Distribution Agreement

The EZ Way to Global Imbalances

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Doctor of Philosophy
Economics

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Abstract

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I report that unanticipated and anticipated shocks to the productivity growth process in the United States (US) relative to that in the Rest of Developed Market (RDM) economies have economically and statistically significant effects on capital flows from and towards Emerging Markets (EM), introducing what I call indirect trade effects. Extending the Colacito, Croce, Ho and Howard (2018) two country model to a three country framework generates global capital flows dynamics that are consistent with the empirical findings.

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Contents

List of Figures

List of Tables

Chapter 1

The EZ Way to Global Imbalances

1.1 Introduction

What is the source and destination of capital flows? In open, 2-economy environments capital goes to countries who experience the highest unanticipated productivity shock, as in Backus, Kehoe, and Kydland (1992) - BKK onwards. More recently, Colacito, Croce, et al. (2018) - CCHH onwards - showed that in a 2-country environment with Epstein-Zin preferences (Epstein and Zin, 1989), capital goes away from countries with the highest anticipated productivity shock towards countries with the highest consumption marginal utility. Assuming unanticipated and anticipated *relative* productivity shocks among 2 countries, in this paper I consider an extension of the CCHH theory to a 3-country environment and ask whether the third economy, who has not received any *relative* productivity shock, can indeed expect capital inflows or outflows.

In a 2-country model where agents can borrow and lend internationally, *relative* productivity shocks, i. e. one country being more productive than the other, generates capital flows between the 2 countries, something that I call *direct* effects from international trade. Moreover, in the analogous 3-country model I argue that capital flows neither coming from nor going to the third economy is only a particular case out of infinitely many possible cases. I show that this will be the case as long as the third country's consumption marginal utility equals that of the country that receives the positive *relative* productivity shock. In general, I show that there can be capital flows coming from or going to the third economy as long as the mentioned consumption marginal utilities differ, something that I refer to as *indirect* effects from international trade.

According to the BKK's productivity channel, in 2-country environments with unanticipated productivity shocks, it is known that capital will flow towards the country that experiences a suddenly higher productivity. In principle, one may guess that in a 3-country environment capital will flow from the third country towards the most productive one, so the former's consumption marginal utility gets higher than the latter's as a result. However, I show that as the most productive country's produced good is increasingly preferred by the third country in comparison to the least productive one, there will be i) less capital going from the least productive towards the most productive economy, i. e. the BKK's productivity channel is weakened; and ii) more capital going from the most productive country towards the third one. This is because the suddenly, most productive economy will share more risk with the third country and share less risk with the suddenly, least productive one.

Similarly and according to the CCHH's risk-sharing channel, in 2-country models with anticipated productivity shocks and Epstein-Zin (EZ) preferences, it is known that capital will go to the country that anticipates being less productive in the future since its consumption marginal utility gets higher. It could seem obvious that in a 3-country environment capital will flow from the anticipated more productive country towards the third economy. Nevertheles, I show that as the anticipated most productive country's produced good is increasingly preferred by the third country in comparison to the anticipated least productive one, there will be i) less capital going from the most productive towards the least productive economy, i. e. the CCHH's risk-sharing channel is weakened; and ii) more capital going from the third country towards the anticipated most productive one. This is because the anticipated most productive economy will share more risk with the third one and share less risk with the anticipated least productive one.

In order to test empirically for such theoretical predictions, I use the CCHH's emprical strategy and extend their G7 countries sample to include the emerging market economies (EM). Specifically, following Colacito and Croce (2013), Bansal, Kiku, and Yaron (2016) and CCHH, I identify unanticipated and anticipated productivity growth innovations by regressing Solow residuals on lagged country-specific price-dividend ratios. In a second step, I take the EM[1] as the home country and consider its net-exports as a function of unanticipated and anticipated productivity growth differentials i) between the US and EM economies and ii) among developed countries, i. e. between the US and the rest of the G7 economies[2] (RDM). The effects of US-EM (both unanticipated and anticipated) productivity growth differentials on the EM trade balance refer to the *direct* trade effects between the US and EM. On the other hand, the effects of US-RDM productivity growth differentials on the EM trade balance refer to the *indirect* trade effects between developed and EM economies.

Four main findings can be drawn from the empirical analysis. First, I show that the EM and RDM shares in US exports have increased and decreased, respectively, during the 1973-2006 time period. This can be seen as the US produced good becoming increasingly preferred by EM and decreasingly preferred by RDM, respectively, over time. This trend leads us to empirically explore the implied weakening of the CCHH's *direct* trade effects

[1]Argentina, Brazil, Chile, China, Colombia, Indonesia, Malaysia, Mexico, Philippines, Thailand, Turkey, South Africa and South Korea.

[2]Canada, France, Italy, Germany, Japan and United Kingdom.

between US and RDM and the emergence of the *indirect* trade effects between developed and EM economies suggested by my theory. Indeed, the second empirical finding shows that this is the case in the data once the CCHH estimation sample is broken down into two consecutive time frames (1973-1991 and 1992-2006), where the breaking point date coincides to the start of the steady increase (decrease) of the EM (RDM) share of US exports around its time trend. From the estimates it can be inferred that the quantitative importance of the CCHH's productivity and risk-sharing motives of capital flows between US and RDM is significantly reduced in the period 1992-2006 relative to 1973-1991.

As a third empirical finding, I report the existence of *direct* trade effects between US and EM, and *indirect* trade effects between developed and EM economies in the 1992-2006 period. Even though the US-EM *direct* effects found in the data can be thought of as a contribution to the rich-to-poor countries capital flows debate[3], it still can be explained by the CCHH theoretical model. Nevertheless, the empirical findings on the *indirect* effects between developed and EM countries is not only a novelty from the empirical evidence point of view, but also support my theoretical predictions. In particular, higher unanticipated productivity growth of the US with respect to RDM deteriorates the EM's net exports, which means that resources are directed to EMs. By contrast, higher anticipated productivity growth of the US with respect to RDM improves the EM's net exports, so resources go away from EMs. This empirical result contributes to the global imbalances literature, particularly shedding light on the importance of the anticipated shocks to the productivity growth differentials among developed economies on the EM's capital flows[4]. Closely enough, the fourth empirical finding consists in reporting the strengthening of the *indirect* trade effects between developed and EM countries during 1992-2006 relative to 1973-1991. This is consistent with the theoretical predictions as the strengthening of the

[3]See Lucas (1990); C. Reinhart, V. Reinhart, and Trebesch (2016); Ahmed and Zlate (2014); C. Reinhart, Rogoff, and Savastano (2003); among others.

[4]See Caballero, Farhi, and Gourinchas (2008); Mendoza, Quadrini, and Ríos-Rull (2009).

developed-EM *indirect* effects coincides with the increasing path of the EM's preference for US's produced good relative to RDM's observed in the data.

Although the domestic moments generated by the three-country model are similar to those obtained using the two-country one, there are important differences. In particular, the volatility of investment relative to output is greater in the three-country economy in comparison to the two-country one. This is due to the possibility for an individual to be able to invest her savings in more-than-one location abroad. By contrast, the volatility of consumption relative to output is lower than that observed in the data because individuals can now share consumption risk with more than one counterpart abroad. This feature of the three-country model becomes particularly important when calibrated to EM as the consumption volatility relative to that of output is less than 1 in the model, even with highly persistent exogenous productivity processes, while it is greater than 1 in the data.

On the other hand, the three-country model overcomes the two-country one in several key international dimensions. Although the two kinds of models generate similar cross-country correlations in terms of consumption, investment and output, it is worth to highlight that the countercyclicality of the trade-balance-to-output ratio generated by the three-country model is even closer to the data than the one generated by the two-country setting. Moreover, another important difference is that in the three-country model it is possible to compare the volatilities of the trade-balance-to-output ratio across US, RDM and EM countries, something that is useful in order to characterize the global capital imbalances. Specifically, the three-country model stochastic simulations produce trade-balance-to-output ratio cross-country relative volatilities that are reasonably close to the data.

Using stochastic simulations I show that the three-country model generates regression coefficients that are reasonably close to the actual empirical estimates. In turn, such coefficients change as the most productive country's produced good becomes increasingly preferred by the third economy in comparison to the least productive one. Such a change in the theoretical model's coefficients induced by the inclusion of a third country resembles the change in the empirical estimates between the 1973-1991 and 1992-2006 time frames. Finally, I argue that this result is key in order to understand the behavior of the global capital imbalances during the 1992-2006 period of time.

The next subsection presents the related literature. Section 1.2 presents a two-period, three country model with recursive preferences and productivity news shocks that shapes the theoretical predictions. Section 1.3 empirically explores the extent to which such theoretical predictions hold in the data. Section 1.4 describes the infinite-horizon version of the theoretical model that aims to reproduce the empirical facts found in section 1.3, at the time that presents the calibration and solution method. Section 1.5 shows the infinite-horizon model quantitative performance and simulation results in order to explain the behavior of the global capital imbalances during 1992-2006. Finally, section 1.6 concludes.

Related Literature.—This paper can be related to the existing literature in several ways. From the empirical point of view, the *direct* and *indirect* effects can be thought of a way to estimate the determinants of capital flows between developed and EM economies (Lucas, 1990; Ahmed and Zlate, 2014; C. Reinhart, Rogoff, and Savastano, 2003; C. Reinhart, V. Reinhart, and Trebesch, 2016).

On the other hand, the *indirect effects* contribute to the global imbalances literature. In particular, Caballero, Farhi, and Gourinchas (2008) emphasize on both unanticipated productivity growth differential shocks among developed economies and financial structure differential shocks between developed and emerging economies to generate capital outflows from EMs. Mendoza, Quadrini, and Ríos-Rull (2009) highlight the importance of uncertainty in heterogeneous financial markets to generate global imbalances. By contrast, my approach doesn't rely on different financial system structures across countries. Instead, I highlight the importance of the presence of both unanticipated and anticipated productivity growth differentials among developed economies in order to produce global capital imbalances, including capital flows from and towards EM.

From a theoretical perspective, my model is the first one to analyze capital flows in a frictionless 3 country dynamic stochastic general equilibrium model with Epstein-Zin preferences and anticipated productivity growth shocks. Other different three country models that analyze capital flows can be found in Zimmermann (1997), Kose and Yi (2006), among others.

Finally, this paper is the first one to connect anticipated productivity growth shocks (long-run risk) (Bansal, Kiku, and Yaron, 2016; Colacito and Croce, 2013; Colacito, Croce, et al., 2018) to global imbalances (Mendoza, Quadrini, and Ríos-Rull, 2009; Caballero, Farhi, and Gourinchas, 2008).

1.2 Three Countries with Recursive Preferences and Risk-sharing Motives

This is the first paper to analyze international capital flows in a complete markets economy with Epstein-Zin preferences, news shocks and three-countries. Hence, I introduce the agents' preferences and then present a two-period CCHH model that includes a third country in order to highlight the intuition behind the resulting *direct* and *indirect* trade effects that come from the productivity and risk-sharing motives.

Let $\tilde{C}_t$, $\tilde{C}_t^*$ and $\tilde{C}_t^{**}$ be the three countries' corresponding consumption bundles, thus the utility function for country 1 has the following EZ form:

$$U_t = \left[(1-\beta) \cdot \tilde{C}_t^{1-1/\psi} + \beta E_t \left[U_{t+1}^{1-\gamma} \right]^{\frac{1-1/\psi}{1-\gamma}} \right]^{\frac{1}{1-1/\psi}}.$$

Utility functions for countries 2 and 3 can be written in an analogous way with the same parameter values and can be denoted by U_t^* and U_t^{**}, respectively. Parameters γ and ψ measure the agent's Relative Risk Aversion (RRA) and Intertemporal Elasticity of Substitution (IES), respectively. In order to have an intuition about how the EZ preferences work, consider the following monotonic transformation of the utility function:

$$V_t = \frac{U_t^{1-1/\psi}}{1-1/\psi}$$

and make a second-order Taylor expansion around the conditional mean of $logV_{t+1}$ to get

$$V_t \approx (1-\beta)\frac{\tilde{C}_t^{1-1/\psi}}{1-1/\psi} + \beta E_t \left[V_{t+1} \right] - \frac{(\gamma - 1/\psi)}{2} \beta \, \mathrm{var}_t \left[V_{t+1} \right] \tag{1.1}$$

Note that if $\gamma = 1/\psi$ then equation (1.1) implies that the utility function reduces to the conventional CRRA case. However, as long as $\gamma > 1/\psi$ (early resolution for uncertainty), then the EZ preferences introduce not only risk aversion for future consumption but also for future utility. The trade-off is that the consumer is willing to accept higher uncertainty about the future only if she is compensated by higher expected future utility.

The Stochastic Discount Factor (SDF) can be written as

$$M_{t+1} = \beta \left(\frac{\tilde{C}_{t+1}}{\tilde{C}_t} \right)^{-\frac{1}{\psi}} \left(\frac{U_{t+1}}{E_t \left[U_{t+1}^{1-\gamma} \right]^{\frac{1}{1-\gamma}}} \right)^{\frac{1}{\psi} - \gamma}. \tag{1.2}$$

According to the second term in the Right Hand Side (RHS) of equation (1.2), the trade-off between future expected utility and risk of future utility is also present in the SDF as long as early resolution of uncertainty is present, i. e. $\gamma > 1/\psi$. Such a term, usually denominated as the continuation utility, is sensitive to the anticipated shock to productivity growth, thus it is key to generate the Colacito, Croce, et al. (2018)'s *risk-sharing channel* of capital flows.

1.2.1 Recursive Risk-Sharing of News in a Three-Country World: Intuition

In this section, I show a two-period CCHH model, i. e. a BKK model with recursive preferences, with three countries instead of two. As in CCHH, I don't consider unanticipated[5] shocks since in such an environment it is simpler to get an intuition of the capital flows due to the interaction between the recursive (EZ) preferences and anticipated[6] shocks. Moreover, I will show that under certain parameter values of the EZ preferences, the international capital flows behavior due to anticipated shocks become qualitatively the same as those that come from unanticipated shocks.

There are three dates in the economy: $t = \{0, 1, 2\}$. At time $t = 1$ agents receive news (θ, ψ) about the productivity that capital will have at time $t = 2$. Specifically, θ represents capital productivity news in country 1 relative to countries 2 and 3, while ψ denotes capital productivity news in country 2 relative to country 3. Since I assume that no other shocks take place in periods $t = \{1, 2\}$ then there will be no uncertainty at time $t = 2$.

Let $\{X_t, Y_t, W_t\}$, $\{X_t^*, Y_t^*, W_t^*\}$ and $\{X_t^{**}, Y_t^{**}, W_t^{**}\}$ be the consumption of goods X, Y and W in countries 1, 2 and 3, respectively. The consumption aggregates for the three

[5] I call *unanticipated* productivity shocks what CCHH call *short-run* productivity shocks.

