Escola de Pós-Graduação em Economia - EPGE
Fundação Getulio Vargas

Ensaios em Economia Internacional

Tese submetida à Escola de Pós-Graduação em Economia
da Fundação Getulio Vargas como requisito de obtenção do
título de Doutor em Economia

Aluno: Enrico Vasconcelos

Professora Orientadora: Maria Cristina Terra

Rio de Janeiro
2007

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Introduction

This thesis is composed of three essays which analyse the effects of trade openness and of credit market frictions in the welfare of individuals. Each essay forms one chapter of this thesis. The first examines the role of trade openness in a crisis context. The second examines the inflationary consequences in a short-term horizon of a policy which reduces trade barriers. The third analyses how credit markets impact the trade pattern and the welfare of individuals when countries trade.

The first chapter investigates empirically the impact of trade openness on the real exchange rate devaluations that results from a large and unexpected fall in capital inflows. In order to test that effect of trade openness, this essay presents two tests which relate the exchange rate variation and the openness level. The first runs an OLS regression in a cross-section data which contains the relevant variables regarding to sudden stops. The second runs a TSLS regression in a time-series-cross-section data. Both tests find strong evidence that trade openness is the economic feature, under exclusive control of the country policymaker, that provides the most powerful effect in the trade balance given currency devaluations.

The second chapter presents a simulation of a policy which reduces the import tariff in a fictitious country that shares the same economic features of Brazilian economy. The framework used to create the economy is based on the financial accelerator model for a small open economy of Gertler, Gilchrist and Natalucci (2003), but I extend it to consider import tariff as a policy variable. The results show that tariff reductions must be coordinated with monetary policy in order to optimize the welfare of individuals.

The third chapter explores the relationship between quality of the credit markets and the trade pattern and considers the effects of that relationship on welfare of individuals. Using a general equilibrium model with innovation financing, this essay derives the trade pattern between two countries equal in all aspects, except in the quality of credit markets. Innovation arises in most of cases in the country with the best credit market, whereas the other country devotes a larger share of its labor endowment to manufacture goods without innovation content. A welfare analysis shows that opening to trade may hurt welfare of individuals for a period, but in the long run all of them are better under free trade than if they were under autarky. This fact raises a question: when the long run benefits of opening to trade compensate the short run costs? Calculations show that opening to trade is more likely to be worth when economies are not small, knowledge spills over countries and multinational corporations exist. Moreover, the inequality between residents of both countries is smaller in this setup.

Chapter 1

Trade Openness Effect in Sudden Stops

Abstract

Using data for 53 developed and emerging economies from 1970 to 2006, this article investigates empirically the impact of trade openness on the real exchange rate devaluations that result from a large and unexpected fall in capital inflows.

JEL Classification Codes: F32, F37
Keywords: sudden stop, trade openness, real exchange rate

1 Introduction

The abrupt interruption of capital inflows and its impact on the economy have been intensively debated since the Mexican crisis in 1994, and, later, the Asian crises, in 1997. This phenomenon is named sudden stop and it was first coined by Dornbusch, Goldfajn and Valdés (1995). Commonly, sudden stops are coped initially with losses of international reserves, followed by a reversion of the current account's net result.

Initially, governments try to accommodate the impact of sudden stops in the balance of payments by spending international reserves, but this strategy fails to succeed since the episode, in most cases, persists for a longer period than the one in which current account deficits can be financed by the total stock of international reserves. The balance of payments deficit is, then, eliminated by a reversal of the current account's net result, specifically by a reversal of the trade balance's net result; since we do not consider the hypothesis of default of existing obligations and liabilities. The growth mechanism of the trade balance, in most cases, is related to a real devaluation of the domestic currency.

It remains necessary to understand why does a real devaluation in the domestic currency happen? The answer brings us back to the famous debate between John Maynard Keynes and Bertil Ohlin over the payment of war debts in Germany during the 20's, which became widely known as the "Transfer Problem".

Keynes argued that, in order to pay for the war damages in foreign currency, Germany would have to raise the resources through surpluses in the trade balance. Hence, tradable goods' prices would have to fall; that is, the terms of trade would have to deteriorate and the deustche mark would have to devalue. Ohlin disagreed with this argument by considering the benefits related to the trade balance surplus. The reparation payments to the Allies would reduce the purchasing power of the Germans, reducing their expenditure in both domestic and imported goods. Besides, domestic goods that were not sold in Germany could be exported. Demand of non-tradable goods would also be reduced and, as a consequence, non-tradable goods' prices would fall as well (real currency devaluation). Then, the resources allocated to their production would migrate to the production of exported goods and to the substitution of imported goods. On the other hand, the beneficiaries countries' purchasing power would increase, raising imports and the consumption of exportable and non-tradable goods. Therefore, the production of tradable goods would fall while the production of non-tradable goods would rise.

Ohlin's argument was qualitatively similar to Keynes' with respect to the behavior of the real exchange rate; that is, it would appreciate in the countries that receive capital and it would depreciate in those countries that transfer capital. However, according to Ohlin, the magnitude of the currency devaluation would depend on the local expenditure adjustment. Nevertheless, the terms of trade behavior did not necessarily coincide in the two arguments. Keynes believed that the deterioration of the terms of trade would be unavoidable while Ohlin conditioned their behavior to the expenditure adjustment that would occur in the two set of countries - the debtors and creditors of capital.

Economies that suffer sudden stops are often receivers of foreign capital and, thus, present an overvalued exchange rate. At the moment of capital inflow contraction, these economies start to behave as those which transfer capital and, in such a new situation, they must generate a trade balance surplus within the dynamics offered by Ohlin, implying a real devaluation of the exchange rate.

The power of the economy to generate the necessary trade balance surplus as to reach equilibrium in the balance of payments without incurring in large real exchange rate devaluations determines the extension of the social losses resulted from the abrupt liquidity restrictions related to sudden stops. In fact, the magnitude of the currency devaluation may be inflated or mitigated by factors that cannot be controlled by local actions (exogenous factors) as economic growth and/or more world trade openness. Yet, the ability to generate trade balance surpluses without incurring in large currency devaluations is a feature that can be developed by public policies independently of international conjectures. This is the reason why we consider important to investigate which institutional framework guarantees the development of this ability in an economy.

The greater is the intensity of the trade balance response to the real exchange rate devaluation, the least necessary is the need for large devaluations in order to reach an equilibrium in the balance of payments. Currency devaluations are particularly harmful to the economies which present the "original sin" as defined by Eichengreen et all (2003). The "original sin" is the lack of capacity to issue debt denominated in local currency, a characteristic that distinguishes emerging and developed economies. Economies that commit this sin suffer sudden stops more frequently[1] while the severity of the related damages are greater since the associated currency devaluation raises the cost of the foreign exchange rate denominated debt. Indeed, it constitutes another reason why we consider important the relationship between the behavior of the trade balance and the currency devaluation.

In this article, we verify that the weight of international trade in the economy is the variable that determines the capacity to generate large trade balance surpluses without incurring in a significant devaluation of the domestic currency. The empirical evidence found in this article shows that, in economies with a greater international trade flow, the growth response of the trade balance surplus for a given currency devaluation tends to be larger. In general terms, the reason behind this behavior is that the real exchange rate devaluation has a greater impact in the trade balance in absolute terms for a larger total volume of exports and imports. For example, suppose that a 1% devaluation in the currency leads to a 1% increase of total exports and a 1% reduction of total imports in an emerging economy. In this respect, the trade balance surplus is proportional to the total volume of exports and imports of an economy before the devaluation.

In the example above, we consider that a real devaluation in the domestic currency has a symmetric effect in exports (+1%) and imports (-1%). However, the results of the empirical analysis carried out in Terra and Vasconcelos (2005)

[1] Calvo et ali (2004) find empirical evidence that support the idea that less trade openness and greater domestic debt dollarization determine the increase in the probability of occurrence of a sudden stop.

shows an asymmetrical effect, that is, exports are more sensitive than imports to real exchange rate devaluations.

This article is organized as follows: in section 2, we show a description of a relationship between the degree of trade openness and power of real exchange rate devaluations on achieving trade balance surplus; in section 3 and 4, we construct an empirical test for the model and analyze the results. Finally, in section 5, we present our conclusion with respect to the importance of trade openness in countries subject to sudden stops shocks.

2 Trade Openness Effect

In this section we present a simple rationale that explains the greater ability of more open economies to generate large trade balance surpluses without incurring in a significant devaluation of the domestic currency.

Consider the trade balance as a function of the real exchange rate

$$TB(q) = P_X(q)X(q) - P_M(q)M(q),$$

where X and M are the exports and imports, respectively, and P_X and P_M are their respective price indexes.

We can rewrite this relation in terms of semi-elasticities and elasticities

$$\begin{aligned} \frac{\partial TB(q)/Y}{\partial q/q} &= \frac{P_X(q)X(q)}{Y}\left\{\frac{\partial\left[P_X(q)X(q)\right]/\left[P_X(q)X(q)\right]}{\partial q/q}\right\} - \\ &\quad \frac{P_M(q)M(q)}{Y}\left\{\frac{\partial\left[P_M(q)M(q)\right]/\left[P_M(q)M(q)\right]}{\partial q/q}\right\} \end{aligned}$$

or equivalently

$$\epsilon_{TB/Y,q} = \eta_X \epsilon_{P_X X,q} - \eta_M \epsilon_{P_M M,q},$$

where $\epsilon_{TB/Y,q}$ is the change of the shares of balance trade with respect to GDP in response to percentage changes in the real exchange rate, while $\epsilon_{P_X X,q}$ and $\epsilon_{P_M M,q}$ are the percentage changes of exports income and imports expenditure in response to percentage changes in the real exchange rate, respectively. As we know, $\epsilon_{TB/Y,q}$, $\epsilon_{P_X X,q} > 0$ and $\epsilon_{P_M M,q} < 0$. η_X and η_M are the shares of exports income and imports expenditure with respect to GDP.

Now, for the sake of comparison, consider two countries i and j that share the same economic features except for the level of trade openness, i.e., they share the same $\epsilon_{P_X X,q}$ and $\epsilon_{P_M M,q}$, but the country i differ from j about their shares of exports income and imports expenditure with respect to GDP. Consequently, the more open country i will have greater η_X and η_M than the closer country j. It's clear that $\epsilon^i_{TB/Y,q} > \epsilon^j_{TB/Y,q}$ and this effect is a direct consequence from the greater volume of trade experienced in the more open economy. We denote this phenomenon as "*openness effect*" and it is caused by both export and import volumes as showed below:

$$\frac{\partial \epsilon_{TB/Y,q}}{\partial \eta_X} = \epsilon_{P_X X,q} > 0$$

and

$$\frac{\partial \epsilon_{TB/Y,q}}{\partial \eta_M} = -\epsilon_{P_M M,q} > 0.$$

3 Data Description

We use quarterly data for 53 countries from 1970 to 2006 extracted from the IFS-IMF database. Not all countries have data available for all periods, hence we may have not been able to identify all the sudden stop episodes which effectively occurred over the period. Moreover, the lack of monthly data reduces the accuracy of the identification of the start and the end of each sudden stop episode.

Next we present the variables that are used in empirical tests of the openness effect.

As a proxy for capital flow, we use the difference between the current account and the international reserves variation. We do not use directly the capital flow data because, for most countries, it is presented only on an annual basis, which does not allow the identification of sudden stops that were initiated and finished in the same calendar year.

The real exchange rate series are bilateral rates, using the CPI indexes for the US and each domestic economy. The trade volume is the sum of exports and imports as a fraction of the size of the economy, proxied by the GDP.

As discussed in the introduction, the extent of financial dollarization affects the costs of an exchange rate depreciation. Therefore, in economies presenting large currency mismatches, the government may resist exchange rate devaluation by implementing policies such as selling international reserves or increasing the domestic interest rates. As a measure of debt dollarization, we use the currency mismatch in the government's balance sheet. It is calculated as the ratio between net liability of the monetary authority denominated in the foreign currency and the amount of (fiat) money in circulation[2].

It is clear that the intensity of the liquidity shock caused by the sudden stop is also crucial for explaining the magnitude of the variation of real exchange rate. Hence, we create a variable to measure the intensity of the shock, given by the annual capital flow variation as a share of the GDP[3].

We add annual growth of world exports as another exogenous variable in our model. This variable captures the trading conjuncture at the moment of the occurrence of sudden stop episodes. We believe that in a context of higher growth of world exports, the growth of exports respond with more intensity

[2] Alesina e Wagner (2003) used the same ratio to measure the debt dollarization level.

[3] Yearly changes are used to avoid seasonal effects.

to exchange rate devaluations and, therefore, there is a lower need for large currency devaluations during sudden stop episodes.

Finally, the yearly variation of the terms of trade is also added as another explaining variable for the real exchange rate depreciation. As already mentioned in the introduction, the terms of trade affect the dynamics of the sudden stop, and their variation should have a strong influence on the trade balance.

The interest rate variation would be another important variable that we should use as a control when assessing the openness effect, but when the exchange rate regime is fixed, the monetary policy becomes a hostage of the exchange rate behavior. Then it would serve as a control only when sudden stops occur during floating exchange rate regimes. However, using the *de facto* classification of exchange rate regimes of Levi-YeYati and Sturzenegger (2002), we find that the number of episodes identified under this regime is very low and not enough to allow reasonable tests.

Identifying Sudden Stops Our criteria to identify sudden stop episodes is based on that of Calvo et al. (2004), but adapted to our quarterly data. A sudden stop episode happens when there is at least one quarter in which the capital flow change[4] is at least two standard deviations lower than the average change[5], or when there are at least two consecutive quarters in which the capital flow change is at least one standard deviation below its average. We do not require persistence for a drop of capital flows greater than two standard deviations because we would risk missing the identification of sudden stops that lasted for less than six months. On the other hand, we do not allow two episodes separated by only one quarter, so that in such situation we consider them both as only one by merging them.

Differently from Calvo et al. (2004), we do not require a GDP contraction to characterize a sudden stop event, since we also want to capture episodes of capital flow contraction in economies that were able to adjust to the shock less costly. In particular, we are interested in investigating whether more open economies are better tailored to promote larger increases in trade balance with relatively lower exchange rate devaluation. As large unexpected swings in the real exchange rate are a source of cost for the economy, more open economies could cope less costly with sudden stops.

It is true that, by not excluding events that did not present a GDP contraction, we risk capturing large changes in capital flows due to positive shocks, such as a positive shock of terms of trade. We have to keep that in mind when interpreting our results.

Using our procedure, we identify 215 sudden stop episodes: 100 of them occurred in OECD countries and 115 in emerging economies. Note, though, that data is not available for the 70's and 80's for the majority of the emerging economies. Restricting to the period between 1990 and 2006, there were 48

[4] A negative variation means that a country transfers more or receives less capital than before.

[5] Both the average and the standart deviations are calculated in a three year window preceding the current quarter.

episodes in developed economies and 84 in emerging ones. Hence, sudden stops seem to be a much more commonly emerging markets phenomenon.

In Figure 1 we observe that a significant number of episodes in the OECD countries occurred during the European Monetary System crises (1990 and 1992) and the Asian crisis (1998), while, in emerging economies, the episodes are concentrated around the Mexican crisis (1994 to 1995), Asian and the Russian crises (1998), Argentinean crisis (2001), and 2003 to 2004. The bunching of crises seems to indicate that the incidence of the episode within a subgroup (developed or emerging) has contagion effect features. Nevertheless, Calvo et al. (2006) find that more closed economies or those with a higher degree of dollar denominated debt have a higher probability of experiencing a sudden stop episode.

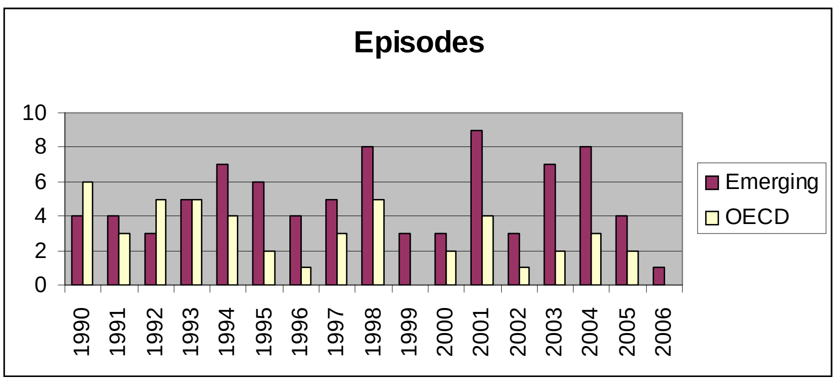

Figure 1

4 Empirical Tests

Once we have identified the episodes, we proceed with two empirical tests for identification of the openness effect. The first one uses cross-section data, while the second uses time-series-cross-section (TSCS) data. We use these both tests because they complement each other with respect to the advantages and drawbacks of their specifications. While the first has trouble with endogeneity issues, the second treats this problem using instruments in order to mitigate the problem. On the other hand, the specification of the second is very much impacted by the lack of accuracy of the identification algorithm with respect to the exact moment of the episode, while the specification of the first test is not much sensitive to this problem.

The both tests confirm very soundly the existence of the openness effect. The first test finds clear evidence that higher share of debt denominated in foreign currencies motivates governments to procrastinate a definite solution to the crisis, while the second test indicates that behavior with less confidence. In the both tests, we have weak evidences that the openness effect is stronger in emerging countries.

4.1 Cross-Section Analysis

In order to identify the relationship between the openness effect and the real exchange rate variation, while avoiding endogeneity problems among the two variables, we build a window called pre-episode. This window comprises the three years before the year which the sudden stop occurred. We also build an episode window that comprises the years in which the sudden stop occurs and the subsequent year. From the episode window, we extract the dependent variable, **real exchange rate variation**, and two explicative variables, **world exports variation** and **terms of trade variation**, calculated as the averages of the annual percentage variation of the real exchange rate, of the world exports, and of the terms of trade, respectively. From the pre-episode window, we extract the **trade openness** and **dollarization**, calculated respectively as the averages of trade openness index and dollarization index. Since the data used to calculate trade openness and dollarization are lagged to the data used to calculate real exchange rate variation, then there is no endogeneity problem between these variables. With respect to world exports variation, there are also no endogeneity problems since this variable belongs to a global context that is not significantly affected by the episode. On the contrary, terms of trade variation is subject to endogeneity issues, which we consider a serious drawback of this specification.

Figure 1 and 2 show the pre-episode and episode windows for the cases in which the episode begins and ends in the same year and for the cases in which it begins and ends in different years.

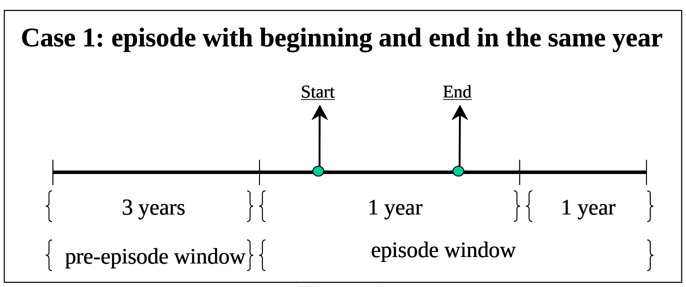

Figure 2

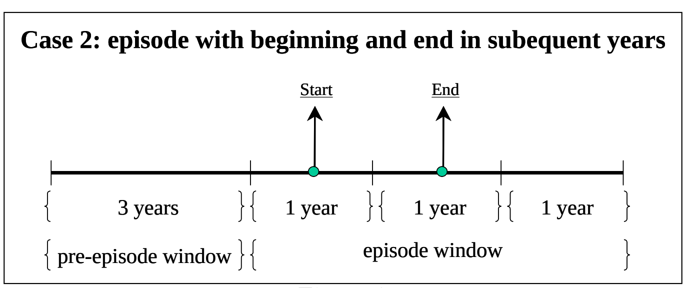

Figure 3

The reason for the existence of an one-year period after the year the sudden stop episode ends is to capture any late variation of the real exchange rate

that occurs in those cases which governments initially attempt to equilibrate the balance of payments using international reserves in order to avoid the costs associated with currency devaluations. Even though this strategy is applied in most cases, it uses to fail because sudden stop episodes normally have a higher persistence exactly in those cases where the currency takes a longer time to devalue. Besides, the end of the episode usually coincides with the currency devaluation[6]. In Figure 3, we show that some episodes confirm these stylized facts.

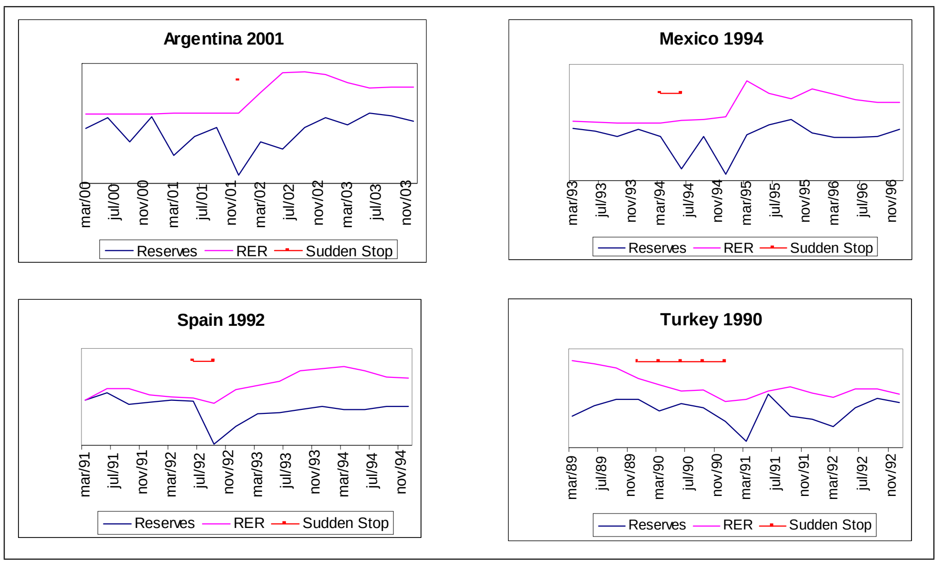

Figure 4

4.1.1 Results

Since we use a cross-section where the observations occur in distinct periods, we cannot assume that the observations are identically distributed. Then, we calculate dispersion measures using the White methodology and, thus, we present confidence measures (p-values) for the coefficients estimation that are robust to the presence of heteroskesdacity.

In table 1 we find empirical evidence that openness effect is present in sudden stop episodes. The coefficient of openness is negative and significant around 1% level of confidence in all regressions. As expected the coefficients of terms of trade shocks, the level of dollarization of debt, and the level of world openness are all negative and statistically significant in all regressions. It indicates that, when there is more trade in the world and/or a country experiences positive shocks in its terms of trade, it needs a lower currency devaluation to generate the necessary trade balance surplus as to reach equilibrium in the balance of

[6]This fact is more appropriate to emerging economies, but it is also valid for developed countries.

payments. The negative coefficient of the level of debt dollarization indicates that countries which have higher share of their debt denominated in foreign currencies, refrain more to devaluate their currencies during these crises.

Table 1. Dependent Variable: $\Delta_{t,t-4}$log(rer)

Variables	(1)	(2)	(3)	(4)
constant	0.0246 **	0.0173	0.0395 ***	0.0747 ***
	(0.0500)	(0.1779)	(0.0044)	(0.0002)
openness	-0.0985 ***	-0.0873 **	-0.1178 ***	- 0.1187 ***
	(0.0039)	(0.0176)	(0.0021)	(0.0015)
sudden stop intensity	0.1298	0.1567	0.1480	0.1933 *
	(0.1994)	(0.1483)	(0.2017)	(0.0934)
terms of trade variation	—–	-0.2501 *	-0.5485 ***	-0.5243 ***
		(0.0846)	(0.0010)	(0.0014)
dollarization	—–	——	-0.0318 ***	-0.0283 ***
			(0.0009)	(0.0026)
world export variation	—–	—–	—–	-1.5365 **
				(0.0159)
Observations	179	136	115	115
Adjusted R^2	0.0375	0.0444	0.1561	0.1928
F statistics	4.4710	3.0902	6.2719	6.4452

Heteroskedastic robust p-value in parentesis

* 10% significative; ** 5% significative; *** 1% significative

Table 2 presents a weak evidence that openness effect is stronger in emerging countries than in OECD ones. Despite the fact that the coefficient of interaction between the dummy d_emerging with openness is negative in all regressions, it is not very significant. In the regressions (3) and (4), those which the fit is reasonable, the level of confidence of this coefficient is between 10% and 13%.

