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The Origins of Global Imbalances

Jan Brůha and Jiří Podpiera*

Abstract

In this paper we study the endogenous response of unequally developed regions to a drop in investment and trade costs in a general equilibrium model. The response is characterized by a rise in foreign direct investment in the underdeveloped region and increased consumption in the developed one, leading to trade imbalances between the regions. We hereby propose that declining investment and trade costs could have caused this century's global imbalances.

JEL Codes: F12, F21, F34, F36.
Keywords: Economic development, foreign direct investment, global imbalances, multi-country general-equilibrium model.

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Nontechnical Summary

We present a hypothesis according to which the recent global imbalances originate from the drop in trade and investment costs back in 1980s. As a matter of fact, countries that are involved in the world current account surplus (especially China) are direct investment receivers. After China adopted new macroeconomic policies, being a strong pull factor for direct investment, direct investment accounted for 80 per cent of the entire direct investment into emerging Asia in 1990–2002 and for 40 per cent of the total direct investment inflow into the emerging market economies. Thus, the drop in investment costs could be seen as a spark, or origin, for the improvements in the Chinese trade balance leading to its current account surplus. The size of the current account surplus is nevertheless also a result of other policies, especially the exchange rate and structurally-induced saving policies. However, these policies only accelerated the dynamics and were not the originating force.

In order to verify the hypothesis, we constructed a model of three unequally developed regions with export self-selectivity and direct and portfolio investment linkages. A decline in investment costs (including barriers to entry) and trade costs in the less developed region activates push factors (search for yield) and leads to direct inflow into the less developed region. The endogenous mechanism for trade self-selectiveness of companies causes foreign-owned companies to opt to export part of their production (due to their higher productivity). This mechanism increases exports and lowers imports and produces a trade surplus in the less developed country. The developed regions share the trade deficit depending on their relative productivity growth.

A calibration of the model to the U.S., Europe, and emerging Asia during 1985 to 2005 confirmed the hypothesis that the current account imbalances in the 2000s could have been caused by the drop in investment and trade costs. Since such a development is a natural consequence of convergence of the less developed region, the current account imbalances could be judged as sustainable up to the size related to the single factor of trade and investment costs.

1. Introduction

The already large and growing literature on current global imbalances identifies the following roots of their formation: (1) macroeconomic policies and technological structural breaks in the U.S. (Bems et al., 2007; Roubini and Setser, 2005) leading to excess liquidity and a housing boom; (2) a global savings glut (Bernanke, 2005) partly due to inadequate provision of health and social insurance in emerging Asia; (3) a world shortage of financial assets (Caballero et al., 2006) or differences in the quality of assets across regions (Mendoza et al., 2007) leading to increased demand for U.S. assets (the share of U.S. assets in the financial wealth of the rest of the world tripled over a decade: from 6–7% in the early 1990s to 17–18% at the beginning of the 2000s); and (4) exchange rate policy in emerging Asia (Ahearne et al. (2007), Obstfeld and Rogoff (2005)) leading to foreign reserves accumulation in Asia and distortions in international trade competitiveness.

However, in our view, while these factors did play an important role in deepening the imbalances, they count rather as secondary factors, since they were present long before the start of the current episode of global imbalances (such as the high propensity to save in Asia or the sound financial system in the U.S.). Macroeconomic policies no doubt played a role, but the current episode of imbalances seems to be much more resilient to the standard adjustment mechanism (exchange rate changes) that worked well in the previous episode in the 1980s. This leads us to search for more fundamental and structural changes that could have triggered today's global imbalances. In our view, and that of some other authors – see Dooley et al. (2004), the primary factors underlying this century's global imbalances are global integration forces represented by a decline in investment and trade costs between developed and developing world regions.

The current episode of global imbalances is distinct from the previous ones in some particularly important aspects. In contrast to the imbalances in the 1980s, when equally developed and financially relatively independent, at least from the point of view of foreign direct investment, world regions were involved (the U.S., Europe, and Japan), the current episode involves mainly the U.S. and emerging Asia. As of 2007, the U.S. current account deficit accounts for 80% of the world current account deficit – countries that record current account deficits. China plus Japan and the oil exporting countries plus Russia meanwhile account for 40% and 50% of the world current account surplus, respectively. Thus, it involves unequally developed and the fastest growing world regions (by respective regional standards) with tight portfolio and foreign direct investment linkages. For instance, in 2002–2006, China reported 9.9% vs. 8.0% in emerging Asia, Russia recorded 6.4% vs. 5.3% in Central and Eastern Europe, and the U.S. grew by 2.9% compared to 2.5% in the advanced countries.

China and, in fact, a part of emerging Asia introduced 'new policies' only after the 1980s. Following its Maoist policies of the 1960–1970s, China opened itself up to rapid science and technology development. During 1990–2002, China attracted 80% of the total FDI inflow into emerging Asia countries and accounted for 40% of the total FDI inflow into emerging market economies. In contrast to China, other countries with large shares of FDI inflows, such as Mexico (10%), Brazil (10%), and countries in Central and Eastern Europe (10%), were driven by privatization. The search for exploiting 'capabilities' – a combination of cheap labor and technological advantage, as Sutton (2007) puts it, resulted in a massive inflow of foreign direct investment from developed countries, led in particular by the U.S. Continuously declining duties and transportation costs provided additional momentum for the region's development. Between 1980 and 2001, total trade costs (duties and transportation costs) fell from 11 to 5% of the customs value – see Baier, Bergstrand (2001). Similarly, Gust et al. (2006) report that, since the late 1980s, tariffs had fallen by 3% in developed countries and by 10% in developing countries.

