{n=1}^N, \{P_{n,t}\}_{n=1}^N, \{q_t\}, \{B_{n,t+1}\}_{n=1}^N\}_{t=1}^T$, *such that for all t, (1) households and firms make an optimal choice given the prices; equation (2.9) and equation (2.12) must hold, and (2) six market clearing conditions hold.*

2.1.5 Mechanism

In the model, the main driving forces of trade imbalances are exogenously given fundamental shocks such as changes in countries' average productivity or preference shifters.[4] Trade costs and capital controls affect trade imbalances by governing how much households respond to those shocks through the channel of effective interest rates. Lower trade costs and capital controls amplify the effects of fundamental shocks and result in larger trade imbalances. In order to understand why lower trade costs and capital controls are associated with higher trade imbalances, let's think about a simple scenario where there are two symmetric countries, and country 1 gets a one-time temporary positive shock on the average productivity.

Without endogenous capital accumulation, country 1 has an incentive to save.[5] Hence, country 1 runs a trade surplus by selling bonds. When trade costs and capital controls exist, the effective real rate of return on bonds for country 1 is lower than otherwise for the following two reasons: First, country 1's price today relative to tomorrow is low because it pays less trade costs today by having less imported goods in its consumption basket. The lower price today pushes the effective interest rate down for country 1.[6] Second, there is a tax on capital

[4]In addition to changes in average productivity and preference shifters, exogenous changes in labor and capital endowment or value-added shares also generate trade imbalances.

[5]This is because a positive productivity shock increases output in country 1. Consumption goes up but not as much as output does. Thus coun/try 1 saves the rest by selling the bonds.

[6]Obstfeld & Rogoff (2000) provide a explanation of how differences in real interest rates caused by trade

outflows which effectively reduces real returns from bonds. Exactly the opposite happens for country 2 that runs a trade deficit by buying bonds. Higher price today relative to tomorrow and a tax on capital inflows raises the effective real interest rate for country 2. As a result, the effective real interest rates vary across countries upon the shock owing to the existence of trade costs and capital controls.

When trade costs and capital controls decline, the effective interest rate that country 1 faces upon the same shock is not as low as what it would face with high trade costs and capital controls. In other words, the effective real interest rate for country 1 is relatively high with lower trade costs and capital controls. Due to the higher ER, there will be less consumption and more saving, implying a larger trade surplus for country 1 compared to the case of high trade costs and capital controls. For country 2, which is a net borrower, the effective interest rate it has to pay is not as high as what it would face with high trade costs and capital controls. In other words, country 2 faces a relatively low effective real interest rate as trade costs and capital controls decrease. Country 2 is willing to consume less and borrow more owing to the lower rate, resulting in a larger trade deficit for country 2. A decrease in trade costs and capital controls leads to equilibrium prices that increase the trade imbalances, and this effect is called the *level effect*.[7]

There is an additional effect called the *tilting effect*, which arises due to the fact that trade costs and capital controls decrease over time.[8] In order to understand the intuition of the tilting effect, let's compare the case of declining trade costs and capital controls with an alternative scenario where trade costs and capital controls remain constant at the initial level. With decreasing trade costs and capital controls, every country is less likely to save in the initial periods, relative to the case of constant trade costs and capital controls, because of

costs, can lead to less trade imbalances.

[7]This terminology is introduced by Reyes-Heroles (2016) which explains the mechanism of how lower trade costs over time lead to larger trade imbalances. The level effect in my model, however, can arise not only from decreasing trade costs but also from lowering capital controls.

[8]The explanation on this additional general equilibrium effect is drawn from Reyes-Heroles (2016).

positive income effects.[9] There are less aggregate savings in the initial periods with declining trade costs and capital controls, and this leads to a higher world interest rate in the initial periods at the equilibrium. A country that saves in the initial periods is less likely to save due to the positive income effects. In contrast, a country that borrows initially is less likely to borrow due to a higher equilibrium interest rate in the initial periods.[10] As a result, the equilibrium imbalances in the initial periods are smaller with declining trade costs and capital controls.

To summarize, when trade costs and capital controls are small, effective interest rates vary less across countries and thus fundamental shocks have more impacts on trade imbalances. Additional tilting effects owing to declining trade costs and capital controls, make the level change in trade imbalances even larger. Through these two effects, lower trade costs and capital controls propagate the effects of fundamental shocks, leading to larger trade imbalances.

2.2 Calibration

In this section, I take the model to the data. There are two main steps: I first identify all the parameters and time-varying exogenous variables that are observable. Second, I calibrate the disturbances that I previously defined as S_t. They are exogenous variables that are not directly observed from the data; thus I recover these disturbances so that the

[9]When trade costs and capital controls decrease over time, there is less incentive for a country to allocate its resources from the initial periods to the future periods by increasing savings as the world economy gets richer in the later years, compared to the case of constant trade costs and capital controls. Thus a country that saves in the initial periods wants to save less while a country that borrows in the initial periods wants to borrow more.

[10]A country that borrows initially has an incentive to borrow more if trade costs and capital controls decrease over time (positive income effects mentioned above). However, the equilibrium world interest rate in the initial periods is higher under the declining trade costs and capital controls, which reduces the borrower's incentive to borrow. The later effects dominate the former, and thus the country that borrows in the initial periods borrow less under the declining trade costs and capital controls than under the constant trade costs and capital controls.

endogenous variables generated by the model match exactly with the actual data on prices, trade shares and net exports. These disturbances are structural residuals of the model that account for the evolution of observed data. I have 24 countries plus the rest of the world, and there is one sector.[11] The time period that I consider is from 1970 to 2007.

2.2.1 Parameters

There are two parameters that I recover by using the data: the shares of value-added in the production function, $\beta_{i,t}$ and the capital shares in the value-added, φ_i. Data on gross output comes either from EU-KLEMS or World Input-Output Database (WIOD), and GDP data comes from UNSTAT.[12] The value-added shares are computed by dividing each country's GDP by its gross output in each year. For the capital shares in value-added, I use the data on labor and capital compensation out of total value-added, which the OECD input-output tables provide. φ_i is computed by capital compensation divided by the sum of labor and capital compensation. For each country, I take the average between 2000 and 2007.

There are three parameter values that I draw from the existing literature. I take a constant value of θ=4 for the variance of Fréchet distribution for all countries as a baseline case. This is consistent with the estimates of trade elasticity by Simonovska & Waugh (2014). I calibrate the elasticity of substitution across tradeable goods as σ=2, consistent with Broda & Weinstein (2006). Lastly, the discount factor is set to δ=0.95, which is standard for annual data. Table 2.1 summarizes parameter values and the source of data.

[11] List of 25 countries: Australia, Austria, Belgium, Brazil, Canada, China, Denmark, Finland, France, Germany, Greece, India, Italy, Japan, Korea, Mexico, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States and the rest of the world (ROW).

[12] United Nations Statistics Division - National Accounts Main Aggregates Database (UNSTAT)

2.2.2 Exogenous variables

The model has three time-varying exogenous variables: the labor endowment, $L_{i,t}$; the capital stock, $K_{i,t}$; and the tax rate on interest income from bonds, $\tau_{i,t}$. The Penn World Table (PWT) 9.1 provides data on the number of persons engaged ($emp_{i,t}$) and real capital stock ($rnna_{i,t}$) - which is based on national accounts. They are taken as labor endowment and capital stock, respectively.

To compute the tax rates, I proceed in the following two steps. First, I construct capital control index by using the normalized Chinn-Ito index.[13] In particular, I define capital control index as one minus normalized Chinn-Ito index which represents a country's capital account openness. Then I convert the indices into equivalent tax rates by relying on six examples of actual capital controls that were implemented; Brazil (2010-11), Chile (1991-96), Colombia (1993-95), Hungary (1999-2000), Malaysia (1999) and Thailand (2010). For each country, I recover the implicit tax rates that correspond to its capital control index. For example, I assume that Brazil's capital control index in 2010, 0.525, is equivalent to a 6 percent tax rate based on Brazilian government's policy on capital controls (*Imposto Sobre Operacoes Financeiras*, IOF). Similarly, I back out the tax rates that are implicitly imposed by each of the other five countries at the time of capital controls by considering the individual policy, and assume that their capital control indices are equivalent to those tax rates. Then, I fit a second order polynomial trend-line that minimizes the distance from the six equivalence-relation points and the origin. This conversion equation allows a one-to-one mapping from the capital control index to the equivalent tax rate for all countries in my sample.[14]

[13] Note that the normalized Chinn-Ito index ranges from zero to one.

[14] The detailed description on how to back out the implicit tax rates for each country and how to derive the trend-line are included in the Appendix

2.2.3 Structural Residuals

The goal in this section is to recover three sets of disturbances to match actual data on three endogenous outcomes of the model: (1) prices, (2) trade shares and (3) net exports. I closely follow the steps taken by Reyes-Heroles (2016).[15]

For the aggregate price index, I first construct GDP deflator by taking the ratio of nominal GDP to real GDP. UNSTAT provides both current and constant GDP data for all sample countries. I then adjust each country's GDP deflator proportionally so that the GDP deflator in 2011 is replaced with the price level of GDP (PPP/XR) from the PWT. Construction of trade share matrices requires data on each country's total expenditure and bilateral trade flows. Note that the (i,j)th element of the trade share matrix, $\pi_{ij,t}$, is defined as country i's import from country j divided by country i's total expenditure.

Total expenditure can be computed by subtracting net exports from gross output, which comes from different sources including EU-KLEMS and WIOD. I compute total net exports based on bilateral trade data from Comtrade and the NBER-United Nations Trade Data. Recall that the world GDP is the numeraire in the model. Therefore, I express net exports in each country as a share of world GDP.

For factor prices, instead of getting actual data on wages and rental rate, I recover them by using the equilibrium conditions of the model. Wages and rental rates are computed as follows, $w_{i,t} = (1-\varphi_i)\frac{GDP_{i,t}}{L_{i,t}}$ and $r_{i,t} = \varphi_i \frac{GDP_{i,t}}{K_{i,t}}$, by using the data on GDP, labor endowment and capital stock.

Define D_t as a set of data that is observed and used to calibrate the sequence of disturbances $\{S_t\}$ for $\forall$ t$\in$[1970,2007].

$$D_t \equiv \{w_{i,t}, r_{i,t}, L_{i,t}, K_{i,t}, \tau_{i,t}, GDP_{i,t}, NX_{i,t}, X_{i,t}, Y_{i,t}, P_{i,t}, \pi_{in,t}\}$$

[15] Reyes-Heroles (2016) recovers four sets of structural residuals; sectoral demand shifters, trade costs, sectoral productivity and intertemporal preference shifters. My model does not have sectoral demand shifters, because I assume one sector. Trade costs and productivity are also recovered at the aggregate level for each country as opposed to the sectoral level.

I assume that the world economy has reached the steady state in 2007. All the exogenous variables in each country remain at the 2007 level after 2007.

Average productivity level and Trade costs

Given the parameter values and the set of data described above, the average productivity level, $T_{n,t}$ and trade costs, $d_{in,t}$ for $\forall$ i,n and t are uniquely recovered by the static equilibrium conditions.

Starting from the trade share equation (2.9), consider the case where i = n. Recall that within-country trade costs are assumed to be 1, $d_{nn,t}$ =1 for $\forall$ n and t. Then the average productivity level is uniquely determined by data on the share of a country's total expenditure on domestic goods, its own price index and the cost of input-bundle. Note that the cost of a country's input bundle is a function of its factor prices and aggregate price, which also directly comes from D_t.

$$T_{n,t} = \pi_{nn,t} \left(\frac{\gamma cost_{n,t}}{P_{n,t}} \right)^{\theta} \tag{2.21}$$

Figure 2.3 shows how the average productivity level that I recovered changes over time for some selected countries in the sample. Panel (a) shows the evolution of $ln(T_{i,t}^{\frac{1}{\theta}})$ for five developed countries; Canada, Germany, Japan, United Kingdom and United States while panel (b) includes five emerging market economies; Brazil, China, India, Korea and Mexico. On average, countries in panel (a) show relatively higher level of productivity throughout the entire period compared to the countries in panel (b).

Trade costs are uniquely identified by prices and trade shares. Take the ratio of the country i's import share from country n ($\pi_{in,t}$) to the country n's domestic share ($\pi_{nn,t}$) by dividing equation (2.9) with (2.21). This gives an expression for bilateral trade costs in terms of two countries' prices and trade shares only. Thus trade costs for each country-pair in every period can be completely recovered by using data from D_t.[16]

$$d_{in,t} = \frac{P_{i,t}}{P_{n,t}} \left(\frac{\pi_{nn,t}}{\pi_{in,t}} \right)^{\frac{1}{\theta}} \tag{2.22}$$

Figure 2.4 displays the simple average of all country-pair bilateral trade costs in each time period. Calibrated trade costs essentially rationalize the data on prices and bilateral trade flows. The average trade costs were about 900 percent ($d_{ni,t}$=9.98) of sales price in 1970, and they consistently and significantly declined over time. In 2007, the average trade costs were approximately 460 percent ($d_{ni,t}$=5.63) of sales price.

Intertemporal Preference Shifters

Intertemporal preference shifters $\hat{\phi}_{i,t+1}$ are calibrated to match actual data on net exports. Euler equation (2.12), which summarizes households' optimal dynamic decisions, can be rearranged by using log preference as follows:

$$\frac{P_{i,t+1}C_{i,t+1}}{P_{i,t}C_{i,t}} = \delta \hat{\phi}_{i,t+1} \left(\frac{1}{q_t} \right) [1 - \tau_{i,t+1}(1 - q_t)] \tag{2.23}$$

Note that consumption expenditure, $P_{i,t}C_{i,t}$ is computed by the difference between $GDP_{i,t}$ and $NX_{i,t}$, both of which directly come from the data. The absolute size of tax rates, $\tau_{i,t}$ also come from data, but the sign has to be determined so that it matches with that of bond holdings.[17] Note also that the price of bond, q_t is endogenously determined by demand and supply of bond in each period. Hence, given the value of δ and data on consumption expenditure and tax rates with the right sign, there are N+1 unknowns to recover in each period, q and $\hat{\phi}_i$ for each i. However, the number of equations that I target to hold is only N; equation (2.23) for each i. Thus I normalize one country's intertemporal preference shifter

[16]Many previous studies related to the gravity model of trade, calibrate trade costs in a similar way. See Head & Mayer (2014a) for more details.

[17]Recall that $\tau_{i,t}$ is positive if $B_{i,t}$>0 while $\tau_{i,t}$ is negative if $B_{i,t}$<0.

to equal one for all time periods and recover the other N.

Here are the steps that I follow.[18] I first the normalize US's intertemporal preference shifters $\hat{\phi}_{US,t+1}$ for all t. Then I back out q_t for each time period by using US's data on consumption expenditure and tax rate in the Euler equation. Given that, I compute the steady state level of bonds for each country, and recover the entire time path of bonds by iterating backwards based on q_t and the data on net exports. I check whether the sign of $B_{i,t}$ and $\tau_{i,t}$ matches for all countries in every time period. I update the sign of $\tau_{i,t}$ according to the sign of bonds until they match. Finally, all other countries' $\hat{\phi}_{i,t+1}$, except the United States, can be recovered by using each country's own data in the Euler equation.

2.2.4 Model Validation

In the previous section, the structural residuals are recovered to match three targeted moments; prices, trade shares and net exports for each country in every period. In this section, I look at the evolution of some untargeted moments in the model to test for model validation. In particular, I compare two variables from the model - the real interest rates and the average productivity level - with actual data.

Real Interest Rates: Model vs Data

I compare the world interest rates recovered from the model with the data on U.S. real interest rates in order to validate the model.[19] Note that the real interest rates are one of the untargeted moments in the model. I compute the U.S. real interest rates for 1970-2007 as the nominal interest rates minus the expected inflation rates following the methodology in Yi et al. (2016);

$$r_{\text{US},t} = i_{\text{US},t} - \pi^e_{\text{US},t} \tag{2.24}$$

[18] A detailed description of these steps is included in Appendix D

[19] The world interest rates recovered from the model are computed as the reciprocal of the price of bonds minus one; $1/q_t - 1$.

In particular, I use the interest rates for the government securities (treasury bills) from IMF's International Financial Statistics (IFS) for the nominal rates. In addition, the expected inflation rate for this year is assumed to be the last year's inflation rate; $\pi^e_{\mathrm{US},t} = \pi_{\mathrm{US},t-1}$. This data comes from the World Bank and they are based on the GDP deflator. Figure 2.6 compares the world interest rates recovered from the model with the data on U.S. real interest rates. The model-based real interest rates have a slightly higher average and more variation over time compared to the data. However, the two series are positively correlated; the correlation is approximately 0.2 (0.4 for the 5-year moving average).[20]

Note that I use the data on U.S. real interest rates as a proxy for the world interest rates, and the expected inflation rates do not necessarily equal actual inflation rates. The model-implied world interest rates also rely on the assumption of perfect foresight. For these reasons, I do not expect for the model to fit the data perfectly, but at least, the fit is reasonable because there is a positive correlation between the model-generated world interest rates and the data.

Average productivity level: Model vs Data

One of the structural residuals that I recovered from the model is a country-specific average productivity level that changes over time. I compare the average productivity level backed out from the model with the data as a second check for the model validation. There are three ways that I construct the aggregate TFP from the data.

(1) I use *rtpna*, TFP at constant national prices (2011=1), from PWT 9.0

(2) I compute TFP as $A_{i,t} = \frac{\mathrm{VA}_{i,t}}{L_{i,t}^{1-\alpha} K_{i,t}^{\alpha}}$

(3) I compute TFP as $A_{i,t} = \frac{\mathrm{VA}_{i,t}}{L_{i,t}}$

[20]The World Bank also provides U.S. real interest rates data, but they are constructed as lending interest rates adjusted for inflation rate that are based on the GDP deflator. This data series is also positively correlated with the model-based world interest rates.

where each country's total value-added comes from UNSTAT while labor and capital stock comes from PWT. Note that all three variables are in real terms and I use a share of capital in production α=1/3 for all countries. Then I compute the correlation between the model-generated average productivity and the data-based TFP for each country and it is summarized in Table 2.2. For most countries, all three measures of TFP are positively correlated with the average productivity recovered from the model. The median is also positive for all three measures. Note that there are two countries - Canada and Italy - whose correlation is negative for all three measures of TFP. That is because those countries' average productivity level recovered in the model actually decreases between 1970 and 2007. Overall, I see the growth of average productivity in the majority of countries both from the model and from the data.

2.3 Counterfactual Exercises

2.3.1 Effects of Trade Costs on Trade Imbalances

Counterfactual trade costs

Counterfactual trade costs are constructed by using the Head-Ries (HR) index.[21] In the literature on gravity equations, HR indices are used as a measure of country-pair bilateral trade frictions, which are the function of trade shares only.

$$HR_{in,t} \equiv \left(\frac{\pi_{in,t}}{\pi_{nn,t}} \frac{\pi_{ni,t}}{\pi_{ii,t}} \right)^{-\frac{1}{2\theta}} \tag{2.25}$$

HR indices are symmetric, by their construction, and they are closely connected to bilateral trade costs in the model, because the arithmetic mean of two countries' trade costs

[21]Note that I define the counterfactual trade costs following the way Reyes-Heroles (2016) does in his main counterfactual exercise.

is exactly equal to this index.[22] Then the counterfactual trade costs are defined as

$$\tilde{d}_{in,t} = d_{in,t} \times \left(\frac{HR_{in,1970}}{HR_{in,t}} \right) \tag{2.26}$$

The basic idea behind the construction of counterfactual trade costs is that I would like to fix every period's HR indices at their 1970 level, instead of fixing trade costs themselves at the 1970 level. A potential problem of the latter is that trade imbalances can be generated by a change in asymmetries across country-pair bilateral trade costs over time. The counterfactual trade costs allow me to capture the effects of a decline in the average trade costs over time.