Table 2. Dependent Variable: $\Delta_{t,t-4}$log(rer)

Variables	(1)	(2)	(3)	(4)
constant	0.0056	0.0057	0.0164	0.0532 **
	(0.6819)	(0.6691)	(0.2481)	(0.0153)
d_emerging	0.0333	0.0237	0.0541	0.0600 *
	(0.1895)	(0.4576)	(0.1344)	(0.0992)
openness	-0.0528	-0.0604	-0.0719 *	-0.0738 *
	(0.1638)	(0.1216)	(0.0793)	(0.0772)
d_emerging * openness	-0.0799	-0.0740	-0.1175	-0.1062
	(0.1127)	(0.2696)	(0.1061)	(0.1246)
Sudden Stop Intensity	0.1376	0.1869 **	0.1920 *	0.2174 **
	(0.1120)	(0.0410)	(0.0704)	(0.0371)
Terms of Trade Variation		-0.2664	-0.5847 ***	-0.5432 ***
		(0.1364)	(0.0000)	(0.0000)
Dollarization			-0.0391 ***	-0.0365 ***
			(0.0000)	(0.0000)
World Export Variation				-1.6663 **
				(0.0319)
Observations	179	136	115	115
Adjusted R^2	0.0385	0.0411	0.1727	0.2149
F statistics	2.7824	2.1567	4.9660	5.4583

Heteroskedastic robust p-value in parentesis

* 10% significative; ** 5% significative; *** 1% significative

4.2 Time-Series-Cross-Section Analysis

We run a two-stage least squares (TSLS) regression in a time-series-cross-section (TSCS) data controlling for fixed effects on both time and cross section dimensions. Yearly real exchange rate logarithmic variation is the dependent variable whereas the explanatory variables are the share of trade volume on gdp denoted by openness, sudden stop intensity, debt dollarization and yearly terms of trade logarithmic variation. The basic specifications is

$$\begin{aligned}\Delta_{t,t-4}\log(\text{rer}) = \; & \alpha + \delta_0 \; d\_episode + \gamma_0 \; d\_sudden\_stop + \\ & \beta_0 \log(openness_{t-4}) + \beta_1 \; d\_episode \log(openness_{t-4}) + \\ & \lambda_0 \log(intensity_t) + \lambda_1 \; d\_sudden\_stop \log(intensity_t) + \\ & \theta_0 \log(dollarization_t) + \\ & \theta_1 \; d\_sudden\_stop \log(dollarization_t) + \\ & \pi_0 \; \Delta_{t,t-4} \log(terms\_of\_trade) + \\ & \pi_1 \; d\_episode \; \Delta_{t,t-4} \log(terms\_of\_trade) + \varepsilon_t.\end{aligned} \tag{1}$$

The openness is lagged one year in order to avoid endogeneity problems with the real exchange rate variation. The dummy variable *d_sudden_stop* is

valued one on the quarters when a sudden stop happened while *d_ episode* is valued one on a window that comprises the quarters where *d_ sudden_ stop* is valued one and a number of subsequent quarters (2, 4 or 6 depending on the specification). The existence of *d_ episode* is meant to capture any late real exchange rate changes that occur when governments initially attempt to avoid the real exchange rate devaluation by using international reserves to equilibrate the balance of payments.

Notice in the regressions specification that the trade volume share with respect to gdp and terms of trade shocks are interacted with *d_ episode* while *sudden stop intensity* and *dollarization* are interacted with *d_ sudden_ stop*. Intensity of the yearly variation of capital flows is a defining property of the crisis, so we cannot analyze its effect on real exchange rate devaluation out of the period of crisis without hurting the crisis' concept. The financial dollarization is a variable that motivates governments to delay and/or mitigate at a first moment the real exchange rate devaluation, so its effects are better estimated on the period of crisis.

Finally, we control all the effects for terms of trade shocks. Terms of trade shocks variation may be subject to endogeneity issues, so we use such variable one-quarter lagged as instrument in a two-stage least square regression in order to mitigate such problem.

4.2.1 Results

We run a TSLS regression in a time-series-cross-section (TSCS) data. We expurgate from our estimates the fixed effects on both time and cross section dimensions in order to take into account not only countries' idiosyncrasies but also the world context for each period which is common to all countries[7]. Since we use a time-series-cross-section (TSCS), where the episodes occur in distinct periods for distinct countries, we cannot assume that the observations are identically distributed in any of both dimensions. Hence, heteroskedastic robust confidence intervals are computed using the Panel Corrected Standard Error (PCSE) methodology introduced by Beck and Katz (1995).

Table 3 presents four regressions' results for samples with 2093 observations which are different only because of the definition of d_episode window. In the second column, the dummies *d_ sudden_ stop* and *d_ episode* are equal valued whereas the episode window comprises the sudden stop window and the 2, 4 and 6 subsequent quarters in the third, fourth, and fifth columns, respectively. Based on the results, we conclude that there is not strong evidence that openness influences the exchange rate devaluation magnitude on the episode period, but they do when this period is extended by encompassing subsequent quarters.

Notice that for the cases where *d_ episode* window encompasses the *d_ sudden_ stop* window and some subsequent quarters, the coefficients of *d_ episode* dummy are always positive (at 10% or 1% levels of confidence) whereas the coefficients of

[7]We have executed the Haussman test in order to compare fixed effect specification with random effect specification. We have concluded that the fixed effect specification is the appropriate one.

d_ sudden_ stop dummy are always negative (at 1% level of confidence). It means that the *d_ sudden_ stop* window does not capture a considerable part of the real exchange rate devaluation that occurs in sudden stop episodes. Moreover, the negative coefficients (around 12% to 14% levels of confidence) of the interaction between the dummy *d_ sudden_ stop* and the logarithm of degree of debt dollarization indicates that governments refrain more at a first moment to devaluate domestic currency the higher is the degree of liabilities denominated in foreign currencies. This evidence confirms that governments attempts to not devaluate domestic currency when it means a very high rise in the cost of the debt. That is the reason why the influence of trade openness on exchange rate devaluation during sudden stop episodes is not well verified in the second column.

The regressions results presented in third, fourth, and fifth columns show negative and significant (at 1% level) coefficients for the interaction between the dummy *d_ episode* and the logarithm of openness, which means that the real exchange rate devaluation in sudden stop episodes is smaller in more open economies. This result is controlled for the intensity of the sudden stop, for the degree of dollarization of liabilities when the episode occurs, and for the terms of trade shocks. As expected, higher intensity of a sudden stop leads to higher real exchange rate devaluation.

Table 3. Dependent Variable: $\Delta_{t,t-4}$log(rer)

Variables	no quarters	2 quarters	4 quarters	6 quarters
Constant	0.5548 ***	0.5404 ***	0.4995 ***	0.5030 ***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
d_episode	-0.0168	0.0448 *	0.0788 ***	0.0618 ***
	(0.5858)	(0.0708)	(0.0002)	(0.0023)
d_sudden_stop	—	-0.0308 ***	-0.0369 ***	-0.0351 ***
	—	(0.0067)	(0.0004)	(0.0004)
log($openness_{t-4}$)	-0.1676 ***	-0.1632 ***	-0.1512 ***	-0.1525 ***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
d_episode * log($openness_{t-4}$)	-0.0041	-0.0147 **	-0.0232 ***	-0.0177 ***
	(0.6752)	(0.0274)	(0.0001)	(0.0013)
log(intensity_t)	-0.1324 ***	-0.1327 ***	-0.1371 ***	-0.1356 ***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
d_sudden_stop * log(intensity_t)	0.2744 ***	0.3268 ***	0.3504 ***	0.3093 ***
	(0.0074)	(0.0004)	(0.0001)	(0.0005)
log(dollarization_t)	0.1259 ***	0.1248 ***	0.1212 ***	0.1226 ***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
d_sudden_stop * log(dollarization_t)	-0.0673	-0.0703	-0.0704	-0.0726
	(0.1443)	(0.1238)	(0.1253)	(0.1153)
$\Delta_{t,t-4}$log(terms of trade)	-0.3049 ***	-0.3236 ***	-0.3330 ***	-0.3147 ***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
d_episode * $\Delta_{t-4,t-8}$log(terms of trade)	0.2187	0.1700	0.1377	0.0626
	(0.1969)	(0.1316)	(0.1836)	(0.5137)
Observations	2093	2093	2093	2093
Adjusted R^2	0.4599	0.4624	0.4652	0.4630

Heteroskedastic robust p-value in parentesis

* 10% significative; ** 5% significative; *** 1% significative

Table 4 presents weak evidence that openness effect has stronger impact in emerging economies during sudden stop episodes than in OECD countries. The coefficients of the interaction among log($openness_{t-4}$), d_episode, and d_emerging are negative in all regressions, but significant at 10% level only in the specification where episode window comprises the sudden stop and the subsequent year.

Table 4. Dependent Variable: $\Delta_{t,t-4}$log(rer)

Variables	2 quarters	4 quarters	6 quarters
Constant	0.5393 ***	0.4918 ***	0.4973 ***
	(0.0000)	(0.0000)	(0.0000)
d_episode	0.0314	0.0480 ***	0.0409 **
	(0.1616)	(0.0132)	(0.0269)
d_sudden_stop	-0.0258 **	-0.0324 ***	-0.0320 ***
	(0.0183)	(0.0012)	(0.0009)
d_episode * d_emerging	0.0409	0.0911 *	0.0625
	(0.4928)	(0.0736)	(0.2097)
d_sudden_stop * d_emerging	-0.0150	-0.0137	-0.0100
	(0.4764)	(0.4649)	(0.5777)
log($openness_{t-4}$)	-0.1628 ***	-0.1489 ***	-0.1508 ***
	(0.0000)	(0.0000)	(0.0000)
d_episode * log($openness_{t-4}$)	-0.0120 *	-0.0151 ***	-0.0121 **
	(0.0593)	(0.0063)	(0.0228)
d_episode * d_emerging * log($openness_{t-4}$)	-0.0088	-0.0239 *	-0.0167
	(0.5750)	(0.0805)	(0.2126)
log(intensity$_t$)	-0.1327 ***	-0.1369 ***	-0.1359 ***
	(0.0000)	(0.0000)	(0.0000)
d_sudden_stop * log(intensity$_t$)	0.3355 ***	0.3619 ***	0.3179 ***
	(0.0004)	(0.0001)	(0.0006)
log(dollarization$_t$)	0.1245 ***	0.1196 ***	0.1218 ***
	(0.0000)	(0.0000)	(0.0000)
d_sudden_stop * log(dollarization$_t$)	-0.0689	-0.0708	-0.0714
	(0.1462)	(0.1397)	(0.1377)
$\Delta_{t,t-4}$log(terms of trade)	-0.3225 ***	-0.3291 ***	-0.3111 ***
	(0.0000)	(0.0000)	(0.0000)
d_episode * $\Delta_{t,t-4}$log(terms of trade)	0.1738	0.1295	0.0540
	(0.1293)	(0.2192)	(0.5785)
Observations	2093	2093	2093
Adjusted R^2	0.4621	0.4665	0.4631

Heteroskedastic robust p-value in parentesis

* 10% significative; ** 5% significative; *** 1% significative

In appendix, we show regressions which change the specification (1) in order to check the robustness of results obtained in tables 3 and 4. Tables 5, 6, and 7 confirm the robustness of the existence of the openness effect during sudden stops episodes. On the other hand, the stronger impact of the effect in emerging countries is only confirmed at 10% level of significance when the episode window comprises the sudden stop and 6 subsequent quarters (table 10). Despite that weak robustness, the coefficient of the interaction among the dummies *d_ episode*, *d_ emerging*, and the variable log($openness_{t-4}$) is negative

in all regressions in tables (8) and (9).

We run the same specifications of tables (3) and (4) in tables (11) and (12), but in a subsample where the time dimension starts in 1990 and ends in 2006. It aims to check if the structural changes which occurred in world economy between the 70's and 90's impacts the strength (or existence) of the openness effect during sudden stops. The results confirm again the robustness of the existence of the openness effect during sudden stops. In this subsample the effect is stronger for all countries, but it is not stronger for emerging countries than for OECD ones.

5 Conclusion

The empirical exercises carried out in this paper aim to understand the behavior of the balance of payments during sudden stop episodes, particularly, the process of reversion of the net results of the current account. The episode's mechanism may be represented by the classical "Transfer Problem" discussed between Keynes and Ohlin during the 20's. In the case of sudden stops, economies play the same role of the First World War's winners as receptors of capital.

Using this metaphor, we can compare sudden stop episodes to a hypothetical and non-declared default by Germany. In this case, the Allies, receptors of capital, taking for granted the regular inflow of resources and, hence, dependent on them to finance their liabilities; have to search for new solutions to reach equilibrium in the Balance of Payments. A possible solution is to increase the trade balance surplus which can be driven by a real exchange rate devaluation and/or by a strong recession of the domestic economy.

We have verified that more open economies can achieve the equilibrium in the Balance of Payments through smaller domestic currency devaluations, which confirms the existence of an openness effect, i.e., the elasticity of trade balance surplus with relation to real exchange rate is higher, the higher is the trade volume experienced by an economy. The results seem to indicate that such effect is greater in emerging economies. We also have found evidences that higher share of debt denominated in foreign currencies motivates governments to procrastinate a definite solution to the crisis.

Real exchange rate devaluations represent a social cost and, therefore, it is desirable that, when necessary, they should be small with a strong real effect. The most important result of these empirical exercises reveal that trade openness is the economic feature, under exclusive control of the country policymaker, that provides the most powerful effect in the trade balance given currency devaluations. Considering this result and the one from Calvo et all (2004), which identifies broader trade openness and lower domestic debt dollarization as characteristics that reduce the probability of sudden stop occurrence, we emphasize the importance of public policies that encourage international trade in emerging economies.

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6 Appendix

Episode window comprising the sudden stop and 2 subsequent quarters

Table 5. Dependent Variable: $\Delta_{t,t-4}$log(rer)

Variables	Specifications		
	I	II	III
Constant	0.4980 ***	0.6559 ***	0.6572 ***
	(0.0000)	(0.0000)	(0.0000)
d_episode	0.0275	0.0144	0.0170
	(0.2507)	(0.5712)	(0.0500)
d_sudden_stop	-0.0318 ***	-0.0348 ***	-0.0348 ***
	(0.0002)	(0.0013)	(0.0026)
log($openness_{t-4}$)	-0.1380 ***	-0.1854 ***	-0.1916 ***
	(0.0000)	(0.0000)	(0.0000)
d_episode * log($openness_{t-4}$)	-0.0071	-0.0040	-0.0048
	(0.2644)	(0.5562)	(0.4830)
log(intensity$_t$)		-0.1933 ***	-0.1909 ***
		(0.0000)	(0.0000)
d_sudden_stop * log(intensity$_t$)		0.2993 ***	0.3486 ***
		(0.0005)	(0.0002)
log(dollarization$_t$)			0.0678 ***
			(0.0000)
d_sudden_stop * log(dollarization$_t$)			-0.0297
			(0.1262)
$\Delta_{t,t-4}$log(terms of trade)			
d_episode * $\Delta_{t,t-4}$log(terms of trade)			
Observations	4027	3422	3142
Adjusted R^2	0.2340	0.3179	0.4652

Heteroskedastic robust p-value in parentesis

* 10% significative; ** 5% significative; *** 1% significative

Episode window comprising the sudden stop and 4 subsequent quarters

Table 6. Dependent Variable: $\Delta_{t,t-4}$log(rer)

Variables	Specifications		
	I	II	III
Constant	0.4760 ***	0.6260 ***	0.6290 ***
	(0.0000)	(0.0000)	(0.0000)
d_episode	0.0804 ***	0.0699 ***	0.0663 ***
	(0.0001)	(0.0014)	(0.0020)
d_sudden_stop	-0.0393 ***	-0.0441 ***	-0.0434 ***
	(0.0000)	(0.0000)	(0.0000)
log($openness_{t-4}$)	-0.1325 ***	-0.1774 ***	-0.1839 ***
	(0.0000)	(0.0000)	(0.0000)
d_episode * log($openness_{t-4}$)	-0.0196 ***	-0.0182 ***	-0.0174 ***
	(0.0005)	(0.0021)	(0.0031)
log(intensity$_t$)		-0.1927 ***	-0.1905 ***
		(0.0000)	(0.0000)
d_sudden_stop * log(intensity$_t$)		0.3524 ***	0.3978 ***
		(0.0000)	(0.0000)
log(dollarization$_t$)			0.0666 ***
			(0.0000)
d_sudden_stop * log(dollarization$_t$)			-0.0299
			(0.1218)
$\Delta_{t,t-4}$log(terms of trade)			
d_episode * $\Delta_{t,t-4}$log(terms of trade)			
Observations	4027	3422	3142
Adjusted R^2	0.2340	0.3179	0.4652

Heteroskedastic robust p-value in parentesis

* 10% significative; ** 5% significative; *** 1% significative

Episode window comprising the sudden stop and 6 subsequent quarters

Table 7. Dependent Variable: $\Delta_{t,t-4}$log(rer)

Variables	Specifications		
	I	II	III
Constant	0.4699 ***	0.6160 ***	0.6191 ***
	(0.0000)	(0.0000)	(0.0000)
d_episode	0.0843 ***	0.0747 ***	0.0698 ***
	(0.0000)	(0.0003)	(0.0006)
d_sudden_stop	-0.0380 ***	-0.0442 ***	-0.0440 ***
	(0.0000)	(0.0000)	(0.0000)
log($openness_{t-4}$)	-0.1311 ***	-0.1749 ***	-0.1815 ***
	(0.0000)	(0.0000)	(0.0000)
d_episode * log($openness_{t-4}$)	-0.0207 ***	-0.0190 ***	-0.0174 ***
	(0.0001)	(0.0007)	(0.0018)
log(intensity_t)		-0.1924 ***	-0.1898 ***
		(0.0000)	(0.0000)
d_sudden_stop * log(intensity_t)		0.3435 ***	0.3855 ***
		(0.0000)	(0.0000)
log(dollarization_t)			0.0667 ***
			(0.0000)
d_sudden_stop * log(dollarization_t)			-0.0300
			(0.1211)
$\Delta_{t,t-4}$log(terms of trade)			
d_episode * $\Delta_{t,t-4}$log(terms of trade)			
Observations	4027	3422	3142
Adjusted R^2	0.2348	0.3189	0.3137

Heteroskedastic robust p-value in parentesis

* 10% significative; ** 5% significative; *** 1% significative

Episode window comprising the sudden stop and 2 subsequent quarters

Table 8. Dependent Variable: $\Delta_{t,t-4}$log(rer)

Variables	I	II	III
Constant	0.4989 ***	0.6568 ***	0.6561 ***
	(0.0000)	(0.0000)	(0.0000)
d_episode	0.0319	0.0222	0.0258
	(0.1805)	(0.3586)	(0.2920)
d_sudden_stop	-0.0157 *	-0.0207 **	-0.0226 **
	(0.0790)	(0.0442)	(0.0435)
d_episode * d_emerging	-0.0116	-0.0143	-0.0170
	(0.8212)	(0.7839)	(0.7388)
d_sudden_stop * d_emerging	-0.0342 *	-0.0354 **	-0.0274
	(0.0537)	(0.0485)	(0.1487)
log($openness_{t-4}$)	-0.1383 ***	-0.1857 ***	-0.1912 ***
	(0.0000)	(0.0000)	(0.0000)
d_episode * log($openness_{t-4}$)	-0.0100	-0.0079	-0.0100
	(0.1300)	(0.2352)	(0.1462)
d_episode * d_emerging * log($openness_{t-4}$)	-0.0065	0.0079	0.0097
	(0.6306)	(0.5891)	(0.4749)
log(intensity$_t$)		-0.1931 ***	-0.1910 ***
		(0.0000)	(0.0000)
d_sudden_stop * log(intensity$_t$)		0.3313 ***	0.3609 ***
		(0.0002)	(0.0003)
log(dollarization$_t$)			0.0674 ***
			(0.0000)
d_sudden_stop * log(dollarization$_t$)			-0.0248
			(0.2197)
$\Delta_{t,t-4}$log(terms of trade)			
d_episode * $\Delta_{t,t-4}$log(terms of trade)			
Observations	4027	3422	3142
Adjusted R^2	0.2304	0.3153	0.3100

Heteroskedastic robust p-value in parentesis

* 10% significative; ** 5% significative; *** 1% significative

Episode window comprising the sudden stop and 4 subsequent quarters

Table 9. Dependent Variable: $\Delta_{t,t-4}$log(rer)

Variables	I	II	III
Constant	0.4732 ***	0.6217 ***	0.6223 ***
	(0.0000)	(0.0000)	(0.0000)
d_episode	0.0482 **	0.0405 *	0.0413 *
	(0.0208)	(0.0539)	(0.0530)
d_sudden_stop	-0.0221 ***	-0.0296 ***	-0.0313 ***
	(0.0054)	(0.0015)	(0.0020)
d_episode * d_emerging	0.0737 *	0.0723	0.0635
	(0.0923)	(0.1062)	(0.1455)
d_sudden_stop * d_emerging	-0.0366 **	-0.0382 **	-0.0297 *
	(0.0193)	(0.0166)	(0.0814)
log($openness_{t-4}$)	-0.1317 ***	-0.1762 ***	-0.1819 ***
	(0.0000)	(0.0000)	(0.0000)
d_episode * log($openness_{t-4}$)	-0.0124 **	-0.0116 *	-0.0130 **
	(0.0339)	(0.0468)	(0.0322)
d_episode * d_emerging * log($openness_{t-4}$)	-0.0166	-0.0165	-0.0126
	(0.1573)	(0.1677)	(0.2821)
log(intensity$_t$)		-0.1917 ***	-0.1899 ***
		(0.0000)	(0.0000)
d_sudden_stop * log(intensity$_t$)		0.3945 ***	0.4248 ***
		(0.0000)	(0.0000)
log(dollarization$_t$)			0.0655 ***
			(0.0000)
d_sudden_stop * log(dollarization$_t$)			-0.0252
			(0.2102)
$\Delta_{t,t-4}$log(terms of trade)			
d_episode * $\Delta_{t,t-4}$log(terms of trade)			
Observations	4027	3422	3142
Adjusted R^2	0.2349	0.3192	0.3136

Heteroskedastic robust p-value in parentesis

* 10% significative; ** 5% significative; *** 1% significative

Episode window comprising the sudden stop and 6 subsequent quarters

Table 10. Dependent Variable: $\Delta_{t,t-4}$log(rer)

Variables	I	II	III
Constant	0.4655 ***	0.6093 ***	0.6105 ***
	(0.0000)	(0.0000)	(0.0000)
d_episode	0.0457 **	0.0372 *	0.0358 *
	(0.0216)	(0.0630)	(0.0785)
d_sudden_stop	-0.0214 ***	-0.0304 ***	-0.0334 ***
	(0.0047)	(0.0007)	(0.0006)
d_episode * d_emerging	0.0892 **	0.0913 **	0.0842 **
	(0.0318)	(0.0321)	(0.0429)
d_sudden_stop * d_emerging	-0.0354 **	-0.0365 **	-0.0268
	(0.0179)	(0.0167)	(0.1012)
log($openness_{t-4}$)	-0.1298 ***	-0.1730 ***	-0.1789 ***
	(0.0000)	(0.0000)	(0.0000)
d_episode * log($openness_{t-4}$)	-0.0117 **	-0.0100 *	-0.0101 *
	(0.0359)	(0.0743)	(0.0815)
d_episode * d_emerging * log($openness_{t-4}$)	-0.0209 *	-0.0220 *	-0.0191 *
	(0.0599)	(0.0534)	(0.0895)
log(intensity_t)		-0.1915 ***	-0.1894 ***
		(0.0000)	(0.0000)
d_sudden_stop * log(intensity_t)		0.3857 ***	0.4135 ***
		(0.0000)	(0.0000)
log(dollarization_t)			0.0654 ***
			(0.0000)
d_sudden_stop * log(dollarization_t)			-0.0254
			(0.2087)
$\Delta_{t,t-4}$log(terms of trade)			
d_episode * $\Delta_{t,t-4}$log(terms of trade)			
Observations	4027	3422	3142
Adjusted R^2	0.2364	0.3209	0.3151

Heteroskedastic robust p-value in parentesis

* 10% significative; ** 5% significative; *** 1% significative

Table 11. Dependent Variable: $\Delta_{t,t-4}$log(rer). Period: 1990 to 2006.