In order to investigate whether a fall in investment and trade costs between unequally developed world regions could trigger macroeconomic adjustments similar to the current global imbalances, we develop a three-region general equilibrium model. In particular, we apply the two-country framework of Ghironi, Melitz (2005), extended by Brůha, Podpiera (2007), which by construction allows for simulation of endogenous effects from investment and trade cost declines, to a three-region setting. A decline in investment costs (including barriers to entry) and trade costs in the less developed region activates push factors (search for yield) and leads to FDI inflow into the region. The endogenous mechanism for trade self-selectiveness of companies causes foreign-owned companies to opt to export part of their production (due to their higher productivity) . This mechanism increases exports and lowers imports and produces a trade surplus in the less developed country. The developed regions share the trade deficit depending on their relative productivity growth. Our modeling framework can thus be viewed as a model with trade and cross-border asset ownership, such as by Caballero et al. (2006), enriched by heterogeneous firms and investment and trade costs.

In our exercise we compare two steady states, i.e., before and after the drop in investment and trade costs, of two relatively equally developed regions (the U.S., and the Eurozone and Japan), where total factor productivity is higher in the U.S. than in the Eurozone and Japan, and one underdeveloped region (emerging Asia, where the total factor productivity is initially low). We find that the endogenous mechanisms act in an intuitive direction. The developed fast-growing country would invest via foreign direct investment in the underdeveloped region, while it would increase its consumption, leading to the current global trade imbalances between these regions. This could explain the world development after the 1980s, when the U.S. invested in the emerging Asia and its own growth was driven by consumption, while the source of growth in emerging Asia was net exports. As for the slower-growing developed region (the Eurozone and Japan), its direct investment in emerging Asia was significant, but, due to slow growth of consumption, the imbalances were very moderate.

The slow-growth developed countries experience less trade imbalances than the fast-growing developed countries from a financial and world trade liberalization perspective (world production, input, and product market integration). From the policy implications point of view, to the extent world integration stands behind the global trade imbalances, the imbalances are natural convergence symptoms after liberalization of investment and trade that will eventually lead to more balanced economic development across world regions. Our findings thus support the argument pursued by Richardson (1995) about trade liberalization reducing inequality.

In the remainder of this paper, we first present the three-region model, and then calibrate it. We then describe the results of our simulations and summarize our major findings in the conclusion.

2. Model

The model is a discrete-time perfect-foresight dynamic general equilibrium model. It consists of three regions. Region U is the U.S., region A is the emerging Asian countries and region E is the Eurozone and Japan. The model is a multi-regional version of the model by Ghironi, Melitz (2005) and Brůha, Podpiera (2007).

2.1 Households

Each region is populated by a representative competitive household that has recursive preferences over discounted stochastic streams of period utilities. The period utilities are derived from region i's final goods consumption C^i. Labor is an immobile factor and is supplied inelastically. We normalize the labor supply in each region to unity. The labor-market clearing condition (see section 2.3) then determines the real wage $\mathbb{W}^i$.

The intertemporal utility function:

$$\mho_t = \sum_{\tau \geq 0} \beta^\tau u(C^i_{t+\tau}),$$

where $0 < \beta < 1$, and u is the increasing and concave momentary function, then determines the intertemporal pricing kernel:

$$\mathcal{K}^\tau_{it} = \beta^\tau u'(C^i_{t+\tau})/u'(C^i_t).$$

Households can invest in the following two types of instruments:

- internationally traded real bonds (denominated in the currency of – say – region U); we denote by B_{ti} the bond holdings of household i at time t; the real interest rate (in the currency of U) is denoted as r^U;
- stocks of domestic and foreign firms; we denote by n^{ij}_t the number of firms located in region i and owned by household j.

Households face quadratic adjustment costs when investing in either type of asset. The adjustment costs are denominated in the asset currency.

The household budget constraint reads as

$$\eta^{Ui}_t B_{it} = (1+r^U_{t-1})\eta^{Ui}_t B_{it-1} + (\mathbb{W}^i_t - C^i_t) + \sum_j \left[\eta^{ji}_t \left(n^{ji}_t \widetilde{\mathbb{P}}^{ji}_t - \frac{\Psi_{ji}}{2}\left(\nu^{ji}_t\right)^2\right)\right] - \eta^{Ui}_t \frac{\Psi_B}{2} B^2_{it} + \mathcal{T}^i_t, \tag{2.1}$$

where η^{ij}_t is the real exchange rate between currencies i and j, C^i_t is the real consumption of household i, $\widetilde{\mathbb{P}}^{ij}_t$ is the expected real profit of an (i, j) firm[1] (profits and costs are denominated in the currency of the firm's location), n^{ij}_t is the stock of (i, j) firms, ν^{ij}_t are new entrants, Ψ_B and Ψ_{ij} are the adjustment cost parameters related to investment in bonds and new firms, respectively, and $\mathcal{T}^i_t$ are lump-sum payments of all adjustment costs to household i.