[6] I call *anticipated* productivity shocks what CCHH call *long-run* or *news* productivity shocks.

countries can be written as:

$$C_t = X_t^{\lambda_1} \cdot Y_t^{\lambda_2} \cdot W_t^{(1-\lambda_1-\lambda_2)}, \quad C_t^* = X_t^{*\lambda_2} \cdot Y_t^{*\lambda_1} \cdot W_t^{*(1-\lambda_1-\lambda_2)}, \tag{1.3}$$

$$C_t^{**} = X_t^{**\lambda_2} \cdot Y_t^{**(1-\lambda_1-\lambda_2)} \cdot W_t^{**\lambda_1}.$$

I assume that country 1 produces X, country 2 produces Y and country 3 produces W, so $\lambda_1 \in (0,1)$ can be viewed as the consumption home bias parameter. Moreover, $\lambda_2 \in (0,1)$ can be interpreted as country 1's preference for country 2 good (Y_t) relative to country 3's (Y_t^{**}).

I assume that individuals have unit IES, $\psi = 1$, in order to get closed form solutions, so preferences are as follows:

$$u_0 = (1-\beta)\log C_0^i + \frac{\beta}{1-\gamma}\log E_0\left[\exp\left\{u_1^i(1-\gamma)\right\}\right] \tag{1.4}$$

where u_0 and u_1 are period 0 and 1 log-utilities, respectively. When $\gamma = 1 = \frac{1}{\psi}$ then the recursive preferences collapse to the additive CRRA preferences. As there are no uncertainty beyond time $t = 1$, then $\ln E_1\left[exp(1-\gamma)u_2\right] = (1-\beta)(1-\gamma)\ln C_2$, so time-1 utility can be written as:

$$u_1 = (1-\beta)\log C_1 + \beta(1-\beta)\log C_2.$$

The preferences specification of countries 2 and 3 are symmetric, so their variables are indexed by $*$ and $**$, respectively. For simplicity, at time-1 total production is fixed and equal to 1 in every country, so it is allocated into time-1 consumption and investment:

$$
\begin{aligned}
1 &= X_1 + X_1^* + X_1^{**} + I_{x,1} + I_{y,1} + I_{w,1} \\
1 &= Y_1 + Y_1^* + Y_1^{**} + I_{x,1}^* + I_{y,1}^* + I_{w,1}^* \\
1 &= W_1 + W_1^* + W_1^{**} + I_{x,1}^{**} + I_{y,1}^{**} + I_{w,1}^{**},
\end{aligned} \tag{1.5}
$$

From the perspective of country 1 (2 and 3), $(I_{x,1}\ I_{y,1}^*, I_{w,1}^{**})$ denotes home investment goods while $\{I_{y,1}, I_{w,1}\}$ $(\{I_{x,1}^*, I_{w,1}^*\}, \{I_{x,1}^{**}, I_{y,1}^{**}\})$ denote home investments abroad. I assume international complete markets in the sense that agents can frictionless trade both consumption and investment goods internationally in every state of nature.

When $t = 2$ take place, home and foreign investment goods are combined in order to get total investment:

$$
\begin{aligned}
G\left(I_{x,1}, I_{x,1}^*, I_{x,1}^{**}\right) &= (I_{x,1})^{\nu_1} \left(I_{x,1}^*\right)^{(1-\nu_1-\nu_2)} \left(I_{x,1}^{**}\right)^{\nu_2} \\
G^*\left(I_{y,1}, I_{y,1}^*, I_{y,1}^{**}\right) &= (I_{y,1})^{\nu_2} \left(I_{y,1}^*\right)^{\nu_1} \left(I_{y,1}^*\right)^{(1-\nu_1-\nu_2)} \\
G^{**}\left(I_{w,1}, I_{w,1}^*, I_{w,1}^{**}\right) &= (I_{w,1})^{1-\nu_1-\nu_2} \left(I_{w,1}^*\right)^{\nu_2} \left(I_{w,1}^*\right)^{\nu_1}
\end{aligned} \tag{1.6}
$$

where $\nu_1 \in (0,1)$ can be viewed as the investment home bias parameter. Time-2 output is then allocated to time-2 consumption:

$$
\begin{aligned}
e^{\theta} G\left(I_{x,1}, I_{x,1}^*, I_{x,1}^{**}\right) &= X_2 + X_2^* + X_2^{**} \\
e^{-\theta+\psi} G^*\left(I_{y,1}, I_{y,1}^*, I_{y,1}^{**}\right) &= Y_2 + Y_2^* + Y_2^{**} \\
e^{-\theta-\psi} G^{**}\left(I_{w,1}, I_{w,1}^*, I_{w,1}^{**}\right) &= W_2 + W_2^* + W_2^{**}
\end{aligned} \tag{1.7}
$$

For the sake of symmetry, I assume that the same (θ, ψ) impact home and foreign productivity with opposite signs, so the cross-country capital reallocation will be determined by relative cross-country productivities.

At $t = 0$ current consumption is symmetrically predetermined at $C_0 = C_0^* = C_0^{**}$ at the time that agents exchange a complete set of securities that are contingent to (θ, ψ) in order to maximize their time-0 utility:

$$\max_{\left\{\{X_t,X_t^*,X_t^{**},Y_t,Y_t^*,Y_t^{**},W_t,W_t^*,W_t^{**}\}_{t=1}^{2},I_{x,1},I_{y,1},I_{w,1},I_{x,1}^*,I_{y,1}^*,I_{w,1}^*,I_{x,1}^{**},I_{y,1}^{**},I_{w,1}^{**}\right\}} \mu_1 u_0+\mu_2 u_0^*+(1-\mu_1-\mu_2)u_0^{**} \tag{1.8}$$

subject to constraints (1.3)-(1.7). Moreover, at time-0 each country has the same share of the allocation of global resources, so the relative time-0 Pseudo-Pareto weights are:

$$S_0^{1,2} = \frac{\mu_1}{\mu_2} = 1, \quad S_0^{3,2} = \frac{1-\mu_1-\mu_2}{\mu_2} = 1.$$

We are interested in the effects of relative productivity shocks (θ, ψ) on each country's net exports. The First Order Conditions with respect to X_1, Y_1 and W_1 are:

$$\begin{aligned} S_1^{1,2}(\theta,\psi)\frac{\partial \ln C_1}{\partial X_1} &= \frac{\partial \ln C_1^*}{\partial X_1^*} = S_1^{3,2}(\theta,\psi)\frac{\partial \ln C_1^{**}}{\partial X_1^{**}} \\ S_1^{1,2}(\theta,\psi)\frac{\partial \ln C_1}{\partial Y_1} &= \frac{\partial \ln C_1^*}{\partial Y_1^*} = S_1^{3,2}(\theta,\psi)\frac{\partial \ln C_1^{**}}{\partial Y_1^{**}} \\ S_1^{1,2}(\theta,\psi)\frac{\partial \ln C_1}{\partial W_1} &= \frac{\partial \ln C_1^*}{\partial W_1^*} = S_1^{3,2}(\theta,\psi)\frac{\partial \ln C_1^{**}}{\partial W_1^{**}} \end{aligned} \tag{1.9}$$

where $S^{1,2}(\theta, \psi)$ is the time-1 ratio of Pseudo-Pareto weights of country 1 relative to country 2, while $S^{3,2}(\theta, \psi)$ is the time-1 ratio of Pseudo-Pareto weights of country 3 relative to country 2. By symmetry among the three countries we have

$$E_0\left[e^{u_1(1-\gamma)}\right] = E_0\left[e^{u_1^*(1-\gamma)}\right] = E_0\left[e^{u_1^{**}(1-\gamma)}\right]$$

which implies that time-1 Pseudo-Pareto weights can be written as

$$S_1^{1,2} = \frac{\mu_1}{\mu_2} e^{(1-\gamma)\left(u_1-u_1^*\right)} \tag{1.10}$$

$$S_1^{3,2} = \frac{(1-\mu_1-\mu_2)}{\mu_2} e^{(1-\gamma)\left(u_1^{**}-u_1^*\right)} \tag{1.11}$$

Since uncertainty is fully resolved in $t = 1$, then the time-1 and time-2 Pseudo-Pareto weights are equal. So, for given values of $\left\{S_1^{1,2}(\theta,\psi)\right\}$ and $\left\{S_1^{3,2}\right\}(\theta,\psi)$ we can solve for time-2 consumption allocations:

$$\frac{X_2}{X_2^*} = \frac{\lambda_1}{1-\lambda_1-\lambda_2} S_1^{1,2}, \quad \frac{X_2}{X_2^{**}} = \frac{\lambda_1}{\lambda_2}\frac{S_1^{1,2}}{S_1^{3,2}} \tag{1.12}$$

$$\frac{Y_2}{X_2^*} = \frac{\lambda_2}{\lambda_1} S_1^{1,2}, \quad \frac{Y_2}{Y_2^{**}} = \frac{\lambda_2}{1-\lambda_1-\lambda_2}\frac{S_1^{1,2}}{S_1^{3,2}} \tag{1.13}$$

$$\frac{W_2}{W_2^*} = \frac{1-\lambda_1-\lambda_2}{\lambda_2} S_1^{1,2}, \quad \frac{W_2}{W_2^{**}} = \frac{1-\lambda_1-\lambda_2}{\lambda_1}\frac{S_1^{1,2}}{S_1^{3,2}} \tag{1.14}$$

and solve for time-1 consumption allocations:

$$\frac{X_1}{X_1^*} = \frac{\lambda_1}{1-\lambda_1-\lambda_2} S_1^{1,2}, \quad \frac{X_1}{X_1^{**}} = \frac{\lambda_1}{\lambda_2}\frac{S_1^{1,2}}{S_1^{3,2}} \tag{1.15}$$

$$\frac{Y_1}{X_1^*} = \frac{\lambda_2}{\lambda_1} S_1^{1,2}, \quad \frac{Y_1}{Y_1^{**}} = \frac{\lambda_2}{1-\lambda_1-\lambda_2}\frac{S_1^{1,2}}{S_1^{3,2}} \tag{1.16}$$

$$\frac{W_1}{W_1^*} = \frac{1-\lambda_1-\lambda_2}{\lambda_2} S_1^{1,2}, \quad \frac{W_1}{W_1^{**}} = \frac{1-\lambda_1-\lambda_2}{\lambda_1}\frac{S_1^{1,2}}{S_1^{3,2}} \tag{1.17}$$

Optimality conditions (1.15)-(1.17) say that the higher $S_1^{1,2}$ is then the greater the global resources going towards country 1 at $t = 1$, with similar implications of $S_1^{3,2}$ for country 3. Using the equilibrium conditions it can be shown that the time-1 trade-balance-to-output ratio of each country is a function of the Pseudo-Pareto weights:

$$\frac{NX_1^c}{X_1} = -\frac{1-\lambda_1-\lambda_2}{\lambda_1}\left(1-\frac{1}{S_1^{1,2}}\right) - \frac{\lambda_2}{\lambda_1}\left(1-\frac{S_1^{3,2}}{S_1^{3,2}}\right) \tag{1.18}$$

$$\frac{NX_1^{*c}}{Y_1^*} = -\frac{1-\lambda_1-\lambda_2}{\lambda_1}\left(1-S_1^{3,2}\right) - \frac{\lambda_2}{\lambda_1}\left(1-S_1^{1,2}\right) \tag{1.19}$$

$$\frac{NX_1^{**c}}{Y_1^*} = -\frac{1-\lambda_1-\lambda_2}{\lambda_1}\left(1-\frac{S_1^{1,2}}{S_1^{3,2}}\right) - \frac{\lambda_2}{\lambda_1}\left(1-\frac{1}{S_1^{3,2}}\right) \tag{1.20}$$

which means that the time-1 endogenous dynamics of capital flows, i. e. trade-balance-to-output ratios, depend exclusively on the adjustment of the Pseudo-Pareto weights $\left\{S_1^{1,2}(\theta,\psi), S_1^{3,2}(\theta,\psi)\right\}$ to the exogenous productivity news shocks (θ,ψ). Let $s_{1,2} \equiv \ln S_1^{1,2}$ and $s_{3,2} \equiv \ln S_1^{3,2}$ be the time-1 Pseudo-Pareto weights expressed in terms of natural logarithms. By using first order approximation it can be shown that the solution to the world planner's problem can be written as:

$$s_{1,2} = \lambda^{\theta}_{s_{1,2}}\theta + \lambda^{\psi}_{s_{1,2}}\psi, \tag{1.21}$$

$$s_{3,2} = \lambda^{\theta}_{s_{3,2}}\theta + \lambda^{\psi}_{s_{3,2}}\psi, \tag{1.22}$$

where,

$$\lambda^{\theta}_{s_{1,2}} = \frac{2(1-\gamma)(1-\beta)\beta\,(2\lambda_1-1)}{1+2\lambda_{u_1}^{s_{1,2}}(\gamma-1)}, \tag{1.23}$$

$$\lambda^{\psi}_{s_{1,2}} = (1-\gamma)\left[\lambda^{\psi}_{u_1} - \lambda^{\psi}_{u_1^*}\right], \tag{1.24}$$

$$\lambda^{\theta}_{s_{3,2}} = 0, \tag{1.25}$$

$$\lambda^{\psi}_{s_{3,2}} = -2(1-\gamma)\lambda^{\psi}_{u_1^*}. \tag{1.26}$$

The term $\lambda_i^{\psi}, i = \{u_1, u_1^*, u_1^{**}\}$, is the effect of ψ on country i-th utility. I can now introduce Lemma 1, Theorem 1 and Lemma 2 that will give more insights about how international consumption preference parameters (λ_1,λ_2) affect coefficients $(\lambda^{\theta}_{s_{1,2}}, \lambda^{\psi}_{s_{1,2}}, \lambda^{\theta}_{s_{3,2}}, \lambda^{\psi}_{s_{3,2}})$ in equations (1.23)-(1.26), which in turn determine the adjustment of $S^{1,2}$ and $S^{3,2}$ due to productivity news shocks (θ,ψ). In other words, let's introduce the *direct* and *indirect* trade effects from *relative* productivity news shocks.