Variables	2 quarters	4 quarters	6 quarters
Constant	0.7151 ***	0.6361 ***	0.6248 ***
	(0.0000)	(0.0000)	(0.0000)
d_episode	0.0811 **	0.1381 ***	0.1342 ***
	(0.0212)	(0.0000)	(0.0000)
d_sudden_stop	-0.0261	-0.0331 **	-0.0313 **
	(0.1193)	(0.0298)	(0.0341)
log($openness_{t-4}$)	-0.2131 ***	-0.1906 ***	-0.1883 ***
	(0.0000)	(0.0000)	(0.0000)
d_episode * log($openness_{t-4}$)	-0.0221 **	-0.03748 ***	-0.0350 ***
	(0.0188)	(0.0000)	(0.0000)
log(intensity_t)	-0.1683 ***	-0.1721 ***	-0.1687 ***
	(0.0000)	(0.0000)	(0.0000)
d_sudden_stop * log(intensity_t)	0.3006 ***	0.3457 ***	0.2988 ***
	(0.0121)	(0.0028)	(0.0085)
log(dollarization_t)	0.1407 ***	0.1343 ***	0.1368 ***
	(0.0000)	(0.0000)	(0.0000)
d_sudden_stop * log(dollarization_t)	-0.0956 **	-0.0935 *	-0.0956 *
	(0.0516)	(0.0596)	(0.0557)
$\Delta_{t,t-4}$log(terms of trade)	-0.3461 ***	-0.3668 ***	-0.3398 ***
	(0.0087)	(0.0047)	(0.0138)
d_episode * $\Delta_{t,t-4}$log(terms of trade)	0.1774	0.1806	0.0800
	(0.3979)	(0.3937)	(0.7003)
Observations	1239	1239	1239
Adjusted R^2	0.3773	0.3896	0.3901

Heteroskedastic robust p-value in parentesis

* 10% significative; ** 5% significative; *** 1% significative

Table 12. Dependent Variable: $\Delta_{t,t-4}$log(rer). Period: 1990 to 2006.

Variables	2 quarters	4 quarters	6 quarters
Constant	0.7076 ***	0.6174 ***	0.6214 ***
	(0.0000)	(0.0000)	(0.0000)
d_episode	0.0858 ***	0.1349 ***	0.1567 ***
	(0.0089)	(0.0000)	(0.0000)
d_sudden_stop	-0.0250	-0.0340 **	-0.0334 **
	(0.1211)	(0.0195)	(0.0164)
d_episode * d_emerging	-0.0053	0.0151	-0.0391
	(0.9434)	(0.8072)	(0.5187)
d_sudden_stop * d_emerging	0.0036	0.0092	0.0100
	(0.8968)	(0.7180)	(0.6843)
log($openness_{t-4}$)	-0.2110 ***	-0.1852 ***	-0.1874 ***
	(0.0000)	(0.0000)	(0.0000)
d_episode * log($openness_{t-4}$)	-0.0266 ***	-0.0396 ***	-0.0446 ***
	(0.0040)	(0.0000)	(0.0000)
d_episode * d_emerging * log($openness_{t-4}$)	0.0084	0.0023	0.0175
	(0.6677)	(0.8897)	(0.2841)
log(intensity_t)	-0.1695 ***	-0.1757 ***	-0.1715 ***
	(0.0000)	(0.0000)	(0.0000)
d_sudden_stop * log(intensity_t)	0.2917 ***	0.3378 ***	0.2974 ***
	(0.0150)	(0.0037)	(0.0094)
log(dollarization_t)	0.1425 ***	0.1353 ***	0.1396 ***
	(0.0000)	(0.0000)	(0.0000)
d_sudden_stop * log(dollarization_t)	-0.1102 **	-0.1103 **	-0.1092 **
	(0.0393)	(0.0417)	(0.0451)
$\Delta_{t,t-4}$log(terms of trade)	-0.3510 ***	-0.3676 ***	-0.3511 ***
	(0.0080)	(0.0047)	(0.0110)
d_episode * $\Delta_{t,t-4}$log(terms of trade)	0.2291	0.2218	0.1233
	(0.2924)	(0.3104)	(0.5630)
Observations	1239	1239	1239
Adjusted R^2	0.3784	0.3914	0.3925

Heteroskedastic robust p-value in parentesis

* 10% significative; ** 5% significative; *** 1% significative

Chapter 2

Inflação, Abertura Comercial e Coordenação de Políticas Macroeconômicas

Abstract

Este artigo estende o modelo do acelerador financeiro para uma pequena economia aberta, desenvolvido por Gertler, Gilchrist e Natalucci (2003), incorporando uma tarifa de importação como variável de política comercial, com o objetivo de verificar se uma política de diminuição de tarifas de importação auxilia ou dificulta a tarefa do banco central no combate à inflação.

Os resultados encontrados, a partir da simulação do modelo para a economia brasileira, surpreendem porque, ao contrário do senso comum, diminuições de tarifa podem implicar no aumento da inflação e fazer o produto real crescer mais do que o produto natural.

Abstract

We extend the small open economy macroeconomic model with financial accelerator, developed by Gertler, Gilchrist and Natalucci (2003). We introduce the import tariff as a trade policy instrument to verify if it can help central banks in the control of inflation. The results show, against the commom wisdom, that tariff reductions may cause more inflation and increase the output gap.

Keywords: monetary policy, openness, credit channel, financial accelerator
Class JEL: E61

1 Introdução

Após mais de uma década da criação do Plano Real a economia brasileira vive um período de razoável estabilidade econômica. A utilização do Banco Central como instrumento político parece não fazer mais parte da realidade brasileira, e reformas institucionais importantes vêm sendo adotadas, como a adoção da nova lei de falências e a criação do crédito com consignação em folha de pagamento.

No entanto, uma questão que tem preocupado os analistas econômicos é a alta taxa de juros e a resiliência da taxa de inflação. Muitos apontam as altas taxas de juros como um entrave ao crescimento sustentado. Por outro lado, defensores da política monetária seguida pelo Banco Central alertam para o perigo de se arrefecer o combate à inflação em uma economia cujo desenvolvimento foi adiado devido a décadas de taxas de inflação elevadíssimas.

Desta forma, faz-se necessário uma melhor compreensão do mecanismo de transmissão da taxa de juros e, conseqüentemente, a adoção de políticas econômicas alternativas que auxiliem a autoridade monetária na difícil tarefa de diminuição da taxa básica de juros sem se desalentar ao combate contra a inflação. Por conseguinte, é imprescindível o desenvolvimento de um modelo que incorpore as características intrínsecas de uma economia emergente.

Economias emergentes são caracterizadas pela existência de mercados de crédito menos eficientes em virtude da presença de fricções decorrentes do problema de principal-agente entre os credores e os tomadores de empréstimos e de desenhos institucionais defeituosos. Tais fricções elevam o custo de financiamento dos projetos de investimento, restringindo, portanto, o crescimento destas economias.

Tendo em vista o grande impacto das imperfeições no mercado de crédito sobre a economia, seria inadequada a aplicação dos modelos macroeconômicos tradicionais, que adotam hipóteses a la Modigliani-Miller (1958), em que a estrutura financeira das empresas não tem efeito sobre os resultados reais da economia. A irrelevância mencionada pode passar como uma simplificação para modelos de economias desenvolvidas, onde o mercado de crédito é mais eficiente e os custos de financiamento são relativamente menos relevantes. No entanto, para economias emergentes a hipótese da existência de imperfeições no mercado financeiro parece ser mais realista e alguns modelos apontam para o fato de que, na realidade, as condições do mercado financeiro não estão apenas sujeitas ao estado da economia, como também possuem forte influência sobre a mesma. Desta forma, para a melhor compreensão do mecanismo de transmissão da taxa de juros em economias emergentes, é necessário a utilização de modelos que incorporem os impactos da estrutura do sistema financeiro sobre o comportamento das variáveis econômicas.

Este artigo é uma versão modificada do modelo do acelerador financeiro de Gertler, Gilchrist e Natalucci (2003)[1]. Introduzimos a tarifa de importação como variável de política comercial porque desejamos descobrir qual o efeito

[1] Estendem o modelo de Bernanke, Gertler e Gilchrist (1999) para uma pequena economia aberta.

de uma política comercial de diminuição de tarifas sobre a inflação. Caso essa política tenha um viés inflacionário, é muito importante uma coordenação das políticas comerciais com a política monetária conduzida pelo banco central para evitar que os indivíduos sejam prejudicados pelos males inflacionários.

O modelo do acelerador financeiro, desenvolvido em Bernanke, Gertler & Gilchrist (1999), é um modelo novo keynesiano dinâmico com rigidez nominal que mostra que o funcionamento interno do mercado de crédito trabalha no sentido de propagar e amplificar os choques na economia. O mecanismo base do modelo é uma relação inversa existente entre o prêmio de risco exigido pelos credores no financiamento dos projetos de investimento e o valor líquido das firmas, consonante com o resultado de Jensen & Meckling (1976) de que o custo de agência entre credores e tomadores de empréstimo é maior quanto menor a quantidade de colateral oferecida pelo tomador para investir no projeto. Tal mecanismo garante ao modelo a presença de ciclos mais acentuados na medida em que o valor das firmas é pró-cíclico enquanto o prêmio de risco exigido pelos credores é anticíclico.

O objetivo é investigar os efeitos de uma coordenação de políticas monetária e comercial sobre o comportamento da taxa de inflação. Seria possível, em um ambiente de imperfeições no mercado de crédito, aliar uma política monetária expansionista (diminuição da taxa de juros) a uma política comercial mais aberta (diminuição da tarifa de importação) de forma a manter a inflação estável? A confirmação dessa suspeita significaria que a abertura comercial poderia ser entendida também como um instrumento a ser utilizado para reduzir os custos inflacionários de uma política monetária expansionista.

O artigo está organizado da seguinte forma: a seção 2 traz a metodologia utilizada, a seção 3 apresenta o modelo, a seção 4 apresenta a calibração do modelo para podermos simular o comportamento da economia brasileira perante choques na taxa de juros e na tarifa de importação, a seção 5 apresenta os resultados e a interpretação da simulação e, finalmente, a seção 6 traz as conclusões e sugestões para pesquisas futuras.

2 Metodologia

O objetivo deste trabalho é analisar os efeitos de uma política monetária expansionista em coordenação com uma política de abertura comercial sobre a taxa de inflação. Para tanto, foi realizada uma simulação para a economia brasileira de uma versão modificada (inclusão de uma tarifa de importação) do modelo do acelerador financeiro para uma pequena economia aberta, desenvolvido por Gertler, Gilchrist e Natalucci no artigo "External Constraints on Monetary Policy and The Financial Accelerator"(2003).

O modelo pode ser dividido em duas etapas: na primeira, deriva-se a oferta de empréstimos a partir do problema de contrato (análise de equilíbrio parcial) entre o credor (bancos) e o investidor (empresário)[2]; em seguida, incorpora-se a oferta de empréstimos, derivada no contrato, em um modelo de equilíbrio geral

[2] Ver apêndice A.

novo keynesiano dinâmico com rigidez nominal para uma pequena economia aberta.

Para encontrar a solução do modelo completo representado por um sistema linear de expectativas racionais, utiliza-se o programa desenvolvido por Christopher Sims (gensys.m)[3].

As imperfeições no mercado de crédito se baseiam na assimetria de informação entre o credor e o tomador de empréstimos, caracterizando o conflito de interesses entre ambos, na medida em que há um incentivo perverso para que os tomadores incorram em um risco maior do que estariam dispostos se estivessem financiando seus investimentos com capital próprio. Desta forma, adota-se a abordagem de "costly state verification", desenvolvida por Townsend (1979), onde o credor arca com um custo para observar o retorno do capital. Esta hipótese será suficiente para gerar uma relação inversa entre a taxa de juros paga pelo tomador pelos empréstimos concedidos (prêmio de risco) e a parte deste investimento que é colateralizada com o capital próprio da empresa.

3 Modelo

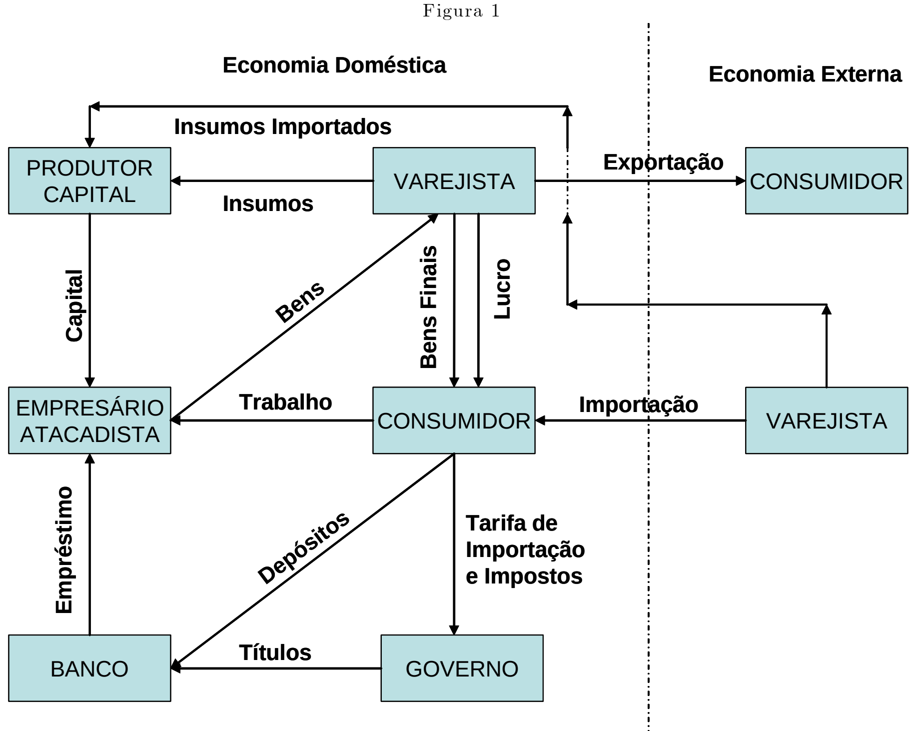
O modelo é uma versão modificada do modelo de Gertler, Gilchrist e Natalucci (2003), a partir de agora denominado GGN, onde incorporamos uma tarifa de importação para o consumo de bens e insumos estrangeiros. Dessa forma, é possível analisar o impacto de políticas comerciais sobre o comportamento das diversas variáveis econômicas. A economia é composta por 7 agentes: os consumidores, os empresários, as empresas de varejo, os produtores de capital, o governo, os bancos e o setor externo.

Os consumidores trabalham e alocam sua renda em depósitos financeiros, consumo de bens domésticos e importados e pagam impostos diretos e indiretos (tarifa de importação). Os bancos são apenas intermediários, recebem depósitos dos consumidores, compram títulos públicos e emprestam aos empresários atacadistas. Os empresários atacadistas operam em concorrência perfeita, adquirem mão-de-obra e capital para a produção de bens no período seguinte. Estes bens são vendidos aos varejistas, que os diferenciam à custo zero e os revendem aos consuimdores domésticos e estrangeiros e aos produtores de capital, cobrando um markup sobre o preço pago ao empresário atacadista (pois operam em concorrência monopolística). Os produtores de capital operam em competição perfeita, adquirem insumos domésticos e estrangeiros para a produção de capital novo e para reparar o capital já depreciado a serem utilizados no período seguinte. O governo conduz as políticas monetária, fiscal e comercial, financia seus gastos correntes com impostos lump-sum, criação de moeda e receita de tarifa de importação (impostos indiretos). Também adota uma política de câmbio flexível, seguindo uma regra de juros de instrumento a la Taylor, onde a taxa de juros nominal é fixada pelo Banco Central de forma

[3] Código obtido em sua home page www.princeton.edu/~sims/. Para maiores informações sobre o método de solução adotado ver "Solving Linear Rational Expectations Models", by Christopher Sims.

a minimizar os desvios da taxa de inflação e do hiato do produto de seus níveis no estado estacionário. Abaixo a figura 1 apresenta um esquema gráfico para o modelo:

Figura 1



Em seguida, apresentamos o problema enfrentado por cada agente individualmente.

3.1 Consumidores

Na economia há um contínuo de consumidores avessos ao risco, que possuem vida infinita, consomem bens domésticos e importados, trabalham e poupam. Os bens domésticos e importados são substitutos imperfeitos e a poupança pode ser alocada na forma de ativos monetários e depósitos junto ao sistema financeiro.

As preferências dos consumidores sobre os bens são representadas por uma CES:

$$C_t = \left[(\gamma)^{\frac{1}{\rho}} \left(C_t^H \right)^{\frac{\rho-1}{\rho}} + (1-\gamma)^{\frac{1}{\rho}} \left(C_t^F \right)^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}} \tag{1}$$

onde ρ é a elasticidade de substituição intratemporal para o bem de consumo composto e γ é a proporção de consumo de bens domésticos, C_t é a cesta de consumo dos bens tradables e, por fim, C_t^H e C_t^F são respectivamente as cestas de consumo dos bens domésticos e importados vendidos em competição monopolística pelos varejistas domésticos.

O índice de preços ao comsumidor correspondente, P_t, é dado por:

$$P_t = \left[(\gamma)\left(P_t^H\right)^{1-\rho} + (1-\gamma)\left(P_t^F\right)^{1-\rho}\right]^{\frac{1}{1-\rho}} \tag{2}$$

O consumidor representativo escolhe $C_{t+i}, H_{t+i}, \frac{M_{t+i}}{P_{t+i}}$ D^*_{t+i} e D_{t+i} de forma a maximizar sua utilidade:

$$\max\ E_0 \sum_{t=0}^{\infty} \beta^t U\left(C_t, H_t, \frac{M_t}{P_t}\right)$$

com

$$U\left(C_t, H_t, \frac{M_t}{P_t}\right) = \frac{\left[(C_t)^{1-\varsigma}(1-H_t)^{\varsigma}\right]^{1-\sigma}}{1-\sigma} + \xi \log\left(\frac{M_t}{P_t}\right) \tag{3}$$

e $\sigma \geq 0$, $\varsigma \in (0,1)$ e $\xi > 0$. H_t é o trabalho e $\frac{M_t}{P_t}$ os saldos monetários reais.

A restrição de recursos do consumidor é:

$$C_t = \frac{W_t}{P_t}H_t + \Pi_t - T_t - \frac{M_t - M_{t-1}}{P_t} - \frac{D_t - (1+i_{t-1})D_{t-1}}{P_t} - \frac{S_t D_t^* - S_t \Psi_t \left(1+i^*_{t-1}\right) D^*_{t-1}}{P_t} \tag{4}$$

onde $\frac{W_t}{P_t}$ é o salário real; Π_t são os dividendos pagos pelas empresas de varejo; T_t são os impostos lump sum; S_t é a taxa de câmbio nominal; D_t e D_t^* os depósitos denominados em moeda doméstica e estrangeira, respectivamente; $(1+i_t)$ e $(1+i_t^*)$ as taxas de juros nominais doméstica e estrangeira, respectivamente; e Ψ_t representa o prêmio de risco pago pelos residentes para obter fundos no exterior (risco país). Assume-se que Ψ_t depende do endividamento externo líquido NF_t[4] e de um choque aleatório ϕ_t, de tal forma que:

$$\Psi_t = f(NF_t)\,\phi_t \tag{5}$$

com $f'(\cdot) > 0$.

As condições de otimalidade para o consumo, trabalho e poupança são:

$$\frac{C_t^H}{C_t^F} = \frac{\gamma}{1-\gamma}\left(\frac{P_t^H}{P_t^F}\right)^{-\rho} \tag{6}$$

$$(1-\varsigma)\frac{1}{C_t}\frac{W_t}{P_t} = \varsigma\frac{1}{1-H_t} \tag{7}$$

$$\lambda_t = \beta E_t\left\{\lambda_{t+1}(1+i_t)\frac{P_t}{P_{t+1}}\right\} \tag{8}$$

onde λ_t, a utilidade marginal do consumo, é dada por:

$$\lambda_t = (1-\varsigma)(C_t)^{(\sigma-1)(\varsigma-1)-1}(1-H_t)^{\varsigma(1-\sigma)} \tag{9}$$

[4] Ao contrário de GGN, assume-se que este prêmio de risco está perfeitamente correlacionado com o nível de endividamento das firmas domésticas.

A condição de otimalidade na escolha dos títulos externos em conjunto com a equação (8) gera a equação da paridade descoberta da taxa de juros:

$$E_t \left\{ \lambda_{t+1} \frac{P_t}{P_{t+1}} \left[(1 + i_t) - \Psi_t \left(1 + i_t^*\right) \frac{S_{t+1}}{S_t} \right] \right\} = 0 \tag{10}$$

3.2 Setor Externo

Para evitar arbitragem no mercado de bens, faz-se necessário a distinção entre o preço dos bens importados no mercado atacadista e o preço de varejo no mercado doméstico, permitindo competição imperfeita e pricing-to-market na economia local. Desta forma, sendo P_t^F o preço do bem importado em moeda doméstica pago pelo consumidor doméstico no mercado varejista, P_t^{F*} o preço do bem importado em moeda estrangeira cobrado pelo varejista estrangeiro[5] e τ_t a tarifa de importação cobrada pelo governo sobre o bem importado. A lei do preço único implica em:

$$P_t^F = (1 + \tau_t) S_t P_t^{F*} \tag{11}$$

Assume-se que a taxa de juros nominal externa $(1 + i_t^*)$ e o preço em moeda estrangeira do bem importado $P_{W,t}^{F*}$ são exógenos e que a demanda externa pelos bens domésticos[6], C_t^{H*}, é dada por:

$$C_t^{H*} = \left[\left(\frac{P_t^{H*}}{P_t^*} \right)^{-\varkappa} Y_t^* \right]^{\nu} \left(C_{t-1}^{H*}\right)^{1-\nu}, \ 0 \leq \nu \leq 1 \tag{12}$$

onde Y_t^* é o produto real externo, P_t^{H*} é o preço do bem doméstico em moeda estrangeira[7] e $\left(C_{t-1}^{H*}\right)^{1-\nu}$ representa a inércia na demanda externa pelos bens domésticos.

3.3 Empresários Atacadistas

Assume-se que o empresário é neutro ao risco e tem vida finita, onde a cada instante as empresas têm uma probabilidade constante (η) de sobrevivência. A cada período t, as firmas investem na aquisição de capital físico e contratam mão-de-obra para gerar produto no período seguinte, utilizando uma tecnologia de retornos constantes de escala. O empresário também adquire renda no mercado de trabalho, ofertando sua mão de obra, H_t^e[8]. A aquisição de capital é financiada

[5] O varejista estrangeiro cobra um markup $\left(\mu^f\right)$ sobre o preço pago ao atacadista estrangeiro $\left(P_W^{F*}\right)$. A seção 3.5 apresenta o problema de fixação de preços dos varejistas.

[6] Como a pequena economia doméstica não afeta o produto, o nível de preços e a taxa de juros externa, esta relação seria uma forma reduzida para a curva de demanda de exportação.

[7] Por hipótese não há incidência de tarifa de importação sobre os bens domésticos.

[8] Assume-se que os empresáios ofertam trabalho inelasticamente, de forma que a oferta de trabalho do empresário é normalizada para um.

com o capital próprio da empresa e com empréstimos junto ao sistema financeiro. A função de produção agregada do bem final em cada período é dada por:

$$Y_t = w_t A_t \left(K_t u_t\right)^{\alpha} L_t^{1-\alpha} \tag{13}$$

onde Y_t é o produto, K_t é a quantidade de capital comprada pelos empresários no instante $t-1$, u_t é a taxa de utilização do capital em t, A_t é um parâmetro tecnológico exógeno e L_t é o trabalho total utilizado na produção, dado por:

$$L_t = H_t^{\Omega} H_t^{e(1-\Omega)},$$

onde $(1-\Omega)$ é a proporção de empresários na força de trabalho total.

Como o empresário opera em concorrência perfeita, seu lucro tem que ser igual a zero:

$$\Pi_t = \frac{P_{W,t}}{P_t} Y_t + \left(Q_t - \frac{P_{I,t}}{P_t} \delta\left(u_t\right)\right) w_t K_t - \frac{W_t}{P_t} H_t - \frac{W_t^e}{P_t} H_t^e - Q_{t-1} K_t = 0$$

O produto bruto, GY_t, consiste na soma das receitas da produção e do valor de mercado do estoque de capital residual. Assume-se a existência de um choque idiossincrático w_t que afeta a produção de novos bens (equação 13) e a sua quantidade efetiva de capital (w_t seria uma medida da qualidade do investimento).