Using the definition of the pricing kernel, the asset portfolio held by household i satisfies:

$$\nu^{ji}_t = \frac{1}{\Psi_{ji}} \left[\sum_{\tau \geq 0} (1-\delta)^\tau \mathcal{K}^\tau_{it} \eta^{ji}_{t+\tau} \widetilde{\mathbb{P}}^{ji}_{t+\tau}\right], \tag{2.2}$$

[1] Henceforth, to economize on notation we will use the following terminology: a firm located in region i and owned by household j will be referred to as an (i, j) firm.

and

$$B_{it} = \frac{1}{\Psi_B}\left[\frac{\eta^{Ui}_{t+1}}{\eta^{Ui}_{t}}\mathcal{K}^1_{it}(1+r^U_t)-1\right]. \tag{2.3}$$

The dynamics of the number of firms are given as:

$$n^{ij}_t = (1-\delta)n^{ij}_{t-1} + \nu^{ij}_t.$$

2.2 Firms

In region i there is a large number of (i,j) firms. Firms differ ex post by total factor productivity: upon entry, they draw a shock z from a distribution $G(z)$. This shock determines the idiosyncratic part of the firm's productivity. At the end of each period, there is an exogenous probability that a firm is hit by an exit shock δ, which is assumed to be independent of aggregate as well as individual states. Hit firms shut down.

The only production factor is labor. Productivity has two components: (a) an idiosyncratic component z_l, which is i.i.d. across firms and which follows distribution $G(z)$ introduced above, and (b) a common component Z_t. The total factor productivity Z^j_t pertains to the ownerships and depends on the calendar time and not on the time of firm entry (the time of entry is henceforth called *vintage*) or the location.

We thus assume that the final output of firm l owned by household j is given as: $q_{lt} = z_l Z^j_t \ell_t$, where ℓ_t is labor hired. Labor is a variable input which can be hired on a period-by-period basis. Let p_{lt} denote the price of a good produced by firm l. We further assume that prices are denominated in the currency of the market of sale.

Firms located in region i may sell products to market k only if special costs are sunk. These costs are paid on a period-by-period basis and are denoted as c^{ijk}.

Let $\mathbb{P}^{ij}_{lt}$ denote the t-period real operating profit of an (i,j) firm. The real profit is given as follows:

$$\mathbb{P}^{ij}_{lt} = \left[\mathbf{1}^{iji}_{lt}\kappa^{iji}_{lt}\frac{p_{lt}}{P^i_t} + \sum_{k\neq i}\mathbf{1}^{ijk}_{lt}\kappa^{ijk}_{lt}\frac{\eta^{ki}_t}{1+\mathbf{t}^{ik}}\frac{p^{k*}_{lt}}{P^k_t}\right] Z^j_t z_l \ell_{lt} - \mathbb{W}^i_t \ell_{lt} - \sum_k \mathbf{1}^{ij}_{kt} c^{ijk},$$

where $0 \leq \kappa^{ijk}_{lt} \leq 1$ is the share of product q_{lt} sold in market k, and $\mathbf{t}^{ik} \geq 0$ represents unit iceberg exporting costs for exporting from region i to region k, $\mathbf{1}^{ijk}_{lt}$ is the indicator of whether an (i,j) firm with productivity z_l exports to market k, and $\mathbb{W}^i_t$ is the real wage prevailing in region i. We set $\mathbf{t}^{ii} = 0$ and it must hold that $\forall l,t$: $\sum_k \mathbf{1}^{ijk}_{lt}\kappa^{ijk}_{lt} = 1$.

We assume that the firm's manager maximizes the expected stream of discounted profits. The discounting respects the ownerships. Thus, the value of the profit stream of an (i,j) firm of vintage t and enjoying the idiosyncratic productivity level z_l is:

$$V^{ij}_t(z_l) = \max_{\{\ell_t\},\{\mathbf{1}^{ij}_{kt}\}} \sum_{\tau\geq 0}^{\infty}(1-\delta)^\tau \mathcal{K}^\tau_{jt}\eta^{ij}_{t+\tau}\mathbb{P}^{ij}_{lt+\tau}. \tag{2.4}$$

The ex-ante expected profit (which by the law of large numbers and perfect foresight is also the ex-post average profit) of an (i, j) firm is given as $\widetilde{\mathbb{P}}_t^{ij} = \int \mathbb{P}_{lt}^{ij} \, \mathrm{d}G(l)$. Similarly, for the value of a new entrant, we define: $\widetilde{V}_t^{ij} \equiv \int V_t^{ij}(z_l) \, \mathrm{d}G(l)$.

Thus, the sequencing starts with households' decisions about the number of new entrants in each region, i.e., household j determines the number of (i, j) new entrants given by (2.2)[2]. The fixed firm setup cost is paid. Then each new entrant draws a productivity level from the distribution G. Then labor demand, export decisions, and production (of both entrants and incumbents) take place. At the end of the period, some firms experience an exit shock and shut down.

We assume that the final goods Q_t^i are composed of the individual varieties available in market i using a consistent aggregation. Appendix A derives the optimal production behavior under Dixit-Stiglitz aggregation with the intratemporal substitution parameter θ. This aggregation is used in the calibration.

2.3 General-equilibrium Closure

The general equilibrium is a sequence of prices and quantities such that all agents optimize and the following conditions are satisfied:

- goods markets clear;
- labor markets clear;
- balances of payments are in equilibrium;
- consistency of portfolios is satisfied.