Lemma 1 (direct effects)**.** *If* $\lambda_1 > \frac{1}{2}$ *and* $\gamma > 1$ *then* $\lambda^{\theta}_{s_{1,2}} < 0$*.*

Proof. If $\lambda_1 > \frac{1}{2}$ and $\gamma > 1$ then the numerator of equation (1.23) is negative. Since u_1 is increasing in C_1, then the effect of $s_{1,2}$ on u_1 is positive, thus $\lambda^{s_{1,2}}_{u_1} > 0$. This implies that the denominator of (1.23) is positive, hence $\lambda^{\theta}_{s_{1,2}} < 0$. □

Lemma 1 reproduces the CCHH main result: with consumption home bias ($\lambda_1 > \frac{1}{2}$) and agents with preference for early resolution of uncertainty ($\gamma > 1$), news of future productivity improvements in country 1 *relative* to countries 2 and 3 ($\uparrow \theta$) lower resources towards country 1 ($\lambda^{\theta}_{s_{1,2}} < 0$), i. e. resources flying from country 1 to country 2. This happens because the risk-aversion is high enough to make the consumption risk-sharing motive to dominate over the productivity motive due to the continuation value that comes from the EZ preferences. It is worth mentioning that when $\gamma < 1$ then the BKK productivity channel dominates over the CCHH risk-sharing channel, so more resources, instead, fly to country 1 ($\lambda^{\theta}_{s_{1,2}} > 0$) and the Pseudo-Pareto weights and trade-balance-to-output ratios behave qualitatively as if the news productivity shock was an unanticipated shock that took place in $t = 1$. This is what I call *direct* trade effects from *relative* productivity shocks, so the *indirect* trade effects are characterized as follows.

Theorem 1 (indirect effects)**.** *Let* $\lambda_1, \lambda_2 \in (0, 1)$ *and* $\lambda_1 + \lambda_2 \leq 1$*. Then* $\lambda^{\psi}_{u_1}$ *and* $\lambda^{\psi}_{u_1^*}$ *are increasing and decreasing functions of* λ_2*, respectively.*

Proof. If $\lambda_1, \lambda_2 \in (0, 1)$ and $\lambda_1 + \lambda_2 \leq 1$, by consumption optimality conditions (1.12)-(1.14) higher λ_2 implies higher C_2 and lower C_2^* for any given value of ψ. Since u_1 is an increasing function of C_2 and u_1^* is an increasing function of C_2^* for any given value of ψ, then it follows that $\lambda^{\psi}_{u_1}$ and $\lambda^{\psi}_{u_1^*}$ are increasing and decreasing functions of λ_2, respectively. □

In order to gain intuition of Theorem 1, suppose that at $t = 1$ there are news of country 2 becoming more productive than country 3 at $t = 2$ ($\uparrow \psi$). Then it is anticipated that country 2's consumption will increase ($\uparrow C_2^*$) while country 3's will decrease ($\downarrow C_3^{**}$) at $t = 2$. Since country 2 will be more productive at $t = 2$, more of its own good will be produced and consumed ($\uparrow Y_2^*$), while a smaller part of it will be consumed by 3 ($\downarrow Y_2^{**}$). Suppose now that there is an increase in λ_2, i. e. country 1 preference for country 2's produced good (Y_2) is stronger. Optimal consumption risk-sharing implies more of the extra country 2's produced good shipped towards country 1 ($\uparrow Y_2, \downarrow Y_2^*$), leading to an increase in time-2 country 1 consumption ($\uparrow C_2$) with a lower increase in country 2 consumption ($\downarrow C_2^*$). As the new productivity is realized in period 2, the continuation utility term in equation (1.2) due to the recursive preferences makes period 1 utility functions to be mainly driven by period 2's new allocations. Therefore, as time-2 country 1 consumption increases and the upwards response of time-2 country 2 consumption is leveled off, then time-1 country 1's recursive consumption marginal utility gets lower ($\uparrow \lambda_{u_1}^{\psi}$) while country 2's becomes smaller ($\downarrow \lambda_{u_1^*}^{\psi}$).

Lemma 2 (indirect effects)**.** *Let $\lambda_1, \lambda_2 \in (0,1)$, $\lambda_1 + \lambda_2 \leq 1$ and $\gamma > 1$. Then $\lambda_{s_{1,2}}^{\psi}$ and $\lambda_{s_{3,2}}^{\psi}$ are both decreasing functions of λ_2.*

Proof. If $\lambda_1, \lambda_2 \in (0,1)$ and $\lambda_1 + \lambda_2 \leq 1$, then, by Theorem 1, $\lambda_{u_1}^{\psi}$ and $\lambda_{u_1^*}^{\psi}$ are increasing and decreasing functions of λ_2, respectively. By equations (1.24) and (1.26), if $\gamma > 1$ then $\lambda_{s_{1,2}}^{\psi}$ and $\lambda_{s_{3,2}}^{\psi}$ are both decreasing functions of λ_2. □

Even though $\lambda_{u_1^*}^{\psi}$ is decreasing in λ_2 (by theorem 1), it is always positive. Therefore, by equation (1.26) as long as $\gamma > 1, \lambda_{s_{3,2}}^{\psi}$ will be positive and decreasing in λ_2. In other words, even though greater ψ will always ship resources from country 3 to country 2 due to a strong enough risk-sharing channel regardless of λ_2, such a flow of resources gets diminished as λ_2 increases, i. e. CCHH's risk-sharing motive between countries 2 and 3 is softened ($\downarrow \lambda_{s_{3,2}}^{\psi}$). Moreover, since by theorem 1 the absolute value of $\lambda_{s_{3,2}}^{\psi}$ is decreasing in λ_2 then if $\gamma < 1$ the BKK's productivity channel is also softened as λ_2 becomes higher.

On the other hand, from equation (1.24) resources from 2 towards 1 depend on how differently ψ affects time-1, country 1's utility $\left(\lambda_{u_1}^{\psi}\right)$ relative to time-1, country 2's utility $\left(\lambda_{u_1^*}^{\psi}\right)$. From (1.24) there will be no *indirect* trade effects from ψ towards or from country 1 as long as $\lambda_{u_1^*}^{\psi} = \lambda_{u_1}^{\psi}$, which is a particular case out of infinitely many possible cases. Hence, in general it should be expected to have resource flows going to or coming from country 1 when news of country 2 becoming more productive in the future than country 3 take place. In particular, if the risk-sharing (productivity) motive is strong enough, i. e. $\gamma > (<)1$, and $\lambda_{u_1^*}^{\psi} > \lambda_{u_1}^{\psi}$ then resources move from (to) 2 to (from) 1, $\lambda_{s_{1,2}}^{\psi} > (<)0$. When λ_2 increases resources will bounce back from 1 (2) towards $2(1), \downarrow (\uparrow)\lambda_{s_{1,2}}^{\psi}$, as $\lambda_{u_1}^{\psi}$ gets greater and λ_{u*}^{ψ} gets smaller. As a result, when $\gamma > (<)1$ time-1 country 1's trade-balance to output ratio $\left(\frac{NX_1}{X_1}\right)$ is increasing (decreasing) in λ_2 and that of country 2's $\left(\frac{NX_1^*}{Y_1^*}\right)$ is decreasing (increasing) in λ_2. To see this, Figures 1.1 and 1.2 show the adjustment of the Pseudo-Pareto weights and the trade-balance-to-output ratios to changes in both ψ and λ_2.

What is the required adjustment in time-1 allocations in order for them to be consistent with the response of $\frac{NX_1}{X_1}$ and $\frac{NX_1^*}{Y_1^*}$ to changes in ψ and λ_2? First, suppose that λ_2 is relatively *low*. With $\gamma > (<)1$ an increase in ψ will deliver the CCHH's risk-sharing (BKK's productivity) *direct* trade effects: country 2 consumption decreases (increases) while country 3 consumption increases (decreases), leading to a country 2 trade surplus (deficit) and country 3 trade deficit (surplus). Now, what does happen to country 1 consumption, C_1? Nothing should happen to C_1 if we were in a two-country setting in which there are no *indirect* trade effects. However, as we have shown in Theorem 1 and Lemma 2, in general in a three-country setting we should expect *indirect* trade effects from an increase in ψ, which in turn will affect C_1. In particular, by theorem 1 suppose that λ_2 is low enough so that $\lambda_{u_1}^{\psi'}$ is relatively small and $\lambda_{u_1^*}^{\psi'}$ is relatively high, such that $\lambda_{u_1}^{\psi'} < \lambda_{u_1^*}^{\psi'}$. Thus, from Lemma 2, if $\gamma > (<)1$ then we will have a trade deficit (surplus) in country

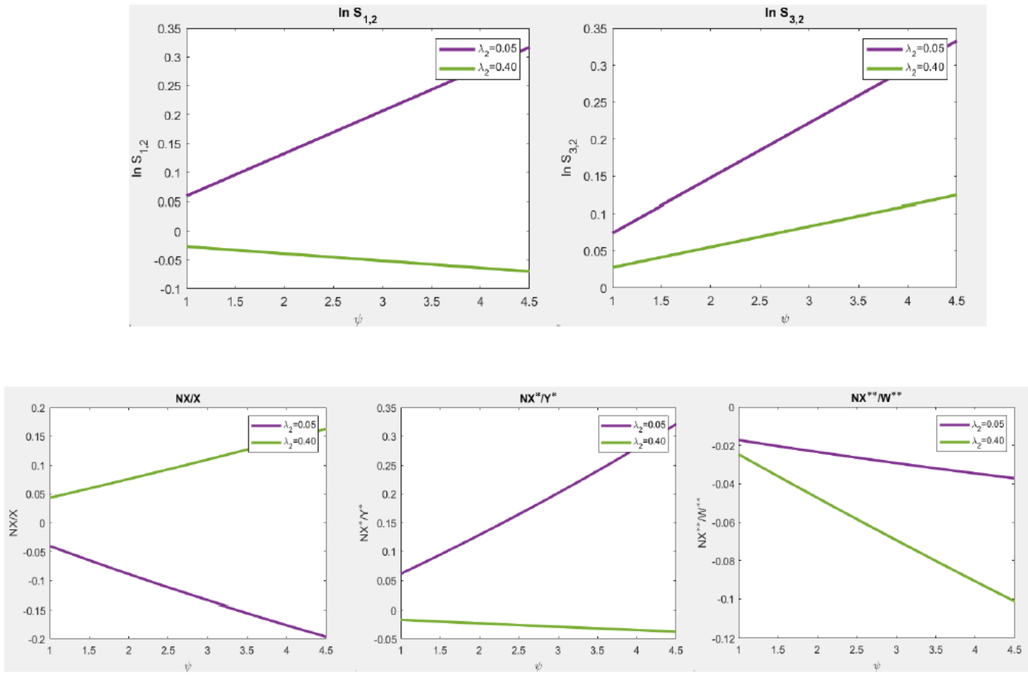

Figure 1.1: Lemma 2 with $\gamma > 1$: strong risk-sharing motive.

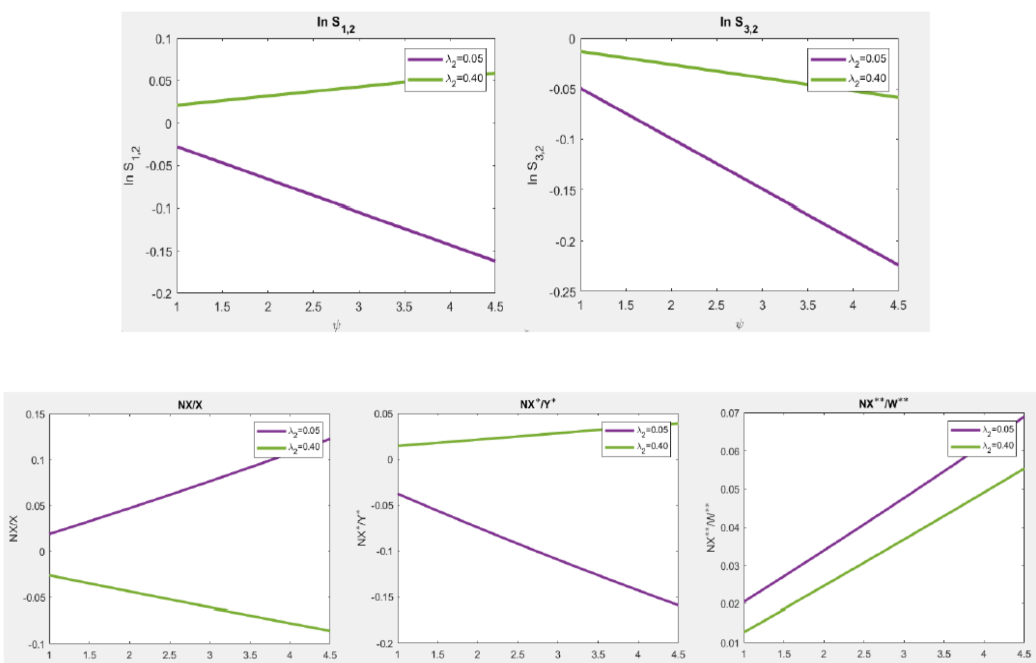

Figure 1.2: Lemma 2 with $\gamma < 1$: strong productivity motive.

1 that corresponds to an increase (decrease) in C_1. In other words, with a relatively *low* value of λ_2 we have the CCHH's risk-sharing (BKK's productivity) principle that makes C_1^{**} to increase (decrease) happening to C_1. Accordingly, when ψ increases there will be resources going not only from (to) country 2 to (from) country 3, but also from (to) country 2 to (from) country 1.

By contrast, suppose now that λ_2 is relatively *high*. By Theorem 1 $\lambda_{u_1^*}^{\psi}$ decreases, regardless of ψ. As a result, when ψ increases and CCHH's risk-sharing motive dominates ($\gamma > 1$), we will have resources still going from country 2 to country 3 ($S_{3,2} > 0$), but in lesser magnitude. Analogously, when BKK's productivity motive dominates ($\gamma < 1$), we will get resources still going from country 3 to country 2 ($S_{3.2} < 0$) but in lesser magnitude. Therefore, with higher λ_2 the *direct* trade effects from ψ are weaker. Moreover, Theorem 1 implies an increase in $\lambda_{u_1}^{\psi}$, for any given realization of ψ. Without loss of generality, suppose that λ_2 is high enough such that $\lambda_{u_1}^{\psi} > \lambda_{u_1^*}^{\psi}$. So, when CCHH's risk-sharing motive dominates ($\gamma > 1$) then we will have resources going back from country 1 to country 2 ($S_{1,2} < 0$) implying a decrease in C_1 and increase in C_1^*, so country 1's trade balance goes up while country 2's goes down. In addition, when BKK's productivity motive dominates ($\gamma < 1$) we will get resources going back from country 2 to country 1 ($S_{1,2} > 0$), implying an increase in C_1 and decrease in C_1^*, so country 1 runs a trade deficit while country 2 runs a trade surplus. Therefore, with higher λ_2 the *indirect* trade effects from ψ are stronger. To see this, Figures 1.3 and 1.4 show the adjustment of each country time-1 consumption to changes in both ψ and λ_2.

In summary, Table 1.1 shows the main theoretical predictions of the two-period, three country model with recursive preferences and risk-sharing motives due to productivity news shocks in country 2 relative to country 3, ψ, and changes in country 1's taste for country 2's produced good, λ_2.