Seja $P_{W,t}$ o preço nominal do bem cobrado pelo empresário no atacado, Q_t o preço real de mercado do capital, $P_{I,t}$ o preço nominal de deslocamento do capital e $\delta\left(u_t\right)$ a taxa de depreciação do capital, que depende da taxa de utilização do capital. Então, o produto bruto é dado por:

$$GY_t = \frac{P_{W,t}}{P_t} Y_t + \left(Q_t - \frac{P_{I,t}}{P_t} \delta\left(u_t\right)\right) w_t K_t \tag{14}$$

Note que o empresário tem a opção de vender o seu capital no final do período ou mantê-lo para a utilização no período seguinte. Assume-se que w_t é uma variável aleatória i.i.d com média um, $E\left\{w_t\right\} = 1$.

A taxa de depreciação é crescente na taxa de utilização do capital, seguindo Baxter e Farr (2001):

$$\delta\left(u_t\right) = \delta + \frac{b}{1+\xi}\left(u_t\right)^{1+\xi} \quad \text{com } \delta, b, \xi > 0 \tag{15}$$

onde ξ é elasticidade da depreciação marginal com relação a taxa de utilização do capital.

A cada instante o empresário contrata mão-de-obra L_t e escolhe a taxa de utilização do capital u_t de forma a maximizar o seu lucro, dado K_t, A_t e w_t. A decisão sobre a aquisição de capital será exposta em seguida.

As demandas por trabalho, tanto dos consumidores quanto dos empresários, são derivadas igualando o produto marginal do trabalho com o salário real:

$$(1-\alpha)\,\Omega \frac{Y_t}{H_t} = \frac{W_t}{P_{W,t}} \tag{16}$$

$$(1-\alpha)(1-\Omega)\frac{Y_t}{H_t^e} = \frac{W_t^e}{P_{W,t}} \tag{17}$$

A condição de otimalidade para a utilização de capital satisfaz[9]:

$$\alpha\frac{Y_t}{u_t} = \delta'(u_t) K_t \frac{P_{I,t}}{P_{W,t}} \tag{18}$$

Com relação a decisão de aquisição de capital o empresário se depara com a escolha de capital no instante t para utilizá-lo na produção do período seguinte $t+1$. O empresário financia parte de sua compra de capital com o seu capital próprio disponível no final do instante t e parte com empréstimos junto ao sistema financeiro. Desta forma, assume-se que não existe outras formas de financiamento (emissão de ações) e que a dívida é denominada em moeda doméstica. Então o financiamento de capital é dividido entre capital próprio e a dívida com o setor bancário da seguinte forma:

$$Q_t K_{t+1} = N_{t+1} + \frac{B_{t+1}}{P_t} \tag{19}$$

Desta forma, a demanda por capital depende do retorno marginal esperado do capital e do custo marginal esperado do financiamento. O retorno marginal do capital é o produto bruto menos os custos com o trabalho, normalizado pelo valor de mercado do capital no instante t :

$$\begin{aligned} 1 + r_{t+1}^k &= \frac{GY_{t+1} - \frac{W_{t+1}}{P_{t+1}} L_{t+1}}{Q_t K_{t+1}} \\ &= \frac{w_{t+1}\left[\frac{P_{W,t+1}}{P_{t+1}}\alpha\frac{\overline{Y}_{t+1}}{K_{t+1}} - \frac{P_{I,t+1}}{P_{t+1}}\delta(u_{t+1}) + Q_{t+1}\right]}{Q_t} \end{aligned} \tag{20}$$

onde $\overline{Y}_{t+1}$ é o nível médio de produto por negócio $\left(Y_{t+1} = w_t \overline{Y}_{t+1}\right)$. O retorno marginal esperado é dado por:

$$E_t\left\{1 + r_{t+1}^k\right\} = \frac{E_t\left\{\frac{P_{W,t+1}}{P_{t+1}}\alpha\frac{\overline{Y}_{t+1}}{K_{t+1}} - \frac{P_{I,t+1}}{P_{t+1}}\delta(u_{t+1}) + Q_{t+1}\right\}}{Q_t} \tag{21}$$

O custo marginal do financiamento depende da situação financeira da empresa. Introduz-se um problema de agência na qual o prêmio de risco cobrado pelo credor externo é inversamente proporcional a quantidade de colateral utilizada pelo empresário. Como em BGG (1999), assume-se a abordagem de costly state verification, onde o choque idiossincrático w_t é conhecido apenas pelo empresário. O credor só observa o retorno realizado do investimento arcando com

[9] A equação iguala o valor marginal do ganho de produto com uma taxa de utilização maior com o custo marginal do aumento da taxa de depreciação do capital.

um custo fixo proporcional à receita bruta do investimento, $\mu\left(1+r_{t+1}^{k}\right)Q_tK_{t+1}$ (custo de agência), onde μ será denominado taxa de perda bancária. O empresário e o credor externo (bancos) negociam um contrato financeiro que induza o empresário a revelar seu verdadeiro ganho e que minimize o custo de agência esperado. Seguindo BGG, o prêmio de financiamento externo, $\chi_t(\cdot)$, pode ser expresso como uma função crescente do nível de alavancagem do empresário $\left(\frac{\frac{B_{t+1}}{P_t}}{N_{t+1}}\right)$:

$$\chi_t(\cdot)=\chi\left(\frac{\frac{B_{t+1}}{P_t}}{N_{t+1}}\right)\quad \text{com } \chi'(\cdot)>0,\ \chi(0)=0,\ \chi(\infty)=\infty \tag{22}$$

O formato de $\chi_t(\cdot)$ depende dos parâmetros primitivos[10] do problema de contrato (costly state verification) derivado no apêndice A. Além disso, note que $\chi_t(\cdot)$ depende apenas do nível de alavancagem agregado pois, em equilíbrio, todas as empresas fazem a mesma escolha. Desta forma, a condição de otimalidade para a demanda por capital satisfaz:

$$E_t\left\{1+r_{t+1}^{k}\right\}=\left[1+\chi_t(\cdot)\right]E_t\left\{(1+i_t)\frac{P_t}{P_{t+1}}\right\} \tag{23}$$

onde $E_t\left\{(1+i_t)\frac{P_t}{P_{t+1}}\right\}$ é o custo de oportunidade do intermediador financeiro (bancos), ou seja, a taxa de juros real esperada.

A equação (23) reflete a relação entre a situação financeira do tomador do empréstimo (empresário) e o custo marginal do financiamento externo e, portanto, a demanda por capital. Observe que, flutuações no preço do capital, Q_t, podem ter efeitos significativos no nível de alavancagem, $\left(\frac{\frac{B_{t+1}}{P_t}}{N_{t+1}}=\frac{\frac{B_{t+1}}{P_t}}{Q_tK_{t+1}-\frac{B_{t+1}}{P_t}}\right)$, capturando a relação entre movimentos nos preços dos ativos e nível de alavancagem.

Adiante, modela-se a evolução do "valor das empresas", ou o seu capital próprio (N_{t+1}).

3.3.1 Valor das Empresas

O valor de uma empresa é composto da renda do trabalho do empresário (W^e) e dos ativos acumulados pela firma durante sua vida útil (V). Assim, o valor líquido agregado das empresas, também denominado como o seu capital próprio, ao final do período t, é dado por:

$$N_{t+1}=\eta V_t+W_t^e \tag{24}$$

onde η é a proporção de empresas que não decretam falência em t e V_t são os ativos acumulados pelas empresas durante sua vida útil. Assume-se que as

[10] A taxa de perda bancária (μ) e a distribuição do choque idiossincrático w_t.

empresas que entram em falência consomem todo o seu ativo acumulado nos períodos anteriores, isto é:

$$C_t^e = (1-\eta) V_t \tag{25}$$

Como as empresas utilizam todo o seu capital próprio (ativo) na aquisição de capital, temos que:

$$V_t = \left(1 + r_t^k\right) Q_{t-1} K_t - \left[(1 + \chi(\cdot))(1 + i_{t-1}) \frac{P_{t-1}}{P_t}\right] \frac{B_t}{P_{t-1}} \tag{26}$$

onde $\left(1 + r_t^k\right)$ é o retorno real do capital ex-post e $(1 + \chi(\cdot))(1 + i_{t-1}) \frac{P_{t-1}}{P_t}$ é o custo do empréstimo ex-post.

Pode-se agora substituir o salário recebido pelo empresário, assim como o valor dos ativos da empresa, de forma a encontrar o valor líquido da firma no final do instante t:

$$\begin{aligned} N_{t+1} &= \eta \left\{ \left(1 + r_t^k\right) Q_{t-1} K_t - \left[(1 + \chi(\cdot))(1 + i_{t-1}) \frac{P_{t-1}}{P_t}\right] \frac{B_t}{P_{t-1}}] \right\} \\ &\quad + (1-\alpha)(1-\Omega) w_t A_t \left(K_t u_t\right)_t^{\alpha} H_t^{\Omega(1-\alpha)} H_t^{e(1-\Omega)(1-\alpha)-1} P_{W,t} \end{aligned} \tag{27}$$

3.4 Produção de Capital

Os produtores de capital competem em dois mercados distintos sob competição perfeita: na produção de capital novo e no reparo do capital já depreciado. Assume-se que o capital já utilizado só é produtivo se for reparado e que a produção de capital novo requer um custo de ajustamento. Ambas atividades utilizam como insumo um bem de investimento composto de bens finais domésticos e estrangeiros:

$$I_t = [(\gamma_i)^{\frac{1}{\rho_i}} (I_t^H)^{\frac{\rho_i - 1}{\rho_i}} + (1-\gamma_i)^{\frac{1}{\rho_i}} (I_t^F)^{\frac{\rho_i - 1}{\rho_i}}]^{\frac{\rho_i}{\rho_i - 1}} \tag{28}$$

onde γ_i é a proporção de insumos domésticos utilizado no investimento e ρ_i é a elasticidade de substituição intratemporal no bem de investimento composto.

Os produtores de capital escolhem os insumos domésticos e estrangeiros de acordo com a seguinte condição de primeira ordem:

$$\frac{I_t^H}{I_t^F} = \frac{\gamma_i}{1-\gamma_i} \left(\frac{P_t^H}{P_t^F}\right)^{-\rho_i} \tag{29}$$

onde o índice de preços do investimento é dado por:

$$P_{I,t} = \left\{(\gamma_i) \left(P_t^H\right)^{1-\rho_i} + (1-\gamma_i) \left[P_t^F\right]^{1-\rho_i}\right\}^{\frac{1}{1-\rho_i}} \tag{30}$$

Para reparar o capital depreciado o produtor requer $\delta(u_t) K_t$ unidades de bens de investimento que são comprados ao custo de $\frac{P_{I,t}}{P_t} \delta_t K_t$. Para a produção de capital novo, utiliza-se bens de investimento e o capital já existente. Seja I_t^n a quantidade de bens de investimento utilizado na produção de novos bens de capital:

$$I_t^n = I_t - \delta(u_t) K_t \tag{31}$$

Cada produtor utiliza uma tecnologia de retornos constantes de escala $\Phi\left(\frac{I_t^n}{K_t}\right) K_t$, onde $\Phi(\cdot)$ é crescente e côncava[11]. Desta forma, a equação de acumulação de capital é dada por:

$$K_{t+1} = K_t + \Phi\left(\frac{I_t^n}{K_t}\right) K_t \tag{32}$$

Cada produtor escolhe os insumos I_t^n e K_t de forma a maximizar os lucros esperados da produção de novos bens de investimento, onde o novo bem de capital é vendido ao preço Q_t. Seguindo BGG, o produtor de capital toma suas decisões com defasagem de um período, capturando a demora na resposta do investimento verificada nos dados. Desta forma, a condição de otimalidade para o investimento satisfaz:

$$E_{t-1}\left\{Q_t \Phi'\left(\frac{I_t}{K_t} - \delta(u_t)\right) - \frac{P_{I,t}}{P_t}\right\} = 0 \tag{33}$$

3.5 As empresas de varejo

Para incorporar rigidez nominal, como nos modelos novo-keynesianos, alguns ofertantes, ao menos, devem ter poder de mercado. Entretanto, caso se assuma que os empresários atacadistas atuam em competição imperfeita, teríamos problemas de agregação já que, neste caso, a demanda por capital individual das empresas não seria linear em seu capital próprio. Para eliminar este problema, optou-se pela introdução de mais um agente na economia: as empresas de varejo.

As empresas domésticas e estrangeiras operam em competição perfeita e vendem seus produtos aos varejistas, que os diferenciam a custo zero, e os revendem aos consumidores, aos produtores de capital, ao governo e aos países estrangeiros cobrando um markup sobre o preço pago ao empresário atacadista. Assume-se que os lucros são repassados lump sum aos consumidores.

Seja $Y_t^H(z)$ a quantidade de produto vendida pelo varejista z, medida em unidades de bens finais, e $P_t^H(z)$ o preço nominal. O total de bens produzidos e o índice de preços correspondente são, seguindo Dixit e Stiglitz (1977), respectivamente:

$$Y_t^H = \left[\int_0^1 Y_t^H(z)^{\frac{(\upsilon-1)}{\upsilon}} dz\right]^{\frac{\upsilon}{\upsilon-1}} \tag{34}$$

$$P_t^H = \left[\int_0^1 P_t^H(z)^{(1-\upsilon)} dz\right]^{\frac{1}{1-\upsilon}} \tag{35}$$

onde $\upsilon > 1$.

[11] No exercício numérico assume-se uma função logarítmica para Φ.

Tem-se então que cada varejista se depara com uma curva de demanda dada por:

$$Y_t^H(z) = \left(\frac{P_t^H(z)}{P_t^H}\right)^{-\upsilon} Y_t^H \tag{36}$$

onde o custo marginal de uma unidade do bem é o preço relativo $\frac{P_{W,t}}{P_t^H}$.

Seguindo o modelo de fixação de preços a la Calvo, uma fração aleatória dos agentes ajusta seus preços a cada período, e a probabilidade de que um agente em particular ajuste seu preço $(1-\theta)$ independe de quanto tempo este está sem reajustá-lo. Desta forma, $\frac{1}{1-\theta}$ é o tempo médio esperado que o preço fica sem se reajustar.

Cada varejista escolhe então o seu preço $P_t^H(z)$, dado a curva de demanda e o preço do bem final, $P_{W,t}$. Seja $\overline{P}_t^H$ o preço fixado pelo varejista que reajusta o seu preço em t e $\overline{Y}_t(z)$ a demanda dado este preço. O varejista escolhe o seu preço de forma a maximizar o seu lucro esperado descontado, dado por:

$$\sum_{k=0}^{\infty} \theta^k E_{t-1}\left[\Lambda_{t,k} \frac{\overline{P}_t^H - P_{W,t+k}}{P_t} \overline{Y}_{t+k}(z)\right]$$

onde a taxa de desconto $\Lambda_{t,k} = \beta^k \frac{C_t}{C_{t+k}}$ é a taxa marginal de substituição intertemporal dos consumidores entre t e $t+k$ e $P_{W,t}$ é o preço nominal do bem final. Diferenciando com relação a $\overline{P}_t^H$ chega-se a:

$$\sum_{k=0}^{\infty} \theta^k E_{t-1}\left\{\Lambda_{t,k}\left(\frac{\overline{P}_t^H}{P_{t+k}}\right)^{-\upsilon} \overline{Y}_{t+k}(z)\left[\overline{P}_t^H - \frac{\upsilon}{(\upsilon-1)} P_{W,t+k}\right]\right\} = 0 \tag{37}$$

O varejista, portanto, fixa seu preço de forma que, em expectativa, sua receita marginal descontada iguale seu custo marginal descontado, dado a restrição de que o preço nominal fixado em t estará vigente no instante $t+k$ com probabilidade θ^k.

Chega-se então ao preço ótimo fixado pelo varejista:

$$\overline{P}_t^H = \mu \prod_{i=0}^{\infty} \left(P_{W,t+i}\right)^{(1-\beta\theta)(\beta\theta)^i} \tag{38}$$

onde $\mu = \frac{1}{1-\frac{1}{\upsilon}}$ é o markup desejado pelo varejista sobre o preço pago ao empresário. Note que, se os preços fossem flexíveis, o preço seria $\overline{P}_t^H = \mu P_{W,t}$. Mas como os preços permanecem fixos por um momento, os varejistas fixam seus preços baseados na trajetória fututa esperada do custo marginal, e não apenas no custo marginal corrente. Desta forma, o índice de preços doméstico será dado por:

$$P_t^H = \left(P_{t-1}^H\right)^{\theta} \left(\overline{P}_t^H\right)^{1-\theta} \tag{39}$$

onde

$$\overline{P}_t^H = \left(\overline{P}_{t+1}^H\right)^{\beta\theta} \left(\mu P_{W,t}\right)^{1-\beta\theta} \tag{40}$$

onde θ é a medida de rigidez.

Os bens importados vendidos domesticamente também são submetidos a um markup sobre o preço do bem produzido pelo empresário estrangeiro. Assume-se que os varejistas externos se deparam com um custo marginal de $P_{W,t}^F$ e fixam seus preços de acordo com a equação de fixação a la Calvo. Seja $\left(1-\theta^f\right)$ probabilidade de que um varejista externo ajuste seu preço. O índice de preços dos bens importados, em moeda estrangeira, será dado por:

$$P_t^{F^*} = \left(P_{t-1}^{F^*}\right)^{\theta^f} \left(\overline{P}_t^F\right)^{1-\theta^f} \tag{41}$$

onde

$$\overline{P}_t^F = \left(\overline{P}_{t+1}^F\right)^{\beta^f\theta^f} \left(\mu^f P_{W,t}^{F^*}\right)^{1-\beta^f\theta^f} \tag{42}$$

onde θ^f é a medida de rigidez da economia estrangeira. Esta especificação para o processo de ajustamento de preços de bens importados que são vendidos domesticamente implica em um desvio temporário da lei do preço único, permitindo a defasagem no pass-through da taxa de câmbio, onde o coeficiente θ^f captura esta defasagem.

3.6 Oferta de Empréstimos

A oferta de empréstimos é obtida no problema de contrato ótimo entre a firma tomadora de empréstimos para aquisição de bens de capital e a instituição financeira credora, que atua apenas como intermediária (lucro zero) entre os poupadores (consumidores) e tomadores (empresários). Como apresentado em GGN, chega-se a relação entre o prêmio de risco cobrado pelo intermediador financeiro e o nível de alavancagem da empresa demandante de empréstimo :

$$\frac{E_t\left(R_{t+1}^k\right)}{R_{t+1}} = \psi\left(\frac{K_{t+1}Q_t}{N_{t+1}}\right) \tag{43}$$

com $\psi'(\cdot) > 0$

Desta forma, pode-se verificar que o prêmio de risco varia inversamente com o valor da empresa. Resultado bastante intuitivo, pois quanto maior o valor da empresa, mais colateral ela dispõe para a aquisição de capital, diminindo o conflito de interesses com o credor externo e, consequentemente, o risco associado ao investimento.

3.7 Governo

O governo conduz as políticas fiscal, monetária e comercial.

3.7.1 Políticas Fiscal e Comercial

Assume-se que o governo financia seus gastos correntes com impostos lump-sum, criação de moeda e receita de tarifa de importação:

$$\frac{P_t^H}{P_t}G_t^H = \frac{M_t - M_{t-1}}{P_t} + T_t + \frac{\tau_t S_t P_t^{F*} C_t^H}{P_t} \tag{44}$$

Log-linearizando[12]:

$$g_t = \vartheta \left(\tau_t + s_t + p_t^{f*} + c_t^h - p_t^h \right) + \varepsilon_t^g \tag{45}$$

onde ϑ é a proporção da receita de tarifa de importação sobre a receita total do governo no estado estacionário:

$$\vartheta = \frac{\tau S P^{F*} C^H}{P^H G^H}$$

3.7.2 Política Monetária

Assume-se que o governo adota uma política de câmbio flexível, seguindo uma regra de juros de instrumento a la Taylor, onde a taxa de juros nominal é fixada pelo Banco Central de forma a minimizar os desvios da taxa de inflação e do hiato do produto de seus níveis no estado estacionário:

$$(1 + i_t) = [(1 + i_t)]^{\rho_i} \left[(1 + rr^{ss}) \left(\frac{P_t}{P_{t-1}} \right)^{\gamma_\pi} \left(\frac{Y_t^H}{Y_t^0} \right)^{\gamma_y} \right]^{1-\rho_i} \tag{46}$$

com $\gamma_\pi > 1$ e $\gamma_y > 0$, rr^{ss} é a taxa de juros real no estado estacionário e Y_t^0 é o produto natural no estado estacionário, ou seja, o produto que vigora sob preços flexíveis na ausência de choques. Assume-se que a taxa de inflação no estado estacionário é zero.

3.8 Restrição de Recursos

A restrição de recursos para o setor de bens domésticos é:

$$Y_t^H = C_t^H + C_t^{eH} + C_t^{H*} + I_t^H + G_t^H \tag{47}$$

onde C_t^{eH} é o consumo de bens domésticos pelos empresários, G_t^H é o consumo do governo e C_t^{H*} é a demanda externa pelos bens domésticos.

3.9 Processos Exógenos

Assume-se que as seguintes variáveis seguem um processo exógeno:

$$a_t = \rho_a a_{t-1} + \varepsilon_t^a \tag{48}$$

[12] Ignorando os dois primeiros termos do lado direito.

$$i_t^* = \rho_{i^*} i_{t-1}^* + \varepsilon_t^{i^*} \tag{49}$$

$$\tau_t = \rho_\tau \tau_{t-1} + \varepsilon_t^\tau \tag{50}$$

$$w_t = +\varepsilon_t^w \tag{51}$$

$$p_{W,t}^{f*} = \rho_{pf^*} p_{W,t-1}^{f*} + \varepsilon_t^{pf^*} \tag{52}$$

$$y_t^* = \rho_{y^*} y_{t-1}^* + \varepsilon_t^{y^*} \tag{53}$$

4 Calibração

Esta seção apresenta a calibração e simulação do modelo modificado de GGN (2003) para a economia brasileira.

4.0.1 Dados e Calibração

O modelo é log-linearizado[13] e posteriormente parametrizado de modo a replicarmos uma economia similar à economia brasileira. Alguns parâmetros foram estimados, enquanto outros foram calibrados, de forma a implicar nos seguintes valores para o estado estacionário:[14]

1. Prêmio de risco de 13,56 % ao ano, aproximadamente a média entre junho de 2000 e maio de 2006. Este dado refere-se ao spread médio mensal das operações de crédito com recursos livres-pessoa jurídica, uma medida de taxa de empréstimo menos taxa de captação (CDB) do sistema financeiro;

2. Probabilidade de default dos projetos de investimento de 4,67%, aproximadamente a média entre junho de 2000 e maio de 2006 da taxa de inadimplência acima de 15 dias das operações de crédito com recursos livres-pessoa jurídica;

3. Investimento como proporção do PIB de 19%, aproximadamente a média entre janeiro de 1995 e dezembro de 2004;

4. Consumo como proporção do PIB de 60%, aproximadamente a média entre janeiro de 1995 e dezembro de 2004;

5. Gastos do governo como proporção do PIB de 19%, aproximadamente a média entre janeiro de 1995 e dezembro de 2004;

6. Exportação como proporção do PIB de 11%, aproximadamente a média entre janeiro de 1995 e dezembro de 2004;

7. Importação como proporção do PIB de 11,5%, aproximadamente a média entre janeiro de 1995 e dezembro de 2004;

[13] Todas equações log-linearizadas do modelo estão presentes no apêndice B.
[14] Fonte: Banco Central do Brasil, IFS e Ipea.

8. Consumo de bens domésticos como proporção do consumo total de 93%, aproximadamente a média entre 1996 e 2004;

9. Investimento em bens domésticos como proporção do investimento total de 60%, aproximadamente a média entre 1996 e 2004;

10. Alíquota média de importação de 10%, aproximadamente a média entre 1999 e 2005;

11. Taxa de utilização do capital de 1, como em GGN.

As tabelas abaixo constam todos os parâmetros utilizados na simulação, assim como suas origens e descrições[15].