The implications of these conditions are described in Appendix B.

3. Calibration

There are two kinds of parameters: constant and variable. The constant parameters include parameters of the production and utility functions. We follow Ghironi, Melitz (2005) in setting their values (for yearly frequency). Thus, the momentary utility function is assumed to be of the constant-relative-risk-aversion form with the intertemporal substitution parameter ε, which takes the conventional value 2; the parameter β is equal to 0.95. The intratemporal substitution parameter θ is calibrated at 3.8; and the exit shock probability δ is set to 0.1.

Further, following Ghironi, Melitz (2005), the adjustment cost parameter is set to 1% for investment in bonds. The same number is used for domestic investment adjustment costs (i.e., when the household invests in a firm located in its region). Thus, $\Psi_B = \Psi_{ii} = 0.01$. Adjustment costs related to FDI between regions U and E are set 10 times higher than investment within the region of residence (i.e., $\Psi_{ij}/\Psi_{ii} = 10$ for $i \neq j$, $i \neq A, j \neq A$). This reflects the notion that engaging in FDI is more difficult than investment within the region of residence due to the need for acquiring expertise in the foreign legal and business environment and culture.

[2] This can be rewritten – using (2.4) – as $\nu_t^{ij} = \Psi_{ij}^{-1} \widetilde{V}_t^{ij}$.

The adjustment costs related to FDI between the U.S. (the Eurozone and Japan) and emerging Asia are taken to be a transitory parameter. By a fall thereof, we model the sharp increase in investment opportunities in emerging Asia since the 1980s. For the year 1985, we set the value to a large number $\Psi_{ij}/\Psi_{ii} = 10^4$ for $i \neq j$, $i = A$ or $j = A$, while for 2005 they equal the value of FDI adjustment costs between advanced regions, i.e., $\Psi_{ij}/\Psi_{ii} = 10$ for all $i \neq j$. The calibration of the sharp fall in FDI adjustment costs is used to explain the value of the FDI inflows to the emerging Asia[3].

Similarly, iceberg costs are used to model the increase in trade openness. For 2005, we set $\mathfrak{t}_{ij} = 0.05$ for $i \neq j$ and this value holds for trade between the U.S. and Europe for 1985 too. On the other hand, we assume that trade between the advanced regions and emerging Asia was twice as costly back in 1985. In particular, we set $\mathfrak{t}_{ij} = 0.10$ in 1985 for $i \neq j$, $i = A$ or $j = A$. The magnitude of the fall in iceberg costs between the advanced regions and emerging Asia reflects the evidence that between 1980 and 2001, the total trade costs (duties and transportation costs) fell from 11 to 5% of the customs value – see Baier, Bergstrand (2001).

We assume that TFP grew by 3% annually in region U (the U.S.). Over the period 1985–2005, TFP seems to have grown slower in region E (the Eurozone and Japan) and faster in region A (emerging Asia). To replicate relative GDP we set $Z^A_{1985}/Z^U_{1985} = 3.5/10$, $Z^E_{1985}/Z^U_{1985} = 9.5/10$, and $Z^A_{2005}/Z^U_{2005} = 5.0/10$, $Z^E_{1985}/Z^U_{1985} = 9.0/10$.

An overview of the parameter values is given in Table 3.1.

However, since we do not account for all factors influencing the size of the current account imbalances in our model (especially the role of Asia's exchange rate policies), we do not expect to fit the data perfectly with the model. We aim to show whether the decline in investment and trade costs[4] would lead to qualitatively consistent developments as observed in reality.

4. Simulation

The simulation was carried out on a calibrated model according to the values in Table 3.1. We start by simulating the change in the world economy between 1985 and 2005 as a response to a simultaneous decline in investment and trade costs. In order to distinguish the relative importance of the decline in investment and trade costs, we perform an additional simulation with a decline in investment costs only. Figure 4.1 contains the main results. The bars in the figure represent the actual change in the main macroeconomic aggregates (*Data*), the results for the simulation of a simultaneous decline in investment and trade costs (*Model*), and the results for the simulation of a fall in investment costs only (*Model w.t.*).

The figure displays eight variables. The first row shows the percentage change between 1985 and 2005 in real GDP and real domestic final demand in the three regions. Our experiment mimics the change observed in the data by means of assumptions about productivity growth. The next row displays the percentage changes in exports and imports between the two years.

[3] In the 1980s the value of U.S. (European) FDI in Asia was about 2% (1%) of Asian GDP, while in the late 1990s and early 2000s, the value of U.S. (European) FDI was 5% (3%) of Asian GDP. Our calibration of Ψ_{ij} replicates these numbers.

[4] It might be worth noting that given the calibration of observed productivity growth, no decline in trade and investment costs would lead to a trade deficit in region A, since the fast growth in the region would soak up imports rather than increase exports and the region would exhibit external debt.

The third row displays the percentage change in the real value of imports from emerging Asia to the two regions and the change in FDI to Asia from the two advanced regions. Finally, the last row displays the change in the real exchange rate and the change in the trade balance in the three modeled regions. The trade-balance figure is the only one that is represented not by percentage changes but by the change in percentage points.

It is apparent that our quantitative experiment with a decline in investment and trade costs can genuinely generate the observed trade imbalances between the advanced and emerging world regions. The intuition behind the results is the following. The most advanced region (the U.S.) has a strong incentive to engage in FDI. This FDI is financed along the transition dynamics by debt, which leads to a current-account deficit.