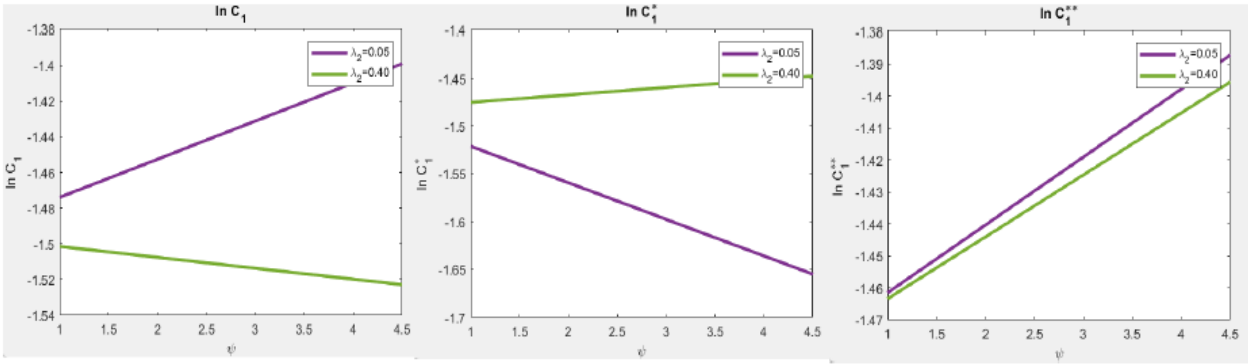

Figure 1.3: Lemma 2 with $\gamma > 1$: strong risk-sharing motive.

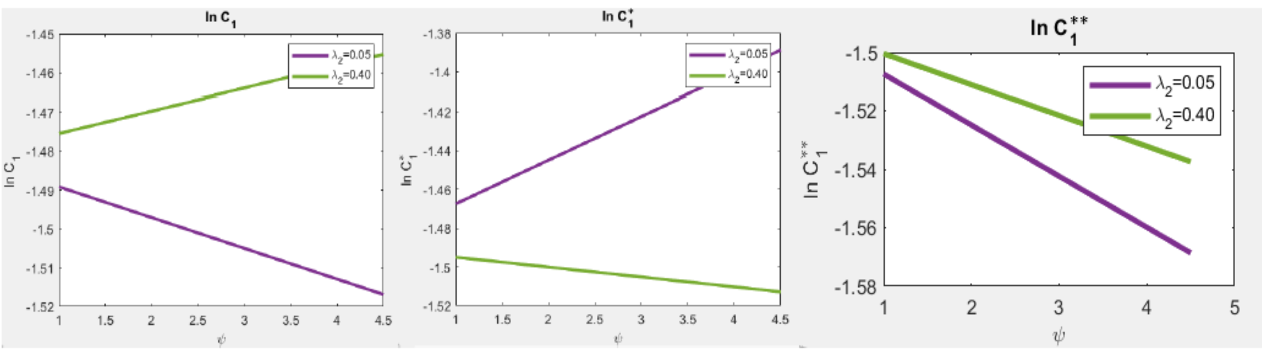

Figure 1.4: Lemma 2 with $\gamma < 1$: strong productivity motive.

			Consumption			Trade balance to output		
			C_1	C_1^*	C_1^{**}	$\frac{NX_1}{X_1}$	$\frac{NX_1^*}{Y_1^*}$	$\frac{NX_1^{**}}{W_1^{**}}$
Low λ_2								
	direct effects	$\gamma > 1$		↓	↑		↑	↓
		$\gamma < 1$		↑	↓		↓	↑
	indirect effects	$\gamma > 1$	↑	↓		↓	↑	
		$\gamma < 1$	↓	↑		↑	↓	
High λ_2								
	direct effects (softer)	$\gamma > 1$		↓	↑		↑	↓
		$\gamma < 1$		↑	↓		↓	↑
	indirect effects (stronger)	$\gamma > 1$	↓	↑		↑	↓	
		$\gamma < 1$	↑	↓		↓	↑	

Table 1.1: Model theoretical predictions

1.3 Empirical Exploration

I empirically explore the main theoretical predictions of the model presented in the last section. Specifically, suppose that country 1 represents the Emerging Market (EM) economies, country 2 the United States (US) and country 3 the Rest of Developed Market (RDM) economies. Let ψ be news of future productivity in US relative to RDM, and let θ be news of future productivity in EM relative to US and RDM:

$$\psi = \eta^{US} - \eta^{RDM}$$

$$\theta = \eta^{EM} - \eta^{US,RDM}$$

where η^i denotes news of future productivity in region $i \in \{US, RDM, EM\}$. Table 1.2 shows the theoretical predictions presented in Table 1.1 already updated with the country regions of interest and with a new column in the middle that considers the adjustment of private investment to relative productivity news shocks (θ, ψ). The inclusion of investment in the empirical exercise allows for the possibility to test if the *direct* and *indirect* trade effects from (θ, ψ) are transmitted through investment as they may do through consumption.

Specifically, I closely follow Colacito, Croce, et al. (2018) with the aim to identify unanticipated and anticipated[7] shocks to productivity growth in the developed market economies (G7) and emerging market economies (EM). Then, I use the identified shocks to assess their effects on the EM and US consumption, investment and trade-balance-to-output ratios.

[7] The term anticipated productivity shock will interchangeably be used with productivity news shock.

		Consumption			Investment			Trade balance to output		
		C_1^{EM}	C_1^{US}	C_1^{RDM}	I_1^{EM}	I_1^{US}	I_1^{RDM}	$\frac{NX_1^{EM}}{GDP_1^{EM}}$	$\frac{NX_1^{US}}{GDP_1^{US}}$	$\frac{NX_1^{RDM}}{GDP_1^{RDM}}$
Low λ_2										
direct effects	$\gamma > 1$		↓	↑		↓	↑		↑	↓
	$\gamma < 1$		↑	↓		↑	↓		↓	↑
indirect effects	$\gamma > 1$	↑	↓		↑	↓		↓	↑	
	$\gamma < 1$	↓	↑		↓	↑		↑	↓	
High λ_2										
direct effects (softer)	$\gamma > 1$		↓	↑		↓	↑		↑	↓
	$\gamma < 1$		↑	↓		↑	↓		↓	↑
indirect effects (stronger)	$\gamma > 1$	↓	↑		↓	↑		↑	↓	
	$\gamma < 1$	↑	↓		↑	↓		↓	↑	

Table 1.2: Model theoretical predictions

1.3.1 Identification of Productivity Growth Shocks

As in Colacito, Croce, et al. (2018), in order to identify the unanticipated and anticipated shocks to productivity growth, I use the Solow residual growth rate as a proxy of the growth rate of productivity, and regress it against the lagged price-dividend ratio:

$$\Delta a_t^i = \theta^i pd_{t-1}^i + \xi_t^i \tag{1.27}$$

for all $i = US, RDM, EM$, where ξ_t^i is the unanticipated component of the productivity growth. According to Baudry and Portier (2006), asset prices contain information about future productivity, therefore they can be considered as news shocks. Let $z_t^i = \theta^i pd_t^i$ be the anticipated component of productivity growth in region i. As in Colacito, Croce, et al. (2018), assume that this anticipated component, z_t^i, follows a first-order autoregressive process of the form:

$$z_t^i = \rho^i z_{t-1}^i + \eta_t^i \tag{1.28}$$

where η_t^i is the anticipated shock to region i's productivity growth. In a second stage, both the estimated unanticipated, ξ_t^i, and anticipated, η_t^i, shocks will be useful to estimate the EM and US trade-balance-to-output ratio regressions.

1.3.2 Data

The aggregates for regions RDM and EM are constructed as weighted averages according to the GDP weight of each country. The information for Net-Exports, real GDPs and Solow residuals were taken from the Penn World Tables (Feenstra, Inklaar, and Timmer, 2015). The price-to-dividend ratios for the G7 countries were taken from Colacito, Croce, et al. (2018). In turn, price-dividend ratios for the EM countries were constructed using Morgan Stanley Capital International (MSCI) variables, like the MSCI index for earnings and asset prices, and then I used the Campbell (2003)'s formulas to calculate the EM price-dividend ratios. The estimation period goes from 1973 to 2006 and its frequency is annual. The time period ends in 2006 in order to exclude the Great recession episode and to compare some empirical results to those found by Colacito, Croce, et al. (2018).

1.3.3 EM Trade-Balance Regressions

Once the unanticipated, ξ_t^i, and anticipated, η_t^i, shocks to productivity growth have been identified, then they will be used to estimate the following set of regressions:

$$\mathbf{Y}_t = \underbrace{\beta_\xi^{US,EM}\left(\xi_t^{US} - \xi_t^{EM}\right) + \beta_\eta^{US,EM}\left(\eta_t^{US} - \eta_t^{EM}\right)}_{\text{direct effects}}$$

$$+ \underbrace{\beta_\xi^{US,RDM}\left(\xi_t^{US} - \xi_t^{RDM}\right) + \beta_\eta^{US,RDM}\left(\eta_t^{US} - \eta_t^{RDM}\right)}_{\text{indirect effects}} + \gamma\mathbf{X}_t + \epsilon_t \quad (1.29)$$

where,

$$\mathbf{Y}_t = \Big\{\Delta\left(\frac{NX_t^{EM}}{GDP_t^{EM}}\right), \Delta\left(\frac{NX_t^{US}}{GDP_t^{US}}\right)$$
$$\Delta\ln C_t^{US} - \Delta\ln C_t^{RDM}, \Delta\ln C_t^{US} - \Delta\ln C_t^{EM}$$
$$\Delta\ln I_t^{US} - \Delta\ln I_t^{RDM}, \Delta\ln I_t^{US} - \Delta\ln I_t^{EM}\Big\}$$

The first set of explanatory variables in (1.29), $\left(\xi_t^{US} - \xi_t^{EM}\right)$ and $\left(\eta_t^{US} - \eta_t^{EM}\right)$, are, respectively, the unanticipated and anticipated productivity growth differentials between the US and the emerging market economies (EM). The effects of these two variables can be viewed as the *direct effects* of productivity growth differentials on the EM and US trade-balance-to-output ratios. The next set of regressors, $\left(\xi_t^{US} - \xi_t^{RDM}\right)$ and $\left(\eta_t^{US} - \eta_t^{RDM}\right)$, are, respectively, the unanticipated and anticipated productivity growth differentials among the G7 countries, i. e. between the US and RDM. In turn, the impact of these two variables can be thought of as the *indirect effects* of productivity growth differentials among the developed world on the EM's resource flows. Finally, $\mathbf{X}_t$ include control variables, like the international oil price (WTI) and the US monetary policy interest rate[8].

In order to correct for the potential generated regressors problem, regression equation (1.29) is jointly estimated with equations (1.27) and (1.28) through Generalized Method of

[8] According to Calvo and Mendoza (1996) and Ahmed and Zlate (2014), such kind of variables are strong determinants of capital flows in emerging market economies.

Moments (GMM). Also, I perform heteroskedasticity and autocorrelation robust (Newey-West) estimation approach. The associated moment conditions are specified in **appendix A**.

1.3.4 Empirical Findings

Four main findings can be drawn from the empirical analysis. First, Figure 1.5 shows the evolution over time of the US exports to EM as a proportion of US total exports towards EM and RDM. This can be interpreted as a measure of λ_2 since it captures the taste that EM has for the US produced goods, relative to the RDM's taste. It looks like the EM and RDM shares in US exports have increased and decreased, respectively, during the 1973-2006 period of time. This can be seen as the US produced good becoming increasingly preferred by EM and decreasingly preferred by RDM, respectively, over time. Such a trend leads us to empirically test the implied weakening of the CCHH's *direct* trade effects between US and RDM and the emergence of the *indirect* trade effects between developed and EM economies suggested by my theory.

In order to carry out such an empirical exploration, I start out by replicating the estimation results of CCHH, not only for their entire sample period 1973-2006, but also for the subperiods 1973-1991 and 1992-2006. The estimation period was divided in order to check if the CCHH's risk-sharing and BKK's productivity motives remain constant across time. The breaking point date was chosen for it to coincide to the changing time trend of my measure of λ_2 in Figure 1.5. Table 1.3 shows that the CCHH estimates during the whole period of time are a combination of the subperiods 1973-1991 and 1992-2006 estimates. Consistently with the two-period, three country model theoretical predictions of the previous section, all of the estimated coefficients corresponding the period 1973-1991 are greater in absolute value than the 1992-2006 estimates. This is the case not only when

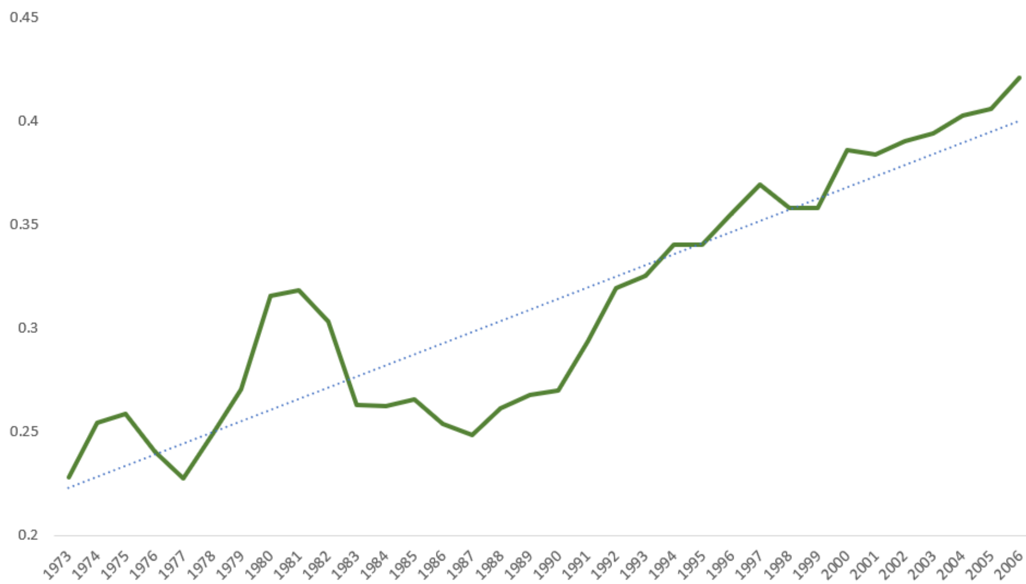

Figure 1.5: Empirical finding 1. λ_2 has increased over time.

$\Delta\left(\frac{NX_t^{US}}{GDP_t^{US}}\right)$ is the dependent variable, but also when US consumption and investment relative to RDM are the dependent variables. Indeed, my second empirical finding is that both the BKK (productivity motive) and CCHH (risk-sharing motive) estimated *direct* trade effects among developed markets have weakened over time, meaning that *direct* consumption risk-sharing and productivity motives become softer during the second half of the period.