Tabela 1: Calibração base

Parâmetro	Valor	Origem	Descrição
β	0.9835	Araújo e Ferreira(1999)	fator de desconto trimestral
α	0.49	Araújo e Ferreira(1999)	fração do capital na renda
χ	2.2	Mendoza (1990)	elasticidade da oferta de trabalho
θ	0.642	Bonomo e Oreng(2003)	prob. do varejista não ajustar seu preço
β^f	0.99	GGN (2003)	fator de desconto trimestral externo
θ^f	0.75	BGG (1999)	prob. do varejista não ajustar seu preço no exterior
$(1-\Omega)$	0.01	como em BGG (1999)	fração do trabalho dos empresários na renda
φ	0.25	BGG (1999)	elasticidade do preço do capital
X	1.2	GGN (2003)	markup no estado estacionário
γ	0.93	Média entre 1995-2005	proporção de bens domésticos na cesta de consumo
γ_i	0.6	Média entre 1995-2005	proporção de bens domésticos na cesta de insumos
$(1-\eta)$	0.06	Najberg, Puga e Oliveira (2000)	taxa de falência das empresas trimestral
μ	0.7	calibrado / Pancevski (2005)	taxa de perda bancária
ρ	0.99	calibrado	coeficiente da CES entre bens domésticos e estrangeiro
ρ_i	0.5	calibrado	coeficiente da CES entre insumos domésticos e estrangeiro
ς	0.28	calibrado	coeficiente de subs trab-lazer da CES na função utilidade
σ	0.2	calibrado	coeficiente da CES na função utilidade
υ	0.5	calibrado	coeficiente da inércia nas exportações
$\varkappa$	33	calibrado	sensibilidade da demanda externa ao preço do bem doméstico
X^I	1.25	calibrado	markup no deslocamento do capital
b	0.092	calibrado	coeficiente da taxa de depreciação do capital
ε	3	calibrado	coeficiente da taxa de depreciação do capital
δ	0.02	calibrado	depreciação do capital trimestral
σ^2	0.5	calibrado	variância do choque idiossincrático, $\log(\overline{w})$
ρ^i	0.9	como em BGG (1999)	parâmetro autoregressivo na regra de Taylor
γ_π	1.11	como em BGG (1999)	coeficiente da inflação na regra de Taylor
γ_y	0.1	como em BGG (1999)	coeficiente do produto na regra de Taylor

[15] Para o exercício numérico todos os coeficientes autoregressivos foram zerados, tornando as variáveis um ruído branco.

Tabela 2: Variáveis no estado estacionário resultantes da calibração base

Parâmetro	Valor	Descrição
K	12.9	estoque de capital no estado estacionário
N	9.15	valor nas empresas no estado estacionário
Y	2.97	produto no estado estacionário
C^h	1.14	consumo be bens domésticos
C^f	0.08	consumo be bens importados
P^h	1.2	índice de preços de bens domésticos
P^f	1.32	índice de preços de bens importados
R^k	1.05	retorno do capital
I^h	0.35	investimento em insumos domésticos
I^f	0.2	investimento em insumos estrangeiros
I	0.55	investimento
ϑ	0.01	receita de tarifa de importação sobre a receita total do governo
$\frac{C^e}{Y}$	0.20	parcela do consumo dos empresários na renda
$\frac{C}{Y}$	0.40	parcela do consumo das famílias na renda
$\frac{Y}{K}$	0.23	produto sobre estoque de capital
$\delta(u)$	0.042	depreciação no estado estacionário
v	0.3	sensibilidade do prêmio de risco
w	2.11	salário do trabalhador no estado estacionário
B	3.56	dívida das firmas no estado estacionário
V	144.51	Capital próprio das firmas no estado estacionário

5 Simulações do Modelo

Esta seção apresenta dois experimentos quantitativos. O primeiro deseja ilustrar o papel desempenhado pela ineficiência decorrente das fricções informacionais entre credores e tomadores de empréstimos na dinâmica de uma política monetária expansionista. O segundo examina o papel desempenhado pela política comercial na redução ou no aumento do custo da política monetária, ou seja, na variação da taxa de inflação.

De início, executamos um choque negativo de 1% na taxa de juros nominal e comparamos a dinâmica de algumas variáveis econômicas relevantes sob dois ambientes distintos. Em um deles não levamos em conta a presença de fricções informacionais entre credores e tomadores de empréstimo, enquanto no outro consideramos a existência dessas fricções. Na presença desses conflitos observamos que a economia responde à política monetária com ciclos mais pronunciados justamente porque, em momentos de queda da taxa de juros, o colateral das fir-

mas vale mais e, dessa forma, a captação de recursos fica mais barata do que quando não se leva em conta esse efeito.

Posteriormente, executamos um choque negativo de 1% na tarifa isoladamente para estudarmos o efeito de uma política de diminuição de barreiras ao comércio no gap entre o produto e o produto natural. Descobrimos que essa política aumenta o gap, e portanto, não é oportuna quando o produto está próximo do produto natural.

Depois executamos uma política monetária expansionista isoladamente e conjugada com choques negativos de 1%, 5% e 10%.na tarifa de importação. Esse exercício mostra que os efeitos inflacionários das duas políticas se somam quando elas são aplicadas simultaneamente.

5.1 Efeito das fricções informacionais entre credores e tomadores de empréstimo em uma política monetária expansionista

As figuras 2 e 3 apresentam as funções impulso-resposta das principais variáveis econômicas diante de um choque negativo na taxa de juros em uma economia que apresenta rigidez nos preços. Os valores que as variáveis tomam a cada momento nos gráficos abaixo significam desvios em relação aos seus valores de *steady state*. Todas as variáveis reais voltam a seus valores de equilíbrio por conta da resposta dada pelo Banco Central expressa na regra de Taylor. Isso significa que o modelo corrente não gera histerese na economia real.

Na ausência de fricções, o prêmio de risco não se altera porque, por construção, o valor do colateral das firmas é constante. No entanto, na presença de fricções, o valor dos colaterais aumenta a medida que os efeitos da política monetária aumentam a demanda pelos bens da firma (comportamento do consumo e do investimento até aproximadamente o quinto trimestre). Colaterais mais valorizados significam menor prêmio de risco a ser pago pelas firmas quando buscam financiamento. De forma análoga, o prêmio de risco se desvaloriza em momentos de contração da atividade econômica. Conclui-se que o investimento é mais pro-cíclico em ambientes com mais fricções informacionais, já que o custo de financiamento varia mais nesse ambiente.

A desvalorização inicial do câmbio implica em inflação positiva nos bens importados, mas ainda assim ela é menor do que a inflação inicial dos bens domésticos, o que implica em uma deterioração dos termos de troca da economia local. Essa deterioração inicial dos termos de troca é exacerbada em um ambiente de fricções informacionais porque a atividade econômica responde com mais intensidade e ,assim, os comportamentos das inflações de bens domésticos e de bens importados se distanciam mais.

Concluímos então que em um ambiente econômico mais sujeito a imperfeições no mercado de crédito, a política monetária se torna mais poderosa, o que não pode ser considerado uma grande vantagem porque a economia também responde com mais intensidade a choques que não estão sob o controle do governo. Nesse ambiente, os setores importador e exportador convivem com muito

mais incerteza quanto ao comportamento do câmbio e dos termos de troca.

Figura 2

Choque negativo de 1% na taxa de juros nominal com e sem presença de fricções informacionais

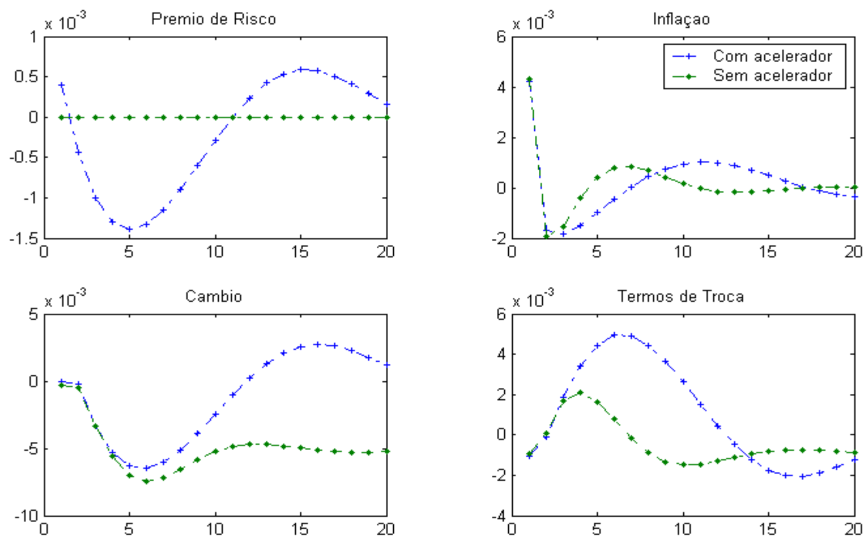
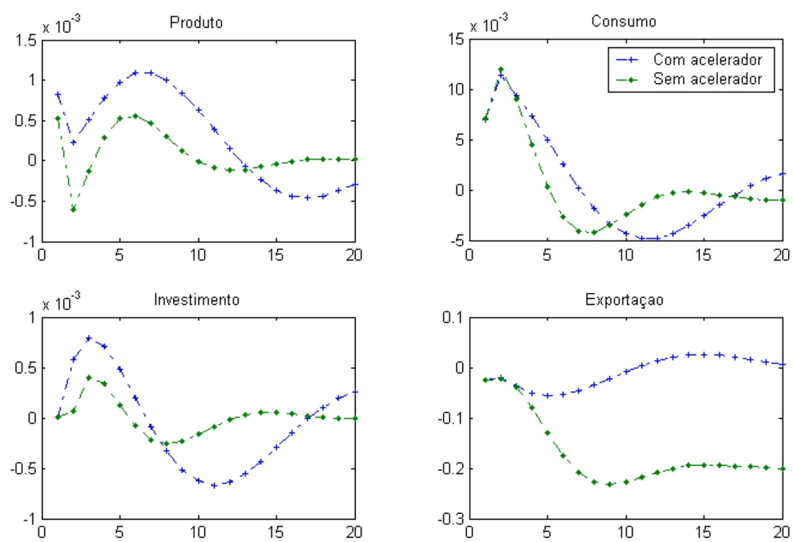


Figura 3

Choque negativo de 1% na taxa de juros nominal com e sem presença de fricções informacionais



5.2 Diminuição da tarifa de importação em uma política monetária expansionista

Inicialmente, examinamos nas figura 4 e 5 o efeito de diminuições na tarifa de importação sem a aplicação simultânea de uma política monetária expansionista. Esse exercício tem a intenção de observar o efeito isolado da diminuição dessa barreira ao comércio no comportamento do produto e da taxa de juros real. Aplicaremos esse exercício em ambientes de perfeita flexibilidade de preços e de rigidez nominal de preços para podermos comparar o comportamento do produto natural com o do produto real.

Percebe-se na figura 4 que quanto maior for a queda na tarifa de importação mais intenso será o choque negativo no produto natural. A amplitude das variações da taxa natural de juros também é maior quanto maior for a queda nas tarifas. Na figura 5, sob rigidez nominal de preços o produto reage positivamente à queda nas tarifas. Comparando o comportamento do produto sob flexibilidade e sob rigidez de preços, concluímos que quanto maior a queda das tarifas, maior será o hiato inicial do produto, o que significa que a economia apresenta atividade econômica incompatível com objetivos anti-inflacionários. O resultado não encontra suporte no senso comum, mas se deve ao comportamento do câmbio induzido pela regra de Taylor seguida pelo Banco Central.

No momento do choque na tarifa de importação, o preço dos bens importados varia de acordo com as variações da tarifa e da taxa de câmbio (equação 11). A queda da tarifa diminui o preço dos bens importados, mas por outro lado, a regra de feedback do Banco Central impõe um aumento na taxa de juros nominal. Dado esse aumento dos juros nominais, a equação da paridade descoberta da taxa de juros (equação 10) leva a uma desvalorização cambial capaz de produzir inflação dos bens importados (apesar da diminuição da tarifa) e, a partir de então, também dos bens domésticos. Todo esse início da dinâmica pode ser verificado na figura 6.

Figura 4

Política de diminuição de barreiras ao comércio

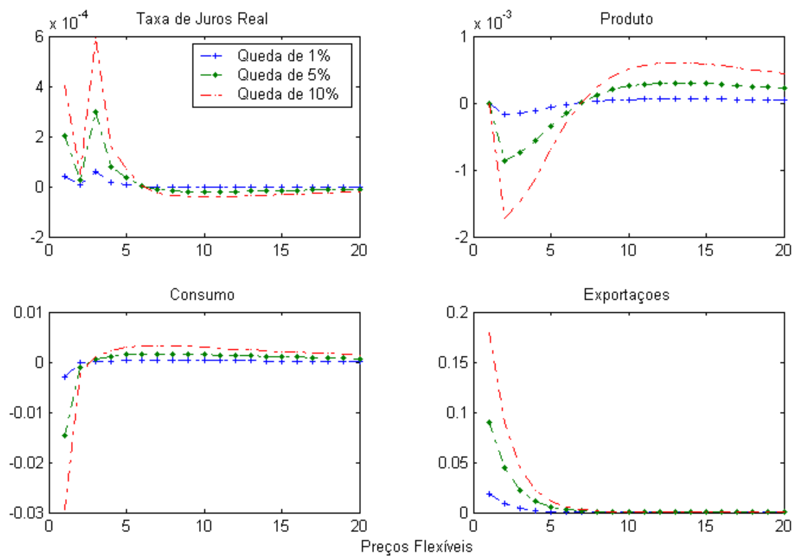


Figura 5

Política de diminuição de barreiras ao comércio

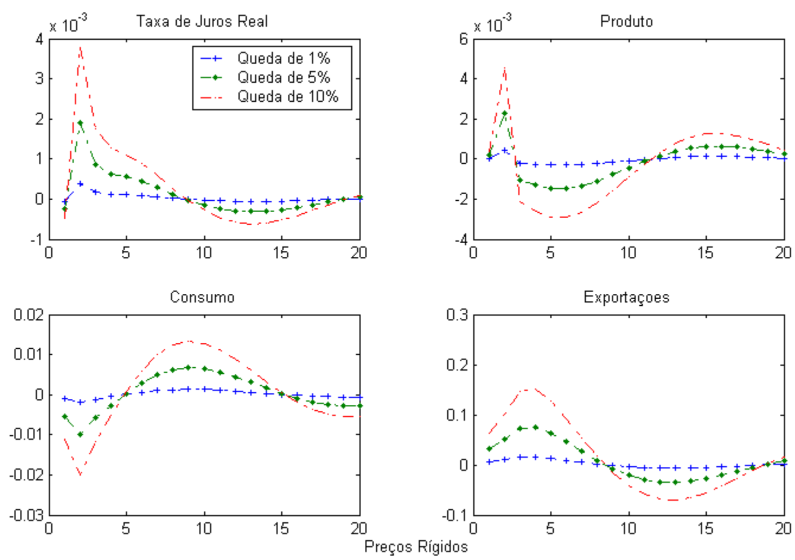
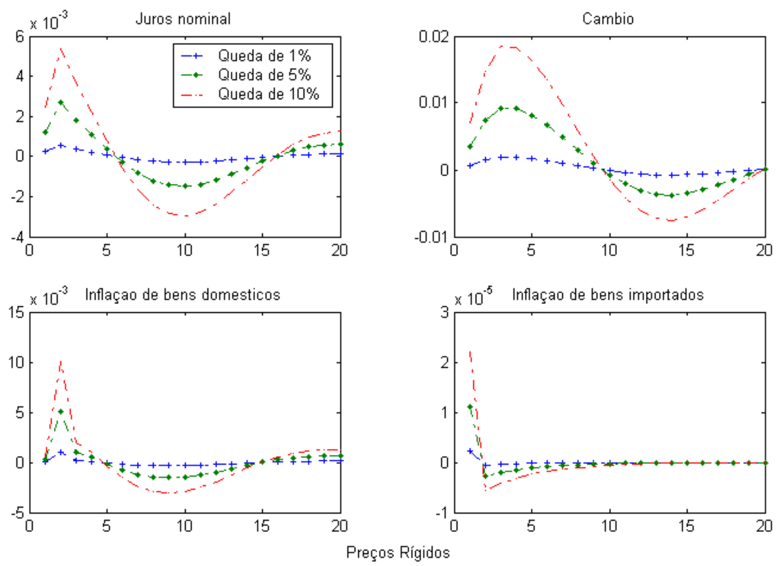


Figura 6

Política de diminuição de barreiras ao comércio



A simultaneidade das políticas monetária expansionista e de diminuição de barreiras comerciais via redução de tarifas de importação é danosa no combate à inflação. Nas figuras 7 e 8, observamos que os efeitos inflacionários da política monetária expansionista se somam aos da política de diminuição de tarifas vistos na figura 6. Nesses experimentos consideramos a política monetária expansionista isolada e também casos em que ela é conjugada a políticas de diminuição de tarifa em 1%, 5% e 10%. Observe nas figuras 8 e 9 que ainda que o produto cresça mais quando há maior queda na tarifa, ele cresce às custas de maior inflação, visto que o produto natural diminui mais intensamente quanto maior for

a queda da tarifa.

Figura 7

Choque negativo de 1% na taxa de juros nominal sob diferentes choques na tarifa de importação

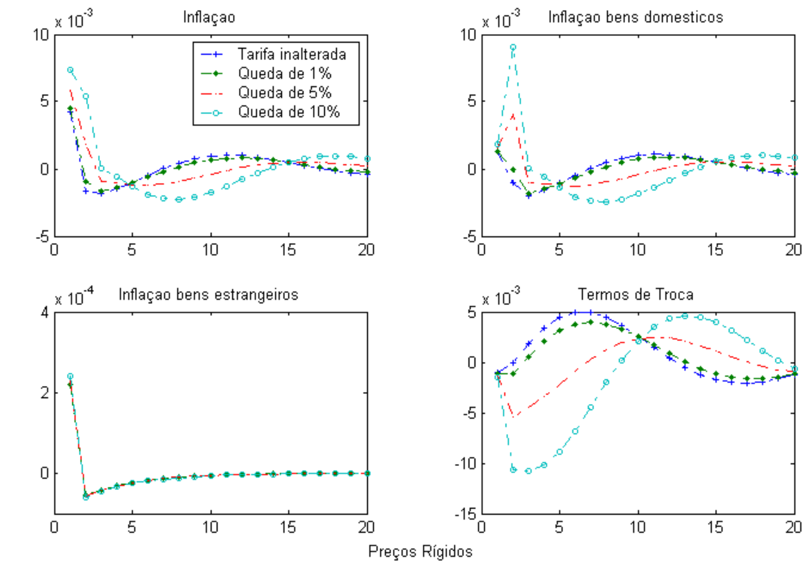


Figura 8

Choque negativo de 1% na taxa de juros nominal sob diferentes choques na tarifa de importação

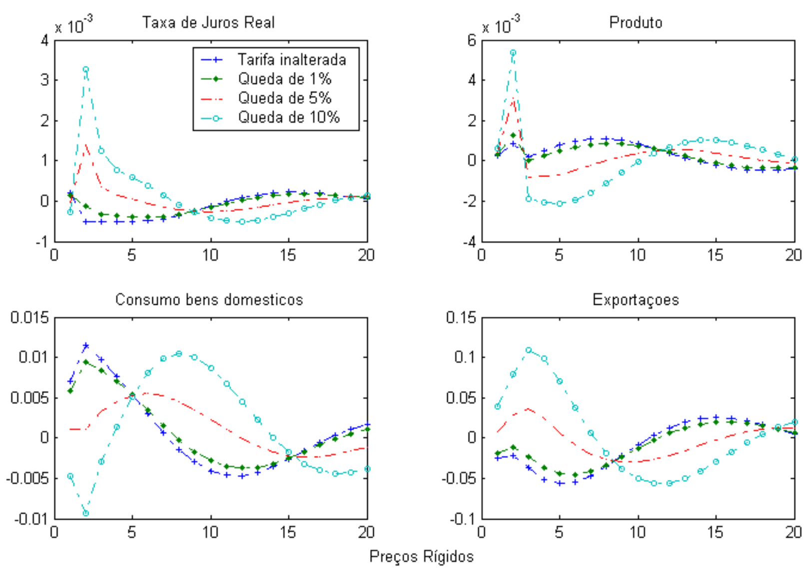
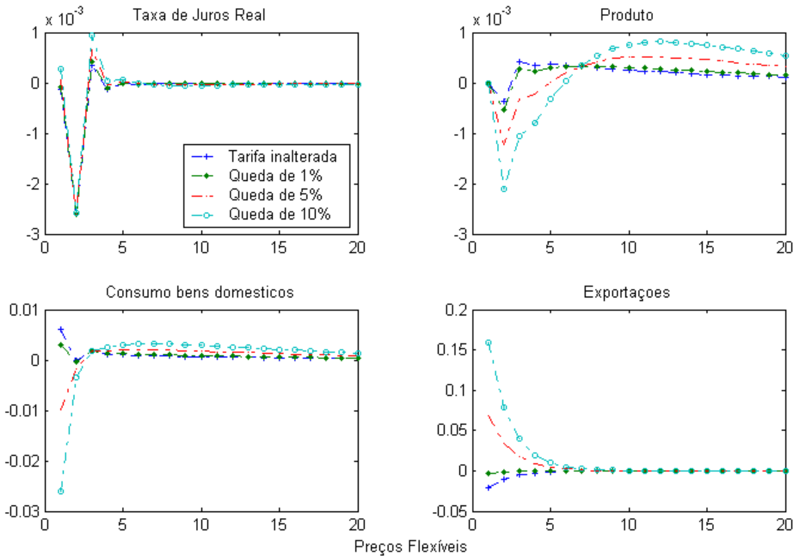


Figura 9

Choque negativo de 1% na taxa de juros nominal sob diferentes choques na tarifa de importação



6 Conclusão

Este artigo estende o modelo do acelerador financeiro para uma pequena economia aberta, desenvolvido por Gertler, Gilchrist e Natalucci (2003), incorporando uma tarifa de importação como variável de política comercial, com o objetivo de verificar se políticas comerciais podem auxiliar os bancos centrais no combate a inflação.

Políticas de diminuição de barreiras comerciais diminuem distorções nos preços e aumentam o bem estar dos indíviduos de maneira geral e, portanto, são desejáveis. Entretanto, os exercícios propostos mostram que políticas que estimulam a eliminação de barreiras comerciais via diminuição de tarifas de importação aumentam o produto da economia e diminuem o produto natural da economia. Dessa forma, é desejável que essa política seja aplicada de maneira coordenada com o banco central para que os efeitos inflacionários não destruam o aumento de bem estar gerado pela diminuição das tarifas.

Como melhorias ao resultado encontrado seria interessante uma análise de sensibilidade dos parâmetros calibrados, verificando a robustez do modelo, e uma análise de bem-estar com a adoção das políticas comercial e monetária expansionistas.

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7 Apêndice A

A seguir descrevemos o apêndice A do artigo de Bernanke, Gertler e Gilchrist (1999),"The Financial Accelerator in a Quantitative Business Cycle Framework".

7.1 O Problema de Contrato

Este apêndice apresenta uma análise detalhada de um equilíbrio parcial em um problema de "costly state verification". Será mostrado que, sob algumas hipóteses, o contrato ótimo estabelece uma relação crescente entre a razão capital/riqueza e o prêmio de risco, e que a probabilidade de default é uma função estritamente crescente do prêmio de risco, garantindo uma solução interior e excluindo a possibilidade de existência de um equilíbrio com racionamento de crédito.

7.1.1 O Problema de Contrato em um Equilíbrio Parcial

A oferta de empréstimos é obtida no problema de contrato ótimo entre a firma tomadora de empréstimos para aquisição de bens de capital e a instituição financeira credora, que atua apenas como intermediária (lucro zero) entre os poupadores (consumidores) e tomadores (firmas).

Inicialmente, procede-se a análise da decisão de investimento por parte das empresas, assumindo como dado, o preço do capital e o retorno esperado do capital, assim como a taxa de juros livre de risco.

A cada instante t o empresário adquire K_{t+1} unidades de capital e H_t unidades de trabalho para gerar produto no período seguinte, onde o subescrito denota o período na qual o capital é utilizado. O preço pago por unidade de capital é Q_t e o retorno do capital é R_t^k. Assume-se que o capital é homogêneo, não importando se o capital utilizado é novo ou já depreciado.