The effect on the emerging economy is symmetric. It has the incentive to attract FDI. Since the FDI to emerging Asia is mainly export-oriented (due to the large markets in the advanced countries and due to the decline in trade costs), it leads to a large trade surplus.

It is worth noting the effects for the second advanced region (E). Although its productivity is close to that of the first advanced region (U), but slightly smaller, the region does not exhibit such large imbalances. Our simulations suggest that an increase in economic performance in region E could indeed alleviate the current macroeconomic imbalances, which corresponds to the findings in the literature, e.g. Laxton et al. (2005). Although the usual mechanism is an increase in demand for U.S. exports, we consider the demand mechanism to be secondary. On the contrary, our model would suggest that the elevated growth potential in region E would at least partially crowd out the demand for U's assets, which would spread the pattern of imbalances more evenly over the advanced regions.

The results of the simulation further hint at some inconsistency in the size of the real effective exchange rate developments. In particular, the real exchange rate between the currencies of U and A turned out to be overvalued. The appreciation of U's currency between 1985 and 2005 was stronger in reality than in the model outcome. In relation to region E, region U's currency has depreciated during the two decades significantly more than would be consistent with the decline in investment and trade costs. Thus, our exercise suggests that beyond the structural factors of the investment and trade cost decline which potentially lead to global imbalances, the actual dynamics were driven by other supporting factors, such as rigid exchange rate policies in region A.

And finally, comparing the two model simulations, i.e., (*Model*) and (*Model w.t.*), we can see that the decline in investment costs is the dominant factor driving the changes.

The qualitative results are quite robust with respect to alternative numerical values. Quantitatively, the most important parameter is the parameter of intratemporal substitution θ. A higher value of this parameter would cause a drop in the trade increase and therefore in the FDI from the advanced regions to region A. This can be expected since high values of θ mean that goods are close substitutes and therefore the gains from trade (and from export-platform FDI) are lower.