As a third empirical finding, estimation results in Table 1.4 report the existence of *direct* trade effects between US and EM, and *indirect* trade effects between developed and EM economies in the 1992-2006 period of time. Even though the US-EM *direct* effects found in the data is a contribution to the rich-to-poor countries capital flows debate, it is not something new from a theoretical perspective since it can be explained by the two-country CCHH theoretical model. Nevertheless, the empirical findings on the *indirect* effects between developed and EM countries is not only a novelty from the empirical evidence point of view, but also supports my theoretical predictions. In particular, higher

Dependent variable	1973-2006		1973-1991		1992-2006	
	$\beta_\xi^{US,RDM}$	$\beta_\eta^{US,RDM}$	$\beta_\xi^{US,RDM}$	$\beta_\eta^{US,RDM}$	$\beta_\xi^{US,RDM}$	$\beta_\eta^{US,RDM}$
$\Delta\left(\frac{NX_t^{US}}{GDP_t^{US}}\right)$	-0.229^{***}	2.357^{**}	-0.211^{**}	3.027^{*}	-0.193^{***}	0.360
	(0.045)	(1.055)	(0.081)	(1.566)	(0.066)	(1.038)
$\Delta\ln C_t^{US} - \Delta\ln C_t^{RDM}$	0.930^{***}	-1.303^{***}	0.890^{***}	-2.000^{***}	0.608^{***}	0.903^{***}
	(0.040)	(0.504)	(0.050)	(0.444)	(0.022)	(0.201)
$\Delta\ln I_t^{US} - \Delta\ln I_t^{RDM}$	5.159^{***}	-24.788^{***}	5.575^{***}	-37.714^{***}	4.361^{***}	-1.365
	(0.171)	(4.344)	(0.130)	(7.156)	(0.130)	(0.958)

Table 1.3: Empirical finding 2. CCHH *direct effects* among developed markets have weakened over time.

unanticipated productivity growth of the US with respect to RDM deteriorates the EM's net exports, which means that global resources are directed to EM. By contrast, higher anticipated productivity growth of the US with respect to RDM improves the EM's net exports, so resources go away from EM. This result sheds light on the role that anticipated productivity growth gaps may have as a determinant of the global capital imbalances. since, according to the existing literature, a great part of the capital flows going from EM towards the US during the 1990s and 2000s have been attributed to i) unanticipated growth differentials between the US, RDM and EM and ii) differences in the development of the financial systems among such countries (Caballero, Farhi, and Gourinchas, 2008; Mendoza, Quadrini, and Ríos-Rull, 2009).

Furthermore, Table 1.5 reports the fourth empirical finding which reports the strengthening of the *indirect* trade effects between developed and EM countries during 1992-2006 relative to 1973-1991. The change in the signs and statistical significance are consistent with the theoretical predictions as the strengthening of the developed-EM *indirect* effects coincides with the increasing path of the EM's preference for US's produced good, relative

Dependent variable	US-EM		US-RDM		
	$\beta_{\xi}^{US,EM}$	$\beta_{\eta}^{US,EM}$	$\beta_{\xi}^{US,RDM}$	$\beta_{\eta}^{US,RDM}$	Adj. R^2
$\Delta\left(\frac{NX_t^{EM}}{GDP_t^{EM}}\right)$	0.327^{***}	-0.507^{***}	-0.017^{***}	0.683^{**}	0.460
	(0.038)	(0.143)	(0.005)	(0.058)	
$\Delta\left(\frac{NX_t^{US}}{GDP_t^{US}}\right)$	-0.049^{***}	0.066^{**}	-0.020^{***}	0.646^{***}	0.422
	(0.010)	(0.029)	(0.004)	(0.042)	
$\Delta \ln C_t^{US} - \Delta \ln C_t^{EM}$	0.781^{***}	-0.789^{***}	-0.594^{***}	-3.916^{***}	0.561
	(0.025)	(0.080)	(0.043)	(0.334)	
$\Delta \ln I_t^{US} - \Delta \ln I_t^{EM}$	4.296^{***}	7.961^{***}	-2.276^{***}	1.832^{**}	0.330
	(0.095)	(1.121)	(0.300)	(0.925)	

Table 1.4: Empirical finding 3. *Indirect* trade effects from and to EM due to ψ. *Direct* trade effects between US and EM due to θ.

Indirect effects	1973-1991		1992-2006	
	$\beta_{\xi}^{US,RDM}$	$\beta_{\eta}^{US,RDM}$	$\beta_{\xi}^{US,RDM}$	$\beta_{\eta}^{US,RDM}$
$\Delta\left(\frac{NX_t^{EM}}{GDP_t^{EM}}\right)$	0.191^{***}	-0.581	-0.024	2.427^{**}
	(0.046)	(0.531)	(0.061)	(1.016)

Table 1.5: Empirical finding 4. *Indirect* effects strenghthened over time.

to RDM.

In general, from all these findings it can be said that the empirical exploration supports the model theoretical predictions. So, the next step will involve the infinite horizon version of the two-period, three-country theoretical model of section 1.2 in order to rationalize the empirical evidence and characterize the global capital imbalances during 1992-2006.

1.4 Infinite-Horizon Model

With the aim of rationalizing the empirical findings of section 1.3, this section presents the infinite horizon version of the two-period model of section 1.2, which is an extension of the two-country CCHH model that includes a third economy. In particular, the environment consists of an infinite horizon, three country, three good, complete markets and frictionless economy á la Backus, Kehoe, and Kydland (1994) (BKK) with Epstein-Zin (EZ) preferences and unanticipated and anticipated productivity growth shocks for each country. The next subsections will describe the preferences, consumption bundles, productivity processes, aggregate resource constraints, optimality conditions and net-exports definitions.

1.4.1 Preferences and Consumption Bundles

Let $\{X_t, Y_t, W_t\}$, $\{X_t^*, Y_t^*, W_t^*\}$ and $\{X_t^{**}, Y_t^{**}, W_t^{**}\}$ be the consumption of goods X, Y and W in countries 1, 2 and 3, respectively. The consumption aggregates for the three countries can be written as:

$$C_t = X_t^{\lambda_1} \cdot Y_t^{\lambda_2} \cdot W_t^{(1-\lambda_1-\lambda_2)}, \quad C_t^* = X_t^{*\lambda_2} \cdot Y_t^{*\lambda_1} \cdot W_t^{*(1-\lambda_1-\lambda_2)}, \tag{1.30}$$

$$C_t^{**} = X_t^{**\lambda_2} \cdot Y_t^{**(1-\lambda_1-\lambda_2)} \cdot W_t^{**\lambda_1}.$$

I assume that country 1 produces X, country 2 produces Y and country 3 produces W, so $\lambda_1 \in (0, 1)$ can be viewed as the consumption home bias parameter. As in Colacito, Croce, et al. (2018), I use Greenwood, Hercowitz, and Huffman (1988) preferences (GHH) to capture the intratemporal trade-off between consumption and leisure. This is to deal with the Raffo (2008)'s insight that most of the net-exports movements should come from the imports quantities rather than from terms-of-trade adjustments for a BKK model to be consistent with the data. The GHH utility indices have functional forms:

$$\tilde{C}_t = C_t - \varphi N_t^{1+\frac{1}{f}}, \quad \tilde{C}_t^* = C_t^* - \varphi N_t^{*1+\frac{1}{f}}, \quad \tilde{C}_t^{**} = C_t^{**} - \varphi N_t^{**1+\frac{1}{f}},$$

where N_t, N_t^* and N_t^{**} denote hours worked in countries 1, 2 and 3, respectively, and $f > 0$ is the labor-consumption elasticity parameter. Let $\tilde{C}_t$, $\tilde{C}_t^*$ and $\tilde{C}_t^*$ be the three countries' corresponding consumption bundles, hence the utility function for country 1 has the following EZ form:

$$U_t = \left[(1-\beta) \cdot \tilde{C}_t^{1-1/\psi} + \beta E_t \left[U_{t+1}^{1-\gamma}\right]^{\frac{1-1/\psi}{1-\gamma}}\right]^{\frac{1}{1-1/\psi}}.$$

Utility functions of countries 2 and 3 can be written in an analogous way with the same parameter values and are denoted by U_t^* and U_t^{**}, respectively. The Stochastic Discount Factor (SDF) can written as

$$M_{t+1} = \beta \left(\frac{\tilde{C}_{t+1}}{\tilde{C}_t}\right)^{-\frac{1}{\psi}} \left(\frac{U_{t+1}}{E_t \left[U_{t+1}^{1-\gamma}\right]^{\frac{1}{1-\gamma}}}\right)^{\frac{1}{\psi}-\gamma}. \tag{1.31}$$

1.4.2 Productivity Growth

Exogenous productivity growth processes for the three countries resemble much of their empirical counterparts. They contain both the corresponding unanticipated and anticipated shocks components. Moreover, as it was found by Ballesteros-Ruiz, Rubio-Ramírez, and Pesavento (2022) in the data, I also assume that countries 1, 2 and 3's productivity levels, A_t, A_t^* and A_t^{**}, are cointegrated. Hence, the Vector Error Correction (VEC) system specification for the world productivity processes can be written as:

$$\Delta a_t = \mu + z_{t-1} + \tau_2 \cdot \log \frac{A^*_{t-1}}{A_{t-1}} + \xi_t, \quad z_t = \rho z_{t-1} + \eta_t$$
$$\Delta a^*_t = \mu^* + z^*_{t-1} - \tau_2 \cdot \log \frac{A^*_{t-1}}{A_{t-1}} - \tau_1 \cdot \log \frac{A^*_{t-1}}{A^{**}_{t-1}} + \xi^*_t, \quad z^*_t = \rho^* z^*_{t-1} + \eta^*_t$$
$$\Delta a^{**}_t = \mu^{**} + z^{**}_{t-1} + \tau_1 \cdot \log \frac{A^*_{t-1}}{A^{**}_{t-1}} + \xi^{**}_t, \quad z^{**}_t = \rho^{**} z^{**}_{t-1} + \eta^{**}_t$$

where ξ_t, ξ^*_t and ξ^{**}_t denote countries 1, 2 and 3 unanticipated productivity growth shocks, respectively, and η_t, η^*_t and η^{**}_t represent countries 1, 2 and 3 anticipated productivity shocks, respectively. Shocks are iid processes, where each one of them has zero mean and constant variance. Finally, parameters τ_1 and τ_2 determine the degree of cointegration between the productivity level processes. I assume that countries 1 and 3's productivity levels follow country 2's.

1.4.3 Aggregate Resource Constraints

Country 1's investment aggregate is the result of combining home and foreign investment goods:

$$G(I_{x,t}, I^*_{x,t}, I^{**}_{x,t}) = I^{\nu_1}_{x,t} \cdot I^{*\nu_2}_{x,t} \cdot I^{**(1-\nu_1-\nu_2)}_{x,t},$$

where $I_{x,t}$ is the country 1's own investment good and $I^*_{x,t}$ and $I^{**}_{x,t}$ are the foreign investment goods coming (imported) from countries 2 and 3, respectively, intended to produce the new country 1's capital stock that will be used to produce good X. Parameters $\nu_1, \nu_2 \in (0, 1)$ are the shares of countries 1 and 2's investment goods in country 1's investment aggregate. Similarly, investment aggregates in countries 2 and 3 are a combination of domestic and foreign investment goods:

$$G^*(I_{y,t}, I^*_{y,t}, I^{**}_{y,t}) = I^{\nu_2}_{y,t} \cdot I^{*\nu_1}_{y,t} \cdot I^{**(1-\nu_1-\nu_2)}_{y,t},$$

$$G^{**}(I_{w,t}, I^*_{w,t}, I^{**}_{w,t}) = I^{\nu_2}_{w,t} \cdot I^{*(1-\nu_1-\nu_2)}_{w,t} \cdot I^{**\nu_1}_{w,t}.$$

Note that, similar to λ_1, parameter ν_1 represents the degree of home investment good bias. Using the corresponding investment aggregates, each country builds up its own capital stock according to the following capital stock law of motions:

$$K_{t+1} = (1-\delta)\, K_t + e^{\omega_{t+1}} G_t(I_{x,t}, I^*_{x,t}, I^{**}_{x,t}) \tag{1.32}$$

$$K^*_{t+1} = (1-\delta)\, K^*_t + e^{\omega^*_{t+1}} G^*_t(I_{y,t}, I^*_{y,t}, I^{**}_{y,t}) \tag{1.33}$$

$$K^{**}_{t+1} = (1-\delta)\, K^{**}_t + e^{\omega^{**}_{t+1}} G^{**}_t(I_{w,t}, I^*_{w,t}, I^{**}_{w,t}) \tag{1.34}$$

where K_t, K^*_t and K^{**}_t denote countries 1, 2 and 3's capital stocks, respectively. I assume that each country has a common depreciation parameter, $\delta \in (0,1)$. Moreover:

$$\omega_{t+1} = \Delta a_{t+1} - \mu, \quad \omega^*_{t+1} = \Delta a^*_{t+1} - \mu^*, \quad \Delta\omega^{**}_{t+1} = a^{**}_{t+1} - \mu^{**}$$

denote countries 1, 2 and 3's investment-specific productivity growth shocks, respectively. Assuming constant resturns to scale on each country production technology, the three countries aggregate budget constraints are given by

$$X^T_t = K^\alpha_t \left(A_t N_t\right)^{1-\alpha} = X_t + X^*_t + X^{**}_t + I_{x,t} + I_{y,t} + I_{w,t} \tag{1.35}$$

$$Y^T_t = K^{*\alpha}_t \left(A^*_t N^*_t\right)^{1-\alpha} = Y_t + Y^*_t + Y^{**}_t + I^*_{x,t} + I^*_{y,t} + I^*_{w,t} \tag{1.36}$$

$$W^T_t = K^{**\alpha}_t \left(A^{**}_t N^{**}_t\right)^{1-\alpha} = W_t + W^*_t + W^{**}_t + I^{**}_{x,t} + I^{**}_{y,t} + I^{**}_{w,t}, \tag{1.37}$$

where X^T_t, Y^T_t and W^T_t represent countries 1, 2 and 3's real GDPs, respectively. Parameter α denotes the capital share on income, assumed to be the same across the three countries. Note that consumption and investment goods can be exchanged with no frictions in all contingent states.