O retorno bruto do capital (*ex post)* para a firma j é $w^j R_{t+1}^k$, onde w^j é um choque idiossincrático e R_{t+1}^k é um choque agregado. Assumiremos que w^j é uma variável aleatória i.i.d. no tempo e entre as firmas, com c.d.f., $F(w)$, contínua e diferenciável sobre um suporte não-negativo e $E\left(w^j\right) = 1$. Por hipótese assume-se ainda a seguinte restrição para a taxa de risco $h(w)$ (que é satisfeita para uma distribuição log-normal):

$$\frac{\partial\left(wh\left(w\right)\right)}{\partial w} > 0$$

onde

$$h\left(w\right) = \frac{F'\left(w\right)}{1 - F\left(w\right)}$$

No final do período t, a empresa possui um valor líquido (capital próprio) de N_{t+1}^j. Para financiar a diferença entre o seu capital próprio e os gastos para aquisição de capital, a empresa deve tomar um empréstimo de B_{t+1}^j, dado por:

$$B_{t+1}^j = Q_t K_{t+1}^j - N_{t+1}^j$$

Os empréstimos são adquiridos junto ao sistema financeiro que, por sua vez, obtém seus recursos junto aos consumidores, e possui um custo de oportunidade, entre t e $t+1$, igual a taxa de juros livre de risco, R_{t+1}.[16]

A partir da utilização da abordagem de "costly state verification", primeiramente desenvolvida por Townsend (1979), o emprestador arca com um custo para observar o retorno realizado do capital e o tomador observa o retorno sem custo. Esta hipótese é suficiente para gerar uma relação inversa entre o prêmio de risco pago pelo tomador e a proporção de capital próprio utilizado no investimento (colateral).[17]

Seguindo esta abordagem, assume-se que o emprestador paga um custo de auditoria, também chamado de taxa de perda bancária, $(0 < \mu < 1)$ proporcional à receita bruta da firma tomadora do empréstimo se este decide observar o retorno realizado do capital. Portanto, o custo para a empresa auditorar o retorno do capital é igual a $\mu w^j R^k_{t+1} Q_t K^j_{t+1}$.[18]

Verifica-se que o lucro por unidade de capital para uma firma específica é igual a wR^k, onde $w \in [0, \infty)$.

Um contrato ótimo especifica um valor $\overline{w}$ tal que:

Condition 1 *se $w \geq \overline{w}$, o tomador paga ao emprestador um montante fixo $\overline{w}R^kQK$ e recebe o restante $(w - \overline{w})\, R^kQK$.*

Condition 2 *se $w < \overline{w}$, o tomador não recebe nada e o emprestador faz a auditoria e recebe $(1-\mu)\, wR^kQK$.*

No equilíbrio, o emprestador recebe um retorno esperado igual a taxa de juros livre de risco R:

$$\left[\overline{w} \Pr(w \geq \overline{w}) + (1-\mu) E\left(w \mid w < \overline{w}\right) \Pr\left(w < \overline{w}\right)\right] R^kQK = R\left(QK - N\right)$$

Definindo $\Gamma\left(\overline{w}\right)$ como a proporção da receita bruta esperada que vai para o emprestador:

$$\Gamma\left(\overline{w}\right) \equiv \int_0^{\overline{w}} wf\left(w\right) \partial w + \overline{w} \int_{\overline{w}}^{\infty} f\left(w\right) \partial w$$

$$0 < \Gamma\left(\overline{w}\right) < 1$$

e observa-se que a receita bruta do emprestador é estritamente côncava em $\overline{w}$ pois:

$$\Gamma'\left(\overline{w}\right) = 1 - F\left(\overline{w}\right)$$

[16] Como o empresário é neutro ao risco e os consumidores são avessos ao risco, o empresário assume todo o risco agregado. No equilíbrio, o intermediário financeiro diversifica perfeitamente o risco idiossincrático envolvido no empréstimo. Portanto, a taxa de juros livre de risco é o custo de oportunidade relevante para o modelo.

[17] Há várias outras especificações, mas a simplicidade e o realismo de Townsend são convidativos.

[18] A hipótese de proporcionalidade é conveniente no contexto e não parece ser tão irrealista.

$$\Gamma''(\overline{w}) = -f(\overline{w})$$

Da mesma forma, definindo $\mu G(\overline{w})$ como o custo de auditoria esperado:

$$\mu G(\overline{w}) \equiv \mu \int_0^{\overline{w}} w f(w)\, \partial w$$

onde

$$\mu G'(\overline{w}) \equiv \mu \overline{w} f(\overline{w})$$

como $0 < \mu < 1$, temos que $\Gamma(\overline{w}) - \mu G(\overline{w}) > 0$ para $\overline{w} \in (0, \infty)$

$$\lim_{\overline{w} \to 0} \Gamma(\overline{w}) - \mu G(\overline{w}) = 0$$

e

$$\lim_{\overline{w} \to \infty} \Gamma(\overline{w}) - \mu G(\overline{w}) = 1 - \mu.$$

Assume–se também que $R^k(1-\mu) < R$, pois, caso contrário, por arbitragem, o emprestador obteria lucro ilimitado realizando a auditoria sempre.

Temos que:

$$h(\overline{w}) \equiv \left(\frac{f(\overline{w})}{1 - F(\overline{w})} \right)$$

e assume-se, por hipótese, que $\overline{w} h(\overline{w})$ é crescente em $\overline{w}$.

Pode-se, então, diferenciar a receita líquida do emprestador com relação a $\overline{w}$:

$$\Gamma'(\overline{w}) - \mu G'(\overline{w}) = (1 - F(\overline{w}))(1 - \mu \overline{w} h(\overline{w})) \lesseqgtr 0 \text{ para } \overline{w} \gtreqless \overline{w}^*$$

A receita líquida alcança o máximo global em $\overline{w}^*$ e:

$$\Gamma'(\overline{w}) G''(\overline{w}) - \Gamma''(\overline{w}) G'(\overline{w}) = \frac{\partial(\overline{w} h(\overline{w}))}{\partial \overline{w}} (1 - F(\overline{w}))^2 > 0 \tag{54}$$

para todo $\overline{w}$ [19].

O problema de contrato ótimo, com custo de auditoria não estocástico, pode ser escrito da seguinte forma:

$$\max_{K, \overline{w}} (1 - \Gamma(\overline{w})) R^k Q K$$

sujeito a:

$$[\Gamma(\overline{w}) - \mu G(\overline{w})] R^k Q K = R(QK - N)$$

Pode-se definir o prêmio de risco (s) e a razão capital/riqueza (k) como:

$$s = \frac{R^k}{R}$$

$$k = \frac{QK}{N}$$

Seja λ o multiplicador de Lagrange da restrição, as condições de primeira ordem do problema, assumindo solução interior, são:

$$\overline{w} \ : \ \Gamma'(\overline{w}) - \lambda [\Gamma'(\overline{w}) - \mu G'(\overline{w})] = 0$$

[19] Esta relação será útil posteriormente.

$$k \quad : \quad \left[(1-\Gamma(\overline{w}))+\lambda(\Gamma(\overline{w})-\mu G(\overline{w}))\right]s-\lambda=0$$

$$\lambda \quad : \quad \left[\Gamma(\overline{w})-\mu G(\overline{w})\right]sk-(k-1)=0$$

Ressaltamos que não se deseja uma solução de canto, pois assume-se não haver racionamento de crédito. Por isso, é necessário demonstrar a existência de solução interior.

Como a receita líquida do emprestador é crescente em $(0,\overline{w}^*)$ e decrescente em $(\overline{w}^*,\infty)$, $\overline{w}>\overline{w}^*$ nunca será solução do problema. Considera-se, então, o caso onde $0<\overline{w}<\overline{w}^*$ (implicando uma solução interior pois $w=0$ não pode ser uma solução se $s>1$).

Assumindo solução interior, chega-se pela C.P.O:

$$\lambda(\overline{w})=\frac{\Gamma'(\overline{w})}{\Gamma'(\overline{w})-\mu G'(\overline{w})}$$

Derivando em relação a $\overline{w}$:

$$\lambda'(\overline{w})=\frac{\mu\left[\Gamma'(\overline{w})G''(\overline{w})-\Gamma''(\overline{w})G'(\overline{w})\right]}{\left[\Gamma'(\overline{w})-\mu G'(\overline{w})\right]^2}>0$$

para $\overline{w}\in(0,\overline{w}^*)$

onde a desigualdade segue da equação (54). Calculando $\lambda(\overline{w})$ quando $\bar{w}$ tende para 0 e para $\overline{w}^*$, temos:

$$\lim_{\overline{w}\to 0}\lambda(\overline{w})=1$$

$$\lim_{\overline{w}\to \overline{w}^*}\lambda(\overline{w})=+\infty$$

Pela C.P.O., pode-se definir uma função $s=\rho(\overline{w})$ tal que:

$$\rho(\overline{w})=\frac{\lambda(\overline{w})}{(1-\Gamma(\overline{w}))+\lambda(\Gamma(\overline{w})-\mu G(\overline{w}))}$$

Derivando em relação a $\bar{w}$, obtemos:

$$\rho'(\overline{w})=\rho(\overline{w})\frac{\lambda'(\overline{w})}{\lambda(\overline{w})}\left(\frac{1-\Gamma(\overline{w})}{1-\Gamma(\overline{w})+\lambda(\Gamma(\overline{w})-\mu G(\overline{w}))}\right)>0$$

para $\overline{w}\in(0,\overline{w}^*)$

Calculando o limite de $\rho(\overline{w})$ quando $\bar{w}$ converge para zero e para $\overline{w}^*$, temos:

$$\lim_{\overline{w}\to 0}\rho(\overline{w})=1$$

$$\lim_{\overline{w}\to \overline{w}^*}\rho(\overline{w})=\frac{1}{\Gamma(\overline{w}^*)-\mu G(\overline{w}^*)}\equiv s^*<\frac{1}{1-\mu}$$

Então, para $s < s^*$, as condições garantem um mapeamento um para um entre o $\overline{w}$ ótimo e o prêmio de risco s.

Defina a função $\Psi(\overline{w}) = k$. Pela C.P.O.:

$$\Psi(\overline{w}) \equiv 1 + \frac{\lambda(\Gamma(\overline{w}) - \mu G(\overline{w}))}{1 - \Gamma(\overline{w})}$$

Derivando $\Psi(\overline{w})$ e calculando o seu limite quando $\bar{w}$ converge para zero e para $\overline{w}^*$, temos:

$$\Psi'(\overline{w}) = \frac{\lambda'(\overline{w})}{\lambda(\overline{w})}(\Psi(\overline{w}) - 1) + \frac{\Gamma'(\overline{w})}{1 - \Gamma(\overline{w})}\Psi(\overline{w}) > 0$$

para $\overline{w} \in (0, \overline{w}^*)$

$$\lim_{\overline{w} \to 0} \Psi(\overline{w}) = 1$$

$$\lim_{\overline{w} \to \overline{w}^*} \Psi(\overline{w}) = +\infty$$

Desta forma, pode-se combinar as equações, expressando a razão capital/riqueza como função crescente do prêmio de risco:

$$k = \psi(s)$$

com $\psi'(s) > 0$ para $s \in (1, s^*)$

Considera-se, no momento, a possibilidade de $\overline{w} = \overline{w}^*$. O tomador escolherá $\overline{w}^*$ apenas se o excesso de retorno s for maior do que s^*, pois:

$$\lim_{\overline{w} \to \overline{w}^*} \rho(\overline{w}) = \frac{1}{\Gamma(\overline{w}^*) - \mu G(\overline{w}^*)} \equiv s^*$$

Neste caso, o credor receberá um excesso de retorno igual a:

$$(\Gamma(\overline{w}^*) - \mu G(\overline{w}^*))\, sk - k = \frac{s - s^*}{s^*} k > 0$$

Como este é estritamente positivo para todo k, o emprestador estará disposto a emprestar uma quantidade arbitrariamente grande, e ambos obteriam lucros ilimitados. A taxa de retorno do capital no equilíbrio irá cair, assegurando $s < s^*$, e garantindo uma solução interior para $\overline{w} \in (0, \overline{w}^*)$.

Até então, foi considerado apenas o risco idiossincrático no modelo. Entretanto, pode-se incorporar risco agregado, gerando a mesma relação do caso anterior:

$$\max_{K, \overline{w}} E((1 - \Gamma(\overline{w}))\, \widetilde{u} sk + \lambda\, [(\Gamma(\overline{w}) - \mu G(\overline{w}))\widetilde{u} sk - (k - 1)])$$

C.P.O.:

$$\begin{aligned} \overline{w} &: \Gamma'(\overline{w}) - \lambda\, [\Gamma'(\overline{w}) - \mu G'(\overline{w})] = 0 \\ k &: E\, [\Upsilon(\overline{w})\, \widetilde{u} s - \lambda(\overline{w})] = 0 \\ \lambda &: [\Gamma(\overline{w}) - \mu G(\overline{w})]\, \widetilde{u} s - (k - 1) = 0 \end{aligned}$$

onde

$$\Upsilon(\overline{w}) \equiv 1 - \Gamma(\overline{w}) + \lambda(\Gamma(\overline{w}) - \mu G(\overline{w}))$$

e $\widetilde{u}$ é o choque agregado.

8 Apêndice B

Este apêndice apresenta o modelo completo log-linearizado, onde as letras maiúsculas se referem as variáveis no estado estacionário e as minúsculas ao desvio em relação ao estado estacionário. Entre parênteses fazemos referência a qual equação do modelo se refere a equação log-linearizada.

$$y_t = \frac{C^h}{Y}c_t^h + \frac{C^e}{Y}c_t^e + \frac{I^h}{Y}i_t^h + \frac{G}{Y}g_t + \frac{C^{h*}}{Y}c_t^{h*} \quad \text{(equação 47)}$$

$$c_t = \Delta c_t^h + (1-\Delta)\, c_t^f \quad \text{(equação 1)}$$

$$\Delta = \frac{(\gamma)^{\frac{1}{\rho}}(C^H)^{\frac{\rho-1}{\rho}}}{(\gamma)^{\frac{1}{\rho}}(C^H)^{\frac{\rho-1}{\rho}} + (1-\gamma)^{\frac{1}{\rho}}(C^F)^{\frac{\rho-1}{\rho}}}$$

$$p_t = \Lambda p_t^h + (1-\Lambda)p_t^f \quad \text{(equação 2)}$$

$$\Lambda = \frac{\gamma(P^H)^{1-\rho}}{\gamma(P^H)^{1-\rho} + (1-\gamma)^{\frac{1}{\rho}}(P^F)^{1-\rho}}$$

$$c_t^h = c_t^f - \rho(p_t^h - p_t^f) \quad \text{(equação 6)}$$

$$y_t - h_t^e = w_t^e - p_{w,t} \quad \text{(equação 16)}$$

$$y_t - h_t = w_t - p_{w,t} \quad \text{(equação 17)}$$

$$h_t\left[1 - \frac{1}{\frac{CP\varsigma}{W(1-\varsigma)}}\right] = c_t + p_t - w_t \quad \text{(equação 7)}$$

$$x_t = p_t - p_{w,t} \quad \text{(definição)}$$

$$\lambda_t = E_t(\lambda_{t+1}) + i_t + p_t - E_t(p_{t+1}) \quad \text{(equação 8)}$$

$$\lambda_t = [(\sigma-1)(\varsigma-1)-1]c_t - \varsigma(1-\sigma)h_t \quad \text{(equação 9)}$$

$$i_t - \Psi_t + i_t^* + E_t(s_{t+1}) - s_t = 0 \quad \text{(equação 10)}$$

$$c_t^{h*} = \upsilon\left[y_t^* - \varkappa\left(p_t^h - s_t - p_t^*\right)\right] + (1-\upsilon)\, c_{t-1}^{h*} \quad \text{(equação 12)}$$

$$y_t = \overline{w}_t + a_t + \alpha k_t + \alpha u_t + (1-\alpha)\,\Omega h_t + (1-\alpha)(1-\Omega)\, h_t^e \quad \text{(equação 13)}$$

$$y_t = (1+\xi)\, u_t + k_t + x_t^I \quad \text{(equação 18)}$$

$$x_t^I = p_t^i - p_{w,t} \quad \text{(definição)}$$

$$\delta(u_t) = \left[b\delta(u)^{1+\xi} + \frac{b^2u^{2(1+\xi)}}{1+\xi}\right]u_t \quad \text{(equação 15)}$$

$$r^k_{t+1} = \epsilon_1 \left[-x_{t+1} + y_{t+1} - k_{t+1}\right] + \epsilon_2 \left[-x^I_{t+1} + x_{t+1} - \delta\left(u_{t+1}\right)\right] + \left(1 - \epsilon_1 - \epsilon_2\right) q_{t+1} - q_t \quad \text{(equação 20)}$$

onde

$$\epsilon_1 = \frac{\alpha \frac{Y}{XKQ}}{\alpha \frac{Y}{XKQ} - \frac{X^I \delta(u)}{XQ} + 1}$$

$$\epsilon_2 = -\frac{\frac{X^I \delta(u)}{XQ}}{\alpha \frac{Y}{XKQ} - \frac{X^I \delta(u)}{XQ} + 1}$$

$$E_t \left[r^k_{t+1}\right] - i_t + E_t \Pi_{t+1} = risco_t \quad \text{(equação 23)}$$

$$risco_t = -\zeta n_{t+1} + \zeta b_{t+1} - \zeta p_t \quad \text{(equação 22)}$$

$$b_{t+1} = p_t + \frac{QK}{B} q_t + \frac{QK}{B} k_{t+1} - \left(1 - \frac{QK}{B}\right) n_{t+1} \quad \text{(equação 19)}$$

$$c^e_t = v_t \quad \text{(equação 25)}$$

$$v_{t+1} = \frac{QK}{V} \left(r^k_{t+1} + q_t + k_{t+1}\right) - \left(1 - \frac{QK}{V}\right) \left[risco_t + r_t + b_{t+1} - p_t\right] \quad \text{(equação 26)}$$

$$n_{t+1} = \frac{V}{N} v_t + \left(1 - \frac{V}{N}\right) w^e_t \quad \text{(equação 24)}$$

$$inv_t = \Xi inv^h_t - \left(1 - \Xi\right) inv^f_t \quad \text{(equação 28)}$$

onde

$$\Xi = \frac{\left(\gamma_i\right)^{\frac{1}{\rho_i}} \left(I^H\right)^{\frac{\rho_i - 1}{\rho_i}}}{\left(\gamma_i\right)^{\frac{1}{\rho_i}} \left(I^H\right)^{\frac{\rho_i - 1}{\rho_i}} + \left(1 - \gamma_i\right)^{\frac{1}{\rho_i}} \left(I^F\right)^{\frac{\rho_i - 1}{\rho_i}}}$$

$$inv^h_t - inv^f_t = \rho_i \left(p^f_t - p^h_t\right) \quad \text{(equação 29)}$$

$$p^i_t = \Gamma p^h_t + (1 - \Gamma) p^f_t \quad \text{(equação 30)}$$

$$\Gamma = \frac{\gamma_i (P^H)^{1-\rho_i}}{\gamma_i (P^H)^{1-\rho_i} + (1 - \gamma_i)^{\frac{1}{\rho_i}} (P^F)^{1-\rho_i}}$$

$$inv^n_t = \lambda inv_t - \left(1 - \lambda\right) \left[k_t + \delta\left(u_t\right)\right] \quad \text{(equação 47)}$$

$$\lambda = \frac{I}{I - \delta\left(u\right) K}$$

$$inv^n_t = q_t + p_t - p^I_t \quad \text{(equação 33)}$$

$$k_{t+1} = k_t + q_t + x_t - x^I_t \quad \text{(equação 32)}$$

$$\overline{p}^H_t = \beta\theta \overline{p}^H_{t+1} + \left(1 - \beta\theta\right) p_{w,t} \quad \text{(equação 40)}$$

$$\overline{p}^F_t = \beta^f \theta^f \overline{p}^F_{t+1} + \left(1 - \beta^f \theta^f\right) p^{f^*}_{w,t} \quad \text{(equação 42)}$$

$$p^H_t = \theta p^H_{t-1} + \left(1 - \theta\right) \overline{p}^H_t \quad \text{(equação 39)}$$

$$p_t^{F^*} = \theta^f p_{t-1}^{F^*} + \left(1-\theta^f\right)\overline{p}_t^F \quad \text{(equação 41)}$$

$$p_t^F = p_t^{F*} + s_t + \tau_t \quad \text{(equação 11)}$$

$$\begin{aligned} p_{w,t} \quad = \quad & -y_t + \left(\frac{WH}{P_wY}\right)w_t + \left(\frac{WH}{P_wY}\right)h_t + \left(\frac{W^eH^e}{P_wY}\right)w_t^e \\ & + \left(\frac{W^eH^e}{P_wY}\right)h_t^e + \left(\frac{PQK}{P_wY}\right)q_{t-1} - \left(\frac{PQKw}{P_wY}\right)q_t - \left(\frac{PQKw}{P_wY}\right)w_t \\ & + (1-w)\left(\frac{PQK}{P_wY}\right)p_t \ + (1-w)\left(\frac{PQK}{P_wY}\right)k_t \\ & + \left(\frac{P^I\delta(u)}{P_wY}\right)p_t^I + \left(\frac{P^I\delta(u)}{P_wY}\right)\delta(u_t) \quad \text{(lucro zero)} \end{aligned}$$

$$i_t = \rho^i i_{t-1} + \left(1-\rho^i\right)\left(\gamma_\pi \pi_t + \gamma_y y_t\right) + \varepsilon_t^i \quad \text{(equação 46)}$$

$$\pi_t = p_t - p_{t-1} \quad \text{(equação 47)}$$

$$\pi_t^h = p_t^h - p_{t-1}^h \quad \text{(equação 47)}$$

$$\pi_t^f = p_t^f - p_{t-1}^f \quad \text{(equação 47)}$$

$$i_t = r_t + E_{t-1}[p_t] - p_{t-1} \quad \text{(equação 47)}$$

$$x_t^f = p_t^f - p_{w,t}^f \quad \text{(equação 47)}$$

$$x_t^H = p_t^H - p_{w,t} \quad \text{(equação 47)}$$

$$g_t = p_{w,t}^f + c_t^F - p_t^H + \varepsilon_t^g \quad \text{(equação 45)}$$

$$\Psi_t = risco_t + \phi_t \quad \text{(equação 5)}$$

Variáveis exógenas:

$$a_t = \rho^a a_{t-1} + \varepsilon_t^a$$

$$i_t^* = \rho^{i^*} i_{t-1}^* + \varepsilon_t^{i^*}$$

$$\tau_t = \rho^\tau \tau_{t-1} + \varepsilon_t^\tau$$

$$p_{W,t}^{f*} = \rho^{p^{f*}} p_{W,t-1}^{f*} + \varepsilon_t^{p^{f*}}$$

$$y_t^* = \rho^{y^*} y_{t-1}^* + \varepsilon_t^{y^*}$$

$$\overline{w}_t = \varepsilon_t^{\overline{w}}$$

Chapter 3

Effects of Credit Market Quality on Trade Pattern

Abstract

Using a general equilibrium model with private innovation financing, this article derives the trade pattern between two countries equal in all aspects, except in the quality of credit markets. Innovation arises in most of the cases only in the country with the best credit market, whereas the other country devotes a larger share of its labor endowment to manufacture goods without innovation content. A welfare analysis shows that opening to trade may hurt welfare of individuals for a period, but in the long run all of them are better under free trade than if they were under autarky. This fact raises a question: when the long run benefits of opening to trade compensate the short run costs? Calculations show that opening to trade is more likely to be worth for all individuals when economies are not small, knowledge spills over countries and multinational corporations exist. Moreover, the inequality between residents of both countries is smaller in this setup.

Keywords: credit markets, innovation financing, trade pattern
Class JEL: F12, G11, O16

1 Introduction

The empirical literature on international trade has identified technological difference across countries as an essential complement to that model in explaining trade patterns (see Leamer and Levinsohn, 1995). Grossman and Helpman (1991) have identified that trade pattern may evolve depending on the rate of innovation in each country, which depends on investments in R&D.

In this article, we propose a general equilibrium model to investigate the role of differences in the quality of credit markets as the driving force of differences in the innovation rate across countries, and, consequently, in trade patterns and in welfare. Here we focus on credit markets, but we believe that it is very much related to the quality of the institutional framework in each country, since it reacts to the law, political, and ethical systems.

The first issue is to define what "*quality of credit markets*" means. Credit markets are the channel through which the wishes of those who want to save are linked to those who want to be financed. Based on this concept, if there are frictions which prevent investors from financing entrepreneurs who are able to pay the return rate required by the formers, this credit market must be not working quite well. Indeed, countries whose institutional framework creates more of those frictions have a worse credit market.