Trade costs fixed to 1970 levels

In the first counterfactual exercise, trade costs are set to the counterfactual trade costs, which are defined as equation (2.26). To be specific, the HR indices are fixed at 1970's level while all other disturbances are assumed to follow the original path. The effects of a decline in trade costs can be quantitatively evaluated by comparing trade imbalances generated under the counterfactual scenario with the actual data.[23]

Figure 2.8 shows how trade imbalances - which are measured as an absolute sum of net exports across all countries as a share of world GDP - evolve over time under the counterfactual exercise along with the actual pattern of the data. Note that the solid line shows the data while the dashed line displays the path of trade imbalances generated in the counterfactual exercise. Table 2.3 summarizes the level of trade imbalances for 1970 and 2007 as well as the difference between two periods. Trade imbalances increase by 2.4 percentage

[22]Equation (2.22) implies that $(d_{in,t} \times d_{ni,t})^{1/2} = \left[\left(\frac{\pi_{in,t}}{\pi_{nn}} \right)^{-\frac{1}{\theta}} \times \left(\frac{\pi_{ni,t}}{\pi_{ii}} \right)^{-\frac{1}{\theta}} \right]^{1/2} = HR_{in,t}$

[23]This is the same counterfactual exercise as in Reyes-Heroles (2016). The difference is, I only have one aggregate sector for each country, while he has multiple sectors. In addition, I let capital control parameters follow the original path as in the calibration, but he assumes a frictionless financial market.

point between 1970 and 2007 from 1.23 percent to 3.66 percent in the first counterfactual exercise. The level difference in trade imbalances in the counterfactual exercise is 57.5 percent of what the actual data suggests.[24] This implies that 42.5 percent of the increase in trade imbalances from 1970 to 2007 can be explained by the decrease in trade costs.[25]

The contribution of declining trade costs on trade imbalances comes mainly from the effects in the later period (1990-2007) compared to the earlier period (1970-1990). The effects of trade costs can be graphically captured by the gap between the solid and the dashed line in Figure 2.8, and this gap is particularly pronounced in the later period after 1990. As also shown in Table 2.5, the contribution of lower trade costs to the level change in trade imbalances is 53 percent in the later period. This is more than 2.5 times larger than their quantitative contribution in the earlier period, which is only about 20 percent.

In terms of the accumulated trade imbalances, however, the contribution of declining trade costs on trade imbalances is not as large compared to the level change in trade imbalances.[26] Table 2.5 shows that the decline in trade costs explains 7.9 percent of the increase in the accumulated trade imbalances between 1970 and 2007.[27] This can be explained by the tilting effects; trade imbalances are higher in the initial periods under the counterfactual exercise than in the data. If I divide the period again and focus on the later period only, it clearly shows a larger contribution of lowering trade costs.[28] As shown in Table 2.5, the decline in trade costs accounts for 19.8 percent of the increase in the accumulated trade imbalances between 1990 and 2007.

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[24]Denote $Diff^D$ and $Diff^{CF1}$ as the difference in the level of trade imbalances between 1970 and 2007 for the actual data and for the first counterfactual exercise, respectively. Then, $\frac{Diff^{CF1}}{Diff^D}=\frac{2.4pp}{4.2pp}=57.5\%$.

[25]Note that the 1970 level of trade imbalances in the data and counterfactual exercise are different, even though the trade costs are exactly the same, because of the tilting effects.

[26]Note that the accumulated trade imbalances are measured as the sum of trade imbalances over all time periods; $\sum_{t=1970}^{2007}[\sum_{i=1}^{N}|NX_{i,t}|]$.

[27]Denote $TrdImb_A^D$ and $TrdImb_A^{CF1}$ as the accumulated trade imbalances across all time periods for the actual data and for the first counterfactual exercise, respectively. Then, $1-\frac{TrdImb_A^{CF1}}{TrdImb_A^D}=7.9\%$

[28]In the earlier period (1970-1990), lower trade costs lead to even smaller accumulated trade imbalances, which is the tilting effect.

2.3.2 Effects of Capital Controls on Trade Imbalances

In the second counterfactual exercise, the goal is to quantify the effects of a decline in capital controls over time. I fix the magnitude of the capital controls, $|\tau_{i,t}|$, at its 1970 level for each country while keeping all other disturbances at their original level. Similar to earlier, the effects of lowering capital controls can be captured by comparing trade imbalances generated under the counterfactual exercise with the actual data.

Figure 2.9 plots the evolution of trade imbalances for the second counterfactual exercise along with the data, and Table 2.3 summarizes the numbers in 1970 and 2007. The level difference in trade imbalances between 1970 and 2007 is 3.3 and 4.2 percentage point for the second counterfactual exercise and the data, respectively. This suggests that 22.1 percent of the trade imbalances that we observe from the data can be explained by the decline in capital controls. Put differently, trade imbalances would have been only 77.9 percent of what the data suggests if capital controls had remained unchanged since 1970.

Unlike trade costs, however, the contribution of declining capital controls on trade imbalances in the later period (1990-2007) is not significantly different from the earlier period (1970-1990). As presented in Table 2.5, the contribution of capital controls is approximately 20 percent and 23 percent for the earlier period and later period, respectively. This is consistent with what Figure 2.9 indicates; the gap between the solid and the dashed line after 1990 is not as noticeable.

In terms of accumulated trade imbalances, Table 2.5 shows that a reduction in capital controls account for only 1 percent of the rise in trade imbalances between 1970 and 2007. The contribution of declining capital controls on the accumulated trade imbalances increases to 8 percent, if I only consider the later period where I disregard the tilting effects. Nonetheless, the effects of lowering capital controls on the accumulated trade imbalances are still smaller compared to those on the level change in trade imbalances.

2.3.3 Effects of Trade Costs and K-Controls on Trade Imbalances

In the final counterfactual exercise, I fix both trade costs and capital controls at their 1970 level. Again, all other disturbances are assumed to follow their original path. The third counterfactual exercise quantitatively assesses the effects of a decline in both trade cost and capital controls on the increase in the size of trade imbalances.

Figure 2.10 presents how trade imbalances develop over time in the data and in the counterfactual scenario. The level of trade imbalances increases by 1.6 percentage point between 1970 and 2007 in the third counterfactual exercise, which is 37.4 percent of what the actual data implies. This means that 62.6 percent of the increase in trade imbalances can be explained by the decrease in trade costs and capitals controls together. In terms of the accumulated trade imbalances, 9.3 percent of the rise in trade imbalances can be accounted for by lower trade costs and capital controls between 1970 and 2007. In addition, as shown in Table 2.5, the quantitative contribution of both factors goes up to 27 percent if I focus on the period after 1990.

Table 2.4 shows the accumulated trade imbalances in the data and in the counterfactual exercises for the entire period and the two sub-periods. Finally, Table 2.5 summarizes how much of the rise in trade imbalances, both in terms of level change and accumulated trade imbalances, is accounted for by lower trade costs, capital controls and both. I conclude that both forms of globalization significantly contribute to the rise in global trade imbalances over time. The quantitative contribution of declining trade costs, however, is larger than lowering capital controls.

2.3.4 Heterogeneous effects on Individual countries

The effects of trade costs and capital controls are heterogenous across countries in the sample. Table 2.6 summarizes the level of trade imbalances for each individual country in 1970 and in 2007 as well as the difference suggested by the data and generated under the first and second counterfactual exercises.

China and the U.S. are the two main contributors to the global trade imbalances, and both countries' trade imbalances are affected more by a decline in trade costs than a decrease in capital controls. If trade costs had remained at the 1970's level, both China and the U.S. would have a much smaller change in trade imbalances. In particular, the level change in Chinese trade surplus and U.S. trade deficit would have been only 0.27 percent and -0.89 percent of world GDP rather than 0.93 percent and -1.64 percent. Instead, if capital controls had not fallen as they did in the data, Chinese trade surplus and U.S. trade deficit would have changed merely by 0.89 percent and -1.59 percent, respectively. These changes are still smaller than what the observed data suggests, but they are larger than the changes induced by fixed trade costs. Figure 2.11 explains all of the above graphically.

In contrast, the effects of capital controls dominate those of trade costs in other countries such as Japan and the United Kingdom. A decline in trade costs has almost no effects on the level change in Japanese trade imbalances. However, if capital controls had not decreased since 1970, Japan would have experienced an increase in trade deficit by 0.04 percent, as opposed to an increase in trade surplus by 0.19 percent. Similarly, for the U.K., if the level of trade costs were fixed at the 1970's level, the trade deficit of the U.K. would have changed by -0.26 percent, which is lower than in the data, -0.35 percent. If the level of capital controls were kept at the 1970's level, the trade deficit in the U.K. would have decreased only by -0.17 percent. This implies that the trade deficit of the U.K is affected more by the decrease in capital controls . Lastly, trade imbalances of certain countries such as Denmark have not been affected greatly by either trade costs or capital controls. The path of net exports for these countries show negligible changes when trade costs or capital controls are assumed to be fixed at the 1970's level.

2.3.5 Welfare gains

I measure welfare gains from the counterfactual exercises in the following way: the percentage increase in consumption in each period that each country would require in order to make the discounted lifetime utility under the counterfactual exercise be the same as in the benchmark case. Denote U_i^D as the discounted lifetime utility for country i in the benchmark scenario; $U_i^D = \sum_{t=1}^{\infty} \delta^{t-1} \phi_{i,t} \ln(C_{i,t}^D)$ where $C_{i,t}^D$ is aggregate consumption in country i at time t implied by the data. Then the welfare gains from lower trade costs or lower capital controls can be computed by the average extra consumption, x_i, such that

$$\sum_{t=1}^{\infty} \delta^{t-1} \phi_{i,t} \ln(C_{i,t}^{CF}(1 + x_i)) = U_i^D \tag{2.27}$$

where $C_{i,t}^{CF}$ is consumption for country i at time t under the counterfactual exercise. The total welfare gains can be decomposed into static and non-static components. Static gains can be computed based on the assumption that each country runs zero trade imbalances in every time period, and the rest will be captured as non-static gains. For the decomposition, I compute the amount of consumption that each country would have had without any trade imbalances by imposing that consumption equals exactly its own production. To be specific, I denote $\{\bar{C}_{i,t}^D\}_{t=1}^{\infty}$ and $\{\bar{C}_{i,t}^{CF}\}_{t=1}^{\infty}$ as the equilibrium consumption path with zero trade imbalances for country i under the benchmark case and the counterfactual exercises, respectively. Then, the static part of the gains, μ_i, can be computed in a similar way as before; $\sum_{t=1}^{\infty} \delta^{t-1} \phi_{i,t} \ln(\bar{C}_{i,t}^{CF}(1 + \mu_i)) = \sum_{t=1}^{\infty} \delta^{t-1} \phi_{i,t} \ln(\bar{C}_{i,t}^D)$. Finally, total welfare gains can be expressed as the sum of static and non-static gains:

$$\ln(1 + x_i) = \ln(1 + \mu_i) + \ln(1 + \nu_i) \tag{2.28}$$

where ν_i captures the non-static welfare gains.

Table 2.7 summarizes the total welfare gains of individual countries from each of the three counterfactual exercises. The decline in trade costs between 1970 and 2007 leads to positive welfare gains for all countries in my sample (column CF1). The welfare gains for the median country is about 1.2 percent of consumption per annum, but the magnitude of the gains varies substantially across countries. There are some countries whose welfare gains are relatively large, such as China (9.23%), Korea (5.51%) and Belgium (5.02%), while other countries like Australia (0.55%) and U.S. (0.51%) seem to have relatively small gains. In contrast, the decrease in capital controls between 1970 and 2007 has different implications for welfare gains. The welfare gains are positive for 9 countries including Finland (0.56%), Korea (0.53%), Brazil (0.49%) and China (0.35%), but they are negative for the other 16 countries, such as Spain (-0.36%) and Australia (-0.49%) (column CF2).

Table 2.8 shows the static and non-static gains from each counterfactual exercise. Column (1) and (2) displays the static and non-static gains from lower trade costs, respectively. All the countries in the sample experience positive static gains, and the magnitude is larger than the non-static gains (except China). This is why even countries with negative non-static gains have positive overall welfare gains. The static gains are relatively large because lower aggregate prices caused by the decline in trade costs, tend to increase consumption.

Column (3) and (4) shows the static and non-static gains from lower capital controls. The static gains are relatively small - compared to both static gains from declining trade costs and non-static gains from lowering capital controls - because the aggregate prices are not affected much by the decrease in capital controls. More than half of the countries in my sample have total welfare losses owing to their negative and large non-static gains, while the other countries have welfare gains mainly because of positive and sizable non-static gains. In particular, countries that have a positive net foreign asset position in the model seem to experience larger negative non-static gains.

Capital controls in the model can be viewed as a way to distort the intertemporal prices. They affect both supply and demand of bonds which determine the world interest rate. The equilibrium world interest rate is lower, on average, when capital controls decrease over time compared to the case of constant capital controls. Lower world interest rate is beneficial for countries that are net borrowers because of lower borrowing costs. In contrast, countries that are net savers are worse off from lower world interest rate. This can be one of the reasons why countries that have a positive net foreign asset position in my model tend to show larger welfare losses from declining capital controls. In the Appendix section A.4.3, I include more detailed comparison between countries that gain and lose from declining capital controls.

Finally, column (5) and (6) presents the static and non-static gains from both lower trade costs and lower capital controls. Every country in my sample has positive welfare gains including those countries that experience welfare losses from lowering capital controls. This is because their negative non-static gains that come from lower capital controls are completely offset by positive and sizable static gains driven from the declines in trade costs.

2.4 Conclusion

In this chapter, I present a dynamic general equilibrium model of international trade that features trade costs and capital controls in order to assess the quantitative contribution of these two factors on the rise in trade imbalances. In the model, a decline in trade costs and capital controls increases global imbalances by increasing the propagation of fundamental shocks that generate trade imbalances. Based on the quantitative model, I evaluate how much of the increase in global trade imbalances that occurred from 1970 to 2007 is explained by lower costs of trade and capital flows over time.

I calibrate trade costs to match the data on country-pair bilateral trade flows by relying on the gravity structure of the model. In contrast, I introduce capital controls in the form of a tax which are constructed based on six examples of actual capital controls, as well as the Chinn-Ito indices. I then conduct counterfactual exercises and show that the decline in trade costs accounts for 42 percent of the observed global trade imbalances while the decline in capital controls can explain 22 percent of the imbalances. In addition, these effects are substantially heterogeneous across countries. I conclude that both forms of globalization have significantly contributed to the increase in global trade imbalances over time.

I also measure welfare gains from declining trade costs and capital controls. A decrease in trade costs leads to lower aggregate prices and thus results in positive and sizable welfare gains for all countries. Conversely, lower capital controls do not necessarily generate welfare gains. Some countries seem to suffer from welfare losses especially those that have a positive net foreign asset position in the model. Lower trade costs and capital controls both increase trade imbalances, but their welfare implications are quite different.

There are two main avenues for further research. First, the model does not have investment, which is an important element for the intertemporal decisions and trade imbalances. One potential extension could be to incorporate the endogenous capital accumulation and to consider the effects of investment in determining trade imbalances. The other limitation comes from the fact that comprehensive capital control measures for a wide range of countries, are not available. I depend on the Chinn-Ito index to construct the measures of capital controls, and they play an important role in quantifying the effects of lowering capital controls. However, this index does not properly capture the heterogeneity in an individual country's capital control measures. A new dataset with finer granularity can help reconfirm the effects of capital controls and provide a more accurate quantification of it.

Table 2.1: Parameters

Parameter	Value	Variable	Source
$\beta_{i,t}$	-	Share of VA in prod.function	EU-KLEMS, WIOD, UNSTAT
φ_i	-	Capital share of VA	OECD STAN
θ	4	Variance of Fréchet distribution	Simonovska & Waugh (2014)
σ	2	Elasticity of substitution across goods	Broda & Weinstein (2006)
δ	0.95	Discount factor	Standard for annual data

Notes: There are five sets of model parameters. I compute the share of value-added ($\beta_{i,t}$) and capital share in value-added (φ_i) using the aggregate data. The values of the other three parameters - the variance of Fréchet distribution (θ), elasticity of substitution across goods (σ) and discount factor (δ) - come directly from the literature.

Table 2.2: **Average Productivity level: Model vs Data**

Country	(1)	(2)	(3)	Country	(1)	(2)	(3)
Australia	-0.12	0.08	0.12	Italy	-0.09	-0.17	-0.23
Austria	0.29	0.29	0.31	Japan	0.86	-0.83	0.90
Belgium	0.34	0.36	0.30	Korea	0.89	0.90	0.89
Brazil	0.89	0.16	-0.19	Mexico	0.94	0.88	0.62
Canada	-0.49	-0.51	-0.61	Netherlands	0.29	0.29	0.27
China	0.64	0.84	0.79	Norway	0.96	0.96	0.96
Denmark	0.67	0.60	0.58	Portugal	0.00	0.86	0.90
Finland	0.58	0.63	0.65	Spain	0.68	0.69	0.71
France	0.77	0.79	0.80	Sweden	0.30	0.40	0.45
Germany	0.42	0.44	0.40	Switzerland	-0.04	0.11	0.03
Greece	-0.40	0.43	0.46	UK	0.85	0.87	0.87
India	0.96	0.98	0.97	US	0.89	0.86	0.86
Median	0.61	0.52	0.60				

Notes: Column (1), (2) and (3) shows the correlation between the model-based average productivity level and the data-based TFP; $\sigma(T_{i,t}, A_{i,t})$. The data-based TFP either comes directly from PWT or it is computed as residuals from the Cobb-Douglas production function.

Table 2.3: Trade imbalances: Data and Counterfactual exercises

	1970	2007	Difference
Data	0.93%	5.15%	4.2 pp
Counterfactual exercise 1	1.23%	3.66%	2.4 pp
Counterfactual exercise 2	1.20%	4.49%	3.3 pp
Counterfactual exercise 3	1.53%	3.11%	1.6 pp

Notes: Trade imbalances are measured as an absolute sum of net exports across all countries in the sample as a share of world GDP. Table summarizes the level of trade imbalances in 1970 and in 2007 generated in the counterfactual exercises along with the data. It also shows the level change in trade imbalances between 1970 and 2007.

Table 2.4: Accumulated Trade Imbalances

	Counterfactual1			Counterfactual2			Counterfactual3		
	(70-07)	(70-90)	(90-07)	(70-07)	(70-90)	(90-07)	(70-07)	(70-90)	(90-07)
Data	104 %	42 %	64 %	104 %	42 %	64 %	104 %	42 %	64 %
CF	96 %	47 %	51 %	103 %	46 %	59 %	94 %	50 %	46 %

Notes: Table 2.4 summarizes the accumulated trade imbalances in the data and in the counterfactual exercises for each of three periods; 1970-2007, 1970-1990 and 1990-2007. Note that the numbers are expressed as a percent of world GDP which is normalized to one.

Table 2.5: Contribution of each factor to the Rise in Trade Imbalances

A. Level Change in Trade Imbalances

	(1970-2007)	(1970-1990)	(1990-2007)
Trade costs	42.5 %	20.3 %	53.0 %
Capital controls	22.1 %	20.6 %	22.8 %
Both	62.3 %	47.4 %	69.9 %

B. Accumulated Trade Imbalances

	(1970-2007)	(1970-1990)	(1990-2007)
Trade costs	7.9 %	-10.7 %	19.8 %
Capital controls	1.0 %	-9.5 %	8.0 %
Both	9.2 %	-18.3 %	27.2 %

Notes: $Diff^{\mathrm{D}}$ and $Diff^{\mathrm{CF}}$ refer to the level change in trade imbalances in the data and the counterfactual exercise, respectively. Then the contribution of declining trade cost, capital controls and both on the level change in trade imbalances can be computed as $1-(Diff^{CF}/Diff^{D})$. Denote $TrdImb_A^{\mathrm{D}}$ and $TrdImb_A^{CF}$ as the accumulated trade imbalances in the data and the counterfactual exercise, respectively. Then the contribution of lowering trade costs, capital controls and both can be computed as $(1-TrdImb_A^{\mathrm{CF}}/TrdImb_A^{D})$.