1.4.4 Optimality Conditions

Let μ_1 and μ_2 be, respectively, the countries 1 and 2's utility Pareto weights in the world planner's welfare function. In this frictionless, complete markets world economy, the social planner chooses

$$\Big\{X_t, X_t^*, X_t^{**}, Y_t, Y_t^*, Y_t^{**}, W_t, W_t^*, W_t^{**}, N_t, N_t^*, N_t^{**}, K_t, K_t^*,$$
$$K_t^{**}, I_{x,t}, I_{y,t}, I_{w,t}, I_{x,t}^*, I_{y,t}^*, I_{w,t}^*, I_{x,t}^{**}, I_{y,t}^{**}, I_{w,t}^{**}\Big\}$$

in order to maximize

$$\mu_1 U_0 + \mu_2 U_0^* + (1 - \mu_1 - \mu_2) U_0^{**} \tag{1.38}$$

subject to sequences of constraint equations (1.32)-(1.37). Thus, the Lagrangean function can be written as

$$
\begin{aligned}
\mathcal{L} =& \mu_1 U_0 + \mu_2 U_0^* + (1-\mu_1-\mu_2) U_0^{**} \\
& + \dots \\
& + \lambda_{1,t} \left(F\left(A_t, K_t, N_t\right) - \left(X_t + X_t^* + X_t^{**} + I_{x,t} + I_{y,t} + I_{w,t}\right)\right) \\
& + \lambda_{2,t} \left(F\left(A_t^*, K_t^*, N_t^*\right) - \left(Y_t + Y_t^* + Y_t^{**} + I_{x,t}^* + I_{y,t}^* + I_{w,t}^*\right)\right) \\
& + \lambda_{5,t} \left(F\left(A_t^{**}, K_t^{**}, N_t^{**}\right) - \left(W_t + W_t^* + W_t^{**} + I_{x,t}^{**} + I_{y,t}^{**} + I_{w,t}^{**}\right)\right) \\
& + \lambda_{3,t} \left((1-\delta) K_{t-1} + e^{\omega_t} G\left(I_{x,t-1}, I_{x,t-1}^*, I_{x,t-1}^{**}\right) - K_t \right) \\
& + \lambda_{4,t} \left((1-\delta) K_{t-1}^* + e^{\omega_t^*} G^*\left(I_{y,t-1}, I_{y,t-1}^*, I_{y,t-1}^{**}\right) - K_t^* \right) \\
& + \lambda_{6,t} \left((1-\delta) K_{t-1}^{**} + e^{\omega_t^{**}} G^{**}\left(I_{w,t-1}, I_{w,t-1}^*, I_{w,t-1}^{**}\right) - K_t^{**} \right) \\
& + \dots
\end{aligned}
$$

Let $P_{k,t} = \frac{\lambda_{3,t}}{\lambda_{1,t}}$, $P_{k,t}^* = \frac{\lambda_{4,t}}{\lambda_{2,t}}$ and $P_{k,t}^{**} = \frac{\lambda_{6,t}}{\lambda_{5,t}}$ be, respectively, the countries 1, 2 and 3's cummulative-prices of capital in local units[9]. Furthermore, let $Q_{k,t} \equiv E_t\left[M_{t+1}^x P_{k,t+1}\right]$, $Q_{k,t}^* \equiv E_t\left[M_{t+1}^y P_{k,t+1}^*\right]$ and $Q_{k,t}^{**} \equiv E_t\left[M_{t+1}^w P_{k,t+1}^{**}\right]$ denote, respectively, the countries 1, 2 and 3's ex-dividend prices of capital in local units. Hence, the social planner's maximization First Order Necessary Conditions (FONC) with respect to capital can be expressed as

$$
\begin{aligned}
K_t: &\quad P_{k,t} = F_{k,t} + (1-\delta) Q_{k,t} \\
K_t^*: &\quad P_{k,t}^* = F_{k^*,t} + (1-\delta) Q_{k,t}^* \\
K_t^{**}: &\quad P_{k,t}^{**} = F_{k^{**},t} + (1-\delta) Q_{k,t}^{**},
\end{aligned}
$$

where $F_{k,t}$, $F_{k^*,t}$ and $F_{k^{**},t}$ represent each country's marginal productivity of capital in period t. Each country's domestic investment choice is given by

[9] These variables are measured in local units of the corresponding country, i. e. they are in X, Y and W units for countries 1, 2 and 3, respectively.

$$I_{x,t}: \quad \frac{1}{\nu_1}\frac{I_{x,t}}{G_t} = E_t\left[M^X_{t+1}\left(\alpha\frac{X^T_{t+1}}{K_{t+1}} + (1-\delta)\,Q_{k,t+1}\right)e^{\omega_{t+1}}\right] \tag{1.39}$$

$$I^*_{y,t}: \quad \frac{1}{\nu_1}\frac{I^*_{y,t}}{G^*_t} = E_t\left[M^Y_{t+1}\left(\alpha\frac{Y^T_{t+1}}{K^*_{t+1}} + (1-\delta)\,Q^*_{k,t+1}\right)e^{\omega^*_{t+1}}\right] \tag{1.40}$$

$$I^{**}_{w,t}: \quad \frac{1}{\nu_1}\frac{I^{**}_{w,t}}{G^{**}_t} = E_t\left[M^W_{t+1}\left(\alpha\frac{W^T_{t+1}}{K^{**}_{t+1}} + (1-\delta)\,Q^{**}_{k,t+1}\right)e^{\omega^{**}_{t+1}}\right], \tag{1.41}$$

where the terms M^X_{t+1}, M^Y_{t+1} and M^W_{t+1} represent the Stochastic Discount Factors (SDF) in each country's local units which in turn can be expressed as

$$M^X_{t+1} = \frac{X_t}{X_{t+1}}\frac{C_{t+1}}{C_t}M_{t+1} = \frac{\lambda_{1,t+1}}{\lambda_{1,t}}, \quad M^Y_{t+1} = \frac{Y^*_t}{Y^*_{t+1}}\frac{C^*_{t+1}}{C^*_t}M^*_{t+1} = \frac{\lambda_{2,t+1}}{\lambda_{2,t}},$$

$$M^W_{t+1} = \frac{W^{**}_t}{W^{**}_{t+1}}\frac{C^{**}_{t+1}}{C^{**}_t}M_{t+1} = \frac{\lambda_{5,t+1}}{\lambda_{5,t}}.$$

The Left Hand Side in optimality conditions (1.39)-(1.41) accounts for the marginal cost of each country domestic investment at time t. On the other hand, the corresponding Right Hand side in such equations is associated to the expected present value of future profits of invested capital by each country in producing their own good.

Note that $P_t = \frac{\lambda_{2,t}}{\lambda_{1,t}}$ measures the terms of trade between countries 2 and 1, i. e. the number of country 1's goods (X) needed to get one unit of country 2's good (Y). Similarly, $P^*_t = \frac{\lambda_{1,t}}{\lambda_{5,t}}$ measures the terms of trade between countries 1 and 3, and $P^{**}_t = \frac{\lambda_{2,t}}{\lambda_{5,t}}$ measures the terms of trade between countries 2 and 3. Moreover, rearranging the Lagrange multipliers associated to the terms of trade measures gives the following country 1's terms-of-trade expression:

$$P_{t+1} = \frac{P^{**}_{t+1}}{P^*_{t+1}}, \tag{1.42}$$

which says that country 1's terms of trade are a non-linear function of countries 2 and 3's terms of trade. Using equation (1.42), foreign investment goods imported by country 1 from countries 2 and 3, intended to produce country 1's new capital which in turn produces good X, are determined by the following optimality conditions:

$$I_{x,t}^{*}: \quad \frac{1}{\nu_2}\frac{I_{x,t}^{*}}{G_t} = E_t\left[\frac{M_{t+1}^{Y}\left(\alpha\frac{X_{t+1}^{T}}{K_{t+1}} + (1-\delta)\,Q_{k,t+1}\right)}{P_{t+1}}e^{\omega_{t+1}}\right] \tag{1.43}$$

$$I_{x,t}^{**}: \quad \frac{1}{(1-\nu_1-\nu_2)}\frac{I_{x,t}^{**}}{G_t} = E_t\left[M_{t+1}^{W}\left(\alpha\frac{X_{t+1}^{T}}{K_{t+1}} + (1-\delta)\,Q_{k,t+1}\right)\frac{P_{t+1}^{**}}{P_{t+1}}e^{\omega_{t+1}}\right] \tag{1.44}$$

Analogously, foreign investment goods imported by country 2 from countries 1 and 3 in order to produce good Y, are given by expressions:

$$I_{y,t}: \quad \frac{1}{\nu_2}\frac{I_{y,t}}{G_t^{*}} = E_t\left[M_{t+1}^{X}\left(\alpha\frac{Y_{t+1}^{T}}{K_{t+1}^{*}} + (1-\delta)\,Q_{k,t+1}^{*}\right)P_{t+1}e^{\omega_{t+1}^{*}}\right] \tag{1.45}$$

$$I_{y,t}^{**}: \quad \frac{1}{(1-\nu_1-\nu_2)}\frac{I_{y,t}^{**}}{G_t^{*}} = E_t\left[M_{t+1}^{W}\left(\alpha\frac{Y_{t+1}^{T}}{K_{t+1}^{*}} + (1-\delta)\,Q_{k,t+1}^{*}\right)P_{t+1}P_{t+1}^{*}e^{\omega_{t+1}^{*}}\right] \tag{1.46}$$

Finally, foreign investment goods imported by country 3 from countries 1 and 2 in order to produce good W, are determined by:

$$I_{w,t}: \quad \frac{1}{\nu_2}\frac{I_{w,t}}{G_t^{**}} = E_t\left[M_{t+1}^{X}\left(\alpha\frac{W_{t+1}^{T}}{K_{t+1}^{**}} + (1-\delta)\,Q_{k,t+1}^{**}\right)\frac{P_{t+1}}{P_{t+1}^{**}}e^{\omega_{t+1}^{**}}\right] \tag{1.47}$$

$$I^*_{w,t}: \quad \frac{1}{(1-\nu_1-\nu_2)} \frac{I^*_{w,t}}{G^{**}_t} = E_t \left[\frac{M^Y_{t+1}\left(\alpha \frac{W^T_{t+1}}{K^{**}_{t+1}} + (1-\delta)\, Q^{**}_{k,t+1}\right)}{P_{t+1} P^*_{t+1}} e^{\omega^{**}_{t+1}} \right] \tag{1.48}$$

Note that the terms of trade enter into the no-arbitrage conditions that determine the amounts of foreign investment towards each country. This means that the international allocation of investment, i. e. international capital flows, is in part governed by the exchange-rate risk of the three countries at the same time.

The FONC with respect to the consumption goods give the optimality conditions for international consumption risk-sharing:

$$\lambda_{1,t} = \mu_1 UMA_{x,t} = \mu_2 UMA_{x^*,t} = (1-\mu_1-\mu_2) UMA_{x^{**},t}$$

$$\lambda_{2,t} = \mu_1 UMA_{y,t} = \mu_2 UMA_{y^*,t} = (1-\mu_1-\mu_2) UMA_{y^{**},t}$$

$$\lambda_{5,t} = \mu_1 UMA_{w,t} = \mu_2 UMA_{w^*,t} = (1-\mu_1-\mu_2) UMA_{w^{**},t},$$

where $UMA_{x,t}$ represents the consumption good X_t marginal utility. Note that consumption risk-sharing takes place with respect to consumption of the same good across different countries, rather than with respect to the entire consumption bundle.

Moreover, labor supply optimality conditions can be written as:

$$\widetilde{C}_{N,t} = -F_{N,t} C_{X,t}$$

$$\widetilde{C}^*_{N^*,t} = -F^*_{N^*,t} C^*_{Y^*,t}$$

$$\widetilde{C}^{**}_{N^{**},t} = -F^{**}_{N^{**},t} C^{**}_{W^{**},t},$$

where $\widetilde{C}_{N,t}$ is the partial derivative of country 1's GHH utility index with respect to labor, N_t, $F_{N,t}$ is the labor marginal productivity and $C_{X,t}$ is the partial derivative of country 1's consumption aggregate with respect to X_t.

1.4.5 Net-Exports

Each country's total net exports is the sum of consumption and investment goods net exports. Specifically, country 1's net exports is defined by the following set of equations:

$$NXC_t = X_t^* + X_t^{**} - \left[P_t Y_t + \left(\frac{1}{P_t^*}\right) W_t\right] \tag{1.49}$$

$$NXI_t = I_{y,t} + I_{w,t} - \left[P_t I_{x,t}^* + \left(\frac{1}{P_t^*}\right) I_{x,t}^{**}\right] \tag{1.50}$$

$$\frac{NX_t}{X_t^T} = \frac{NXC_t + NXI_t}{X_t^T}, \tag{1.51}$$

where NXC_t, NXI_t and $\frac{NX_t}{X_t^T}$ denote the country 1's consumption good net exports, investment good net exports and total trade-balance-to-output ratio, respectively. Similarly, country 2's net exports equations are given by:

$$NXC_t^* = Y_t + Y_t^{**} - \left[\left(\frac{1}{P_t}\right) X_t^* + \left(\frac{1}{P_t^{**}}\right) W_t^*\right] \tag{1.52}$$

$$NXI_t^* = I_{x,t}^* + I_{w,t}^* - \left[\left(\frac{1}{P_t}\right) I_{y,t} + \left(\frac{1}{P_t^{**}}\right) I_{y,t}^{**}\right] \tag{1.53}$$

$$\frac{NX_t^*}{Y_t^T} = \frac{NXC_t^* + NXI_t^*}{Y_t^T} \tag{1.54}$$

where NXC_t^*, NXI_t^* and $\frac{NX_t^*}{Y_t^T}$ denote the country 2's consumption good net exports,

Productivity	Avge. growth (μ) 0.018	Long-run shock corr. (ρ_{lr}) 0	Short-run shock corr. (ρ_{sr}) 0
Technology	Capital share (α) 0.3	Home inv. bias (ν_1) 0.7	Foreign inv. share (ν_2) 0.15
Preferences	IES (ψ) 1.2	sub. disc. factor (β) 0.97	home bias ($\lambda_1 = \nu_1$) 0.7

Table 1.6: Parameter values

investment good net exports and total trade-balance-to-output ratio, respectively. Finally, country 3's net exports definitions can be written as follows:

$$NXC_t^{**} = W_t + W_t^* - \left[P_t^* X_t^{**} + P_t^{**} Y_t^{**}\right] \tag{1.55}$$

$$NXI_t^{**} = I_{x,t}^{**} + I_{y,t}^{**} - \left[P_t^* I_{w,t} + P_t^{**} I_{w,t}^*\right] \tag{1.56}$$

$$\frac{NX_t^{**}}{W_t^T} = \frac{NXC_t^{**} + NXI_t^{**}}{W_t^T} \tag{1.57}$$

where NXC_t^{**}, NXI_t^{**} and $\frac{NX_t^{**}}{W_t^T}$ denote the country 3's consumption good net exports, investment good net exports and total trade-balance-to-output ratio, respectively.