In this study, we develop a model that focus on moral hazard as the informational friction which plagues the investor-entrepreneur relationship. The intensity of this friction is responsible for the rate of return in innovation projects which defines the level of investment made in innovation.

Despite the institutional arrangements such as the quality of credit market, the model considers other sources of incentives for investments in innovation. R&D activity itself generates knowledge spillovers that prevent inventors from appropriating all the benefits of their own efforts. When an agent innovates, he contributes to a public pool of knowledge that makes future innovations cheaper than the present ones, which benefits its competitors. This particularity of innovation activity prevents investments from being at their optimal level, but, on the other hand, knowledge spillovers are socially desirable because they provide incentives that make innovation a self-perpetuating process[1]. The model takes into account the existence of knowledge spillovers either in national or international scope.

Another source of incentive for investments in innovation that we take into account is the possibility of separation between R&D and production facilities in different countries. This possibility allows multinational corporations to locate their activities where they are more efficient.

R&D investments are more sensitive to the quality of credit markets than production because in R&D projects, in general, investors are less informed about entrepreneur activities; there is less liquidation value in failed projects; and entrepreneurs have more valuable outside options, since they gather more human capital during the current project and, consequently, become more at-

[1] See Romer (1990)

tractive to other projects. On the other hand, as moral hazard problems are weaker in manufacturing activities, they are more sensitive to the input prices, which affect the production costs. Therefore, separation of activities in different countries may increase the R&D investment through the exploitation of comparative advantages.

The basic model presented in this paper is inspired on Grossman and Helpman (1991) with respect to the way that innovation creates dynamic comparative advantages for countries, and to the way that it becomes an endless and self-sustained process. We extend the original model to shed light on the interaction between credit markets and the innovation process, which determines the world trade pattern and the distribution of welfare among countries.

This paper is organized as follows. Section two presents and analyses a stylized general equilibrium model in a closed economy where firms engage in three activities: production of a traditional or a high-tech consumption goods, production of intermediate goods used as inputs by the high-tech final good producers, and development of new intermediate goods. Development of intermediate goods needs to be financed by individuals, who maximize utility over an infinite horizon, manage R&D projects, and supply inelastically labor in R&D projects and production activities (manufacturing of traditional and intermediate goods). Intermediate goods manufacturing firms are monopolists and their profits are paid out as dividends to shareholders. Final goods manufacturing firms are perfectly competitive, so they make no profits.

In this setup, economy may reach an equilibrium where the innovation rate and wage are constant and positive. They are greater, the better is the institutional framework in economy, in particular, the less is the moral hazard intensity in investors-entrepreneurs relationship.

Section three extends the model of section two to a world with two open economies which are different only in the quality of their credit markets and there are no knowledge spillovers between them. These extreme assumptions aim to assess the effect of the credit markets differences on the trade pattern and welfare of residents considering an environment where all benefits of local industrial research is appropriated by domestic innovators. In this setup, only the country with the best credit market innovates.

Section four, on the other hand, analyses the equilibria of this same model when knowledge spillovers are international in scope. Unlike the section three, both countries may innovate even though one of them has a better credit market. As expected, the equilibria which arise in this environment imply less inequality between welfare of residents and higher world aggregate welfare than the previous section.

Section five studies the consequences of the existence of multinationals corporations in the model of section four. Multinationals can develop R&D activity and intermediate goods manufacturing in different countries. In this setup, the country with the best credit market does not necessarily concentrate all innovation. In this setup, we verify the least difference of welfare between residents of both countries.

Section six analyses the welfare of individuals under autarky as well under

all free trade equilibria found in sections 3, 4, and 5. Opening to trade may hurt welfare of individuals for a period, but in the long run all of them are better under free trade than if they were under autarky. The relevant point is to know whether the present value of welfare is greater under autarky or under free trade. Calculations show that opening to trade is more likely to be worth when economies are not small, when there are knowledge spillovers between countries and multinational corporations exist.

Finally, section seven presents suggestions for further research and concludes.

2 Model Setup

In this model economy, individuals are at the same time consumers and owners of all firms. There are two types of firms: those that produce final goods, and those that invent and then produce different varieties of the intermediate good. Final consumption goods are either of the traditional type, which uses only labor in production, of high-tech, using only intermediate goods as input. Both R&D and the production of intermediate goods use only labor in production. Final goods market is competitive, while each intermediate good producer has monopoly power over his variety. We use a representative consumer setup, where all variables are in per capita values.

2.1 Consumers

Preferences of the representative consumer are represented by the following utility function:

$$U_t = \int_t^\infty e^{-\rho(\tau-t)} \log C(\tau) d\tau,$$

where $C(\tau) \equiv C_Y(\tau)^\sigma C_Z(\tau)^{1-\sigma}$, and $C_Y(\tau)$ and $C_Z(\tau)$ are the high-tech and traditional final goods consumptions at time τ. $\sigma \in (0,1)$ is the subjective discount rate.

He can lend or borrow at the instantaneous interest rate $r(t)$, so that his intertemporal budget constraint is represented by:

$$\int_t^\infty e^{-[R(\tau)-R(t)]} P(\tau)C(\tau)d\tau \leq \int_t^\infty e^{-[R(\tau)-R(t)]} Inc(\tau)d\tau + W(t),$$

where $R(t) \equiv \int_0^t r(\tau)\, d\tau$, W is the initial wealth, Inc is the net income per capita, which is given by the sum of incomes from labor and from the ownership of the firms. It will be described in subsection *2.4*. Finally, P is the consumer price index that minimizes the expenditure in final goods:

$$P(\tau) = \left(\frac{P_Y(\tau)}{\sigma}\right)^\sigma \left(\frac{P_Z(\tau)}{1-\sigma}\right)^{1-\sigma}. \quad (1)$$

It is straightforward to show that the solution of the consumer intertemporal problem yields the optimal spending evolution:

$$\frac{\dot{E}(\tau)}{E(\tau)} = r(\tau) - \rho, \text{ for } \tau \geq t \tag{2}$$

and the final good consumption:

$$C_Z(\tau) = \frac{(1-\sigma)E(\tau)}{P_Z(\tau)}, \text{ and} \tag{3a}$$

$$C_Y(\tau) = \frac{\sigma E(\tau)}{P_Y(\tau)}, \text{ for all } \tau \geq t, \tag{3b}$$

where $E(\tau) \equiv P(\tau)C(\tau)$ are total consumer expenditures.

2.2 Final Goods Production

Traditional goods, Z, are produced using only labor, whereas only intermediate goods are used in the high-tech good production, Y, according to:[2]

$$Z = L_z, \quad \text{and} \tag{4a}$$

$$Y = \left[\int_0^{n(t)} x(j)^{\alpha} dj \right]^{\frac{1}{\alpha}}, \; 0 < \alpha < 1, \tag{4b}$$

where $n(t)$ is the number of varieties of intermediate goods invented until period t, and $x(j)$ and L_z are the quantity of the intermediate good j and labor used as inputs in the high-tech and traditional goods production, respectively. Note that the high-tech good production is more productive the more varieties of intermediate goods exist. This is an interesting feature for our purposes, as the innovation activity will be the major source of comparative advantages between countries when they are open to trade.

The final goods market is perfectly competitive, hence prices will equal the minimum feasible unit manufacturing costs:

$$P_z = w, \text{ and} \tag{5a}$$

$$P_y = \left[\int_0^{n(t)} p(j)^{-\frac{\alpha}{1-\alpha}} dj \right]^{-\left(\frac{1-\alpha}{\alpha}\right)}, \; \forall t, \tag{5b}$$

where w is the wage rate.

[2] The indication that the variable is a function of time is suppressed whenever it is not confusing to do so.

Finally, the demand for each variety of intermediate goods is given by:

$$x(j) = \frac{p(j)^{-\frac{1}{1-\alpha}}}{\int_0^{n(t)} p(j)^{-\frac{\alpha}{1-\alpha}} dj} \sigma E,\ j \in [0, n(t)], \tag{6}$$

where σE is, from equation (3b), the aggregate expenditure on high-tech good or, equivalently, the aggregate sales revenue of high-tech good.

2.3 Intermediate Goods

2.3.1 Production

We assume that each intermediate good is manufactured by a single producer, that has monopoly power over it. This assumption may be justified by a positive cost of imitation which, combined with the assumption that firms engage in ex-post price competition in a Bertrand fashion, yields no incentive to imitate. Once invented, an intermediate good is produced using one unit of labor per unit of production. Each producer of an intermediate good faces the demand function given by equation (6).

Due to the symmetry across firms, in the Bertrand-Nash equilibrium the prices of all intermediate goods will be equal and given by:

$$p(j) = p_x \equiv \frac{w}{\alpha},\ j \in [0, n(t)]. \tag{7}$$

The demand for each intermediate good and profits thereby generated are:

$$x(j) = x \equiv \frac{\sigma E}{n p_x} = \frac{\alpha \sigma E}{n w}, \text{ and} \tag{8a}$$

$$\pi(j) = \pi \equiv \frac{(1-\alpha)\sigma E}{n},\ j \in [0, n(t)], \tag{8b}$$

respectively.

2.3.2 R&D

To be produced, an intermediate good has first to be invented, and invention is achieved through R&D. We assume that the experience at R&D generates public knowledge that renders the next generation of innovation more productive. In order to model this phenomenon, we follow Grossman and Helpman (1991) and assume the existence of a public pool of information which contains the stock of accumulated knowledge. The measure of this pool K is taken to be the same as that of the existing intermediate goods diversity, that is:

$$K(t) = n(t). \tag{9}$$

We are aware that the assumption in equation (9) has some important drawbacks. First, it does not consider nor the obsolescence of past contributions

neither any complementarities between different kinds of knowledge. Second, spillovers do not happen instantaneously, as suggested by the equation, but, rather, gradually. Finally, it does not consider heterogeneity between industries with respect to degree of informational content. Nevertheless, as it is the easiest way to model the phenomenon, we use this representation for simplicity.

The R&D activity uses only labor as input, but its result is uncertain. The research is successful with an instantaneous probability q, and L_γ units of labor generates $K(t)L_\gamma(t)/a$ new varieties, where a is a parameter of labor productivity in R&D. With probability $1-q$, no new brands are invented. Therefore, the expected outcome of this project is $qv(t)\frac{n(t)L_\gamma(t)}{a}$, where $v(t)$ is the value of a blueprint. This value is the present value of the stream of future profits π generated by the intermediate good production, that is:

$$v(t) = \int_t^\infty e^{-[R(\tau)-R(t)]}\pi(\tau)d\tau. \tag{10}$$

Entrepreneurs borrow from the credit market to engage in R&D to try and invent new brands. According to the debt contract, if the project is successful, the inventing firm pays an agreed upon amount for its debt. If unsuccessful, there is no payment to the creditor. Following Tirole (2006), we assume that the probability of success of an investment project depends on unobservable actions taken by the entrepreneurs. In particular, 'good behavior' yields a higher probability of success, q_H, and no private benefits to the managers of the firms. 'Bad behavior', on its turn, yields a lower probability of success, q_L, but managers are able to retain a share B of the investment made in this project. A higher share B means that investors' rights are less protected by the legal or regulatory institutions.

To have an interesting case, we assume that the expected outcome of the project is greater than its costs only if the managers have good behavior. Clearly, investors will only lend to the inventing firm if the financing contract promotes good behavior from managers. As managers' behavior cannot be observed, it cannot be written in a contract. The only way to induce good behavior is to have debt repayments that will make managers themselves prefer good behavior. If R_b is the amount the firm manager retain after paying its debt in case of success, good behavior will be induced when:[3]

$$q_H R_b \geq q_L R_b + BwL_\gamma. \tag{11}$$

Thus, the firms must retain a minimum of $R_b^* \equiv \frac{BwL_\gamma}{q_H - q_L}$ of the outcome of a successful project to make the objectives of both parts aligned, as implicit in the incentive compatibility constraint (11).

[3]Note that the condition below implies risk neutrality from managers. Although all individuals have concave utility functions, implying risk aversion, they behave as if risk neutral with respect to this investment outcome for two reasons. First, there is no aggregate uncertainty. By the law of large numbers, an exact share of q_H or q_L (depending on the manager's behavior) of the projects undertaken will be successful. Second, as each individual manager owns an equal share of all R&D projects, they can take advantage of the law of large numbers.

Additionally, investors will only be willing to invest in R&D if the expected rate of return in innovation projects is larger than the rate of return of the riskless asset, that is,

$$\frac{q_H v n L_\gamma}{a} - wL_\gamma - q_H R_b \geq rwL_\gamma.$$

Substituting R_b^* in the equation above and rearranging terms, we write the participation constraint of investors as:

$$\frac{q_H}{a}\frac{vn}{w} \geq \Psi, \text{ where } \Psi \equiv (1+r) + \frac{q_H}{q_H - q_L}B. \tag{12}$$

Equation (12) states that the project is undertaken only if its returns is strictly higher than $1+r$, as $\Psi > 1+r$ due to the credit market imperfection.

We will adopt, without loss of generality, the simplifying assumption that the effective measure of productivity of labor in the R&D activity, $\frac{q_H}{a}$, is equal to 1. Thus, the investors participation constraint becomes:

$$\frac{vn}{w} \geq \Psi. \tag{13}$$

Note that the left-hand side of equation (13) is the return of the project. When this ratio is greater than $1+r$, the project has positive expected net return. Ψ may be interpreted as a measure of the credit market imperfection. Note that, when $\Psi = 1+r$, all projects with positive expected net return are financed, whereas, when $\Psi > 1+r$, the projects with expected return in the range $[1+r, \Psi)$ are not financed, although they have positive expected net return. The higher the value of Ψ, the larger is the range of projects with positive expected net return that are not financed due to informational asymmetry problems. The credit market imperfection is increasing in the private benefit accrued to managers with bad behavior, $\frac{\partial \Psi}{\partial B} > 0$, and decreasing in the degree of observability and/or accountability, $\frac{\partial \Psi}{\Delta q} < 0$, where $\Delta q \equiv q_H - q_L$.

2.4 Individuals Income

All individuals are simultaneusly workers, owners of final goods firms, entrepreneurs in intermediate goods firms, and investors. Each individual has an equal share of all final goods firms. As those firms are in competitive markets, profits are zero, hence no income is accrued from this ownership. To preserve the conflict of interests between entrepreneurs and investors, we assume that each individual invests in half of the intermediate goods firms, and invest in the other half. We detail these roles below.

Entrepreneurs For simplicity, we assume that there is a sufficiently large number of firms, so that the law of large number applies and there is no aggregate uncertainty. At every moment, exactly a fraction q_H of all investment projects are successful. Each manager receives every moment the $\frac{1}{L}$ share of the total $q_H R_b^*$ for his fraction of these firms.

Investors Each individual invests $\frac{wL_\gamma}{L}$ in innovation projects. The entrepreneurs retains $q_H R_b^*$ of the investment returns, and the investor receives at each period his share $\frac{1}{L}$ of the monopoly profit $\pi = \frac{(1-\alpha)\sigma E}{n}$ from production of each of the n successfully invented varieties.

Workers Individuals are endowed with one unit of labor and they supply it inelastically. Thus, their labor income is given the wage rate w. There are L individuals in the economy, hence that is also the total labor supply.

Aggregate Income Summing up the individual's revenue for each of his activities, we get:[4]

$$Inc = \frac{w\left(L - L_\gamma\right) + \left(1-\alpha\right)\sigma E}{L}. \tag{14}$$

Note that all individuals have the same behavior and they participate as workers and entrepreneurs in the same number of firms. Hence, their net income per capita is equal.

2.5 Equilibrium in a Closed Economy

Following Grossman and Helpman (1991), we normalize $P_y(t)$ and $P_z(t)$ so that $E(t) = 1, \forall t$. Then, in equilibrium, expressions (2), (3), (4), (5), and (8) become:

$$r\left(t\right) = \rho, \tag{15a}$$

$$C_Z = Z = \frac{\left(1-\sigma\right)}{w}, \quad C_Y = Y = \frac{n^{\frac{1-\alpha}{\alpha}}\alpha\sigma}{w}, \tag{15b}$$

$$P_z = w, \quad P_y = \frac{w}{\alpha n^{\frac{1-\alpha}{\alpha}}}, \tag{15c}$$

$$x = \frac{\alpha\sigma}{nw}, \quad \pi = \frac{h}{n}, \tag{15d}$$

where $h \equiv \sigma\left(1-\alpha\right)$.

There are two equilibrium conditions from the financing of R&D projects. First, the inequality $\frac{vn}{w} > \Psi$ (see equation 12) cannot arise in equilibrium when firms maximize profits. If that were the case, entrepreneurs' profits would be higher the larger were investments, leading unbounded R&D. As labor supply is fixed, this would not be an equilibrium. Hence, the financing equilibrium condition (FEC) in the R&D activity is given by:

$$\frac{vn}{w} \leq \Psi, \text{ with equality when } \dot{n} > 0. \text{ (FEC)} \tag{16}$$

Second, assuming that agents have access to a riskless bond that pays $r\left(t\right)$, the non-arbitrage condition implies that the expected rate of return of the risky

[4] Note that, in aggregate, the individual's payments, as investors, to entrepreneurs cancels out with what they receive as entrepreneurs.

investment in R&D must be equal to the riskless rate,[5] that is:

$$\pi(t) + \dot{v}(t) = r(t)v(t),$$

which can be rewritten as:

$$\frac{\dot{v}(t)}{v(t)} = r(t) - \frac{\pi(t)}{v(t)}. \tag{17}$$

From log-differentiating the FEC (expression 16) when $\dot{n} > 0$,[6] we get:

$$\frac{\dot{w}}{w} = \frac{\dot{v}}{v} + \gamma, \tag{18}$$

where $\gamma \equiv \frac{\dot{n}}{n}$. Substituting it in the no-arbitrage condition (17), and using the results in equations (15), we can write the non-arbitrage condition (NAC) for the innovating country as:

$$\frac{\dot{w}}{w} = \gamma + \rho - \frac{h}{w\Psi}. \text{ (NAC)} \tag{19}$$

Equilibrium is characterized when the aggregate equity $V \equiv vn$ (or the aggregate market value of firms) is constant. It means that in equilibrium, we must have that:

$$\frac{\dot{v}}{v} + \gamma = 0.$$

The condition above is equivalent to:

$$\frac{\dot{w}}{w} = 0,$$

given the financing equilibrium condition in R&D, which implies equation (18) if new varieties are to be produced.

Finally, there is the labor market equilibrium condition. The labor market clears when the sum of demands for labor in R&D (L_γ), intermediate goods production (L_X), and traditional good production (L_Z) equals the labor supply L. We have already seen that one unit of labor produces either one unit of intermediate good or one unit of traditional good. Hence, from equations (15b) and (15d), we get that $L_Z = \frac{(1-\sigma)}{w}$ and $L_X = \frac{\alpha\sigma}{w}$. As for the demand for labor in R&D, note that, from our assumptions, the innovation rate is $\frac{dn}{dt} = \left(\frac{q_H}{a}\right) nL_\gamma$. Therefore, $L_\gamma = \gamma$, using the simplifying assumption that $\frac{q_H}{a} = 1$. Thus, the labor market clearing condition (LMC) is:

$$\gamma + \frac{(1-h)}{w} = L. \text{ (LMC)} \tag{20}$$

The NAC and LMC, in equations (19) and (20), respectively, determine the equilibrium values for w and γ, which are:

[5] We refer to the argument in footnote 3 for the risk neutral behavior of the individual here.
[6] As we are interested in equilibria with active innovation, that is, $\dot{n} > 0$.

$$\bar{\gamma} = \frac{hL - \rho(1-h)\Psi}{h + (1-h)\Psi}, \tag{21}$$

and:

$$\bar{w} = \frac{h + (1-h)\Psi}{\Psi(L+\rho)}. \tag{22}$$

This equilibrium is feasible if $\bar{\gamma} \geq 0$, i.e.:

$$\frac{L}{\rho} \geq \frac{(1-h)\Psi}{h}.$$

The wage and innovation rates are constant in equilibrium. In fact, it must be the case at all times, since the steady-state is unstable[7], as one can see in Figure 1.

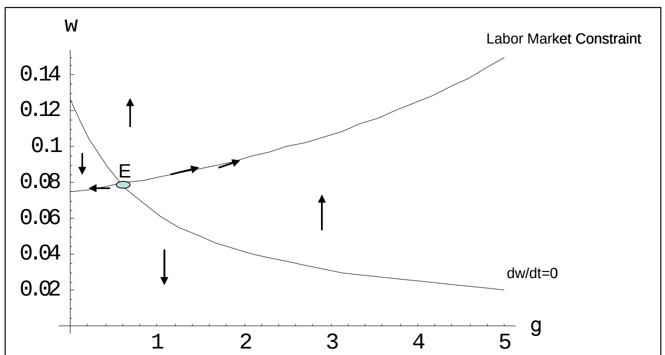

Figure 1: $\alpha = \sigma = \frac{1}{2}; \rho = 0.99; \Psi = 2; L = 10$

The fact that $\bar{\gamma}$ and $\bar{w}$ are constant means that the allocation of labor remains constant across all activities (R&D, traditional good production, and intermediate goods production). Nevertheless, the ratio $\frac{Y}{Z}$ increases at the instantaneous rate $\frac{1-\alpha}{\alpha}\bar{\gamma}$, as the productivity of the intermediate goods in good Y's production rises with the increase in the number of varieties. Consequently, its price also decreases as the number of intermediate goods varieties increases. The rate of output growth converges to $\frac{1-\alpha}{\alpha}\bar{\gamma}$ in the long run.

Proposition 3 *In economies where credit market frictions are less severe (lower Ψ), investment in R&D activity and wages are higher and the number of varieties increases faster.*

Proof. *It is straightforward to check that $\frac{\partial \bar{\gamma}}{\partial \Psi} = -\frac{(1-h)h}{[(1-h)\Psi + h]^2} < 0$ and $\frac{\partial \bar{w}}{\partial \Psi} = -\frac{h}{\Psi^2(L+\rho)} < 0$. As for the impact of credit market quality on investment of R&D, the FEC for $\gamma > 0$ can be written as:*

$$I = \frac{vn\bar{\gamma}}{\Psi}, \tag{23}$$

[7]Note that the equilibrium in Grossman and Helpman's model is also unstable.

where $I \equiv wL_\gamma$ is the aggregate investment made on innovation projects. We have, then, that $\frac{\dot{I}}{I} = \frac{\dot{v}}{v} + \gamma = 0$ by log-differentiating equation (23). Finally, from equation (18) we have that , $\frac{\dot{v}}{v} = -\gamma$ in equilibrium, as $\frac{\dot{w}}{w} = 0$. Using these results, we get that the level of investment is constant, and it will be higher when Ψ is smaller. ■

3 The Open Economy

We extend the previous model to a world economy with two countries engaging in international trade, with free flow of financial capital. As we want to focus on the effect of the quality of credit market on the trade patterns and on welfare on both countries, we abstract from other effects by setting both countries with equal endowments, equal individuals preferences, and equal access to technology. Hence, the only difference between them is the degree of credit market frictions, which will be responsible for the trade pattern, through the differences in innovation rates, wages, and output growth on the long run.

We also assume that both countries have run in autarky for the same length of time before they start to trade. From Proposition 3, we have that the country with the best credit market will have a larger number of intermediate goods when they open to trade.

Hereafter we denote the country with the best credit market as the 'best' country and the other one as the 'worst' (needless to say, with no meaning other than the reference to the quality of the credit market). The superscript i , $i = best, worst$, is used to denote the two countries, so that $\Psi^{best} < \Psi^{worst}$.

We study separately the equilibrium under alternative assumptions with respect to knowledge spillovers across countries, to trade in intermediate goods, and to technology transfers. When there is no international spillover of knowledge, the stock of knowledge available for each country is proportional to the number of intermediate goods that were invented in that country, as in:

$$K^i(t) = n^i(t),\ \forall t, \tag{24}$$

while with international knowledge spillovers it encompasses all varieties invented in both countries, that is:

$$K(t) = n^{best}(t) + n^{worst}(t),\ \forall t. \tag{25}$$

In the first two subsections we assume away technology transfers, that is, each intermediate good must be produced where it was invented, and analyze the cases with and without international spillover of knowledge and intermediate goods trade. The last subsection studies the case when an intermediate good can be invented in one country and produced in the other, under international knowledge spillovers.