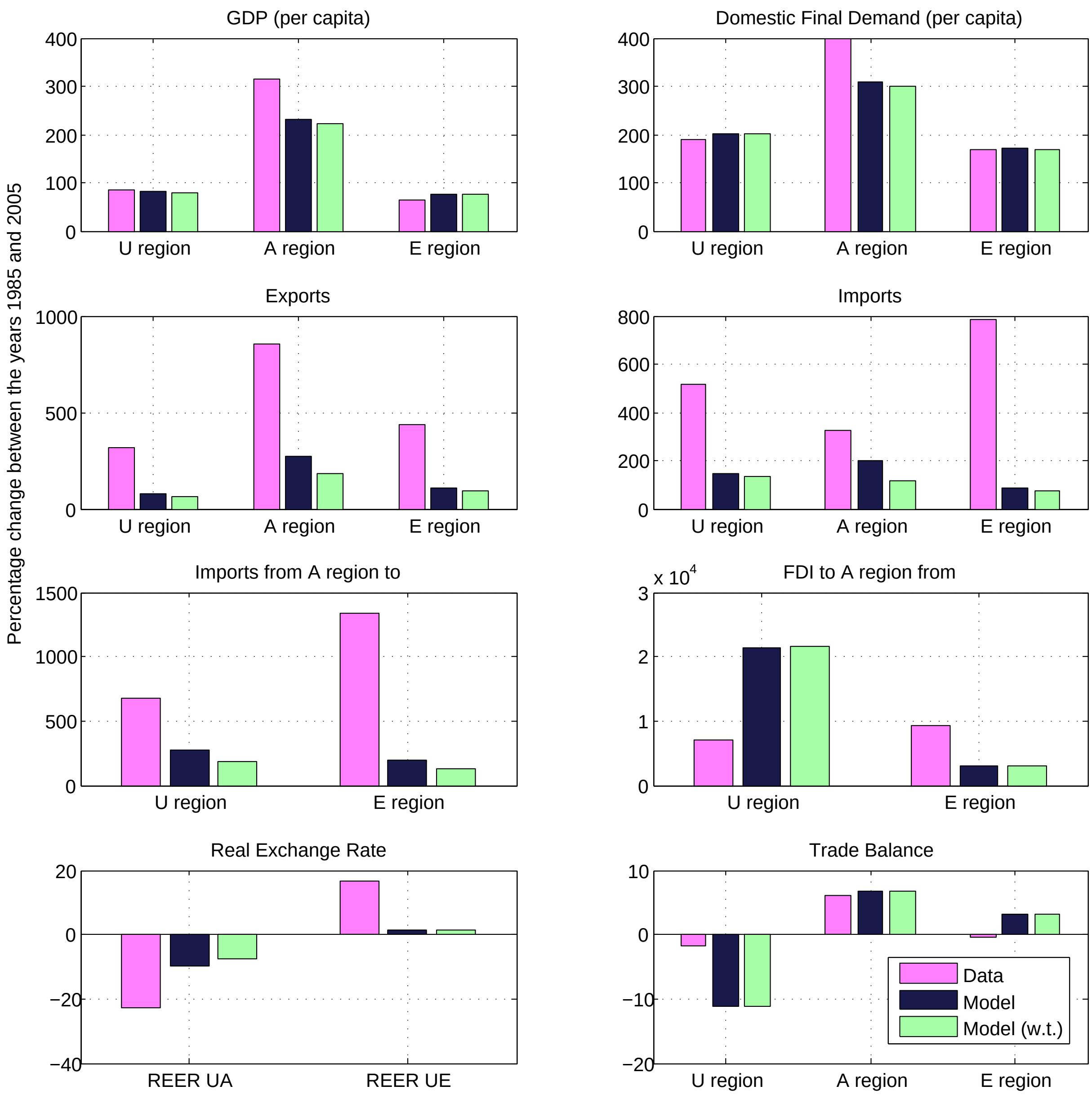
5. Conclusion

In this paper we propose that the current century's global imbalances could have been triggered by a decline in investment and trade costs. Our motivation consists in the two major distinctions between the current and previous episodes of global imbalances, namely, the fact that the current episode involves unequally developed world regions with significant investment linkages and that the regions involved are growing above their regional benchmarks. These two symptoms are common to underdeveloped countries integrating and converging to their advanced counterparts. As a matter of fact, the emerging Asia opened up to foreign capital inflows starting only in the 1980s, which could be taken as a point of reference. Therefore, we use a three-region model with unequally developed regions to simulate the effects of a decline in investment and trade costs on external balances. We calibrate the model to the U.S., the Eurozone and Japan, and emerging Asia and show that the decline in investment and trade costs between 1985 and 2005 genuinely produces trade imbalances between the three regions similar to those observed in reality. Generally, the effects generated by the decline in investment costs dominate those induced by the trade cost decline. Therefore, we conclude that the decline in investment costs primarily triggered economic integration between developed and underdeveloped world regions and probably originated the current episode of global imbalances.

Table 3.1: Parametrization of the Model

Constant parameters	Value	
Parameter of intratemporal substitution θ	3.80	
Parameter of impatience β	0.95	
Probability of deadly shock δ	0.10	
Parameter of intertemporal substitution ε	2.00	
Annual US TFP growth γ	0.03	
Adjustment costs (bond) Ψ_B	0.01	
Adjustment costs (domestic firms) Ψ_{ii}	0.01	
Adjustment costs (FDI) $\Psi_{ij},\ i \neq j,\ i \neq A, j \neq A$	0.10	
Icebergs $\mathbf{t}_{ij},\ i \neq j,\ i \neq A, j \neq A$	0.05	
Transitory parameters	Value in 1985	Value in 2005
Icebergs $\mathbf{t}_{ij},\ i \neq j,\ i = A,$ or $j = A$	0.10	0.05
Adjustment costs (FDI) $\Psi_{ij},\ i \neq j$ $i = A,$ or $j = A$	100	0.10
Z^U	10	$10(1+\gamma)^{20}$
Z^E	9.5	$9.0(1+\gamma)^{20}$
Z^A	3.5	$5.0(1+\gamma)^{20}$

Figure 4.1: Simulation Results



A. Derivation of the Optimal Production Plan

In this part of the paper, we characterize the optimal production plan of firms under a particular market structure – the Dixit-Stiglitz market structure.

A.1 Market Structure

The Dixit-Stiglitz approach is used to model the market structure. The final good Q^i in region i[5] is composed of a continuum of intermediate goods, some of which are produced in region i and some of which are imported. There is imperfect substitution between these goods with a parameter of intratemporal substitution θ. The aggregate good in the domestic region is defined as:

$$Q_t^i = \left(\sum_m \sum_j n_t^{mj} \int_{\Omega^{mji}} (q_{lt})^{\frac{\theta-1}{\theta}} \; G(\mathrm{d}l) \right)^{\frac{\theta}{\theta-1}}, \tag{A.5}$$

where q_{lt} is the output of firm l; Ω^{mji} denotes the set of products of firms located in region m, owned by household j, eligible to sell their products to market i. The sets Ω^{mji} are further characterized in Section A.2 below. The market structure implies the following definition of the region i aggregate price index:

$$P_t^i = \left(\sum_m \sum_j n_t^{mj} \int_{\Omega^{mji}} (p_{lt})^{1-\theta} \; G(\mathrm{d}l) \right)^{\frac{1}{1-\theta}},$$

where p_{lt} is the price of products of firm l at time t.

The CES market structure implies that the demand for an individual firm's products in market i satisfies:

$$q_{lt} = \left(\frac{p_{lt}}{P_t^i} \right)^{-\theta} Q^i. \tag{A.6}$$

A.2 Optimal Production Plans

In this subsection, we derive the optimal production plans. The timing protocol is described in Section 2.2.

Let us derive the optimal production plan for an (i, j) firm. The real cost function associated with the linear production function is given as:

$$\mathbb{C}(q, \mathbb{W}_t^i, Z_t^j, z_l) = \mathbb{W}_t^i \frac{q}{Z_t^j z_l}.$$

The Dixit-Stiglitz market structure implies that the price is a mark-up over marginal costs. Thus, given the inverse of the demand function (A.6), the optimal production decision for market k

[5] The final good is a consumption as well as an investment good, so that Q^i can be interpreted as domestic absorption.

takes the following form:

$$\kappa_{lt}^{ijk} q_{lt}^{ij} = \left[\frac{\theta - 1}{\theta} \frac{\eta_t^{ki}}{1 + \mathbf{t}^{ik}} \frac{Z_t^j z_l}{\mathbb{W}_t^i} \right]^{\theta} Q_t^k.$$