Even though contemporaneous utility indices are GHH in order to deal with Raffo (2008)'s insight, it is worth noting that foreign investment optimality conditions (1.43)-(1.48) take the terms of trade into account in order to determine the international capital flows, which makes the terms of trade adjustment very important in order to determine the trade balance quantities.

1.4.6 Calibration and Solution Method

For the sake of comparison, the benchmark model calibration closely follows Colacito, Croce, et al. (2018). Table 1.6 shows the parameter values used for the benchmark economy. The same steady state annual productivity growth rate is assumed for the three countries ($\mu = \mu^{*} = \mu^{**} = 1.8\%$), which is the average annual output per-capita growth rate for the US in the period 1929-2006, according to the (US) BEA data. For simplicity, I set the correlations between the unanticipated and anticipated productivity growth shocks across countries equal to zero ($\rho_{lr} = \rho_{sr} = 0$). On the other hand, capital contribution to output and annual capital depreciation are set to $\alpha = 0.3$ consistent with BKK. Moreover, home bias parameters are set to be equal between consumption and investment.

Benchmark preferences structural parameters are taken from Colacito, Croce, et al. (2018). Specifically, the labor elasticity with respect to consumption is set to $f = 1.5$, which is standard in the literature. Finally, due to comparison purposes I take the Intertemporal Elasticity of Substitution (IES) and subjective discount factor parameter values from Colacito, Croce, et al. (2018), i. e. $IES_1 = IES_2 = IES_3 = 1.2$ and $\beta = 0.97$.

The model is solved using perturbation methods. In particular, third order approximation to the policy functions is performed using Dynare. This is done for the SDFs utility continuation values to take into account the high persistence of the anticipated productivity shocks and to capture the time-varying future utility variance that is present in the recursive preferences.

1.5 Infinite-Horizon Model Results

This section aims to provide shocks to the model in order to realize whether it is able to rationalize the empirical findings drawn from section 1.3 and to what extend it is able to produce reasonable moments of key variables with respect to the data. Then, I discuss how the simulation results of the infinite-horizon model can help explain the evolution of the global capital imbalances over the period 1992-2006.

1.5.1 Model performance and simulation results

I start by describing the estimation process of the remaining parameters of the infinite-horizon model. The goal is to use GMM techniques in order to estimate the model structural parameters, $\left\{\gamma^{US}\left(=\gamma^{RDM}\right), \gamma^{EM}, \tau_1, \tau_2, \delta, \rho, \rho^*\left(=\rho^{**}\right), \lambda_2\right\}$, in order to match some key, targeted empirical moments:

$$\left\{\beta_\xi^{US,EM}, \beta_\eta^{US,EM}, \beta_\xi^{US,RDM}, \beta_\eta^{US,RDM}, \frac{std\left(\Delta C_t\right)}{\Delta X_t^T}, \frac{std\left(\Delta I_t\right)}{\Delta X_t^T}, \frac{std\left(\Delta C_t^*\right)}{\Delta Y_t^T}, \frac{std\left(\Delta C_t^{**}\right)}{\Delta W_t^T}\right\}$$

.

Table 1.7 shows the GMM estimates of the remaining model structural parameters. Regarding the production technology parameters, the US-RDM implied cointegration adjustment parameter, $\tau_1 = 0.005$, is close to the 0.007 estimated by Rabanal, Rubio-Ramírez, and Tuesta (2011). Moreover, the US-EM implied cointegration adjustment parameter ($\tau_2 = 0.0172$) turned out to be close to the 0.0167 estimated by Ballesteros-Ruiz, Rubio-Ramírez, and Pesavento (2022). The estimated value of δ is 0.031, while the persistence parameter of the anticipated productivity growth process is $\rho = 0.99$ for EM

Parameters	γ^{US}	γ^{EM}	τ_1	τ_2	δ	ρ	ρ^*	λ_2
Values	22.22	6.54	0.005	0.0172	0.031	0.99	0.70	0.29

Table 1.7: Estimated parameter values.

and $\rho^* = \rho^{**} = 0.70$ for the US and RDM[10]. Such a high estimated value of ρ is in line with Aguiar and Gopinath (2007) as it is a known fact that the permanent component of productivity is more persistent in EM than in developed markets. Additionally, the estimated value of $\rho^* = \rho^{**}$ is close to the estimated one by CCHH.

With respect to the preference parameters, the GMM estimates show that the risk aversion parameter turns to be greater in developed markets than in EM, which is consistent with recent estimates in the literature (l'Haridon and Vieider, 2019). Additionally, the estimated value of λ_2, the EM preference for US produced good relative to RDM's, turned out to be 0.29, which is close to its upper limit 0.30.

The estimated value of λ_2 being close to its upper limit is important because it confirms that it is needed a relatively high value of λ_2 in order to generate theoretical model estimates of equation (1.29) that are the closest to the ones obtained in the data. Such a comparison of empirical estimates are presented in Table 1.8, where the dependent variables are $\Delta\left(\frac{NX_t^{EM}}{GDP_t^{EM}}\right)$ and $\Delta\left(\frac{NX_t^{US}}{GDP_t^{US}}\right)$, i. e. my measures of EM and US capital flows, respectively. From Table 1.8 it can be observed that the quantitative model generate regression estimates that are reasonably close to the data estimates. In addition to that, Figure 1.6 shows how such coefficients change when λ_2 is lower than 0.29. In particular, it can be seen that the higher is λ_2 the weaker the *direct* trade effects between US and RDM (charts at the bottom) and the stronger the *indirect* trade effects between the

[10] I follow Colacito, Croce, et al. (2018) in assuming $\rho^* = \rho^{**}$.

Dependent variable		*US-EM*		*US-RDM*		
		$\beta_\xi^{US,EM}$	$\beta_\eta^{US,EM}$	$\beta_\xi^{US,RDM}$	$\beta_\eta^{US,RDM}$	Adj. R^2
$\Delta\left(\frac{NX_t^{EM}}{GDP_t^{EM}}\right)$	Data	0.327^{***}	-0.507^{***}	-0.017^{***}	0.683^{**}	0.460
		(0.038)	(0.143)	(0.005)	(0.058)	
	Model	0.114^{***}	-0.953^{***}	-0.042^{***}	0.446^{***}	0.850
		(0.001)	(0.022)	(0.002)	(0.004)	
$\Delta\left(\frac{NX_t^{US}}{GDP_t^{US}}\right)$	Data	-0.049^{***}	0.066^{**}	-0.020^{***}	0.646^{***}	0.422
		(0.010)	(0.029)	(0.004)	(0.042)	
	Model	-0.082^{***}	0.512^{***}	-0.024^{***}	0.177^{***}	0.733
		(0.001)	(0.019)	(0.001)	(0.004)	

Table 1.8: Theoretical vs econometric GMM estimated parameters.

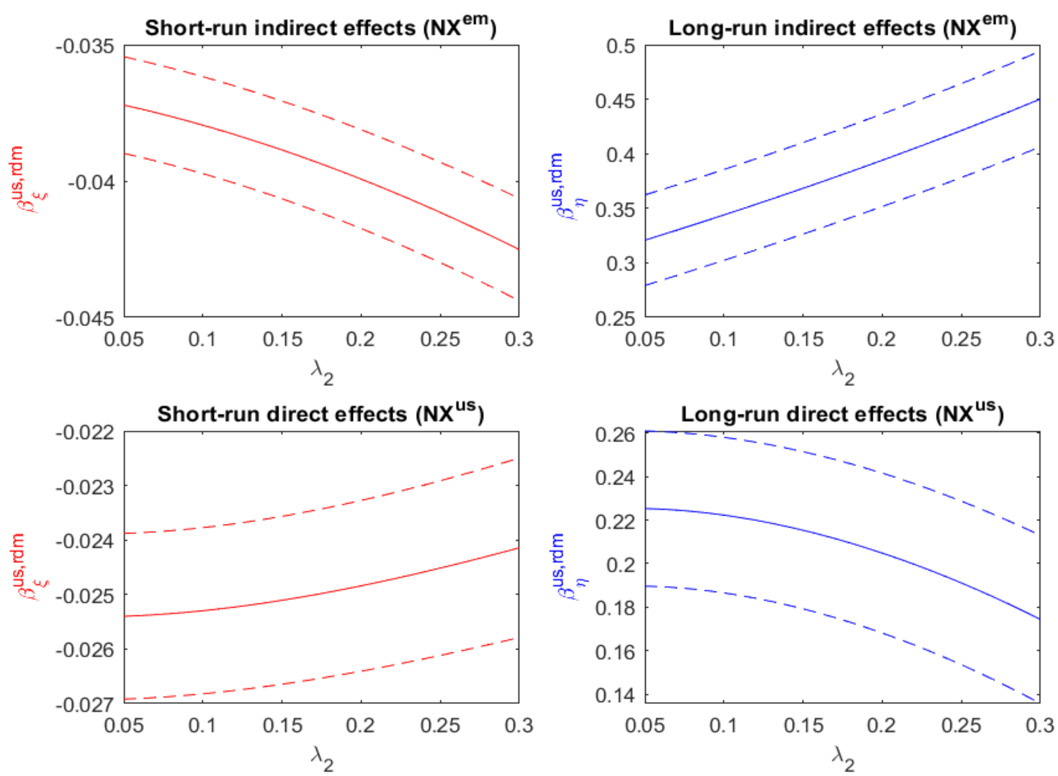

Figure 1.6: *Direct* and *indirect* trade effects due to a 1 unit increase in ψ as function of λ_2.

developed markets and EM (charts at the top) due to an increase in ψ. This means that the quantitative model is able to rationalize the empirical findings in section 1.3, in which the analysis of the data showed that the US-RDM *direct* effects and developed markets-EM *indirect* effects from changes in *relative* productivity news in the US relative to RDM, ψ, got weaker and stronger, respectively, as my measure of λ_2 in the data increased over time.

Regarding the model's quantitative performance, Table 1.9 shows the domestic moments generated by the quantitative theoretical model. While doing an good job in generating correlations and consumption, investment and labor relative volatilities to output in each country, it is worth noting that the model does pretty well in replicating the countercyclicality of the trade-balance-to-output ratios. In particular, the three-country model does better than CCHH as the former is able to generate an even closer correlation between the trade-balance-to-output ratio and output for the US.

In the international front, while my model does an acceptable job in replicating the consumption, investment and output international cross-country correlations, just like CCHH does, the three-country model does great in generating trade-balance-to-output ratio cross-country relative volatilities. In particular, Table 1.10 shows that the volatility of the EM's trade-balance-to-output ratio relative to the US's generated by the quantitative model is 1.52 while in the data it is 1.53. Analogously, the volatility of the RDM's trade-balance-to-output ratio relative to the US's generated by the quantitative model is 0.77 while in the data it is 0.80. This is important since it means that the quantitative model is able to capture the second moments of the international capital flows among EM, RDM and US, i. e. the global capital imbalances.

Domestic moments	Vol. relative to GDP			Corr.(Δ., Δ.)		
EM	ΔN_t	ΔC_t	ΔI_t	(C_t, I_t)	(C_t, N_t)	$\left(\frac{NX_t}{X_t^T}, X_t^T\right)$
Data	0.48	1.01	4.15	0.11	-0.06	-0.26
Colacito, et al. (2018)	-	-	-	-	-	-
3-country model	0.30	0.80	7.16	-0.43	-0.42	-0.27
US	ΔN_t^*	ΔC_t^*	ΔI_t^*	(C_t^*, I_t^*)	(C_t^*, N_t^*)	$\left(\frac{NX_t^*}{Y_t^T}, Y_t^T\right)$
Data	0.74	0.80	3.18	0.61	0.65	-0.39
Colacito, et al. (2018)	0.49	0.61	2.53	0.83	0.84	-0.24
3-country model	0.39	0.86	3.84	0.15	0.01	-0.36
RDM	ΔN_t^{**}	ΔC_t^{**}	ΔI_t^{**}	(C_t^{**}, I_t^{**})	(C_t^{**}, N_t^{**})	$\left(\frac{NX_t^{**}}{W_t^T}, W_t^T\right)$
Data	0.44	0.80	2.36	0.45	0.28	-0.43
Colacito, et al. (2018)	-	-	-	-	-	-
3-country model	0.57	0.55	4.38	0.56	0.65	-0.49

Table 1.9: Model domestic moments.

International moments	Corr.(Δ., Δ.)		Relative volatilities
US, EM	$(X_t^T, Y_t^T) - (C_t, C_t^*)$	(I_t, I_t^*)	$\frac{std\left[\Delta\left(\frac{NX_t}{X_t^T}\right)\right]}{std\left[\Delta\left(\frac{NX_t^*}{Y_t^T}\right)\right]}$
Data	0.19	0.09	1.53
Colacito, et al. (2018)	-	-	-
3-country model	0.02	-0.78	1.52
US, RDM	$(W_t^T, Y_t^T) - (C_t^{**}, C_t^*)$	(I_t^{**}, I_t^*)	$\frac{std\left[\Delta\left(\frac{NX_t^{**}}{W_t^T}\right)\right]}{std\left[\Delta\left(\frac{NX_t^*}{Y_t^T}\right)\right]}$
Data	0.04	0.21	0.77
Colacito, et al. (2018)	-0.20	0.27	-
3-country model	-0.54	0.26	0.80

Table 1.10: Model international moments.

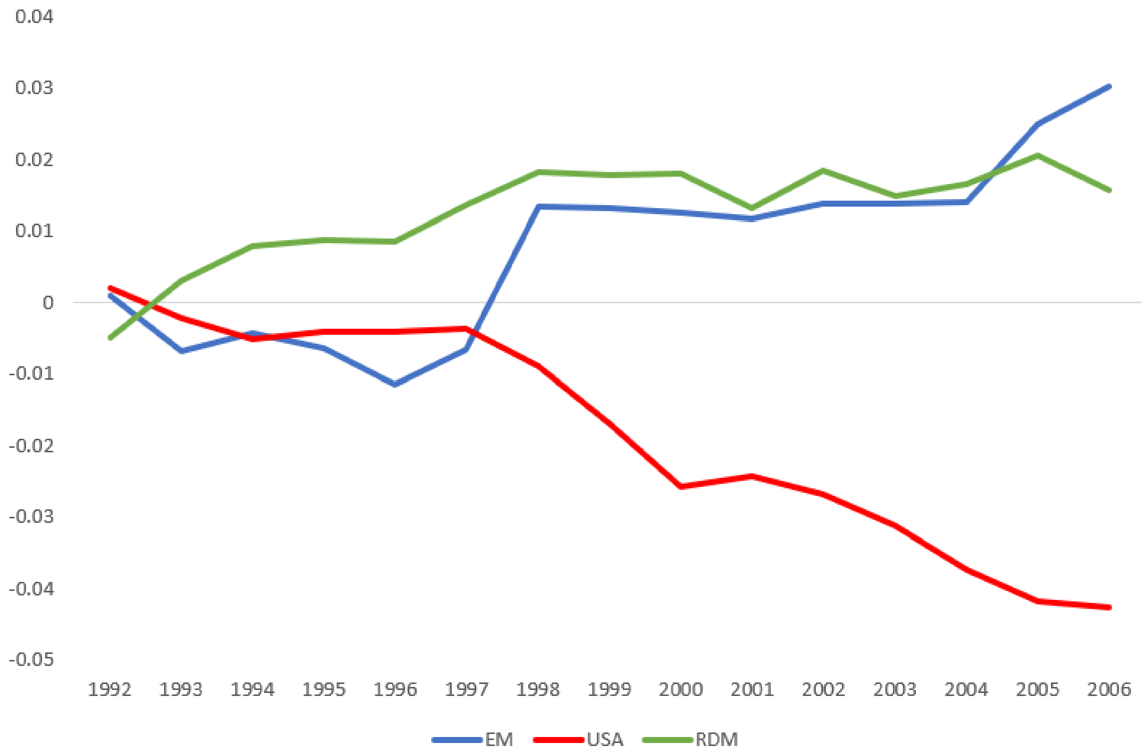

Figure 1.7: Global capital imbalances during 1992-2006.