Table 2.6: Level difference in Trade imbalances: Individual countries

	Data			Counterfactual1			Counterfactual2		
	1970	2007	Diff	1970	2007	Diff	1970	2007	Diff
Australia	0.03 %	-0.04 %	-0.07 pp	0.03 %	-0.03 %	-0.06 pp	0.01 %	-0.00 %	-0.02 pp
Austria	-0.02 %	0.00 %	0.02 pp	-0.02 %	-0.01 %	0.01 pp	-0.03 %	0.02 %	0.05 pp
Belgium	-0.00 %	0.03 %	0.04 pp	0.01 %	-0.02 %	-0.03 pp	-0.00 %	0.04 %	0.04 pp
Brazil	0.00 %	0.07 %	0.06 pp	-0.00 %	0.06 %	0.06 pp	0.01 %	0.06 %	0.05 pp
Canada	0.11 %	0.07 %	-0.04 pp	0.10 %	0.09 %	-0.01 pp	0.11 %	0.07 %	-0.04 pp
China	0.00 %	0.93 %	0.93 pp	0.16 %	0.43 %	0.27 pp	0.01 %	0.90 %	0.89 pp
Denmark	-0.03 %	0.01 %	0.04 pp	-0.03 %	0.01 %	0.04 pp	-0.03 %	0.01 %	0.04 pp
Finland	-0.00 %	0.01 %	0.02 pp	-0.00 %	0.01 %	0.02 pp	0.01 %	-0.00 %	-0.01 pp
France	-0.03 %	-0.12 %	-0.09 pp	-0.04 %	-0.10 %	-0.05 pp	-0.12 %	-0.01 %	0.11 pp
Germany	0.13 %	0.47 %	0.33 pp	0.17 %	0.38 %	0.21 pp	0.14 %	0.47 %	0.33 pp
Greece	-0.04 %	-0.09 %	-0.05 pp	-0.04 %	-0.08 %	-0.04 pp	-0.04 %	-0.07 %	-0.03 pp
India	0.00 %	-0.13 %	-0.13 pp	-0.02 %	-0.07 %	-0.05 pp	0.00 %	-0.12 %	-0.13 pp
Italy	-0.05 %	-0.02 %	0.03 pp	-0.06 %	-0.01 %	0.05 pp	-0.00 %	-0.07 %	-0.06 pp
Japan	-0.03 %	0.16 %	0.19 pp	-0.01 %	0.18 %	0.19 pp	0.05 %	0.01 %	-0.04 pp
Korea	-0.03 %	0.03 %	0.06 pp	-0.03 %	0.00 %	0.03 pp	-0.03 %	0.02 %	0.05 pp
Mexico	-0.02 %	-0.02 %	0.00 pp	-0.02 %	-0.01 %	0.01 pp	-0.03 %	-0.02 %	0.00 pp
Netherlands	-0.01 %	0.10 %	0.11 pp	-0.00 %	0.08 %	0.08 pp	-0.01 %	0.10 %	0.11 pp
Norway	-0.03 %	0.10 %	0.12 pp	-0.03 %	0.09 %	0.12 pp	-0.02 %	0.09 %	0.11 pp
Portugal	-0.02 %	-0.05 %	-0.03 pp	-0.02 %	-0.04 %	-0.02 pp	-0.02 %	-0.04 %	-0.02 pp
Spain	-0.06 %	-0.24 %	-0.17 pp	-0.09 %	-0.18 %	-0.08 pp	-0.09 %	-0.16 %	-0.07 pp
Sweden	0.01 %	0.03 %	0.02 pp	0.00 %	0.03 %	0.02 pp	0.01 %	0.03 %	0.02 pp
Switzerland	-0.04 %	0.02 %	0.05 pp	-0.03 %	0.02 %	0.05 pp	-0.03 %	0.02 %	0.05 pp
UK	-0.04 %	-0.39 %	-0.35 pp	-0.07 %	-0.33 %	-0.26 pp	-0.14 %	-0.30 %	-0.17 pp
US	0.17 %	-1.48 %	-1.64 pp	-0.09 %	-0.97 %	-0.89 pp	0.15 %	-1.43 %	-1.59 pp
ROW	0.02 %	0.57 %	0.55 pp	0.14 %	0.45 %	0.31 pp	0.09 %	0.44 %	0.34 pp

Notes: Tables shows the level of trade imbalances for each individual country in 1970 and in 2007 suggested by data as well as under the counterfactual exercises. This table also displays the level difference in trade imbalances for individual countries between 1970 and 2007.

Table 2.7: Total Welfare Gains from the Counterfactual Exercises

Country	CF1	CF2	CF3	Country	CF1	CF2	CF3
Australia	0.55 %	-0.49 %	0.16 %	Japan	0.78 %	0.14 %	0.90 %
Austria	2.56 %	-0.24 %	2.39 %	Korea	5.51 %	0.53 %	5.81 %
Belgium	5.02 %	-0.12 %	4.95 %	Mexico	1.94 %	0.22 %	2.04 %
Brazil	0.76 %	0.49 %	1.16 %	Netherlands	2.82 %	-0.07 %	2.78 %
Canada	0.98 %	-0.06 %	0.94 %	Norway	1.06 %	0.20 %	1.28 %
China	9.23 %	0.35 %	9.52 %	Portugal	2.13 %	-0.21 %	1.96 %
Denmark	0.82 %	-0.01 %	0.84 %	Spain	1.81 %	-0.36 %	1.59 %
Finland	1.19 %	0.56 %	1.72 %	Sweden	0.70 %	-0.03 %	0.69 %
France	1.31 %	-0.18 %	1.17 %	Switzerland	1.20 %	-0.04 %	1.18 %
Germany	1.63 %	-0.06 %	1.60 %	UK	0.93 %	-0.21 %	0.74 %
Greece	1.15 %	-0.33 %	0.89 %	US	0.51 %	-0.05 %	0.48 %
India	0.73 %	-0.05 %	0.71 %	ROW	1.46 %	0.17 %	1.59 %
Italy	1.21 %	0.03 %	1.24 %				
W-average	1.99 %	0.01 %	2.00 %	W-sum	49.70 %	0.22 %	50.04 %

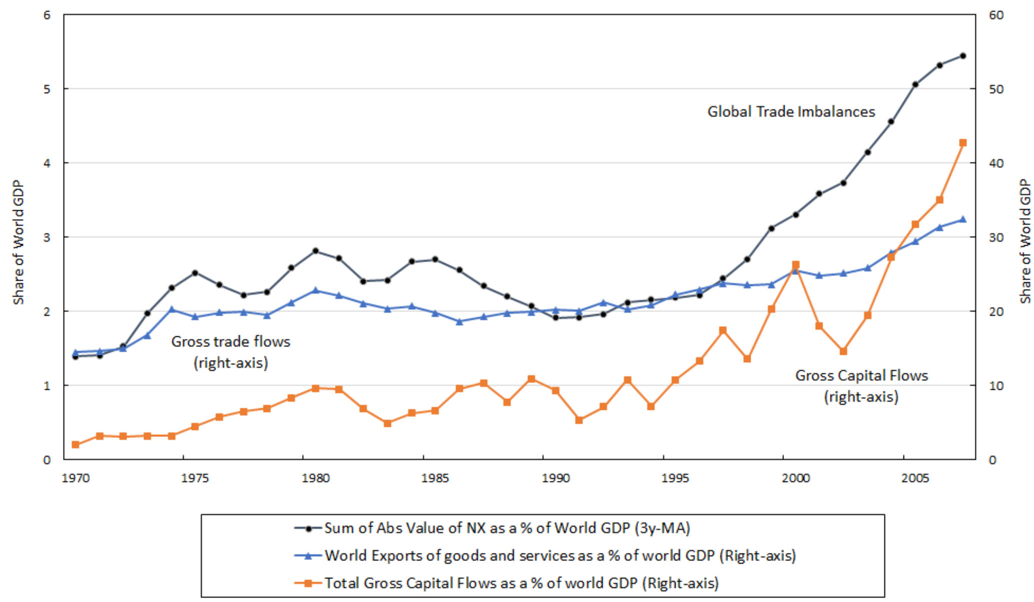
Notes: Table 2.7 summarize the total welfare gains from lowering trade costs (column CF1), capital controls (column CF2) and both (column CF3) for each country. I compute the weighted-average and weighted-sum of all sample countries' welfare gains by using the share of GDP in 2007.

Table 2.8: Static and Non-Static Welfare Gains

	CF1		CF2		CF3	
	Static (1)	Non-static (2)	Static (3)	Non-Static (4)	Static (5)	Non-Static (6)
Australia	0.62 %	-0.07 %	-0.03 %	-0.45 %	0.60 %	-0.43 %
Austria	2.39 %	0.17 %	-0.04 %	-0.20 %	2.36 %	0.02 %
Belgium	4.44 %	0.55 %	-0.03 %	-0.09 %	4.43 %	0.50 %
Brazil	0.70 %	0.06 %	0.04 %	0.45 %	0.74 %	0.42 %
Canada	1.16 %	-0.18 %	-0.00 %	-0.06 %	1.16 %	-0.22 %
China	2.60 %	6.47 %	0.04 %	0.31 %	2.60 %	6.75 %
Denmark	0.85 %	-0.03 %	-0.00 %	-0.00 %	0.85 %	-0.01 %
Finland	1.15 %	0.04 %	0.06 %	0.50 %	1.20 %	0.52 %
France	1.36 %	-0.05 %	-0.03 %	-0.15 %	1.34 %	-0.17 %
Germany	1.46 %	0.16 %	-0.01 %	-0.05 %	1.46 %	0.14 %
Greece	1.00 %	0.15 %	-0.04 %	-0.29 %	0.97 %	-0.08 %
India	0.90 %	-0.17 %	-0.00 %	-0.04 %	0.90 %	-0.18 %
Italy	1.23 %	-0.02 %	0.00 %	0.03 %	1.23 %	0.01 %
Japan	0.79 %	-0.00 %	0.02 %	0.12 %	0.80 %	0.10 %
Korea	5.08 %	0.41 %	0.06 %	0.47 %	5.11 %	0.66 %
Mexico	1.98 %	-0.04 %	0.01 %	0.21 %	1.98 %	0.06 %
Netherlands	2.61 %	0.21 %	-0.01 %	-0.06 %	2.60 %	0.18 %
Norway	0.94 %	0.12 %	0.03 %	0.17 %	0.98 %	0.30 %
Portugal	2.05 %	0.08 %	-0.03 %	-0.18 %	2.03 %	-0.06 %
Spain	1.84 %	-0.03 %	-0.06 %	-0.30 %	1.80 %	-0.21 %
Sweden	0.69 %	0.01 %	-0.01 %	-0.02 %	0.68 %	0.00 %
Switzerland	1.17 %	0.02 %	-0.00 %	-0.04 %	1.17 %	0.00 %
UK	1.02 %	-0.08 %	-0.03 %	-0.18 %	0.99 %	-0.25 %
US	0.62 %	-0.11 %	-0.01 %	-0.04 %	0.62 %	-0.14 %
ROW	1.38 %	0.08 %	0.01 %	0.15 %	1.39 %	0.20 %
W-Average	1.65 %	0.33 %	-0.00 %	0.01 %	1.65 %	0.34 %
W-sum	41.32 %	8.14 %	-0.06 %	0.28 %	41.25 %	8.54 %

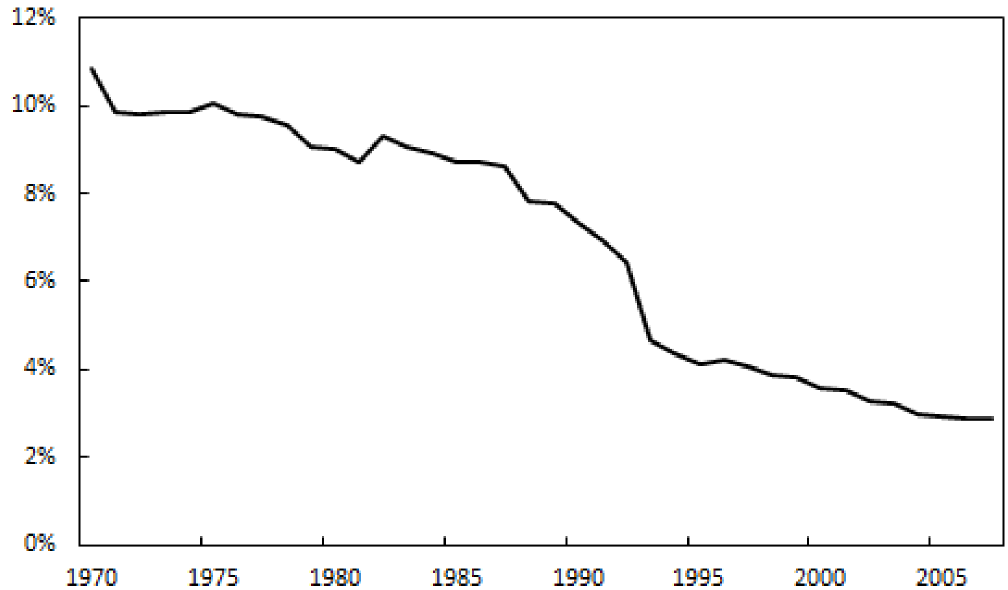
Table 2.8 summarizes the static and non-static gains from each of three counterfactual exercises. CF1, CF2 and CF3 refers the welfare gains from declining trade costs, capital controls and both, respectively. Again, I compute the weighted-average and weighted-sum of all sample countries' welfare gains by using the share of GDP in 2007.

Figure 2.1: Trade imbalances and Gross trade and capital flows, 1970-2007



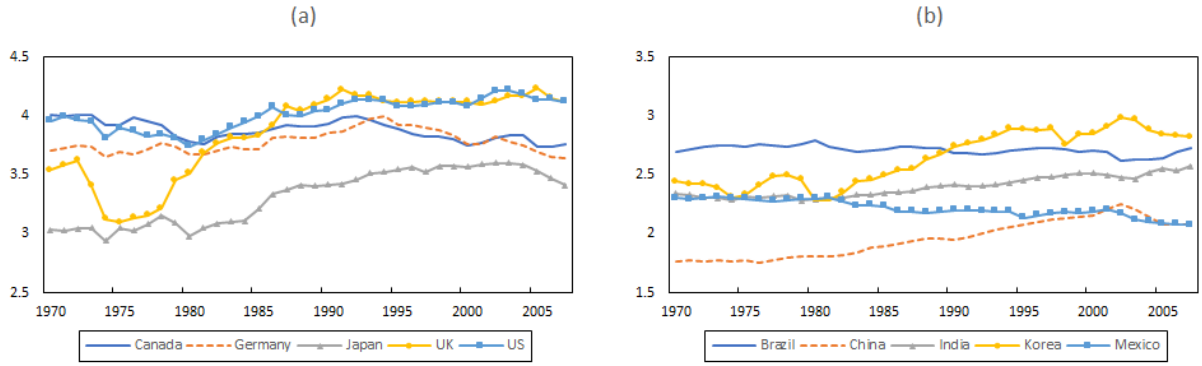
Notes: The black line (circle) shows the evolution path of global trade imbalances over time. Note that it is computed as a 3-year moving average. The blue line (triangle) is world exports of goods and services while the orange line (square) is total gross capital flows.
Source: UN National Account Statistics and Broner et al. (2013)

Figure 2.2: Simple average of tax rates constructed, 1970-2007



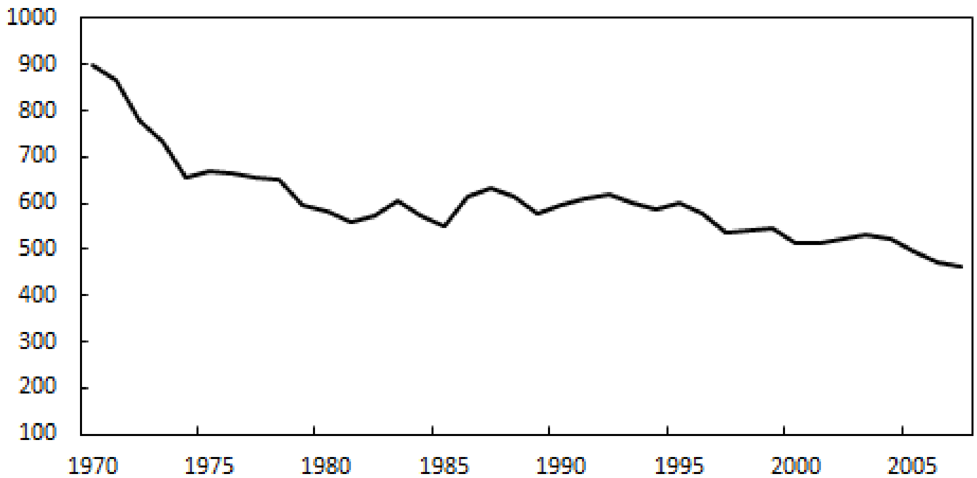
Notes: This figure shows the simple average of tax rates across 25 countries in the sample. Tax rates are constructed by converting each country's capital control indices into the equivalent tax rates based on six examples of capital controls. The average tax rate was about 11 percent in 1970, but it decreased to 3 percent in 2007.

Figure 2.3: Average Productivity level, 1970-2007



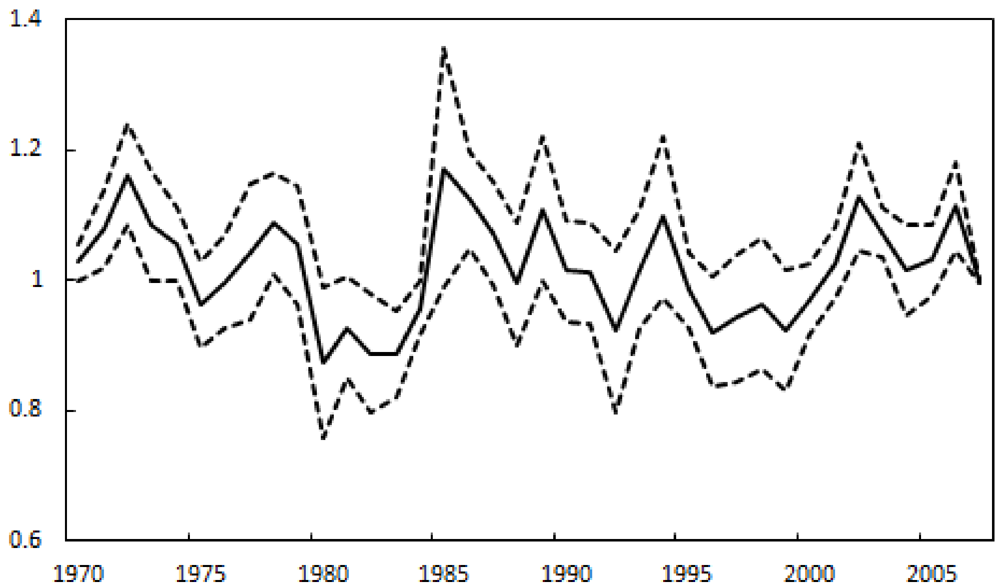
Notes: This figure plots $ln(T_{i,t}^{\frac{1}{\theta}})$ for selected countries. Panel (a) includes the average productivity level for 5 developed countries (Canada, Germany, Japan, United Kingdom and United States) while panel (b) shows 5 emerging market economies (Brazil, China, India, Korea and Mexico).

Figure 2.4: Simple Average Bilateral Trade Costs, 1970-2007



Notes: Trade costs can be recovered by relying on the gravity structure of bilateral trade flows in the model. Figure 2.4 shows the simple average of trade costs across all country-pairs in each year. Trade costs are expressed as a percentage, $(d_{ni,t} - 1) \times 100$.