Since $\sum_k \mathbf{1}_{lt}^{ijk} \kappa_{lt}^{ijk} = 1$ for all (i, j) and (l, t), the exporting shares, provided that the firm sells in at least one market, satisfy:

$$\kappa_{lt}^{ijk} = \frac{\mathbf{1}_{lt}^{ijk} \left(\frac{\eta_t^{ki}}{1+\mathbf{t}^{ik}} \right)^{\theta} Q_t^k}{\mathbf{1}_{lt}^{iji} Q_t^i + \sum_{m \neq i} \mathbf{1}_{lt}^{ijm} \left(\frac{\eta_t^{mi}}{1+\mathbf{t}^{im}} \right)^{\theta} Q_t^m} = \frac{\mathbf{1}_{lt}^{ijk} \left(\frac{\eta_t^{ki}}{1+\mathbf{t}^{ik}} \right)^{\theta} Q_t^k}{\sum_m \mathbf{1}_{lt}^{ijm} \left(\frac{\eta_t^{mi}}{1+\mathbf{t}^{im}} \right)^{\theta} Q_t^m}.$$

If the firm does not sell to any market, than we can define $\kappa_{lt}^{ijk} = 0$ for all k.

To characterize the lumpy decisions of firms to sell to a given market, we assume that firms do so provided that doing so is not loss-making. Lemma 1 below shows when this will be so.

Define the 'effective' demand as follows:

$$\xi_{lt}^{ij} \equiv \mathbf{1}_{lt}^{iji} Q_t^i + \sum_{m \neq i} \mathbf{1}_{lt}^{ijm} \left(\frac{\eta_t^{mi}}{1 + \mathbf{t}^{im}} \right)^{\theta} Q_t^m.$$

The total production of a firm can be then written as follows:

$$q_{lt} = z_l^{\theta} \left[\frac{\theta - 1}{\theta} \frac{Z_t^j}{\mathbb{W}_t^i} \right]^{\theta} \xi_{lt}^{ij},$$

and real turnovers on the domestic and foreign markets, respectively, are given by $z_j^{\theta-1} \left[\frac{\theta-1}{\theta} \frac{Z_t^j}{\mathbb{W}_t^i} \right]^{\theta-1} Q_t^i$, and $z_l^{\theta-1} \left(\frac{\eta_t^{ki}}{1+\mathbf{t}^{ik}} \right)^{\theta} \left[\frac{\theta-1}{\theta} \frac{Z_t^j}{\mathbb{W}_t^i} \right]^{\theta-1} Q_t^k$.

Real production costs read as follows:

$$\mathbb{C}_{lt}^{ij} = z_j^{\theta-1} \left[\frac{\theta - 1}{\theta} \right]^{\theta} \left[\frac{Z_t^j}{\mathbb{W}_t^i} \right]^{\theta-1} \xi_{lt}^{ij},$$

so the real operating profit in period t is given as[6]:

$$\mathbb{P}_{lt}^{ij} = \mathcal{W}_1 z_j^{\theta-1} \left[\frac{Z_t^j}{\mathbb{W}_t^i} \right]^{\theta-1} \xi_{lt}^{ij}.$$

[6] Define $\mathcal{W}_1 \equiv \left[\frac{\theta-1}{\theta}\right]^{\theta-1} - \left[\frac{\theta-1}{\theta}\right]^{\theta} = \frac{1}{\theta-1} \left[\frac{\theta-1}{\theta}\right]^{\theta}$.

Lemma1
An (i, j) firm with productivity level z_l sells to market k (i.e., $\mathbf{1}_{lt}^{ijk} = 1$) provided that:

$$z_l \geq \frac{\mathbb{W}_t^i}{Z_t^j} \left[\frac{c^{ijk}}{\mathcal{W}_1} \left(Q_t^k \left(\frac{\eta^{ik}}{1 + \mathbf{t}^{ik}} \right)^\theta \right)^{-1} \right]^{\frac{1}{\theta - 1}},$$

otherwise it does not sell to market k, i.e., $\mathbf{1}_{lt}^{ijk} = 0$.

Proof of Lemma 1
Since operating profit $\mathbb{P}_{lt}^{ij}$ is linear in quantities sold to market k and the lumpy eligibility costs are paid on a period-by-period basis, one concludes that entering the market k is not loss-making if:

$$\mathcal{W}_1 z_l^{\theta-1} \left[\frac{Z_t^j}{\mathbb{W}_t^i} \right]^{\theta - 1} Q_t^k \left(\frac{\eta^{ik}}{1 + \mathbf{t}^{ik}} \right)^\theta - c^{ijk} \geq 0.$$

Rearranging the terms yields the lemma. *Q.E.D.*

Corollary to Lemma 1
Define

$$\overline{z}_{kt}^{ij} \equiv \frac{\mathbb{W}_t^i}{Z_t^j} \left[\frac{c^{ijk}}{\mathcal{W}_1} \left(Q_t^k \left(\frac{\eta^{ik}}{1 + \mathbf{t}^{ik}} \right)^\theta \right)^{-1} \right]^{\frac{1}{\theta - 1}}.$$

Thus, the export decision takes the simple form: all (i, j) firms export to market k if and only if their productivity z_l is higher than the cut-off $\overline{z}_k^{i,j}$. This is an extension of the result of Melitz (2003) to the multi-region setting. Therefore, the set of (i, j) firms exporting to market k is given by $1 - G(\overline{z}_k^{i,j})$, where G is the cumulative distribution function for z.