1.5.2 Discussion

The results of the infinite-horizon model and empirical evidence help explain the dynamics of the global capital imbalances during the 1992-2006 time period. In particular, Figure 1.7 shows the evolution of the trade-balance-to-output ratio of EM, US and RDM over time. At least three patterns of capital flows can be observed: i) stagnation of the RDM trade surplus; ii) increasing trade deficit in the US; and iii) increasing trade surplus in EM.

What the current theories of capital flows and global imbalances can say about facts i), ii) and iii)? Since we have observed a higher Total Factor Productivity (TFP) growth in US relative to RDM during 1992-2006, then there should have been a BKK-like strong productivity motive that generated an increasing surplus in RDM and a deficit in US. However, such a story doesn't meet the reality since the RDM trade surplus has stagnated during such a period of time.

What does CCHH have to say about the patterns observed in the global capital flows dynamics? Persistently higher TFP growth in US relative to RDM can be viewed as an anticipated relative productivity growth shock in favor of the US. In such a case, there should have been a huge, dominating risk-sharing motive over the productivity motive, so we should have observed a trade surplus in the US with a deficit in RDM. Nevertheles, since we observe the opposite behavior in Figure 1.7, then I hypothesize that there may be something else behind the observed pattern of global capital flows.

Moreover, one of the most accepted theories so far about the behavior of global imbalances during 1992-2006 is Caballero, Farhi, and Gourinchas (2008)'s. They argue that the even higher TFP growth rate in EM relative to US observed during 1992-2006 plus the fact that EM has had lower financial development than the US, altogether encouraged EM individuals to invest their excess of savings in the US, generating an even further trade deficit in the US accompanied by an increasing surplus in EM. That is true according to facts ii) and iii). Nevertheless, their theory doesn't explain fact i) which is the stagnation over time of the RDM trade surplus. Hence, again, there should be something else behind the whole story of the global capital imbalances.

Capital flows patterns shown in Figure 1.7 may comprehensively be explained through the theoretical and empirical results found in the last sections, approach that I will call *the EZ way* onwards. One advantage of *the EZ way* is that it doesn't rely on the presence of financial frictions in order to generate the outcomes seen in Figure 1.7. First, the fact that the RDM trade surplus has stagnated can be understood as the result of a weaker BKK productivity motive between US and RDM because of the sustained increase in

λ_2 observed during 1992-2006. Second, the increase over time in λ_2 strengthened the *indirect* trade effects between EM and developed economies, such that the persistent higher TFP growth in US relative to RDM should have translated into capital flowing from EM towards US, as reflected in the growing trade surplus in EM and deficit in US. Third, the observed persistently higher TFP growth in EM relative to US can be thought of an anticipated productivity growth shock in favor of EM, or a fall in θ. From section 1.3 we have seen that the EM-US *direct* trade effects from productivity news shocks θ should have taken resources from EM towards US due to a strong CCHH's risk-sharing motive, thereby widening the trade surplus in EM and deficit in US.

In sum, contrary to previous approaches like BKK, CCHH and Caballero, Farhi, and Gourinchas (2008), *the EZ way* offers a more comprehensive explanation to the evolution of the global capital imbalances during 1992-2006. According to *the EZ way*, such a behavior is the the result of the adjustment of global capital flows to unanticipated and anticipated *relative* productivity growth shocks among EM, US and RDM, (θ, ψ), charaterized by changes in *direct* and *indirect* trade effects due to the secular increase of λ_2 over time.

1.6 Conclusions

I perform a theoretical and empirical exploration of the possibility of *direct* and *indirect* trade effects from unanticipated and anticipated *relative* productivity growth shocks in a three-country framework, in order to understand the behavior of the global capital imbalances during 1992-2006.

From a theoretical point of view, I analyze international capital flows in a three-country, complete markets economy with Epstein-Zin (EZ) preferences and productivity news shocks. This is done with the aim to highlight the intuition behind the resulting *direct* and *indirect* trade effects that come from *relative* productivity news shocks that take place among the three countries. The main theoretical contribution consists in showing the existence of *indirect* trade effects from *relative* productivity shocks, i. e. capital flows going to or coming from Emerging Market (EM) economies as an optimal adjustment to productivity improvement news in the United States (US) relative to the Rest of Developed (RDM) market economies.

In the empirical front, I report four main findings that support the theoretical testable predictions implied by the model. First, I show that the EM and RDM shares in US exports have increased and decreased, respectively, during the 1973-2006 period of time. This can be seen as the US produced good becoming increasingly preferred by EM and decreasingly preferred by RDM, respectively, over time. Second, I consider such a trend as an exogenous event and then show that, once the CCHH estimation sample is broken down into two consecutive time frames (1973-1991 and 1992-2006), it coincides with the weakening of the CCHH's *direct* trade effects between US and RDM and the emergence of the *indirect* trade effects between developed and EM economies suggested by my theory. Third, I report the existence of *direct* trade effects between US and EM, and *indirect* trade effects between developed and EM economies in the 1992-2006 period of time. In particular, the *indirect* trade effects consist on higher unanticipated productivity growth of the US with respect to RDM deteriorating the EM's net exports, which means that resources are directed to EMs. By contrast, higher anticipated productivity growth of the US with respect to RDM improves the EM's net exports, so resources go away from EMs. Fourth, I report the strengthening of the *indirect* trade effects between developed and EM countries during 1992-2006 relative to 1973-1991.

The theoretical predictions and empirical evidence help explain the dynamics of the global capital imbalances during the 1992-2006 period of time. This event has been characterized by i) stagnation of the RDM trade surplus; ii) increasing trade deficit in the US; and iii) increasing trade surplus in EM. Specifically, such capital flow patterns may comprehensively be explained through what I call the *the EZ way* approach. One advantage of this approach is that it doesn't rely on the presence of financial frictions in order to understand the targeted capital flows behavior. First, the fact that the RDM trade surplus has stagnated can be understood as the result of a weaker BKK productivity motive between US and RDM because of the sustained increase in the EM preference for the US's produced goods relative to RDM's (λ_2) observed during 1992-2006. Second, the increase over time in λ_2 strengthened the *indirect* trade effects between EM and developed economies, such that the observed persistent higher TFP growth in US relative to RDM should have translated into capital flowing from EM towards US, as reflected in the growing trade surplus in the former and deficit in the latter countries. Third, the observed persistently higher TFP growth in EM relative to US could have been translated into an anticipated productivity growth shock in favor of EM, or a fall in θ. From the empirical findings, we see that the EM-US *direct* trade effects from productivity news shocks θ should have taken resources from EM towards US due to a strong CCHH's risk-sharing motive, thereby widening the trade surplus in EM and deficit in US.

In sum, the overall results suggest that the behavior decribed by i), ii) and iii) is an adjustment of global capital flows to unanticipated and anticipated *relative* productivity growth shocks among EM, US and RDM, charaterized by changes in *direct* and *indirect* trade effects due to the secular increase in λ_2 over time.

Related future research should be focused on different directions. One potential way is the incorporation of capital controls and terms-of-trade taxes to study their effects on international capital flows and welfare. On the other hand, since there are both *direct* and *indirect* trade effects of unanticipated and anticipated shocks to productivity growth differentials on EM capital flows, the implications on EM sovereign default risk would also be an important task to assess. Another potential research way, would be the incorporation of financial frictions into the three country model in order to study global capital imbalances in the times during and after the 2008 global financial crisis.

Appendix A

Additional GMM Estimation Details

In this section I present details about the Generalized Method of Moments (GMM) estimation, like the moment conditions and additional results with respect to the productivity growth dynamics.

Specifically, the parameters

$$\left\{\theta^{US}, \theta^{RDM}, \theta^{EM}, \rho^{US}, \rho^{RDM}, \rho^{EM}, \beta_{\xi}^{US,EM}, \beta_{\eta}^{US,EM}, \beta_{\xi}^{US,RDM}, \beta_{\eta}^{US,RDM}, \gamma\right\}$$

are estimated using the following orthogonality conditions

$$\frac{1}{T}\sum_{t=1}^{T}\left(\Delta a_t^{US} - \theta^{US}\cdot pd_{t-1}^{US}\right)\cdot pd_{t-1}^{US} = 0 \tag{A.1}$$

$$\frac{1}{T}\sum_{t=1}^{T}\left(\Delta a_t^{RDM} - \theta^{RDM}\cdot pd_{t-1}^{RDM}\right)\cdot pd_{t-1}^{RDM} = 0 \tag{A.2}$$

$$\frac{1}{T}\sum_{t=1}^{T}\left(\Delta a_t^{EM} - \theta^{EM}\cdot pd_{t-1}^{EM}\right)\cdot pd_{t-1}^{EM} = 0 \tag{A.3}$$

$$\frac{1}{T}\sum_{t=1}^{T}\left(\theta^{US}\cdot pd_{t}^{US}-\rho^{US}\cdot\theta^{US}\cdot pd_{t-1}^{US}\right)\cdot\theta^{US}\cdot pd_{t-1}^{US}=0 \tag{A.4}$$

$$\frac{1}{T}\sum_{t=1}^{T}\left(\theta^{RDM}\cdot pd_{t}^{RDM}-\rho^{RDM}\cdot\theta^{RDM}\cdot pd_{t-1}^{RDM}\right)\cdot\theta^{RDM}\cdot pd_{t-1}^{RDM}=0 \tag{A.5}$$

$$\frac{1}{T}\sum_{t=1}^{T}\left(\theta^{EM}\cdot pd_{t}^{EM}-\rho^{EM}\cdot\theta^{EM}\cdot pd_{t-1}^{EM}\right)\cdot\theta^{EM}\cdot pd_{t-1}^{EM}=0 \tag{A.6}$$

$$\frac{1}{T}\sum_{t=1}^{T}\Bigg[\Delta\left(\frac{NX_t^{EM}}{GDP_t^{EM}}\right)-\beta_{\xi}^{US,EM}\left(\xi_t^{US}-\xi_t^{EM}\right)-\beta_{\eta}^{US,EM}\left(\eta_t^{US}-\eta_t^{EM}\right)-\beta_{\xi}^{US,RDM}\left(\xi_t^{US}-\xi_t^{RDM}\right)$$
$$-\beta_{\eta}^{US,RDM}\left(\eta_t^{US}-\eta_t^{RDM}\right)-\gamma(ILF)_t\Bigg]\left(\xi_t^{US}-\xi_t^{EM}\right)=0 \tag{A.7}$$

$$\frac{1}{T}\sum_{t=1}^{T}\Bigg[\Delta\left(\frac{NX_t^{EM}}{GDP_t^{EM}}\right)-\beta_{\xi}^{US,EM}\left(\xi_t^{US}-\xi_t^{EM}\right)-\beta_{\eta}^{US,EM}\left(\eta_t^{US}-\eta_t^{EM}\right)-\beta_{\xi}^{US,RDM}\left(\xi_t^{US}-\xi_t^{RDM}\right)$$
$$-\beta_{\eta}^{US,RDM}\left(\eta_t^{US}-\eta_t^{RDM}\right)-\gamma(ILF)_t\Bigg]\left(\eta_t^{US}-\eta_t^{EM}\right)=0 \tag{A.8}$$

$$\frac{1}{T}\sum_{t=1}^{T}\Bigg[\Delta\left(\frac{NX_t^{EM}}{GDP_t^{EM}}\right)-\beta_{\xi}^{US,EM}\left(\xi_t^{US}-\xi_t^{EM}\right)-\beta_{\eta}^{US,EM}\left(\eta_t^{US}-\eta_t^{EM}\right)-\beta_{\xi}^{US,RDM}\left(\xi_t^{US}-\xi_t^{RDM}\right)$$
$$-\beta_{\eta}^{US,RDM}\left(\eta_t^{US}-\eta_t^{RDM}\right)-\gamma(ILF)_t\Bigg]\left(\xi_t^{US}-\xi_t^{RDM}\right)=0 \tag{A.9}$$

$$\frac{1}{T}\sum_{t=1}^{T}\Bigg[\Delta\left(\frac{NX_t^{EM}}{GDP_t^{EM}}\right)-\beta_\xi^{US,EM}\left(\xi_t^{US}-\xi_t^{EM}\right)-\beta_\eta^{US,EM}\left(\eta_t^{US}-\eta_t^{EM}\right)-\beta_\xi^{US,RDM}\left(\xi_t^{US}-\xi_t^{RDM}\right)$$

$$-\beta_\eta^{US,RDM}\left(\eta_t^{US}-\eta_t^{RDM}\right)-\gamma(ILF)_t\Bigg]\left(\eta_t^{US}-\eta_t^{RDM}\right)=0 \quad \text{(A.10)}$$

$$\frac{1}{T}\sum_{t=1}^{T}\Bigg[\Delta\left(\frac{NX_t^{EM}}{GDP_t^{EM}}\right)-\beta_\xi^{US,EM}\left(\xi_t^{US}-\xi_t^{EM}\right)-\beta_\eta^{US,EM}\left(\eta_t^{US}-\eta_t^{EM}\right)-\beta_\xi^{US,RDM}\left(\xi_t^{US}-\xi_t^{RDM}\right)$$

$$-\beta_\eta^{US,RDM}\left(\eta_t^{US}-\eta_t^{RDM}\right)-\gamma(ILF)_t\Bigg](ILF)_t=0 \quad \text{(A.11)}$$

As in Colacito, Croce, Ho and Howard (2018), I assume $\theta^{US} = \theta^{RDM} = \theta^{US}$ and $\rho^{US} = \rho^{RDM} = \rho^{US}$. Table 1.4 shows the results of the productivity growth estimated parameters for different control specifications.

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