Figure 2.5: Intertemporal preference shifter, 1970-2007

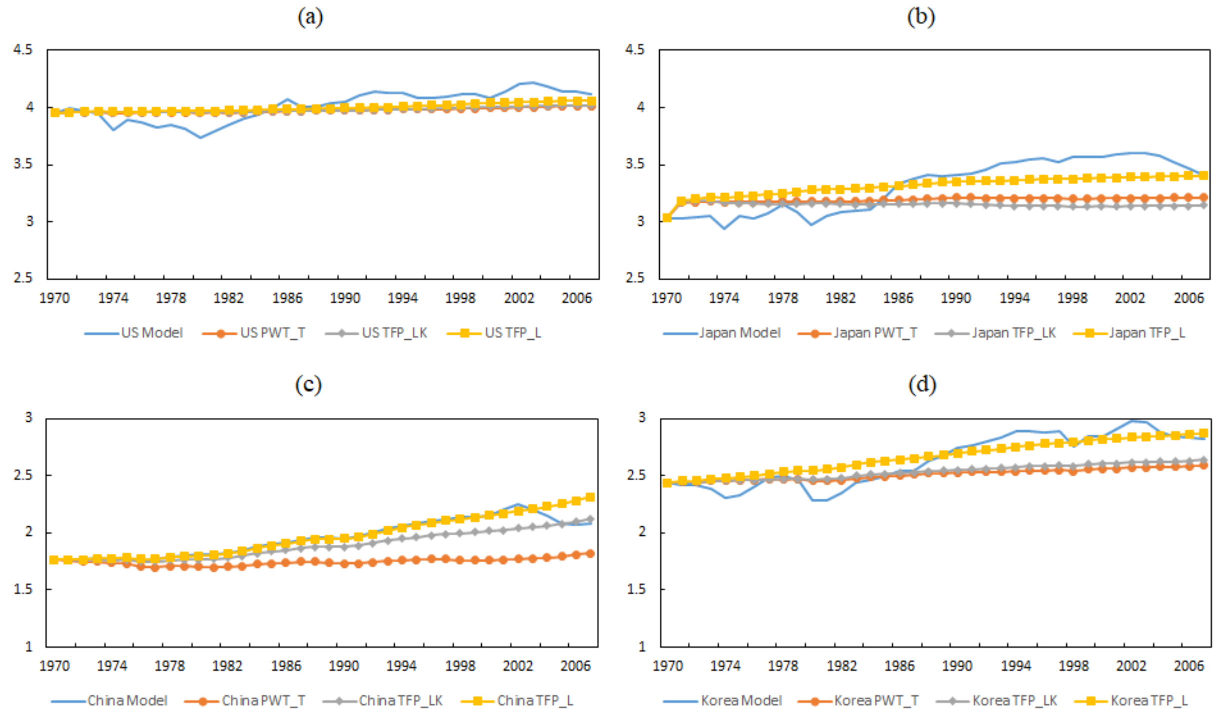


Notes: Figure 2.5 displays the mean (solid line) and one standard deviation bands (dashed-lines) of intertemporal preference shifters, $\hat{\phi}_{i,t+1}$, across all sample countries in each time period. USA's intertemporal preference shifters are normalized to one in every period, $\hat{\phi}_{US,t+1}$=1 for $\forall$t.

Figure 2.6: Real Interest Rates: Model vs Data

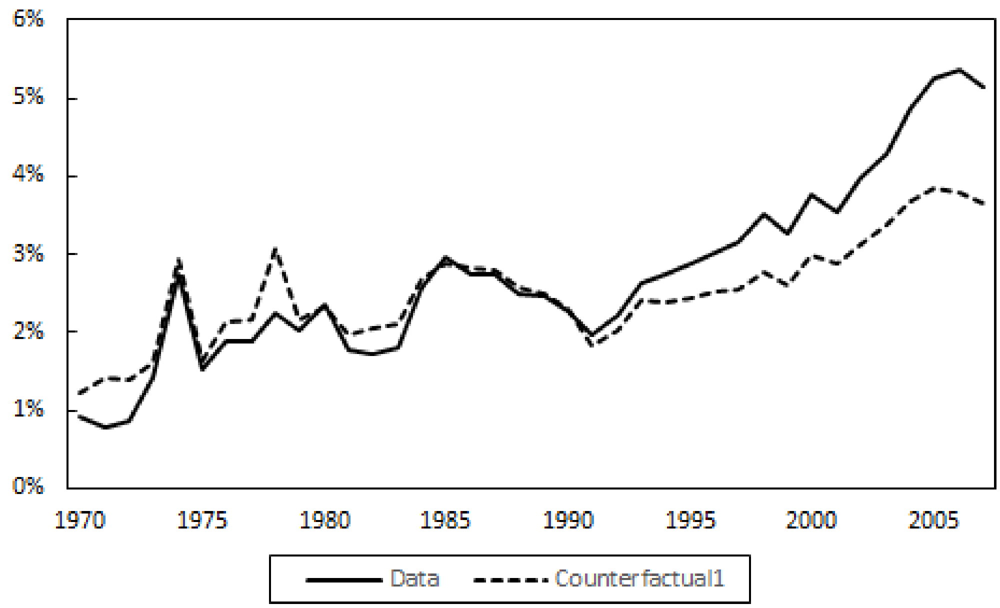
Notes: Panel (a) compares the world interest rates recovered from the model with data on U.S. real interest rates while panel (b) shows those of 5-year moving average. The correlation between two series is positive and it is 0.2 and 0.4, respectively.

Figure 2.7: Average Productivity: Model vs Data



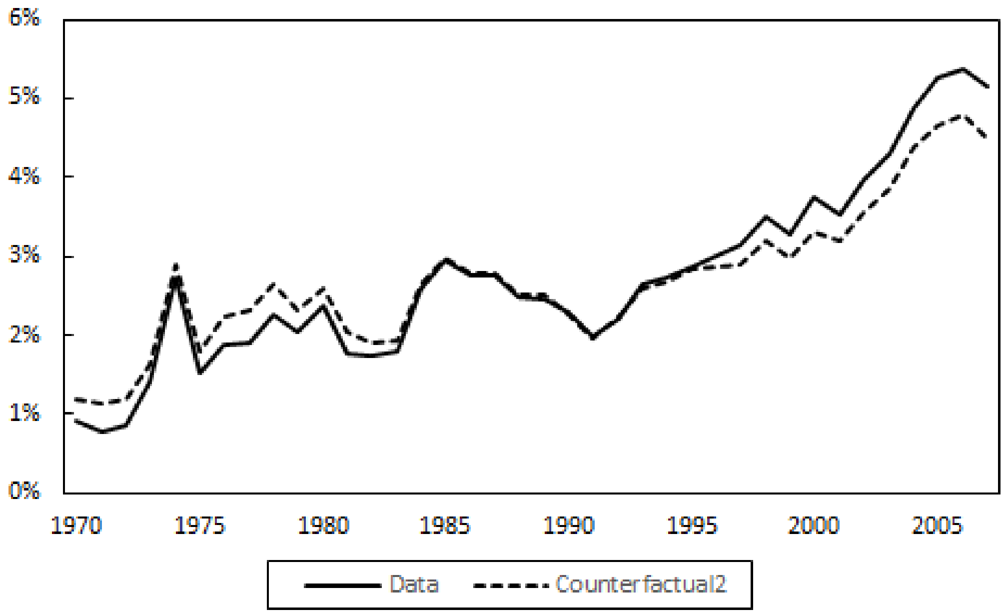
Notes: Panel (a)-(d) show the average productivity recovered from the model with the data-based TFP for the U.S., Japan, China and Korea, respectively. All three measures of TFP are re-scaled such that their 1970's level equals the average productivity level backed out from the model.

Figure 2.8: **Trade imbalances (Counterfactual exercise 1)**



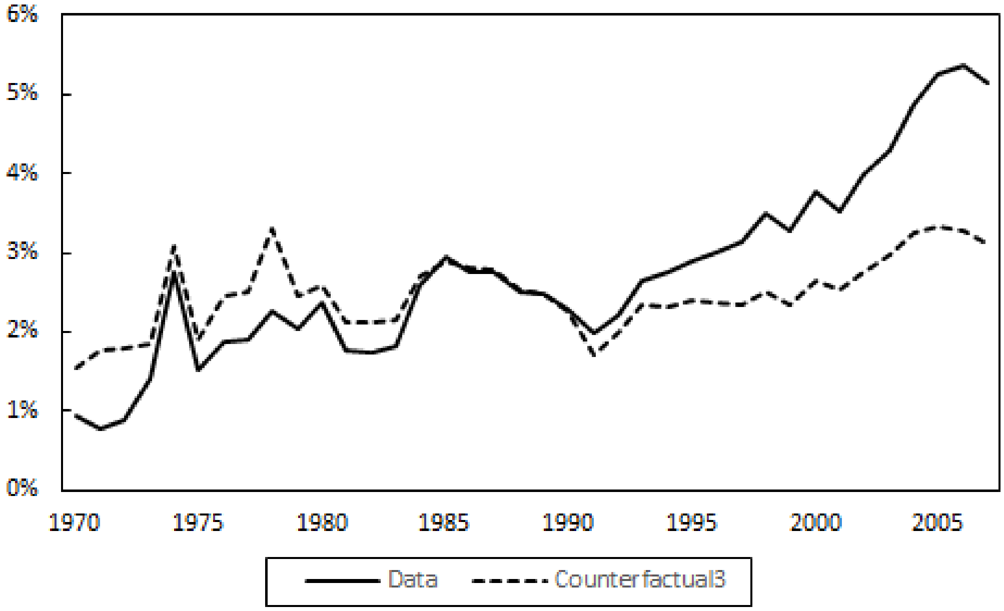
Notes: Figure 2.8 plots the absolute sum of net exports across 25 countries in my sample. The solid line shows the data while the dashed line displays the evolution path of trade imbalances generated under the first counterfactual exercise. In the first counterfactual exercise, HR indices in each period are fixed at their 1970 level.

Figure 2.9: Trade imbalances (Counterfactual exercise 2)



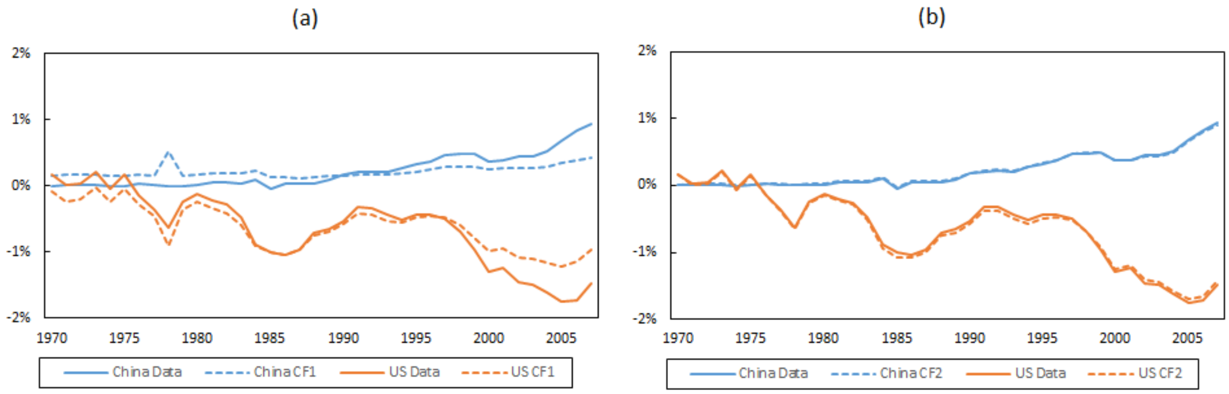
Notes: The solid line shows the data and the dashed line displays the evolution path of trade imbalances generated under the second counterfactual exercise. In the second counterfactual exercise, I fix the magnitude of the capital controls at the 1970's level for each of the sample countries in my sample, $|\tau_{i,t}|$=$|\tau_{i,1970}|$ for $\forall$i.

Figure 2.10: Trade imbalances (Counterfactual exercise 3)



Notes: The solid line shows the data and the dashed line displays the evolution path of trade imbalances generated under the third counterfactual exercise. In the third counterfactual exercise, I fix both trade costs and capital controls at their 1970 level.

Figure 2.11: Trade imbalances: China and US



Notes: Figure 2.11 shows the evolution of trade imbalances for China and the United States. The solid blue and orange lines in both panels represent the observed data for China and the U.S., respectively. The dashed line in panel (a) displays the imbalances under the first counterfactual exercise while that in panel (b) describes the result of the second counterfactual exercise.

Chapter 3

Empirical Investigation on the Relationship between Trade Imbalances, Trade Costs and Capital Controls

The objective of this chapter is to examine the empirical relationship between trade imbalances, trade costs and capital controls. The model suggested in Chapter 2 implies that trade costs and capital controls affect trade imbalances by interacting with fundamental shocks such as productivity shocks. In other words, those fundamental shocks lead to larger trade imbalances when the level of trade costs or capital controls are relatively low. In this Chapter, I empirically test this propagation role of trade costs and capital controls based on three different approaches; I estimate a fixed effects regression with panel data, a 2-country dynamic regression and a 2-country vector autoregression (VAR) to investigate the empirical relationship among them.

3.1 Data and Variables

In this section, I summarize the source of data and describe variables of interests. I consider 24 countries and time period from 1970 to 2007.[1] There are four main variables of interests; trade imbalances, productivity growth, trade costs and capital controls. Table 3.1 summarizes each variable's abbreviation, description as well as the sources of data.

Trade imbalances are defined as changes in net exports as a share of GDP.[2] I denote measures of trade imbalances as $\Delta NX_{i,t} = \frac{(NX_{i,t} - NX_{i,t-1})}{Y_{i,t-1}}$ for each country i at time t. Both net exports and GDP come from United Nations Statistics Division - National Accounts Main Aggregate Database (UNSTAT). Productivity growth, which is denoted as $\Delta A^g_{i,t}$, is a percentage change in total factor production (TFP), which either comes directly from Penn World Table (PWT) (*rtfna*) or is computed as residuals from the Cobb-Douglas production function. The latter is computed as follows:

$$A_{i,t} = \frac{VA_{i,t}}{L_{i,t}^{1-\alpha_i} \cdot {K_{i,t}}^{\alpha_i}} \tag{3.1}$$

where $VA_{i,t}$ is total value-added for country i at time t (in real terms, UNSTAT), $L_{i,t}$ and $K_{i,t}$ (PWT) represents labor and capital stock (in real terms) for country i at time t and α_i (=1/3) is a share of capital in production. $K_{i,t}$ is *rkna* from the PWT. Note that the productivity growth based on TFP measure that comes directly from PWT is used in the baseline regression. TFP that is computed as the residuals from the Cobb-Douglas production function is used as a robustness check.

The average annual TFP growth for each of 24 countries is summarized in Table 3.2. Panel A shows the average annual productivity growth for each country based on TFP

[1]Lists of 24 countries: Australia, Austria, Belgium, Brazil, Canada, China, Denmark, Finland, France, Germany, Greece, India, Italy, Japan, Korea, Mexico, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and United States.

[2]Note that I define trade imbalances as changes in net exports as a share of GDP in previous period as opposed to current GDP in order to avoid the endogeneity issue.

measures from PWT. The average across all 24 countries is approximately 0.55% (stdev: 0.58%). In contrast, panel B displays the average productivity growth computed based on TFP as residuals from the Cobb-Douglas production function. The average across all countries is about 1.05% (stdev: 0.85%) between 1970 and 2007.

Trade costs are constructed as a weighted average of Head-Ries (HR) index. In the literature, HR indices are used as a measure of country-pair bilateral trade frictions, which are the function of trade shares only. They are closely connected to bilateral trade costs in the model since the arithmetic mean of two countries' trade costs exactly equals this index. HR indices are defined as follows:

$$HR_{in,t} \equiv \left(\frac{\pi_{in,t}}{\pi_{nn,t}} \frac{\pi_{ni,t}}{\pi_{ii,t}} \right)^{-\frac{1}{2\theta}} \tag{3.2}$$

where $\pi_{in,t}$ is the share of country i's total expenditure on goods from country n at t and θ=4 is variance of a Fréchet distribution from which productivity of producing the intermediate goods is drawn. To construct the measure of trade costs for country i in each time period, I take the weighted average of country i's HR index across all its trading partners. I use the import shares for the weights.

On average, trade costs declined over time; the simple average across all 24 sample countries' trade costs decreased from 340% (trade costs measure of 4.4) in 1970 to 240% (trade costs measure of 3.4) in 2007. Table 3.3 summarizes the measures of trade costs in 1970 and in 2007 for each individual country. Some countries such as China and Mexico experience a significant decrease in trade costs while other countries such as Canada or the United Kingdom shows a relatively small decline in trade costs.

Capital controls are computed as one minus normalized Chinn-Ito index (Chinn & Ito, 2006) where the Chinn-Ito index represents a country's degree of capital account openness. The average capital control measures were 0.55 in 1970 but decreased to 0.14 in 2007. Table

3.3 summarizes the measures of capital controls in 1970 and in 2007 for each individual country. There are three countries - Canada, Switzerland and the United States - whose capital control measures remain at zero for the whole time period, 1970-2007. Capital control measures for India remained unchanged at the level of 0.83. All other countries except Mexico show that capital controls decreased over time.

3.2 Fix Effects Regression with Panel data

One of the well-known business cycle facts is that net exports are counter-cyclical (Backus et al., 1992). This is consistent with Glick & Rogoff (1995), which find that current account imbalances respond negatively to a country-specific productivity shock. Given this relationship between a country's productivity growth and its trade imbalances, the level of trade costs and capital controls affect trade imbalances by interacting with the productivity growth. In particular, the model described in the first essay predicts that the effects of productivity growth on trade imbalances are larger if trade costs or capital controls are relatively low. In order to test this propagation role of trade costs or capital controls, I first consider a panel regression with both country and time fixed effects[3]. I include the interaction of productivity growth and trade costs (or the interaction of productivity growth and capital controls) to evaluate how they contribute to trade imbalances by interacting with productivity growth. The full specification is given as equation (3.3) and (3.4):

$$\Delta NX_{i,t} = \beta_0 + \beta_1 \Delta A^g_{i,t} + \beta_2 \Delta A^g_{i,t} \cdot TC_{i,t} + \beta_3 TC_{i,t} + D_i + D_t + \epsilon_{i,t} \tag{3.3}$$

$$\Delta NX_{i,t} = \beta_0 + \beta_1 \Delta A^g_{i,t} + \beta_2 \Delta A^g_{i,t} \cdot KC_{i,t} + \beta_3 KC_{i,t} + D_i + D_t + \epsilon_{i,t} \tag{3.4}$$

I estimate two equations separately with 24 countries in my sample and repeat the

[3]This approach allows me to control for omitted variable bias arising from unobserved heterogeneity

estimation with 22 countries except Canada and Norway. Trade imbalances ($\Delta NX_{i,t}$) and productivity growth ($\Delta A^g_{i,t}$) are defined in the previous section. $TC_{i,t}$ and $KC_{i,t}$ is trade costs and capital controls, respectively, which are also defined in section 3.1. Finally, D_i and D_t denotes country and time fixed effects.

From the fixed effects regression estimation, I would expect negative sign for $\hat{\beta}_1$, which implies that productivity growth is negatively associated with changes in trade imbalances. Given that, I would also expect positive sign for $\hat{\beta}_2$, which indicates that an increase in the level of trade costs or capital controls makes the negative effects of productivity growth less negative. In other words, positive $\hat{\beta}_2$ suggests that lower trade costs or capital controls leads to larger negative effects of productivity growth on trade imbalances.

Table 3.4 summarizes the results. Panel A in Table 3.4 shows that $\hat{\beta}_1$ is negative for both equations with trade costs and capital controls, which is consistent with Glick & Rogoff (1995). The estimated β_1 is, however, statistically significant in the equation with capital controls, equation (3.4), but not in the equation with trade costs, equation (3.3). The estimated $\hat{\beta}_2$ is negative in the equation with trade costs while it is positive in the equation with capital controls. Since $\hat{\beta}_2$ is positive - though it is not statistically significant at 10% level - in equation (3.4), the negative effect of productivity growth on changes in net exports becomes smaller as capital controls increase. In other words, the propagation role of capital controls suggested by the model in the first essay is supported by this panel regression approach. The positive sign of $\hat{\beta}_2$ in equation (3.3), however, contradicts the model's prediction on the propagation role of trade costs.