Now we are able to derive the expected present value of the operating-profit flows of a new entrant. The ex-post value of the flow, after the shock z_l is revealed, is (expressed in the currency of the owner):

$$V_t^{ij}(z_l) = z_j^{\theta-1} \mathcal{W}_1 \sum_{\tau \geq 0} \eta_{t+\tau}^{ij} \left((1 - \delta)^\tau \mathcal{K}_{jt}^\tau \left[\frac{Z_t^j}{\mathbb{W}_{t+\tau}} \right]^{\theta - 1} \xi_{lt+\tau}^{ij} \sum_k \mathbf{1}_{lt+\tau}^{ijk} c^{ijk} \right).$$

The ex-ante expected value $\widetilde{V}_t^{ij}$ satisfies:

$$\widetilde{V}_t^{ij} = \mathcal{W}_1 \sum_{\tau \geq 0}^{\infty} \eta_t^{ij} \left((1 - \delta)^\tau \mathcal{K}_{jt}^\tau \left[\frac{Z_t^j}{\mathbb{W}_{t+\tau}} \right]^{\theta - 1} \int \xi_{lt+\tau}^{ij} z_j^{\theta - 1} \, \mathrm{d}G(l) - \int \sum_k \mathbf{1}_{lt+\tau}^{ijk} c^{ijk} \, \mathrm{d}G(l) \right). \tag{A.7}$$

Note that ξ_{lt}^{ij} should be inside the integral, since ξ_{lt}^{ij} depends on the productivity z_l through the choice of $\mathbf{1}_{lt}^{ijk}$.

B. A Detailed Overview of the General-Equilibrium Conditions

The general equilibrium requires that:

- goods markets clear;
- labor markets clear;
- balances of payments are in equilibrium;
- consistency of portfolios is satisfied.

B.1 Goods Market Equilibrium

The final good Q^i is divided between consumption and investment:

$$Q_t^i = C_t^i + I_t^i, \tag{B.8}$$

where C_t^i is the consumption of households living in region i. Investment I_t consists of eligibility costs c^{ijk} that are spent in the region of production.

Therefore, the aggregate investment in region i follows:

$$I_t^i = \sum_j n_t^{ij} \sum_k c^{ijk} \int \mathbf{1}_{lt}^{ijk} \, G(\mathrm{d}l) = \sum_j n_t^{ij} \sum_k c^{ijk} \left(1 - G(\overline{z}_{kt}^{ij})\right).$$

The second equality follows from Lemma 1.

B.2 Labor Market Equilibrium

A region i is endowed with one unit of labor, which is supplied inelastically. The wage $\mathbb{W}_t^i$ is set to equate the total labor demand with the inelastic labor supply. Because of the linearity of the production functions, it can be easily derived that the total labor demand in region i is given as $\sum_k \sum_m n_t^{ik} \int \mathbf{1}_{lt}^{ikm} \kappa_{lt}^{ikm} \frac{q_{lt}}{z_{lt} Z_t^k} \, G(\mathrm{d}l)$. The first summation is over ownership, the second summation is over markets, and the integral adds firms with different levels of idiosyncratic productivity z_l.

Therefore, the three market clearing conditions read as

$$1 = \sum_k \sum_m n_t^{ik} \int \mathbf{1}_{lt}^{ikm} \kappa_{lt}^{ikm} \frac{q_{lt}}{z_{lt} Z_t^k} \, G(\mathrm{d}l),$$

for $i \in \{U, E, A\}$.

B.3 Balance-of-payments Equilibrium Condition

The balance-of-payments equilibrium condition for region i is given as:

$$\sum_j \mathcal{X}_t^{ij} + \sum_j \eta_t^{ji} n_t^{ji} \widetilde{\mathbb{P}}_t^{ji} + \eta_t^{Ui} \left((1 + r_t^U) B_{it-1} - B_{it}\right) = \sum_k \eta_t^{ik} \mathcal{X}_t^{ki} + \sum_k \eta^{ik} n_t^{ik} \widetilde{\mathbb{P}}_t^{ik},$$

where $\mathcal{X}_t^{ij}$ is the value of exports from region i to region j (expressed in the currency of i). The real export values satisfy[7]:

$$\mathcal{X}_t^{ij} = \sum_k n_t^{ik} \int \mathbf{1}_{lt}^{ikj} \kappa_{lt}^{ikj} \frac{p_{lt}}{P_t^i} q_{lt} \, G(\mathrm{d}l) = \sum_k n_t^{ik} \kappa_{lt}^{ikj} \frac{p_{lt}}{P_t^i} q_{lt} \left(1 - G(\overline{z}_{kt}^{ij})\right).$$

Note that – by Walras's law – only two of the three balance-of-payments equilibrium conditions are needed.

B.4 The Derivation of Portfolio Consistency

In equilibrium, it must hold that $\sum_i B_{it} = 0$. This condition determines the real interest rate r_t^U.

[7] The trade balance of region i is then given as

$$\mathrm{TB}_t^i = \sum_j \mathcal{X}_t^{ij} - \sum_k \eta_t^{ik} \mathcal{X}_t^{ki}.$$

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