Panel B in Table 3.4 summarizes the results with 22 countries only. Canada and Norway are excluded from the sample because those two countries are commodity exporters and their productivity growth is positively associated with trade imbalances.[4] The results

[4]Note that Canada and Norway are not the only countries from the sample whose productivity growth is positively associated with the changes in net exports

are not greatly different from the 24-country case. The main difference is that the magnitude of $\hat{\beta}_1$ and $\hat{\beta}_2$ is larger, and $\hat{\beta}_2$ is now statistically significant at the 10% level. R^2 is also larger when Canada and Norway are not included.

One way to interpret this result is to compare the effect of one percentage point increase in productivity growth on trade imbalances based on 1970's level of capital controls (KC=0.55) with that based on 2007's level of capital controls (KC=0.14).[5] A one percentage point increase in productivity growth is associated with 0.15 percentage point decrease in trade imbalances if capital controls are at the 1970's average level. The same productivity growth is, however, associated with 0.22 percentage point decrease in trade imbalances if capital controls are at the 2007's average level. This comparison clearly shows that lower capital controls lead to larger trade imbalances by interacting with productivity growth.

As a robustness check, I compute productivity growth based on TFP level that are computed as residuals from the Cobb-Douglas production function. Table 3.5 summarizes the results, and they are not significantly different from the baseline case. There is no evidence that trade costs magnify the effects of productivity growth on trade imbalances, but the results are consistent with the propagation role of capital controls.

The panel regression approach employed in this section does not support the propagation role of trade costs. One potential problem is the way trade costs are measured. Trade costs are inferred from the gravity structure of the model that links trade flows to the underlying trade frictions. In particular, trade costs are computed as a weighted average of Head-Ries index which is a function of trade shares. This measure of trade costs involves aggregation issues and also relies heavily on a particular parameter or functional form.[6] In addition, HR indices are, by their construction, symmetric between two countries. The asymmetry in trade costs can be another source of measurement error.[7] Improvements in

[5] As reported in Table 3.3, the simple average of capital controls across 24 countries was 0.55 in 1970 while it was 0.14 in 2007.

[6] See Anderson & Van Wincoop (2004) for more details about the measurement of trade costs.

[7] Waugh (2010) argues that the systematic asymmetry in trade frictions is essential to understand income

measuring trade costs help lead to a positive coefficient for the interaction term between productivity growth and trade costs, implying the propagation role of trade costs.

3.3 2-country Dynamic Regression

In this section, I test the propagation mechanism of trade costs and capital controls by estimating a 2-country dynamic regression; two countries are country J and the rest of the world (ROW).[8] This approach allows me to model dynamic responses by considering the lagged values as well as the relevant variables. In particular, country J's trade imbalances are affected by the ROW's productivity and their level of trade costs or capital controls as well as its own. I construct the ROW's variables, which are country J-specific, as a weighted average of all countries except country J. The weights are computed based on bilateral trade flows.[9] The full specification for a 2-country version dynamic regression is given as follows:

$$\begin{aligned}\Delta NX_{J,t} = \beta_0 + \beta_1 \Delta NX_{J,t-1} + \beta_2(\Delta A^g_{J,t-1} \cdot TC_{J,t-1}) + \beta_3(\Delta A^g_{R,t-1} \cdot TC_{R,t-1}) \\ + \beta_4 \Delta A^g_{J,t-1} + \beta_5 \Delta A^g_{R,t-1} + \beta_6 TC_{J,t-1} + \beta_7 TC_{R,t-1} + \epsilon_{i,t}\end{aligned} \tag{3.5}$$

$$\begin{aligned}\Delta NX_{J,t} = \beta_0 + \beta_1 \Delta NX_{J,t-1} + \beta_2(\Delta A^g_{J,t-1} \cdot KC_{J,t-1}) + \beta_3(\Delta A^g_{R,t-1} \cdot KC_{R,t-1}) \\ + \beta_4 \Delta A^g_{J,t-1} + \beta_5 \Delta A^g_{R,t-1} + \beta_6 KC_{J,t-1} + \beta_7 KC_{R,t-1} + \epsilon_{i,t}\end{aligned} \tag{3.6}$$

Glick & Rogoff (1995) suggests that country J's productivity growth affects its trade imbalances negatively ($\hat{\beta}_4 < 0$). In contrast, I would expect the ROW's productivity growth is positively associated with country J's trade imbalances ($\hat{\beta}_5 > 0$). This is because positive productivity growth in other countries can be considered as negative productivity growth

differences between countries.

[8]Note that I consider an autoregressive distributed lag (ADL) framework.

[9]The weight allocated to country i in constructing country J-specific ROW is the sum of country J's imports from country i and country J's exports to country i, divided by country J's total trade. The weight for country J itself is zero, and the weights are summed up to one.

in country J in relative terms. If the propagation mechanism implied by the model holds, the interaction term would have the opposite sign as that of productivity growth. In other words, the interaction of country J's productivity growth and country J's trade costs (or capital controls) will have a positive sign ($\hat{\beta}_2>0$) while the interaction term for the ROW will have a negative sign ($\hat{\beta}_3<0$).

Table 3.6 and Table 3.7 summarize the results of dynamic regression estimation with trade costs and capital controls, respectively. In Table 3.6, there are twelve countries whose productivity growth is negatively associated with trade imbalances ($\hat{\beta}_4<0$), and the corresponding interaction term is positive ($\hat{\beta}_2>0$) for those countries except Denmark. This implies that lower trade costs makes the negative effects of productivity growth on trade imbalances more negative. In addition, there are fourteen countries whose trade imbalances are positively affected by the ROW's productivity growth ($\hat{\beta}_5>0$), and the corresponding interaction term is negative ($\hat{\beta}_3<0$). For those countries, the ROW's productivity growth leads to an increase in that country's trade imbalances, and this increase becomes larger as trade costs decline.

In Table 3.7, there are only four countries whose results are consistent with the propagation role of capital controls as well as Glick & Rogoff (1995); $\hat{\beta}_4$ is negative and $\hat{\beta}_2$ is positive. In addition, there are fourteen countries whose trade imbalances respond positively to the ROW's productivity growth ($\hat{\beta}_5>0$). Their interaction term with the ROW's capital controls is negative except one country, Netherlands. For these countries, a decrease in capital controls amplifies the effects of productivity growth on trade imbalances. As a robustness check, I use GDP-based weights in constructing ROW's variables.[10] Table 3.8 and Table 3.9 summarize the results for trade costs and capital controls, respectively. They are not significantly different from the baseline case.

[10]The weights are computed based on each country's constant GDP in every year. The weight for country i in constructing country J-specific ROW is the share of country i's constant GDP over the sum across all countries' GDP except country J. The share for country J itself is set to zero.

The evidence that supports the propagation role of trade costs or capital controls is found only in about a half of the countries in my sample by taking this 2-country dynamic regression. In other words, the estimation results suggest that trade costs and capital controls amplify the effects of productivity growth in some countries, but not in others. Compared to a panel regression approach used in section 3.2, a dynamic regression approach allows me to better capture dynamic effects and to include other relevant information such as other country's productivity growth or its level of trade costs or capital controls. The dynamic regression approach, however, doesn't explore all of the country data available due to the degrees of freedom problem.[11]

3.4 2-country Vector Autoregression

Trade costs and capital controls, in general, have decreased over time in most of the countries. Hence the level of trade costs and capital controls, on average, is higher in the earlier period (1970s-1980s) compared to the latter period (after 1990s). The main prediction of the model from the first essay is that the level of trade costs and capital controls matters for the relationship between productivity growth and trade imbalances. In particular, the effects of productivity growth on trade imbalances are larger if trade costs and capital controls are relatively low. Then I would expect that the relationship between productivity growth and trade imbalances is stronger in the later period relative to the earlier period.

I estimate 2-country VAR(1) with two variables - productivity growth and trade imbalances - separately for two time periods; 1970-1989 and 1990-2007. If the propagation mechanism implied by the model holds, the productivity growth will be more negatively associated with trade imbalances in the latter period. I define a vector of two countries'

[11] It is not possible to include each individual country's productivity growth and its level of trade costs or capital controls as a right-hand-side variable in equation (3.5) or (3.6). This is why I construct a country-specific ROW and consider only two countries in each of dynamic regression estimation.

productivity growth and trade imbalances as $Z_t = [\Delta A^g_{J,t},\ \Delta A^g_{ROW,t},\ \Delta NX_{J,t},\ \Delta NX_{ROW,t}]$. Then I estimate the following VAR(1) process:

$$Z_t = A_0 + A_1 Z_{t-1} + e_t \tag{3.7}$$

I first estimate VAR(1) for the case where country J is the United States. Note that the ROW is constructed by using the trade-based weights. The estimated results for the earlier and latter periods are summarized in Table 3.10 (Row (1) and (2)). Based on the prediction of the model, I would expect that the U.S. (ROW's) productivity growth is negatively associated with the U.S. (ROW's) trade imbalances, and the relationship is stronger in the later period compared to the earlier period. Similarly, the U.S. (ROW's) productivity growth is positively related with the ROW's (U.S.) trade imbalances, and again the effects are larger in the later period. The results of VAR(1) with the United States, however, do not support this prediction; the U.S. productivity growth is more negatively related to U.S. trade imbalances in the earlier period (compare -0.2711 with -0.1608 which is the third row of column 1 in $\hat{A}_1$). The effects of the U.S. productivity growth on the ROW's trade imbalances are also smaller in the later period (compare 0.2810 with 0.1779 which is the fourth row of column 1 in $\hat{A}_1$).

I then estimate VAR(1) for the case where country J is China, Japan and Germany as well. Rows (3)-(8) in Table 3.10 summarize the results for these three countries. The negative effects of Japanese productivity growth on Japanese trade imbalances are larger in the later period compared to the earlier period. However, this does not hold for China and Germany. Overall, the results from the VAR estimation do not support the prediction of the model. There are numerous other things that could change between two time periods that I consider, other than trade costs and capital controls, such as the way monetary policy or fiscal policy works.[12] This can be a part of the reason why I do not find any convincing evidence that is consistent with the propagation mechanism.

3.5 Conclusion

I test the propagation mechanism of trade costs and capital controls based on three empirical approaches. A fixed effects regression with panel data shows that changes in trade imbalances respond negatively to productivity growth, and a decrease in capital controls makes this negative effect even more negative. The propagation role of trade costs, however, is not supported by this approach. In the 2-country dynamic regression, trade costs and capital controls amplify the effects of productivity growth on trade imbalances in some countries, but not in others. Finally, the 2-country VAR(1) does not provide any evidence that supports the prediction of the model. In sum, there is mixed evidence on the propagation role of trade costs and capital controls.

There are future research possibilities that will help to improve the evidence on the empirical relationship between trade imbalances, trade costs and capital controls. First, an alternative measure of trade costs, such as a measure that incorporates an asymmetry in trade costs between imports and exports, could be considered to test the propagation mechanism. In addition, other important variables that determine trade imbalances, such as monetary policy or fiscal policy, could be taken into account in evaluating how trade costs and capital controls affect trade imbalances by interacting with productivity growth.

[12]For example, if fiscal policy is an important variable that determines trade imbalances by interacting with trade costs or capital controls, the estimated coefficients could possibly be biased due to the *omitted variable* problem. However, further detailed investigation needs to be undertaken.

Table 3.1: Description of variables and data source

Variable	Abbreviation	Description	Source
Trade imbalances	$\Delta NX_{i,t}$	Changes in net exports as a % of GDP	UNSTAT
		$\Delta NX_{i,t} = \frac{(NX_{i,t} - NX_{i,t-1})}{Y_{i,t-1}}$	
Productivity growth	$\Delta A^g_{i,t}$	A percentage change in the TFP level	PWT
		$\Delta A^g_{i,t} = \frac{\mathrm{A}_{i,t} - \mathrm{A}_{i,t-1}}{\mathrm{A}_{i,t-1}}$	UNSTAT
Trade costs	$TC_{i,t}$	A weighted-average of HR index	EUKELMS
			Comtrade, NBER-UN
Capital controls	$KC_{i,t}$	Capital control measures	Chinn-Ito
		$KC_{i,t}$ = 1 - (normalized Chinn-Ito)	

Notes: There are four main variables of interests; trade imbalances, productivity growth, trade costs and capital controls. Table 3.1 summarizes each variable's notation, description and the sources of data.

Table 3.2: Average annual TFP growth for each country

A. TFP is *rtfpna* from PWT.

Australia	0.23 %	France	0.95 %	Netherlands	0.93 %
Austria	0.84 %	Germany	1.30 %	Norway	0.99 %
Belgium	0.93 %	Greece	-0.07 %	Portugal	-0.07 %
Brazil	-0.14 %	India	0.49 %	Spain	0.58 %
Canada	0.12 %	Italy	0.04 %	Sweden	0.75 %
China	0.64 %	Japan	0.45 %	Switzerland	0.20 %
Denmark	0.62 %	Korea	1.64 %	UK	0.83 %
Finland	1.41 %	Mexico	-0.99 %	US	0.63 %

B. TFP is residuals from the Cobb-Douglas production function

Australia	1.08 %	France	0.87 %	Netherlands	0.69 %
Austria	1.18 %	Germany	1.21 %	Norway	1.54 %
Belgium	1.35 %	Greece	1.24 %	Portugal	0.61 %
Brazil	0.78 %	India	1.58 %	Spain	0.77 %
Canada	0.31 %	Italy	0.74 %	Sweden	1.20 %
China	3.93 %	Japan	-0.28 %	Switzerland	0.13 %
Denmark	0.64 %	Korea	2.16 %	UK	1.39 %
Finland	1.58 %	Mexico	-0.28 %	US	0.70 %

Notes: One of the four main variables of interests is productivity growth which is defined as a percentage change in TFP. TFP measure either comes directly from Penn World Table (*rtfna*) or is computed as residuals from the Cobb-Douglas production function. Panel A and B summarize the average annual TFP growth for each country from two different sources of TFP.

Table 3.3: Changes in trade costs and capital controls, 1970-2007

A. Changes in Trade Costs between 1970 and 2007

Country	Diff	1970	2007	Country	Diff	1970	2007
Australia	0.55	4.61	4.06	Italy	0.54	3.71	3.17
Austria	0.88	4.04	3.16	Japan	0.63	3.74	3.11
Belgium	0.53	3.20	2.67	Korea	1.59	4.72	3.12
Brazil	1.51	5.74	4.23	Mexico	2.14	5.63	3.49
Canada	0.04	3.20	3.16	Netherlands	0.26	3.17	2.91
China	3.98	6.71	2.72	Norway	1.01	4.84	3.84
Denmark	0.38	4.02	3.63	Portugal	1.39	5.24	3.85
Finland	0.41	4.22	3.81	Spain	1.45	5.00	3.55
France	0.41	3.57	3.16	Sweden	0.47	3.86	3.38
Germany	0.51	3.24	2.73	Switzerland	1.49	4.87	3.38
Greece	0.78	5.54	4.76	UK	0.15	3.51	3.36
India	1.83	5.56	3.73	US	0.58	3.58	3.00
Average	0.98	4.40	3.42				

B. Changes in Capital Controls between 1970 and 2007

Country	Diff	1970	2007	Country	Diff	1970	2007
Australia	0.28	0.59	0.30	Italy	0.59	0.59	0.00
Austria	0.55	0.55	0.00	Japan	0.59	0.59	0.00
Belgium	0.17	0.17	0.00	Korea	0.25	0.83	0.59
Brazil	0.54	1.00	0.46	Mexico	-0.30	0.00	0.30
Canada	0.00	0.00	0.00	Netherlands	0.30	0.30	0.00
China	0.17	1.00	0.83	Norway	0.59	0.59	0.00
Denmark	0.59	0.59	0.00	Portugal	0.83	0.83	0.00
Finland	0.83	0.83	0.00	Spain	0.83	0.83	0.00
France	0.88	0.88	0.00	Sweden	0.30	0.30	0.00
Germany	0.00	0.00	0.00	Switzerland	0.00	0.00	0.00
Greece	0.83	0.83	0.00	UK	1.00	1.00	0.00
India	0.00	0.83	0.83	US	0.00	0.00	0.00
Average	0.41	0.55	0.14				

Notes: Panel A and B show the level of trade costs and capital controls for each country both in 1970 and in 2007. The table also shows how much trade costs and capital controls decrease in each country between 1970 and 2007. The *average* is computed as a simple average across 24 countries.

Table 3.4: Results of panel regression estimation

A. With all 24 countries

	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	R^2
(3.3)	-0.018	-0.024	-0.002	0.1786
	(0.154)	(0.034)	(0.002)	
(3.3)	-0.007	-0.025		0.1774
	(0.154)	(0.034)		
(3.4)	-0.170**	0.079	0.002	0.1781
	(0.063)	(0.084)	(0.003)	
(3.4)	-0.171**	0.081		0.1778
	(0.063)	(0.084)		

B. With 22 countries (except Canada and Norway)

	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	R^2
(3.3)	-0.082	-0.014	-0.002	0.2359
	(0.141)	(0.031)	(0.002)	
(3.3)	-0.070	-0.015		0.2340
	(0.141)	(0.031)		
(3.4)	-0.237***	0.151†	0.003	0.2385
	(0.059)	(0.078)	(0.003)	
(3.4)	-0.238***	0.151*		0.2377
	(0.059)	(0.078)		

Std. Err. in parentheses.
$^{\dagger}p<0.1$, $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$

Notes: This table reports the results of panel regression estimation with 24 countries (panel A) and with 22 countries except Canada and Norway (panel B). Note that (3.3) refers the regression specification with trade costs while (3.4) is the regression specification with capital controls.

Table 3.5: Robustness Check: Results of panel regression

A. With all 24 countries

	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	R^2
(3.3)	0.084	-0.044	-0.001	0.1766
	(0.156)	(0.035)	(0.002)	
(3.3)	0.121	-0.052		0.1762
	(0.144)	(0.033)		
(3.4)	-0.122†	0.030	0.002	0.1781
	(0.062)	(0.084)	(0.003)	
(3.4)	-0.127*	0.038		0.1739
	(0.061)	(0.083)		

B. With 22 countries (except Canada and Norway)

	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	R^2
(3.3)	-0.026	-0.026	-0.002	0.2353
	(0.143)	(0.032)	(0.002)	
(3.3)	0.034	-0.039		0.2341
	(0.131)	(0.030)		
(3.4)	-0.202**	0.106	0.002	0.2350
	(0.059)	(0.078)	(0.003)	
(3.4)	-0.207***	0.115		0.2347
	(0.058)	(0.076)		

Std. Err. in parentheses.
$^{\dagger}p<0.1$, $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$

Notes: In the robustness check, productivity growth is based on TFP that is computed as residuals from the Cobb-Douglas production function. This table reports the results of panel regression estimation with 24 countries (panel A) and with 22 countries except Canada and Norway (panel B). Note that (3.3) refers the regression specification with trade costs while (3.4) is the regression specification with capital controls.

Table 3.6: Results of 2-country dynamic regression (Trade Costs)

Country J	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	$\hat{\beta}_5$	$\hat{\beta}_6$	$\hat{\beta}_7$
Australia	-0.146	1.223	-1.442	-5.453	5.804	-0.027	0.031
Austria	-0.352†	-1.443	1.222	4.963	-4.776	0.020	-0.038
Belgium	0.138	2.421	-1.527	-7.241	5.744	-0.019	0.009
Brazil	0.298	0.641†	-3.053	-3.075†	11.05	-0.003	0.007
Canada	-0.029	-2.323	0.631	7.286	-2.413	-0.014	-0.007
China	0.062	-0.137†	-0.348	0.649†	1.362	-0.001	-0.024
Denmark	-0.197	-0.014	-1.333	-0.470	5.599	0.032	0.007
Finland	0.141	0.331	-0.578	-1.630	1.938	0.026	-0.014
France	-0.205	-2.772	-1.197	9.386	4.518	0.084	0.005
Germany	-0.008	-1.691	2.272	5.073	-8.848	-0.010	-0.034*
Greece	-0.152	-0.288	1.950	1.474	-8.424	-0.029	0.008
India	-0.027	0.288*	0.259	-1.394*	-1.396	0.001	0.004
Italy	-0.085	1.805	-4.747**	-6.143	18.57**	0.048	0.037†
Japan	-0.134	-1.307	0.684	4.299	-2.747	-0.018	-0.007
Korea	0.395†	-1.049	-6.455*	3.951	24.15*	0.123*	-0.105
Mexico	-0.230	-0.235	1.681	0.584	-6.912	-0.017	0.023
Netherlands	0.081	8.159*	-0.004	-25.42*	0.121	-0.078	-0.003
Norway	0.270	1.060	0.623	-5.214	-2.388	-0.028	0.007
Portugal	-0.004	-0.952	2.125	3.891	-6.220	0.028	-0.107
Spain	0.455*	0.433	-4.531*	-1.583	17.35*	0.012	0.010
Sweden	-0.190	0.714	0.481	-2.850	-1.931	0.037	-0.037†
Switzerland	-0.117	1.081†	-4.181*	-4.126†	15.75*	0.038*	-0.030
United Kingdom	0.061	-0.389	-2.427	0.887	9.773	0.046	0.014
United States	0.082	-0.108	-0.594	0.066	2.690	0.025*	-0.007

$^{\dagger}p<0.1$, $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$

Notes: This table reports the estimation results for the 2-country dynamic regression with trade costs (equation 3.5). Numbers in the colored cells imply that the signs are as expected.

Table 3.7: **Results of 2-country dynamic regression (Capital Controls)**

Country J	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	$\hat{\beta}_5$	$\hat{\beta}_6$	$\hat{\beta}_7$
Australia	-0.170	0.970	-0.055	-0.574†	-0.062	-0.017	0.019
Austria	-0.308	-0.743	-0.383	-0.107	0.033	0.022	-0.047
Belgium	0.147	-0.160	-0.804	-0.066	0.037	0.006	0.002
Brazil	0.162	-0.551	4.986	0.504	-3.225	-0.041	-0.024
Canada	0.014	0.000	-0.349	0.168	0.190	0.000	-0.005
China	-0.119	-4.125**	3.104	3.920**	-1.677	0.022	-0.065
Denmark	-0.282	-1.104	4.170	-0.225	-1.422	-0.003	-0.005
Finland	0.224	-2.106†	-1.906	0.469	0.498	0.048	-0.020
France	-0.278	0.254	-1.657	0.119	0.406	0.022	-0.038
Germany	0.131	0.000	0.442	0.009	-0.158	0.000	-0.030
Greece	-0.144	-0.282	4.547	0.200	-2.568	0.033	-0.067
India	0.179	0.000	0.982	0.161**	-0.773	0.000	0.012
Italy	-0.074	-0.200	-4.504	0.308	1.203	0.003	0.036
Japan	0.091	-1.139†	-0.375	-0.033	0.025	-0.018	0.021
Korea	0.461†	-0.983	-10.68	0.853	2.701	0.008	0.081
Mexico	-0.192	-0.172	-0.118	-0.333	0.219	-0.032*	-0.035
Netherlands	0.184	-0.484	0.358	-0.033	0.054	0.021	-0.017
Norway	0.285	0.704	4.843	-1.253	-1.515	0.035	-0.113
Portugal	0.061	-0.937	5.154	0.041	-1.105	0.080	-0.277
Spain	0.267†	4.598**	-11.58**	-1.980**	3.981**	0.092**	-0.109†
Sweden	-0.185	-1.770	1.791	0.169	-0.798	0.090	-0.102
Switzerland	-0.192	0.000	-2.445	0.031	0.204	0.000	0.007
United Kingdom	0.015	0.021	-0.130	-0.567*	0.199	0.003	-0.008
United States	0.159	0.000	-0.872	-0.299**	0.767†	0.000	0.009

$^{\dagger}p<0.1$, $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$

Notes: This table reports the estimation results for the 2-country dynamic regression with capital controls (equation 3.6). Numbers in the colored cells imply that the signs are as expected.

Table 3.8: **Robustness Check: Results of dynamic regression (Trade Costs)**

Country J	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	$\hat{\beta}_5$	$\hat{\beta}_6$	$\hat{\beta}_7$
Australia	-0.188	-0.117	-3.055	0.214	12.04	0.039	0.013
Austria	-0.305†	-0.409	1.994	1.140	-7.850	-0.018	-0.021
Belgium	0.223	2.669	-1.372	-8.018	4.985	-0.033	0.009
Brazil	0.322†	0.155	-0.586	-0.759	0.603	0.044**	-0.065†
Canada	-0.040	-2.440	1.862	7.801	-7.921	-0.002	-0.016
China	0.122	-0.130†	0.237	0.602†	-1.308	-0.006	0.010
Denmark	-0.270	-3.807	3.261	14.36	-13.15	0.070	-0.042
Finland	0.209	-0.859	-2.475	3.351	9.421	0.041	0.013
France	-0.228	-0.988	-0.960	3.544	3.316	0.050	0.000
Germany	0.052	-1.102	2.213	3.264	-8.450	-0.020	-0.027†
Greece	-0.143	-1.038	0.572	5.051	-2.385	0.001	0.015
India	0.114	0.332†	1.432	-1.490†	-5.979	-0.006	0.010
Italy	-0.046	3.604	-7.478**	-12.07	28.68*	0.043	0.057*
Japan	0.067	-0.756	0.285	2.449	-1.259	-0.022†	-0.002
Korea	0.321*	-0.710	-13.24**	2.507	50.85**	0.174***	-0.086
Mexico	-0.119	-0.261	0.647	0.756	-2.979	-0.016	0.030
Netherlands	0.190	9.669**	-1.040	-29.77**	3.913	-0.098*	0.004
Norway	0.282	-0.787	1.913	2.229	-7.143	0.012	-0.004
Portugal	0.336	0.405	-6.346	-2.240	23.84	-0.022	0.092
Spain	0.269	-0.848	-2.296	3.942	8.341	-0.041	0.078
Sweden	-0.090	0.397	0.939	-1.684	-3.848	0.008	-0.027
Switzerland	-0.109	0.749	-2.090	-2.940	7.271	0.027	-0.035
United Kingdom	-0.049	-0.034	-2.429	-0.319	9.702	-0.056	0.026
United States	-0.034	0.295	-0.564	-1.287	2.525	0.028†	-0.011

$^{\dagger}p<0.1$, $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$

Notes: This table reports the estimation results for the 2-country dynamic regression with trade costs (equation 3.5). Numbers in the colored cells imply that the signs are as expected.

Table 3.9: Robustness Check: Results of dynamic regression (Capital Controls)

A. Trade Costs

Country J	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	$\hat{\beta}_5$	$\hat{\beta}_6$	$\hat{\beta}_7$
Australia	-0.173	0.919	-2.590	-0.504†	1.035	-0.018	0.037
Austria	-0.296	-1.233	1.022	-0.073	-0.437	0.030	-0.058
Belgium	0.200	0.320	-0.146	-0.186	-0.230	0.002	-0.007
Brazil	0.195	0.165	1.471	-0.213	-1.659	-0.021	-0.001
Canada	0.010	0.000	3.385	0.296	-2.024	0.000	-0.032
China	0.114	-2.819*	-1.394	2.612*	0.223	-0.009	-0.026
Denmark	-0.281	-0.899	5.402	-0.088	-2.551	-0.010	0.005
Finland	0.087	-2.751*	3.104	0.430	-1.052	0.018	-0.004
France	-0.148	0.475	-1.356	-0.032	0.147	-0.007	0.014
Germany	0.139	0.000	0.575	-0.023	-0.020	0.000	-0.027
Greece	-0.161	-0.206	2.186	0.105	-1.245	0.022	-0.046
India	0.176	0.000	1.160	0.154**	-0.902	0.000	0.012
Italy	0.005	0.048	-8.384†	0.137	2.700	-0.023	0.124†
Japan	0.043	-1.598†	1.310	-0.062	-0.810	-0.025†	0.013
Korea	0.274	-0.157	-20.35*	-0.009	7.238†	0.093	0.097
Mexico	-0.094	-0.933	-4.080†	0.111	1.427	-0.032*	-0.003
Netherlands	0.182	-0.515	-2.174	-0.150	1.275	0.042†	-0.010
Norway	0.264	0.084	6.043	-0.861	-2.530	-0.014	-0.036
Portugal	0.277	-1.285	-1.550	0.607	0.376	0.020	-0.063
Spain	0.687***	3.028†	-7.635†	-1.318	2.449	0.079**	-0.114
Sweden	-0.113	-1.113	-2.169	-0.058	0.884	0.043	-0.045
Switzerland	-0.082	0.000	-4.318	0.090**	0.913	0.000	0.009
United Kingdom	0.013	0.011	-1.494	-0.553**	0.740	-0.002	0.006
United States	0.099	0.000	-1.193	-0.253**	0.921	0.000	0.009

$^{\dagger}p<0.1$, $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$

Notes: This table reports the estimation results for the 2-country dynamic regression with capital controls (equation 3.6). Numbers in the colored cells imply that the signs are as expected.

Table 3.10: Results of Vector Autoregression

Country (Year)	VAR(1)
(1) USA (1970-1989)	$\hat{A}_0 = \begin{pmatrix} 0.0051 \\ 0.0043 \\ -0.0021 \\ 0.0021 \end{pmatrix}$ $\hat{A}_1 = \begin{pmatrix} -0.0190 & -0.3128 & -0.4175 & 0.7370 \\ -0.0042 & 0.0932 & -0.2475 & 0.7209 \\ -0.2711 & 0.3143 & -0.0177 & -0.2315 \\ 0.2810 & -0.8447 & -0.5368 & -0.2266 \end{pmatrix}$
(2) USA (1990-2007)	$\hat{A}_0 = \begin{pmatrix} 0.0148 \\ 0.0060 \\ -0.0045 \\ 0.0011 \end{pmatrix}$ $\hat{A}_1 = \begin{pmatrix} -0.0764 & -0.9921 & 0.1365 & 0.4969 \\ -0.0862 & -0.1567 & -0.3923 & -0.0781 \\ -0.1608 & 0.6273 & 0.4133 & -0.0835 \\ 0.1779 & 0.1301 & 0.3754 & -0.0382 \end{pmatrix}$
(3) CHN (1970-1989)	$\hat{A}_0 = \begin{pmatrix} -0.0051 \\ 0.0077 \\ 0.0013 \\ 0.0011 \end{pmatrix}$ $\hat{A}_1 = \begin{pmatrix} 0.3508 & 0.1331 & 0.0665 & -0.4453 \\ 0.0287 & 0.0427 & 0.0530 & 0.5137 \\ -0.1695 & -0.1212 & -0.1901 & 0.7105 \\ -0.0105 & -0.3080 & -0.0748 & -0.1019 \end{pmatrix}$
(4) CHN (1990-2007)	$\hat{A}_0 = \begin{pmatrix} 0.0072 \\ 0.0090 \\ 0.0078 \\ -0.0023 \end{pmatrix}$ $\hat{A}_1 = \begin{pmatrix} 0.7399 & 0.1209 & -0.0783 & -1.8617 \\ -0.0255 & -0.3516 & -0.0587 & -0.3870 \\ 0.4565 & -1.8807 & 0.2704 & -2.6084 \\ 0.0421 & 0.1247 & 0.0163 & 0.3656 \end{pmatrix}$
(5) JPN (1970-1989)	$\hat{A}_0 = \begin{pmatrix} 0.0054 \\ 0.0038 \\ 0.0015 \\ -0.0011 \end{pmatrix}$ $\hat{A}_1 = \begin{pmatrix} 0.0561 & 0.0909 & 0.6389 & -1.0215 \\ 0.0005 & 0.0499 & 0.4370 & 0.1616 \\ -0.1257 & -0.1517 & 0.2932 & -0.9107 \\ 0.0514 & -0.2841 & 0.2060 & -0.5064 \end{pmatrix}$
(6) JPN (1990-2007)	$\hat{A}_0 = \begin{pmatrix} -0.0018 \\ 0.0070 \\ 0.0004 \\ -0.0033 \end{pmatrix}$ $\hat{A}_1 = \begin{pmatrix} 0.0559 & 0.1919 & -0.4228 & -0.6099 \\ -0.1329 & 0.4512 & -0.1570 & -0.0572 \\ -0.1849 & 0.0506 & 0.0717 & 0.4735 \\ 0.0511 & 0.2981 & -0.1240 & 0.4310 \end{pmatrix}$
(7) DEU (1970-1989)	$\hat{A}_0 = \begin{pmatrix} 0.0058 \\ 0.0049 \\ -0.0004 \\ 0.0023 \end{pmatrix}$ $\hat{A}_1 = \begin{pmatrix} 1.1118 & -0.5182 & -0.0290 & 1.2148 \\ -0.1807 & 0.7314 & -0.1771 & 1.5336 \\ 0.0950 & -0.1081 & 0.3177 & 0.0049 \\ 0.0312 & -0.4367 & 0.1345 & -0.6491 \end{pmatrix}$
(7) DEU (1990-2007)	$\hat{A}_0 = \begin{pmatrix} 0.0076 \\ 0.0097 \\ 0.0036 \\ -0.0020 \end{pmatrix}$ $\hat{A}_1 = \begin{pmatrix} 0.0560 & 0.1538 & -0.3362 & -0.3644 \\ -0.1044 & -0.2522 & -0.1358 & -0.0471 \\ 0.0990 & 0.0382 & 0.1598 & -0.8455 \\ 0.0382 & 0.1751 & -0.0066 & 0.4047 \end{pmatrix}$

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Appendix A

A.1 Equilibrium condition

A.1.1 Express gross output in terms of GDP

The market for nontradeable goods must clear in each country every period. The supply of a final good should be equal to its demand, which is the sum of final consumption and its use for intermediate goods. This condition can be rewritten in terms of total expenditure:

$$X_{i,t} = P_{i,t}C_{i,t} + P_{i,t}M_{i,t} \tag{A.1}$$

$P_{i,t}M_{i,t}$ can be replaced by $(1-\beta_{i,t})Y_{i,t}$ because $\beta_{i,t}$ is the share of value-added. Then the equation above can be re-expressed as follows:

$$P_{i,t}C_{i,t} = X_{i,t} - (1-\beta_{i,t})Y_{i,t} \tag{A.2}$$

Total expenditure is the difference between total gross output and net exports ($X_{i,t} = Y_{i,t} - NX_{i,t}$), and consumption expenditure is the difference between GDP and net exports

$(P_{i,t}C_{i,t} = GDP_{i,t} - NX_{i,t})$. I solve for the gross output:

$$Y_{i,t} = \frac{GDP_{i,t}}{\beta_{i,t}} \tag{A.3}$$

A.1.2 Market clearing condition for tradeable goods

Consider the resource constraint in the economy and solve for total expenditure.

$$X_{i,t} = Y_{i,t} - q_t B_{i,t+1} + B_{i,t} \tag{A.4}$$

Then the market clearing condition for tradeable goods can be expressed as follows:

$$Y_{i,t} = \sum_{n=1}^{N} \pi_{ni,t} X_{n,t} \tag{A.5}$$

$$\Leftrightarrow \quad Y_{i,t} = \sum_{n=1}^{N} \pi_{ni,t}[Y_{n,t} - q_t B_{n,t+1} + B_{n,t}] \tag{A.6}$$

$$\Leftrightarrow \quad Y_{i,t} = \sum_{n=1}^{N} \pi_{ni,t} Y_{n,t} + \sum_{n=1}^{N} \pi_{ni,t}[-q_t B_{n,t+1} + B_{n,t}] \tag{A.7}$$

A.2 Data

A.2.1 Nominal and Real GDP

Data on nominal GDP (current prices, US$) and real GDP (2010 constant prices, US$) comes from United Nations Statistical Division - National Accounts Main Aggregates Database (UNSTAT). Since these variables are available for the world, the ROW's values are computed by the difference between the world's value and the sum of all sample countries.

A.2.2 Gross output

The goal is to construct gross output for all sample countries between 1970 and 2007. EU-KLEMS provides gross output data for all countries except Brazil, China, India, Mexico, Norway and Switzerland. Note that gross output from EU-KLEMS is denominated in the national currency (millions). I use exchange rate data, which can be obtained from UNSTAT, to convert it into U.S. dollars. There are missing values for Canada (2005-2007) and Japan (1970-1972, 2007).

Missing values for Canada and Japan I compute the gross output for Canada (2005-2007) and for Japan (2007) by using the national input-output table from World Input-Output Database (WIOD). Note that the national input-output table is available after 2000, and the values are denoted in millions of U.S. dollars. For Japanese gross output between 1970-1972, I assume that gross output had grown at the same rate as GDP growth in this period, which comes from UNSTAT.

Gross output for Brazil, China, India, Mexico, Norway, Switzerland, and the ROW To construct gross output for six countries whose data is not available from EU-KLEMS, I first compute gross output between 2000 and 2007 by using the national input-output table from WIOD. Gross output for 1970-1999 is computed by assuming that its growth rate is equal to that of GDP (which comes from UNSTAT). Basically the ratio of value-added to gross output before 2000 is fixed at its 2000's level. ROW's gross output for 2000-2007 is computed as world gross output minus the sum of 24 sample countries' gross output. Similarly as before, ROW's gross output before 2000 is computed by assuming that its growth rate is the same as that of GDP.

The value-added share ($\beta_{i,t}$) I compute the value-added shares, $\beta_{i,t}$, by dividing nominal GDP with the gross output for each country in every period.

A.2.3 Price

GDP deflator I download nominal and real GDP data from UNSTAT. The GDP data is available for all the sample countries as well as for the world between 1970-2007. The aggregate price level can be computed by dividing nominal with real GDP. The real GDP is based on 2010 constant prices, but I convert them so that the base year becomes 2011. Note that the ROW's aggregate price is also computed as its nominal GDP divided by its real GDP.

Price level of GDP I download price level of GDP (PPP/XR) in 2011 from the Penn World Table (PWT) 9.1. Note that the price level of USA GDP is normalized to 1 in 2011. This price is not available for the world. Hence the ROW's price is computed as the weighted average of all the countries' price available except the sample countries. I adjust GDP deflator for each country proportionally so that the GDP deflator in 2011 is replaced with the price level of GDP from the PWT.

A.2.4 Labor and Capital

Labor endowment The labor endowment $L_{i,t}$ is directly from the PWT 9.1. I use the variable '*emp*' (number of persons engaged, in millions). This data is available for all the sample countries. The ROW's labor endowment is computed by the sum of all the countries' labor endowment available from the PWT except the sample countries.

Capital stock Capital stock $K_{i,t}$ also directly comes from the PWT 9.1. I use the variable '*rnna*' (Capital stock at constant 2011 national prices, in millions 2011US$). The ROW's capital stock can be computed by subtracting all the sample countries' capital stock from the world's capital stock, which is the sum of all countries' capital stock except the sample countries.

Capital shares in value-added (φ_i) To compute the capital shares in value-added, I download the input-output table (value-added) from OECD, which is available for all sample countries between 1995-2007. For each country and year, I newly compute the total value-added as the sum of labor and capital compensation only. I compute the labor and capital share based on newly defined total value-added. Finally, I take the average between 2000 and 2007 for each country. For the ROW, I take the average of all sample countries.

Wage and rental rate Factor prices, wage and rental rate, can be computed by using labor endowment, capital stock and GDP data.

$$w_{i,t} = (1 - \varphi_i)\frac{GDP_{i,t}}{L_{i,t}} \quad \text{and} \quad r_{i,t} = \varphi_i \frac{GDP_{i,t}}{K_{i,t}} \tag{A.8}$$

A.2.5 Bilateral Trade

Bilateral trade data comes from two main sources: NBER-United Nations Trade Data (1970-1999) and Comtrade (2000-2007).[1] A country's imports from the ROW are computed by its imports from the world minus its imports from all the other countries. For instance, Korea's imports from the ROW are Korea's imports from the world minus Korea's imports from all the other sample countries. The ROW's imports from each individual country are computed by that country's exports to the world minus all other countries' imports from that country. For instance, the ROW's imports from Korea is Korea's exports to the world minus all the other sample countries' imports from Korea.

Missing trade values There are 112 missing values from NBER-United Nations Trade data (1970-1999). Some of those values are replaced by using Comtrade import or export data (SITC). I recovered the other missing values by assuming that bilateral trade had increased linearly for the periods that are missing. If 1970's values are missing, those are assumed to be equal to 1971's level. For Chinese imports from USA between 1970-1971, I recovered them by assuming that the growth rate of trade flows, is the same as that for USA's imports from China. Similarly, India's imports from China are missing for 1970-1976, and they are recovered by assuming that its growth rate is the same as that for China's imports from India.

Negative trade values There are two data points where bilateral trade data is negative. Brazil's imports from the ROW and ROW's imports from Mexico in 1983. Each of them are replaced by the average of its value in 1982 and 1984.

[1]NBER-United Nations Trade Data: http://cid.econ.ucdavis.edu/nberus.html
Comtrade data: I use classification HS, commodity codes TOTAL from Comtrade

ROW's imports from China The ROW's imports from China are computed by the difference between world's imports from China and the sum of China's exports to all other sample countries. Note that I use the sum of China's exports to other countries instead of all others' imports from China. This is because the latter makes ROW's imports from China negative.

Total net exports Total net exports of a country in each time period is computed by the country's total exports minus total imports at that time period. Total exports (imports) are the sum of that country's exports (imports) to (from) each of its trading partners.

A.2.6 Trade share matrix, $\Pi_{ni,t}$

The construction of $\Pi_{ni,t}$ matrices requires gross output, bilateral trade and total net exports. Note that n (row) is a destination country while i (column) is a source country. Then (n,i)th element of $\Pi_{ni,t}$ is defined as

$$\Pi_{ni,t} = \frac{X_{ni,t}}{X_{n,t}} \tag{A.9}$$

where $X_{ni,t}$ is country n's import from country i at time t and $X_{n,t}$ is country n's total expenditure at time t. Total expenditure, $X_{n,t}$, is calculated by the difference between gross output and total net exports. The diagonal element is its own-country's spending as a share of total expenditure. Given each row, all the columns should be summed up to 1.

A.2.7 Tax rate

There are two steps to compute the tax rates. First, I construct capital control index by using the Chinn-Ito index. The Chinn-Ito index is a *de jure* measure of financial openness, and it represents a country's capital account openness which is available for 182 countries between 1970-2016.[2] I define capital control index as one minus normalized Chinn-Ito index. A country has a higher degree of capital controls as its capital control index is close to one.

Next the goal is to convert each country's capital control index into the equivalent tax rates. To do that, I look at six examples of capital controls that are implemented (Brazil, Chile, Colombia, Hungary, Malaysia and Thailand). The Brazilian government introduced a system of market-based capital controls in the form of financial transaction tax in 2008 (*Imposto Sobre Operacoes Financeiras*, IOF) to prevent an excessive inflow of capital.[3] In 2010, a 6 percent tax was placed on fixed income bonds and derivative. In 2011, a 6 percent tax was also imposed on overseas loans and bonds with maturities up to one year (Alfaro et al., 2017). I assume that the capital control index of 0.525, which is Brazil's capital control index in 2010, is equivalent to 6 percent.

The Chilean economy, however, adopted capital controls in the form of unremunerated reserve requirement (URR) during the 90's (*encaje*).[4] Nonremunerated 20 percent reserve requirement was introduced in 1991, but it was raised to 30 percent in 1992. Herrera & Valdés (2001) evaluate the effects of capital controls of this type on interest rate differentials, and conclude that the maximum interest rate differentials for 12-month operations are 1.40 percent in the case of Chile.

$$r_c - r = 1.4\% \tag{A.10}$$

where r_c and r refers to the interest rate for Chile and the U.S. Note that I use the U.S. interest rate for the world interest rate.

[2]Chinn-Ito index (updated to 2016): http://web.pdx.edu/ ito/Chinn-Ito_website.htm

[3]In 2008, a 1.5 percent financial transaction tax was imposed on incoming foreign fixed income investments to curb capital inflows and to reduce the appreciation of the currency. Due to the resurgence of excessive capital inflows after the recovery from the financial crisis, capital controls were re-introduced in 2009. In particular, a 2 percent tax was imposed on fixed income as well as portfolio and equity investments. The Brazilian currency, however, kept appreciating and therefore the tax was raised to 4 percent and further to 6 percent in 2010.

[4]URR is one type of capital controls that is intended to discourage capital flows through the price-mechanism. Foreign investors are required to deposit a certain fraction of their capital inflows with the central bank without interest earning. This effectively functions as a tax on capital inflows.

There is no arbitrage condition between Chilean and U.S. interest rates, which is given as follows:

$$\frac{1}{q} = \frac{1 - \tau_c(1 - q_c)}{q_c} \tag{A.11}$$

$$\Leftrightarrow \quad r = (1 - \tau_c) r_c \tag{A.12}$$

where q and q_c is the price of bond in the U.S. and Chile while τ_c is the tax equivalent of capital controls in Chile.

Data on the U.S. real interest rates can be obtained from World Bank; they are reported in the first row of the table below. Then the Chilean interest rates can be computed by using the equation (A.10); the second row in the table. Finally, the implicit tax rates imposed by the Chilean government can be backed out by using the no arbitrage condition (equation (A.12)); the third row in the table.

Year	1991	1992	1993	1994	1995	1996
r	4.97 %	3.88 %	3.54 %	4.91 %	6.61 %	6.33 %
r_c	6.37 %	5.28 %	4.94 %	6.31 %	8.01 %	7.73 %
τ_c	21.98 %	26.50 %	28.36 %	22.20 %	17.49 %	18.11 %

I take the average of the implicit tax rates between 1991-1996; 22.44 percent. Note that the capital control index for Chile during this time period was 1 except in 1995. I assume that the capital control index of 1 is equivalent to 22.44 percent.

Colombia experienced a similar type of capital controls as Chile (the URR) during the 1990s to discourage capital inflows, especially short-term inflows.[5] Ocampo & Tovar (2003)

[5] In particular, the Colombian government imposed a 47 percent of one-year reserve requirement for all loans with a maturity of less than 18 months in September 1993. In March 1994, the reserve requirement and the minimum maturity increased to 50-93 percent and 36 months. In August 1994, the range of reserve requirement extended to 42.8-140 percent, covering the loans with a maturity from 30 days to 60 months.

computed the tax equivalent of Colombia's reserve requirement, and it is approximately 20 percent, on average, between 1993-1995 for the 12-month maturity loans.[6] Note that the capital control index of Colombia between 1993-95 was 1. I assume that Colombia's capital controls index is equal to the tax equivalent of its reserve requirement, 20 percent.

Capital controls prevailed in Hungary mainly in the form of regulations in the foreign exchange market before 2001 when Hungary experienced the financial market liberalization.[7] The Hungarian government introduced Act XCV in 1995 to regulate the foreign exchange market, which includes the tools that discourage banks and firms to have international borrowing.[8] Varela (2017) looked at the *Business Environment and Enterprise Performance Survey (BEEPS)* of the World Bank and the European Bank for Reconstruction and Development studies to study the effects of financial liberalization in Hungary. One finding from the *BEEPS* is that the interest rate differential between domestic and foreign firms was 3.2 percentage points before the liberalization in 2001, but it decreased to 0.65 percentage points by 2004.

$$r_H - r = \begin{cases} 3.2\% & \text{before the liberalization} \\ 0.65\% & \text{after the liberalization} \end{cases} \tag{A.13}$$

where r_H and r refers to the interest rate for Hungary and the U.S. As in prior cases, I use the U.S .real interest rate for the foreign rate.

Capital controls in the form of URR remained until 2000 when the Colombian government finally decided to remove it. Look at Ocampo & Tovar (2003) for the details on the regulations for the years between 1996-1999.

[6]In their calculation, the tax equivalent of reserve requirement is a function of the deposit rate, the ratio of the maturity of the loan to the maturity of reserve requirement, and the expected devaluation.

[7]Restrictions in the foreign exchange market, such as limiting the sales and purchases of a national currency or financial assets, are another form of capital controls that are implemented to reduce international capital flows.

[8]In particular, there were restrictions on using currency forward instruments that allowed hedging against foreign exchange risks and buying or selling foreign currency. Look at Varela (2017) for the detailed description on Hungary's capital controls.

Here I follow the same steps as I did for the case of Chile to recover the equivalent tax rates of capital controls implemented in Hungary. I start with the U.S. real interest rates, and compute the Hungarian interest rates by using the equation (A.13). Note that I use the interest rate differential of 3.2 percent for the interest rates in 1999-2000 while that of 0.65 percent is used for the year 2001-2003. Finally, the implicit tax rates can be backed out by using the no arbitrage condition between Hungarian and U.S. interest rates.

Year	1999	2000	2001	2002	2003
r	6.37 %	6.80 %	4.54 %	3.09 %	2.09 %
r_H	9.57 %	10.00 %	5.19 %	3.74 %	2.74 %
τ_H	33.45 %	31.99 %	12.53 %	17.37 %	23.75 %

I compute the average tax rates before and after the liberalization separately and take the difference between the two; the average tax rates before (1999-2000) and after (2001-2003) the liberalization is 32.72 percent and 17.88 percent, respectively. Then the difference is 14.84 percent. I assume that Hungary's capital control index in 1999-2000, 0.5844, is equivalent to 14.84 percent.

Malaysia introduced capital controls following the Asian financial crisis to discourage substantial capital outflows. The Malaysian government adopted a number of administrative exchange and capital control measures in 1998, and some of the measures were revised in 1999.[9] An exit tax was imposed on all capital that entered Malaysia before February 15, 1999. In particular, a 10 percent tax was levied if repatriated between 9 and 12 months of entry.[10] In addition, for the investments made in Malaysia after February 15, 1999, they

[9] The Malaysian control measures were mainly designed to eliminate speculation against the Malaysian currency, ringgit. They blocked or restricted the transfer of ringgit abroad, for instance, by requiring the year-long moratorium on repatriation of investments nonresidents' approval for the sales or purchases of ringgit forward. Kaplan & Rodrik (2002) provides the detailed summary of Malaysian capital controls

[10] The exit levies were imposed with a declining scale; a 30 percent if repatriated within 7 months of entry, a 20 percent if repatriated between 7 and 9 months of entry, a 10% if repatriated between 9 and 12 months of entry and no tax if repatriated after one year of entry.

imposed a 10 percent tax on profits if repatriated after one year of entry.[11] I assume that the capital control index of Malaysia in 1999, which equals 0.5241, is equivalent to the tax rate of 10 percent.

Finally, I consider the case of Thailand that used capital control measures to deal with massive capital inflows and to curb the appreciation of Thai baht during 2000s.[12] The Thai government imposed a 15 percent withholding tax on foreign investors' interest and capital gains on Thai government and state-owned company bonds in 2010. I assume that the capital control index of Thailand in 2010, which is equal to 0.8343, can be converted into a 15 percent tax rate.

The second-order polynomial trend-line can be drawn by minimizing the distance from those six example points and the origin. Then all other countries' capital control indices can be converted into the equivalent tax rates by using the following equation:

$$\tau_{i,t} = 0.0582\times(\text{K-control}_{i,t})^2 + 0.1513\times(\text{K-control}_{i,t}) \tag{A.14}$$

where (K-control) $\in [0,1]$ is the capital control index that I constructed based on the normalized Chinn-Ito index.

A.2.8 Missing Chinn-Ito index

China's normalized Chinn-Ito index between 1970-1983 is missing, which I recovered as 0. The Netherlands' index is missing between 1975-1980, which is assumed to be the same as its 1974's index. Finally, Switzerland's index is not available between 1970 and 1995, and it is assumed to be 1 for all of that time period.

[11] In contrast, a 30 percent tax was imposed on profits if repatriated within one year.

[12] The Thai government introduced a number of capital controls measures; some policy measures that promote capital outflows were introduced in 2003, while the Chilean-style capital restrictions were imposed in 2006.

A.3 Intertemporal Preference shifters

A.3.1 Steps to recover $\hat{\phi}_{i,t+1}$

The households' optimal dynamic decisions can be rearranged by using the log preference as follows:

$$\frac{P_{i,t+1}C_{i,t+1}}{P_{i,t}C_{i,t}} = \delta\hat{\phi}_{i,t+1}\left(\frac{1}{q_t}\right)[1-\tau_{i,t+1}(1-q_t)] \tag{A.15}$$

Here are the detailed-steps that I proceed to recover $\hat{\phi}_{i,t+1}$:

1. I first normalize USA's intertemporal preference shifter $\hat{\phi}_{US,t+1}$ for all t.

2. I back out q_t by using USA's data on consumption expenditure ($P_{US,t}C_{US,t}$) and tax rate ($\tau_{US,t}$) in the Euler equation. The price of bonds can be recovered easily, because the tax rate for the U.S. is zero for all periods. Note that consumption expenditure can be computed as the difference between GDP and net exports (both of them directly come from the data).

$$q_t = \underbrace{\delta}_{\delta=0.95}\ \underbrace{\hat{\phi}_{US,t+1}}_{\text{Normalized=1}}\ \underbrace{[1-\tau_{US,t+1}(1-q_t)]}_{=1\text{ (because }\tau_{US}=0)}\underbrace{\left(\frac{P_{US,t}C_{US,t}}{P_{US,t+1}C_{US,t+1}}\right)}_{\text{Data}} \tag{A.16}$$

3. Based on the price of bonds and net exports, the whole path of $B_{i,t+1}$ can be determined.

   a. Compute the steady state level of bonds in each country.[13]

$$B_{i,ss} = -\frac{NX_{i,ss}}{1-q_{ss}} \tag{A.17}$$

[13] Starting with net exports equation: $NX_{i,t} = q_t B_{i,t+1} - B_{i,t}$. At the steady state, $B_{i,t+1} = B_{i,t} = B_{i,ss}$. Therefore, $NX_{i,ss} = -\ (1-q_{ss})B_{i,ss}$

b. Given the last period's bond holdings ($B_{i,t+1}$), back out each country's bond holdings in the previous period ($B_{i,t}$) by using q_t that I recovered in step 2 and the actual data on net exports ($NX_{i,t}$):

$$B_{i,t} = q_t B_{i,t+1} - NX_{i,t} \tag{A.18}$$

4. Check whether the sign of $\tau_{i,t}$ and $B_{i,t}$ matches for all countries in every period.[14] If two signs don't match, update the sign of $\tau_{i,t}$ based on $B_{i,t}$. Repeat step 2 and 3 until they all match.

5. Recover $\hat{\phi}_{i,t+1}$ for all countries except USA using the Euler equations. Note that consumption expenditure and the magnitude of tax rate for each country directly comes from the data. In contrast, the sign of tax rate is determined in step 4 while the price of bond is recovered in step 2.

$$\hat{\phi}_{i,t+1} = \frac{1}{\delta}\left(\frac{q_t}{1 - \tau_{i,t+1}(1 - q_t)}\right)\frac{P_{i,t+1}C_{i,t+1}}{P_{i,t}C_{i,t}} \tag{A.19}$$

A.4 Capital controls

A.4.1 Model capital controls

Capital controls are any measures imposed by a government to regulate or restrict the cross-border flows of capital into and out of a country's capital account. Capital controls take various forms including explicit or implicit taxation on international capital flows, foreign exchange controls that limit the sales or purchases of foreign currencies, quantity-based measures such as caps on the allowed volume of financial transactions, or even administrative

[14] Note that the absolute size of $\tau_{i,t}$ comes from the actual data, but its sign is determined by the sign of bonds. Thus I need to make sure the sign of $\tau_{i,t}$ and $B_{i,t}$ match for each country in every time period.

procedures.[15] Such controls are introduced and used not only to reduce the size and volatility of certain types of capital flows, but also to change the composition of the flows, to stabilize the exchange rate fluctuations, to maintain macroeconomic or financial stability, or to enhance the independence of monetary policy.

The main purpose of capital controls that this paper focuses on, is to reduce the volume of bond transactions by distorting the relative intertemporal prices. In particular, I model capital controls in the form of a tax on interest income from bonds following the way Heathcote & Perri (2016) introduce capital controls in their work.[16] The magnitude of tax is assumed to be exogenously given, which are constructed in section A.2.7 based on the Chinn-Ito index as well as six examples of actual capital controls.[17] I only determine the sign of taxes based on the net foreign asset position in the model.[18]

Capital controls of this type raise or lower the effective interest rates depending on a country's net foreign asset position, and thus affect the country's intertemporal saving decisions and its trade imbalances.[19] However, the way I introduce capital controls doesn't take into account the nominal exchange rates or the implementation of monetary policy, which are important factors when considering capital controls. In addition, they don't fully capture substantial heterogeneity in country-specific measures for capital controls.

[15]See Ariyoshi et al. (2000) for more details on different types of capital controls.

[16]They assume that the tax rate is a function of a policy parameter and also proportional to the aggregate net foreign asset position. Unlike their assumption, I do not distinguish the tax rate from the policy parameter and simply consider the sign of bond holdings.

[17]My goal is not to characterize the optimal capital controls or to assess the effectiveness of imposing capital controls. Rather, capital controls are exogenously given and I evaluate the effects of a decline in capital controls on trade imbalances quantitatively.

[18]Costinot et al. (2014) also emphasize the role of capital controls in manipulating the terms of trade. Unlike Heathcote & Perri (2016), however, the sign of taxes depends on a country's relative growth rate as opposed to the sign of net foreign asset position.

[19]Less bond transactions are seen under the counterfactual exercise where capital controls remain at the higher level, i.e., capital controls do contribute to lower flows of capital.

A.4.2 Individual country's capital controls in the model

Figure A.2 shows how an individual country's (magnitude of) tax rates change over time and its level in 1970. In general, capital controls decrease over time, but the patterns vary across countries. Out of a total of 25 countries, there are fifteen countries whose 1970's level of capital controls is the maximum: Australia, Austria, Brazil, China, Denmark, Finland, France, Greece, Japan, Korea, Norway, Portugal, Spain, Sweden and the United Kingdom. Among these fifteen countries, however, some countries' tax rates decrease relatively monotonically over time but others don't. There are four countries whose tax rates are zero for the whole periods: Canada, Germany, Switzerland and United States.[20] In other words, capital controls don't exist for these four countries. In India, the tax rates are not equal to zero (16.67 percent), but they remain unchanged over time. Finally, there are five countries whose 1970's level of capital controls is not its maximum: Belgium, Italy, Mexico, Netherlands and the ROW. In particular, Mexico's 1970's level of capital controls is zero, which is the minimum level of controls.

A.4.3 Welfare gains from lowering capital controls

Some countries in my model experience positive welfare gains while others show negative welfare gains from declining capital controls. It turns out that countries that have welfare gains tend to have a negative net foreign asset position while countries that experience welfare losses seem to have a positive net foreign asset position. A change in the world interest rate at the equilibrium provides one explanation of why some countries gain and others lose from lowering capital controls. The equilibrium world interest rate is lower on average when capital controls decrease over time (baseline) compared to the counterfactual

[20]Note that the normalized Chinn-Ito index which is used to construct the tax rates is one from 1970 to 2007 for these four countries, i.e., capital controls measures and the corresponding tax rates are zero between 1970-2007.

scenario where capital controls remain constant at the initial level. Net borrowing countries are better off becasue of lower costs of borrowing while net saving countries are worse off because of lower returns from saving bonds.

In addition, countries that lose from declining capital controls have relatively lower consumption growth and GDP growth than countries that gain from lowering capital controls. Note that countries that have negative welfare gains tend to be a net saver and thus they impose controls on capital outflows. This is consistent with Costinot et al. (2014) that claim it is optimal for a slow-growing country to tax capital outflows. Countries with relatively lower consumption and GDP growth have an incentive to tax capital outflows so that they can raise the intertemporal prices, which can be welfare-improving. Put differently, reducing tax on capital outflows can lower these countries' welfare. This logic can apply to the countries with relatively higher consumption and GDP growth as well, but they experience smaller decrease in capital controls on average.[21]

A.5 Additional Quantitative Exercises

A.5.1 Two sub-periods: 1970-1990 vs 1990-2007

In section 2.3, I conduct the counterfactual exercises where I fix either trade costs or capital controls at the 1970's level. In order to quantify how much of the increase in trade imbalances between 1970 and 2007 observed from the data is explained by each of the two factors, I compare the changes in the level of trade imbalances between 1970 and 2007 under the counterfactual exercise with that under the baseline case.[22]

[21] The average reduction in capital control measures for the top six welfare-gaining countries (Finland, Korea, Brazil, China, Mexico and Norway) is 9.2 percent while it is 14.5 percent for the top six welfare-losing countries (Australia, Spain, Greece, Austria, Portugal and United Kingdom) from lowering capital controls.

[22] The results of the counterfactual exercises show that the decrease in trade costs and capital controls accounts for 42 percent and 22 percent of the increase in trade imbalances between 1970 and 2007, respectively (Column (7) in Table A.1).

In this section, I divide the period into two sub-periods (1970-1990 and 1990-2007) and evaluate the quantitative contribution of these two factors for each sub-period. Table A.1 summarizes the level of trade imbalances in 1970, 1990 and 2007 for three counterfactual exercises as well as for the baseline case (Column (1)-(3)). It also includes the changes in the level of trade imbalances for each of three different time periods: 1970-2007, 1970-1990 and 1990-2007 (Column (4)-(6)). Finally, the contribution of trade costs and capital controls is computed for each sub-period by comparing the level changes in trade imbalances under the counterfactual exercise with those from the data. A decrease in trade costs explains 20 percent of the trade imbalances that occurred between 1970-1990 while it accounts for 53 percent of them for the period between 1990-2007 (Column (7)). A decline in capital controls explains 21 percent and 23 percent of the trade imbalances that occurred between 1970-1990 and 1990-2007, respectively (Column (8)). Both trade costs and capital controls contribute to the rise in trade imbalances more in the later period (1990-2007) compared to the earlier period (1970-1990).

A.5.2 Variance of net exports across countries

In this paper, I define global trade imbalances as the sum of absolute value of net exports across all countries in the sample. The measure is in terms of a share of world GDP because the world GDP is normalized to one in every period. In this section, I compute the variance of net exports across countries as an alternative measure of global imbalances and see how they evolve over time under the counterfactual exercises. I reassess the role of declining trade costs and capital controls in explaining the increase in the variance of net exports.

Figure A.3 plots the evolution path of this new measure - the variance of net exports across countries as a share of world GDP - for the baseline case as well as for the three counterfactual exercises. The patterns are similar to those of trade imbalances - though the magnitude is quite different. Table A.2 summarizes the variance of net exports and the level change of this measure over the period between 1970-2007. When trade costs are fixed at the 1970's level, the level change in the variance of net exports is only about 0.00066 percentage point, which is 42 percent of what the data implies (0.00159 pp). In contrast, when capital controls remain at the 1970's level, the level change in the variance is 0.00139 percentage point which is 87 percent of what the actual data suggests, i.e., 58 percent of the rise in the variance of net exports can be explained by lowering trade costs while only 13 percent of them can be attributed to lowering capital controls. This is consistent with my main results that are based on global trade imbalances measure.

A.5.3 Trade Costs or K-controls fixed at 1970's level vs 1 percent lower than 1970's level

In this section, I examine how much a 1 percent decrease in trade costs or capital controls leads to the level changes in trade imbalances between 1970 and 2007. I compare two counterfactual exercises; one where trade costs or capital controls are fixed at their 1970's level and the other where two factors are fixed at 1 percent lower than 1970's level. When trade costs are remained at 1970's level - the average Head-Ries index in 1970 is approximately 7.83 - the level of trade imbalances rises from 1.23 percent to 3.66 percent, resulting in 2.43 percentage point increase in the level difference. When trade costs decrease by a 1 percent from the 1970's level - the average Head-Ries index goes down to 7.75, the level change in trade imbalances is 2.45 percentage point, which is 0.82 percent higher than that under the previous counterfactual exercise, i.e., a 1 percent decrease in trade costs is associated 0.82 percent increase in trade imbalances. When capital control are fixed at 1970's level - the average of capital control tax rates is 10.85 percent in 1970 - the level of trade imbalances changes from 1.29 percent in 1970 to 4.49 percent, generating 3.29 percentage point increase. When capital controls decline by a 1 percent from the 1970's level - the average tax rates is 10.74 percent - the level change in trade imbalances is 3.33 percentage point, which is 1.35 percent higher than the earlier counterfactual exercise, i.e., a 1 percent decrease in capital controls is associated with 1.35 percent increase in trade imbalances.

A.6 Computation

Recall that I denote N and T as the number of countries and the number of time periods. The initial period's bond holdings for each country, $\{\tilde{\mathsf{B}}_{i,1}\}_{i=1}^{N}$, and initial period's price of bond, q_0, are given. I solve for counterfactual equilibria by following the methodology of Alvarez & Lucas Jr (2007).

1. Guess a steady state level of bonds for each country, $\{B_{i,ss}\}_{i=1}^{N}$, such that the sum is exactly equal to zero, $\sum_{i=1}^{N} B_{i,ss} = 0$.

2. Inner-loop:

   (a) Given $B_{i,t+1}$, guess a wage for each country in every period, $\{\{w_{i,t}\}_{i=1}^{N}\}_{t=1}^{T}$. Compute the rental rate, $r_{i,t}$, by using $r_{i,t} = \frac{\varphi_i}{1-\varphi_i}\frac{L_{i,t}}{K_{i,t}}w_{i,t}$.

   (b) Compute $\text{GDP}_{i,t} = (w_{i,t}L_{i,t} + r_{i,t}K_{i,t})$ for $\forall$ i and t. Normalize the wage and the rental rate so that the world GDP in each time period is equal to 1; $\sum_{i=1}^{N}(\text{GDP}_{i,t})$ $= 1$ for $\forall$t.

   (c) Given $w_{i,t}$ and $r_{i,t}$, solve for the aggregate price, $P_{i,t}$, which is given as

$$P_{i,t} = \gamma \left[\sum_{n=1}^{N} T_{n,t}(cost_{n,t}d_{in,t})^{-\theta} \right]^{-\frac{1}{\theta}} \tag{A.20}$$

   Note that $cost_{n,t}$ is a function of wages, rental rates and prices.

(d) Given the aggregate prices as well as factor prices, compute the trade shares, $\pi_{ni,t}$, such that

$$\pi_{ni,t} = T_{n,t} \left(\frac{\gamma cost_{n,t} d_{in,t}}{P_{i,t}} \right)^{-\theta} \tag{A.21}$$

(e) Compute the price of bonds at the steady state. q_{ss} can be derived by using the USA's Euler equation in the last period. Note that the intertemporal preference shifters for USA is normalized to one for all time periods.

$$1 = \delta \left(\frac{1}{q_{ss}} \right) [1 - \tau_{US,ss}(1 - q_{ss})] \quad \Leftrightarrow \quad q_{ss} = \frac{\delta(1 - \tau_{US,ss})}{1 - \delta\tau_{US,ss}} \tag{A.22}$$

(f) Given $B_{i,ss}$ and q_{ss}, compute the steady state level of net exports; $NX_{i,ss} = (q_{ss} - 1)B_{i,ss}$. Also compute the steady state level of consumption expenditures; $PC_{i,ss} = GDP_{i,ss} - NX_{i,ss}$.

(g) Recover the whole time path of q_t and $PC_{i,t}$ by iterating backwards starting from the steady state.

i. Assume that $\{PC_{i,t}\}_{i=1}^{N} = \{PC_{i,ss}\}_{i=1}^{N}$ and $q_t = q_{ss}$.

ii. Given $\{PC_{i,t}\}_{i=1}^{N}$ and q_t, I'd like to recover $\{PC_{i,t-1}\}_{i=1}^{N}$ and q_{t-1} simultaneously. Note that there are (N+1) unknowns to be determined.

iii. The system of equations to be held include:

$$\frac{PC_{i,t}}{PC_{i,t-1}} = \delta\hat{\phi}_{i,t} \left(\frac{1}{q_{t-1}} \right) [1 - \tau_{i,t}(1 - q_{t-1})] \tag{A.23}$$

$$\sum_{i=1}^{N} (PC_{i,t-1}) = 1 \tag{A.24}$$

iv. By iterating backwards, I can recover the whole time path of q_t and $PC_{i,t}$.

(h) Compute the demand side of the net exports as a difference between GDP and consumption expenditure: $NX^D_{i,t} = GDP_{i,t} - PC_{i,t}$.

(i) Solve for the total expenditure, $X_{i,t}$, by solving the following two equations simultaneously:

$$X_{i,t} = P_{i,t}C_{i,t} + (1 - \beta_{i,t})Y_{i,t} \tag{A.25}$$

$$Y_{i,t} = \sum_{n=1}^{N} \pi_{ni} X_{n,t} \tag{A.26}$$

(j) Compute the supply side of the net exports as a difference between gross output and total expenditure: $NX^S_{i,t} = Y_{i,t} - X_{i,t}$.

(k) Compute $T^w = \max|NX^D_{i,t} - NX^S_{i,t}|$. If T^w is not sufficiently small, update the wage as follows and go back to (a) until it gets sufficiently close to zero.

$$w_{i,t} = w_{i,t}(1 + \nu^w \cdot Z^w_{i,t}) \tag{A.27}$$

where ν^w is an adjustment factor and $Z^w_{i,t} = \frac{T^w}{w_{i,t}L_{i,t}}$.

(l) If T^w is close enough to zero, I define $NX_{i,t}$ as $NX^D_{i,t}$.

3. Given q_t and $NX_{i,t}$ as well as $B_{i,ss}$, determine the whole path of bonds as follows:

$$B_{i,t} = q_t B_{i,t+1} - NX_{i,t} \tag{A.28}$$

4. Compare the first period's bonds recovered in Step 3 with the initial bonds distribution. i.e., compute $T^B = \max|\tilde{\mathsf{B}}_{i,1} - B_{i,1}|$. If T^B is not sufficiently small, update the steady state level distribution of bonds as follows and go back to Step 1 until it gets sufficiently close to zero.

$$B_{i,ss} = B_{i,ss} + \nu^B \cdot Z^B_i \tag{A.29}$$

where ν^B is an adjustment factor and $Z_i^B = T^B \left(\Pi_{t=1}^T q_t\right)$.

5. If T^B is close enough to zero, I stop.

Table A.1: Two sub-periods: Trade imbalances and Contribution of each factors

	Level of TI			Level Δ in TI			Contribution		
	1970	1990	2007	(70-07)	(70-90)	(90-07)	(70-07)	(70-90)	(90-07)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Data	0.93%	2.29%	5.15%	4.2 pp	1.4 pp	2.9 pp			
CF1	1.23%	2.31%	3.66%	2.4 pp	1.1 pp	1.3 pp	42.5%	20.3%	53.0%
CF2	1.20%	2.28%	4.49%	3.3 pp	1.1 pp	2.2 pp	22.1%	20.6%	22.8%
CF3	1.53%	2.25%	3.11%	1.6 pp	0.7 pp	0.9 pp	62.6%	47.4%	69.9%

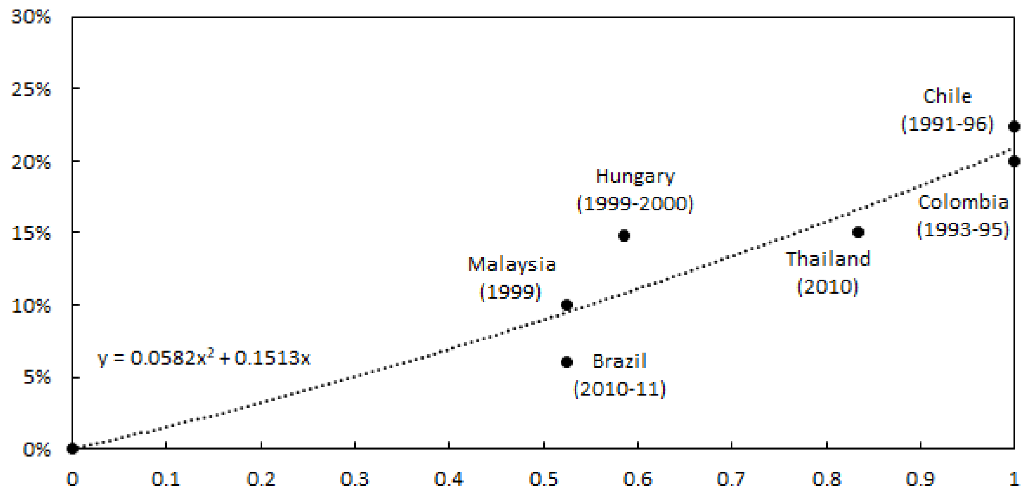
Table A.2: Results of Counterfactual Exercises based on the Variance of NX

	1970	2007	Level Δ in Var	Contribution
Data	0.00003%	0.00162 %	0.00159 pp	
CF1	0.00005%	0.00071 %	0.00066 pp	58.48%
CF2	0.00005%	0.00143 %	0.00139 pp	12.80%
CF3	0.00008%	0.00060 %	0.00052 pp	67.42%

Table A.3: Trade costs and K-controls fixed at 1970's level vs 1% lower than 1970's level

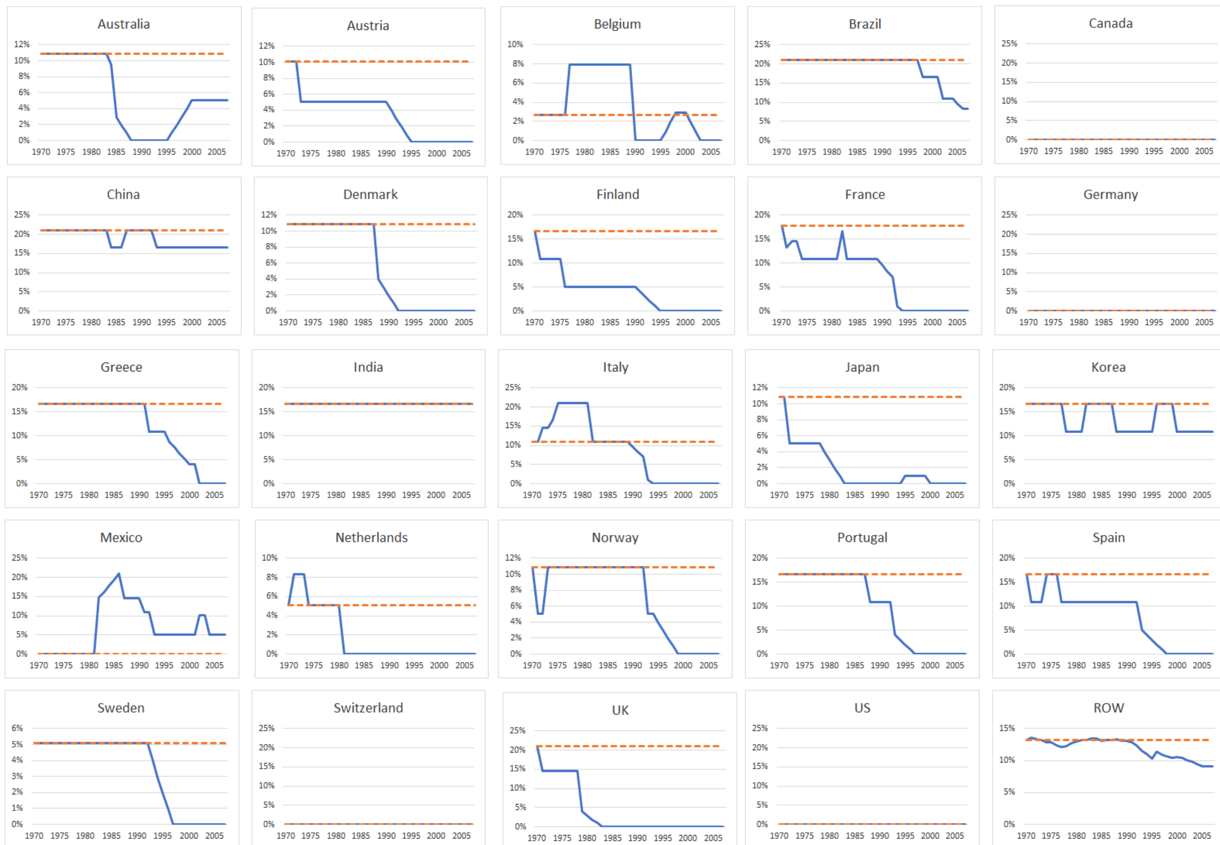
	1970	2007	Diff	TC		1970	2007	Diff	KC
TC1970	1.23%	3.66%	2.43pp	7.83	KC1970	1.20%	4.49%	3.29pp	10.85%
1%↓TC1970	1.22%	3.67%	2.45pp	7.75	1%↓KC1970	1.19%	4.52%	3.33pp	10.74%
Growth			0.82%	−1%	Growth			1.35%	−1%

Figure A.1: Equivalent tax rates



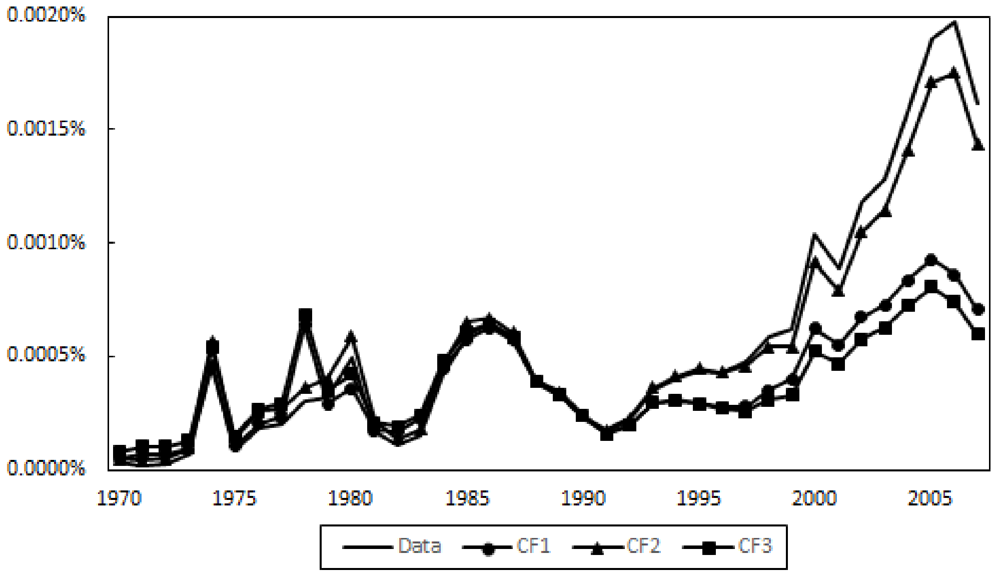
Notes: Figure A.1 shows capital control measures on the x-axis and the equivalent tax rates on the y-axis. Six examples of capital controls (Brazil, Chile, Colombia, Hungary, Malaysia and Thailand) are included in the figure. The second-order polynomial trend-line can be derived by minimizing the distance from those six points as well as the origin. Based on this trend-line, there is one-to-one conversion from the capital control measure to the equivalent tax rate.

Figure A.2: Capital control taxes: Data vs CF2



Notes: The solid blue line shows the magnitude of tax rates for a individual country which is constructed by the equation (A.14) while the dashed orange line is the level in 1970. In the second counterfactual exercise, the magnitude of capital controls is assumed to be fixed at the 1970's level.

Figure A.3: Variance of Net exports



Notes: The solid line shows the data while the other lines display how the variance of net exports evolve over time under the each of three counterfactual exercises that I conducted in the main part of the paper.