As in the closed economy case, we normalize final good prices so that $E^{best} + E^{worst} = 1$ at all times. With international trade of final goods, the country's

output of the traditional final good, Z^i, is defined as the country's market-share of global demand for that good, s_z^i, that is:

$$Z^i = s_z^i C_Z. \tag{26}$$

As final goods markets are competitive, the country with lowest producing cost captures all the market, hence:

$$s_z^i = \begin{cases} 0, \text{ if } w^i > w^k; \\ s_z^i \in [0,1], \text{ if } w^i = w^k; \text{ and} \\ 1, \text{ if } w^i < w^k. \end{cases} \tag{27}$$

The country's output of high-tech final good is:

$$Y^i = \left[\int_0^{k^i(t)} x^i(j)^\alpha dj \right]^{\frac{1}{\alpha}}, \tag{28}$$

where:

$$k^i(t) = \begin{cases} n^i(t), \text{ when international trade of intermediate goods is not allowed;} \\ n(t) \equiv n^{best}(t) + n^{worst}(t), \text{ when there is trade of intermediate goods.} \end{cases}.$$

Competition among suppliers of both countries implies that the equilibrium prices are set at the lowest manufacturing cost, hence we have that:

$$P_z = Min\left\{w^{best}, w^{worst}\right\}, \text{ and} \tag{29a}$$

$$P_y = \begin{cases} Min\left\{ \frac{w^{best}}{\alpha (n^{best})^{\frac{1-\alpha}{\alpha}}}, \frac{w^{worst}}{\alpha (n^{worst})^{\frac{1-\alpha}{\alpha}}} \right\} \\ \text{when intermediate goods trade is not allowed;} \\ \\ \frac{\alpha}{\left[\frac{n^{best}}{(w^{best})^{\frac{\alpha}{1-\alpha}}} + \frac{n^{worst}}{(w^{worst})^{\frac{\alpha}{1-\alpha}}} \right]^{\frac{1-\alpha}{\alpha}}} \\ \text{when it is allowed.} \end{cases} \tag{29b}$$

The demand for each variety of the intermediate good produced in country i is given by:

$$x^i(j) = \frac{p^i(j)^{-\frac{1}{1-\alpha}}}{\int_0^{n(t)} p^i(j)^{-\frac{\alpha}{1-\alpha}} dj} s^i \sigma, \quad j \in [0, n], \tag{30}$$

where s^i represents either s_y^i, the high-tech good market share of firms from country i when trade of intermediate goods is not allowed, or s_x^i, the intermediate goods market share of firms from country i when there is trade of

intermediate goods. s_y^i and s_x^i are, respectively:

$$s_y^i = \begin{cases} 0, \text{ if } \frac{w^i}{\alpha(n^i)^{\frac{1-\alpha}{\alpha}}} > \frac{w^k}{\alpha(n^k)^{\frac{1-\alpha}{\alpha}}} \\ s_y^i \in [0,1], \text{ if } \frac{w^i}{\alpha(n^i)^{\frac{1-\alpha}{\alpha}}} = \frac{w^k}{\alpha(n^k)^{\frac{1-\alpha}{\alpha}}} \\ 1, \text{ if } \frac{w^i}{\alpha(n^i)^{\frac{1-\alpha}{\alpha}}} < \frac{w^k}{\alpha(n^k)^{\frac{1-\alpha}{\alpha}}} \end{cases}, \text{ and} \tag{31}$$

$$s_x^i = \frac{n^i(w^i)^{-\frac{\alpha}{1-\alpha}}}{n^{best}(w^{best})^{-\frac{\alpha}{1-\alpha}} + n^{worst}(w^{worst})^{-\frac{\alpha}{1-\alpha}}}. \tag{32}$$

The price, demand and profits function for intermediate goods invented in country i remain analogous to those of the closed economy case in equations (7), (8a) and (8b):

$$p^i = \frac{w^i}{\alpha}, \tag{33}$$

$$x^i = s^i \frac{\alpha\sigma}{w^i}, \tag{34}$$

$$\pi^i = \frac{s^i h}{n^i}. \tag{35}$$

Consumers' behavior is exactly the same as in the closed economy, since there is no difference between final goods manufactured by domestic or foreign firms.

3.1 Without International Knowledge Spillover

Given the knowledge pool available for each country when there are no knowledge spillovers in equation (24), the FEC (16) becomes:

$$\frac{v^i n^i}{w^i} \leq \Psi^i, \text{ with equality when } \dot{n}^i > 0. \tag{36}$$

The NAC (19) for the innovating country is now:

$$\frac{\dot{w}^i}{w^i} = \gamma^i + \rho - \frac{s^i h}{w^i \Psi^i}, \text{ if } v^i n^i = w^i \Psi^i, \tag{37}$$

and the new LMC (20) is:

$$\gamma^i + s^i \frac{\alpha\sigma}{w^i} + s_z^i \frac{(1-\sigma)}{w^i} = L. \tag{38}$$

In current setup, the equilibrium conditions yield the same characterization as in the closed economy case, that is:

$$\frac{\dot{w}^i}{w^i} = 0, \ i = best, worst.$$

3.1.1 Equilibrium Without Intermediate Goods Trade

The high-tech good is manufactured only in the country in which its price is lower. The country that loses the high-tech good market will also lose all its market for intermediate goods, when its trade is not allowed. All blueprints invented in that country become useless, and no further innovation takes place.

Both countries cannot innovate simultaneously

Proposition 4 *Without trade in intermediate goods and without international knowledge spillovers, there is no equilibrium where both countries innovate under free trade of final goods.*

Proof. In the appendix. ■

The intuition of the proof in the following. In the case of factor price equalization (FPE), the country that has the larger stock of blueprints when international trade starts takes the whole high-tech good market.[8] Only in this country intermediate goods have a positive value, as there is no trade in these goods. Hence, only this country innovates and the situation is self-perpetuating.

In the case of non-FPE, the relation between the wages in the two countries that is necessary for the production of high-tech good to take place in both countries is not compatible with labor market clearing conditions. More specifically, the country with the worst credit market has a smaller stock of blueprints, which makes it less productive in the high-tech good sector. In order for the countries to be equally competitive in this sector, it is necessary that the worst country has a lower wage. Let us now look at the total demand for labor in both countries, given such wages differentials. First, its lower wage makes the worst country capture all the market of traditional goods. Second, this country has higher demand for labor for producing intermediate goods. Finally, both countries have the same demand for labor for innovation, as they innovate at the same rate.[9] Hence, the worst country would have a higher demand for labor than the best, which is not possible in equilibrium because, by assumption, their labor supplies are the same. Therefore, an equilibrium with both countries innovating is also not possible when there is no FPE.

Only the best country innovates

Corollary 5 *Without trade in intermediate goods and without international knowledge spillovers, only the country with the best credit market innovates under free trade of final goods, and it captures all the market of high-tech goods.*

Proof. From proposition 4, we know that only one country innovates in equilibrium, and this will be the best country for the following reason. Under FPE,

[8] The best country is more productive in those goods, and, as wages are equal in both countries, its production costs are lower.

[9] They must innovate at the same rate in order for both to remain equally competitive in the high-tech sector with constant wages.

we have already seen that the best country would clearly capture all the market for high-tech goods as it has a higher stock of blueprints when trade starts. With no FPE, if it were the worst country to be the one to innovate, it would be necessary that $\bar{w}^{best} > \bar{w}^{worst}$ to generate $p_y^{worst} < p_y^{best}$ (see equation (29b)) But, in that case, the worst country would also capture all the market for the traditional good, as can be seen from equation (27). The demand for labor in the best country would then be zero, which cannot be an equilibrium. Therefore, the best country is always the one that innovates, and it captures all the market the high-tech good. ■

For the innovating country, which is the one with better credit market, the equilibrium conditions are given by the NAC and the LMC in equations (37) and (38), respectively. The equilibrium condition for the worst country is the LMC given by:

$$(1 - s_z^{best}) \frac{(1-\sigma)}{w^{worst}} = L. \tag{39}$$

Solving the system of equations (37), (38) and (39), under FPE, that is $\bar{w}^{best} = \bar{w}^{worst} \equiv \bar{w}$, we have the following equilibrium values for the innovation rates and wages in each country:

$$\bar{\gamma}^{best} = \frac{2hL - (1-h)\,\rho\Psi^{best}}{h + (1-h)\,\Psi^{best}}, \tag{40a}$$

$$\bar{\gamma}^{worst} = 0, \tag{40b}$$

$$\bar{w} = \frac{h + (1-h)\,\Psi^{best}}{\Psi^{best}\,(2L+\rho)}, \tag{40c}$$

$$\bar{s}_z^{best} = \frac{\Psi^{best}\,(1-\sigma)\,(L+\rho) - L\left(\alpha\sigma\Psi^{best} + h\right)}{\Psi^{best}\,(2L+\rho)\,(1-\sigma)} \tag{40d}$$

remembering that $h \equiv \sigma\,(1-\alpha)$.

This equilibrium is feasible only if $\bar{\gamma}^{best} > 0$ and $\bar{s}_z^{best} \in [0,1]$, i.e.,

$$\frac{L}{\rho} > \frac{(1-h)\,\Psi^{best}}{2h} \text{ and} \tag{41a}$$

$$\frac{L}{\rho} \geq \frac{(1-\sigma)\,\Psi^{best}}{(1+\Psi^{best})\,h - (1-2\alpha\sigma)\Psi^{best}}. \tag{41b}$$

In the non-FPE equilibrium, the only possible configuration for wages in equilibrium is $\bar{w}^{best} > \bar{w}^{worst}$.[10] It implies that $\bar{s}_z^{best} = 0$, yielding the following

[10] Note that $\bar{w}^{best} < \bar{w}^{worst}$ is not an equilibrium because in that case $\bar{s}_z^{best} = 1$. The best country would then get all demand, not only from high-tech goods, by also from traditional goods, while the worst country would produce nothing.

equilibrium values:

$$\bar{\gamma}^{best} = \frac{hL - \alpha\sigma\rho\Psi^{best}}{h + \alpha\sigma\Psi^{best}} \tag{42a}$$

$$\bar{\gamma}^{worst} = 0 \tag{42b}$$

$$\bar{w}^{best} = \frac{h + \alpha\sigma\Psi^{best}}{(L+\rho)\,\Psi^{best}} \tag{42c}$$

$$\bar{w}^{worst} = \frac{1-\sigma}{L}. \tag{42d}$$

This equilibrium is feasible only if $\bar{\gamma}^{best} > 0$ and $\bar{w}^{best} > \bar{w}^{worst}$, i.e.,

$$\frac{L}{\rho} > \frac{\alpha\sigma\Psi^{best}}{h} \text{ and} \tag{43a}$$

$$\frac{L}{\rho} < \frac{(1-\sigma)\,\Psi^{best}}{(1+\Psi^{best})\,h - (1-2\alpha\sigma)\Psi^{best}}. \tag{43b}$$

Comparing wages and innovation rates of the best country in autarky (expressions 21 and 22) to those in FPE (40) and non-FPE (42) equilibria, we see that, when countries start to trade, the innovation rate jumps upwards and wage jumps downwards in the best country.[11]

The feasibility conditions for FPE equilibrium (expressions 41a and 41b) show that the FPE equilibrium exists only when the size of the economies (L) is large enough *vis-a-vis* the share of expenditures on high-tech good (σ) and the quality level of the best credit market (Ψ^{best}). The intuition is the following. The labor supply in the economy where innovation takes place has to satisfy all demand for labor from R&D activity and from intermediate goods manufacturing, while still remaining some labor supply to produce the traditional good. Therefore, the production of high-tech goods and the innovation rate cannot be too large with respect to the size of the economy. High-tech good production is large when the share of expenditures in high-tech goods (σ) is high, while innovation rate is high when the moral hazard in the best country is less severe (Ψ^{best} is low).

When the size of economies does not allow for the innovating country to cope with all demand for labor from R&D activity and from intermediate goods manufacturing under the wage $\bar{w}$, the wage adjusts (jumps upwards) in that country in order to balance the supply and demand for labor. In this case the country with best credit market specializes on R&D and high-tech good manufacturing, while the other country specializes on traditional good manufacturing.

3.1.2 Equilibrium With Intermediate Goods Trade

When trade of intermediate goods is allowed, countries may produce intermediate goods even if they do not produce the high-tech good. There is no waste of

[11] Notice that here we are talking about nominal wages. We will see in the next section that real wages increases in the best country.

past invention when countries engage in international trade, as it was the case when intermediate goods trade was not allowed.

Both countries cannot innovate simultaneously

Proposition 6 *Without international knowledge spillovers, there is no equilibrium where both countries innovate under free trade of final and intermediate goods.*

Proof. In the appendix. ■

Only the best country innovates

Proposition 7 *Without international knowledge spillovers, only the best country innovates under free trade of final and intermediate goods, and both economies tend to the equilibrium of the case without international trade as time goes to infinity.*
Proof. *In the appendix.* ■

Analogously to the case without trade of intermediate goods, the NAC and the LMC for the innovating country, the best one, are given by equations (37) and (38). As for the worst country, the LMC is given by:

$$\left(1 - s_x^{best}\right) \frac{\alpha\sigma}{w^{worst}} + \left(1 - s_z^{best}\right) \frac{(1-\sigma)}{w^{worst}} = L. \quad (44)$$

Log-differentiating the definition of the market share of intermediate goods in equation (32) we get that:

$$\frac{\dot{s}_x^{best}}{s_x^{best}} = (1 - s_x^{best})\gamma^{best}, \quad (45)$$

if it is an equilibrium with FPE, and:

$$\frac{\dot{s}_x^{best}}{s_x^{best}} = (1 - s_x^{best}) \left(\gamma^{best} - \frac{\alpha}{1-\alpha} \frac{\dot{w}^{best}}{w^{best}}\right), \quad (46)$$

in the case of non-FPE.

Note that $s_x^{best} \in (0,1)$ when economies open to trade, and it increases continuously as time passes, tending to 1 as time goes to infinity. Meanwhile, s_z^{best} decreases continuously (equation (44)), and all other variables approach the same equilibrium value as in the case without trade in intermediate goods.

3.2 With International Knowledge Spillover

We now assume that domestic innovating firms can access a worldwide pool of knowledge under free trade, as represented in equation (25).

The FEC becomes:

$$\frac{v^i n^i}{w^i} \leq s_n^i \Psi^i, \text{ with equality when } \dot{n}^i > 0, \tag{47}$$

where $s_n^i \equiv \frac{n^i}{n}$. Differentiating it in the case of equality, we get:

$$\frac{\dot{v}^i}{v^i} + \gamma^i = \frac{\dot{s}_n^i}{s_n^i} + \frac{\dot{w}^i}{w^i}. \tag{48}$$

We also have, from the differentiation of the definition of s_n^i, that:

$$\frac{\dot{s}_n^i}{s_n^i} = s_n^j(\gamma^i - \gamma^j). \tag{49}$$

Substituting (49) into (48) yields:

$$\frac{\dot{w}^i}{w^i} = \frac{\dot{v}^i}{v^i} + \sum_{k=best,worst} s_n^k \gamma^k. \tag{50}$$

Finally, we substitute the non arbitrage condition (17) into the previous expression to derive the new NAC for the innovating country:

$$\frac{\dot{w}^i}{w^i} = \sum_{k=best,worst} s_n^k \gamma^k + \rho - \frac{s^i h}{s_n^i w^i \Psi^i}, \tag{51}$$

where s^i is either s_y^i, the share in the high-tech good production in equation (31), or s_x^i, the share in the intermediate good production in equation (32), depending on whether trade in intermediate good is allowed or not.

The LMC in each country is given by:[12]

$$s_n^i \gamma^i + s^i \frac{\alpha\sigma}{w^i} + s_z^i \frac{(1-\sigma)}{w^i} = L. \tag{52}$$

As usual, equilibrium is characterized when the aggregate equity value is constant. Using the result in equation 48, we have that:

$$\frac{\dot{V}^i}{V^i} = \frac{\dot{v}^i}{v^i} + \gamma^i = \frac{\dot{w}^i}{w^i} + \frac{\dot{s}_n^i}{s_n^i} = 0, \; i = best, worst. \tag{53}$$

Note that the equation (53) does not ensure that wages are constant. According to the equation, they may decrease while the blueprints share of the country increases, in such a way as to keep the value of the aggregate equity constant. This cannot be considered an equilibrium as labor allocation would be changing across productive activities. Thus, we also require that, in equilibrium:

$$\frac{\dot{w}^i}{w^i} = \frac{\dot{s}_n^i}{s_n^i} = 0. \tag{54}$$

[12] The labor resources used in R&D activity by country i, L_{γ^i}, is calculated as follows. We have that the innovation rate is given by $\frac{dn^i}{dt} = \left(\frac{q_H}{a}\right) nL_{\gamma^i}$. Using the simplifying assumption that $\frac{q_H}{a} = 1$, we have that $L_{\gamma^i} = \frac{1}{n}\frac{dn^i}{dt} = s_n^i \gamma^i$.

3.2.1 Equilibrium Without Intermediate Goods Trade

When there is no trade in intermediate goods, they have no value in the country that loses the market of high-tech good, so there is no further innovation in that country after trade opening.[13] Innovation can only take place in both countries if the high-tech good price is equal in both countries .

Both countries innovate There is no FPE equilibrium with both countries innovating for the same reason there is no such equilibrium in the case of no knowledge spillovers, established in Proposition 4. There is, however, the possibility of non-FPE equilibrium, which is characterized as follows.

For both countries to innovate, it is necessary that both produce the high-tech good, hence $p_y^{best} = p_y^{worst}$. According to equation (29b), this implies:

$$s_n^{best} \equiv \frac{n^{best}}{n^{best} + n^{worst}} = \frac{\left(w^{best}\right)^{\frac{\alpha}{1-\alpha}}}{W}, \tag{55}$$

where $W \equiv \left(w^{best}\right)^{\frac{\alpha}{1-\alpha}} + \left(w^{worst}\right)^{\frac{\alpha}{1-\alpha}}$. It also implies that $w^{best} > w^{worst}$, as $n^{best} > n^{worst}$ when countries start to trade.[14] Furthermore, given that wages are constant in the steady state, the rate of growth of varieties in each country must be equal, that is, $\gamma^{best} = \gamma^{worst}$.

The NAC in equation (51) must hold for both countries in equilibrium, which, combined with the results above, yield:

$$s^{best} = \frac{\Psi^{best}\left(w^{best}\right)^{\frac{1}{1-\alpha}}}{V}, \tag{56}$$

where $V \equiv \Psi^{best}\left(w^{best}\right)^{\frac{1}{1-\alpha}} + \Psi^{worst}\left(w^{worst}\right)^{\frac{1}{1-\alpha}}$.

Substituting equations (55) and (56) back into the NAC, we get that:

$$\gamma = \frac{hW}{V} - \rho. \tag{57}$$

We now substitute equations (55), (56) and (57) into the LMC for each country in equation (38), using the fact that $s_z^{best} = 0$, as $w^{best} > w^{worst}$. We get two functions that implicitly define w^{best} and w^{worst} in equilibrium:

$$\begin{aligned} \left(w^{best}\right)^{\frac{\alpha}{1-\alpha}}\left(\frac{h + \alpha\sigma\Psi^{best}}{V} - \frac{\rho}{W}\right) &= L, \text{ and} \\ \left(w^{worst}\right)^{\frac{\alpha}{1-\alpha}}\left(\frac{h + \alpha\sigma\Psi^{worst}}{V} - \frac{\rho}{W}\right) + \frac{1-\sigma}{w^{worst}} &= L. \end{aligned}$$

[13] It is true that the inventions in the country that does not produce the high-tech good would increase the world stock of knowledge, thereby lowering the cost of new inventions also in the other country. This positive externality, however, has no market value.

[14] One could wonder whether there could be an equilibrium path in which the worse country innovates faster when trade begins, so that eventually $n^w > n^b$, and a steady state could be reached with such configuration. This cannot happen, though, because there would be a moment when $n^w = n^b$. At that moment $p_y^w = p_y^b$ would imply $w^w = w^b$, and the FEC could not be satisfied simultaneously for both countries, as shown in the proof for proposition 4.

Note that this result is different from the case with no international knowledge spillovers, and the reason for it is the following. When there is no knowledge spillovers, the country with a lower stock of varieties of the intermediate goods has a lower productivity in R&D, whereas the productivity is the same in the case of knowledge spillovers. Hence, with the spillover of knowledge, when both countries increase their varieties stock at an equal rate, the one with a lower stock will dedicate less labor to this activity.

The Best Country always Innovates The existence of knowledge spillovers does not change the result that if only one country innovates, it will be the one with the greater number of blueprints when international trade starts, which is the country with best credit markets.

The FPE or the non-FPE allocations which arise as steady-state equilibria are the same of the ones which arise when there are no knowledge spillovers and no trade of intermediate goods, presented in section 3.1.1.

3.2.2 Equilibrium With Intermediate Goods Trade

Both Countries Innovate

Proposition 8 *When there are international knowledge spillovers, there is a set of values for the parameters of the economies such that there is a non-FPE equilibrium where both countries innovate under free trade of final and intermediate goods.*

Proof. In the appendix. ■

Log-differentiating the definition of the market share s^i in equation (32), we get:

$$\dot{s}_x^{best} = s_x^{best}\left(1 - s_x^b\right)\left[\left(\gamma^{best} - \gamma^{worst}\right) - \frac{\alpha}{1-\alpha}\left(\frac{\dot{w}^{best}}{w^{best}} - \frac{\dot{w}^{worst}}{w^{worst}}\right)\right].$$

It is then clear that $\gamma^{best} = \gamma^{worst}$ in the steady-state with $s_x^{best} \in (0,1)$. Substituting this result in the NAC for each country (equation (51)), and using the definition of the market share of intermediate goods in equation (32), we get that:

$$\frac{w^{worst}}{w^{best}} = \left(\frac{\Psi^{best}}{\Psi^{worst}}\right)^{1-\alpha}, \text{ and} \tag{58}$$

$$s_x^{best} = \frac{s_n^{best}\left(\Psi^{best}\right)^{\alpha}}{s_n^{best}\left(\Psi^{best}\right)^{\alpha} + \left(1 - s_n^{best}\right)\left(\Psi^{worst}\right)^{\alpha}}. \tag{59}$$

With equations (58) and (59), and the LMCs for both countries, in equation (52), we obtain the equilibrium values for the model variables. This equilibrium is only possible for the blueprint shares implicitly defined by:

$$A\rho\left(\bar{s}_n^{best}\right)^2 + B\bar{s}_n^{best} + LC^w = 0,$$

where:

$$
\begin{aligned}
A &= (1-\sigma)\left(\Psi^{worst}\right)^{1-\alpha}\left[\left(\Psi^{best}\right)^{\alpha}-\left(\Psi^{worst}\right)^{\alpha}\right]+\alpha\sigma\left(\Psi^{best}-\Psi^{worst}\right) \\
B &= L\left\{(1-\sigma)\left(\Psi^{worst}\right)^{1-\alpha}\left[\left(\Psi^{best}\right)^{\alpha}-\left(\Psi^{worst}\right)^{\alpha}\right]-\alpha\sigma\left(\Psi^{best}+\Psi^{worst}\right)-2h\right\}+ \\
& +\rho C^{w}+h+\alpha\sigma\Psi^{best} \\
C^{w} &= \left[h+(1-h)\,\Psi^{worst}\right]
\end{aligned}
$$

The Best Country always Innovates

Proposition 9 *When there are international knowledge spillovers, the best country innovates in any equilibrium with innovation, under free trade of final and intermediate goods. If the best country is the only one to innovate, both economies tend to the equilibrium of the case without international knowledge spillovers when there is no trade of intermediate goods.*

Proof. In the appendix. ■

The equilibria allocation in this setup are equal to those that arise when there are no knowledge spillovers and without trade of intermediate goods, presented in section 3.1.1. Their existence are subject to the same feasibility conditions (41a) and (41b), for FPE equilibrium, and conditions (43a) and (43b), for the no-FPE equilibrium.

3.3 International Knowledge Spillover and Multinational Corporations

Here, we relax the assumption that invention and manufacturing of an intermediate good variety must be located in the same country. The rationale is that the benefits of having innovation and manufacturing facilities together can be less profitable than the benefits of exploring comparative advantage of countries.

Now the variables p^i, x^i, π^i denote no longer price, demand and profits of intermediate good varieties produced in country i, but invented in this country. In previous sections one could use the both interpretations interchangeably, since production and invention of a variety were located in the same place, but now the whole production of intermediate goods is located wherever the wage is lower no matter where these goods were invented. These variables are given by:

$$
\begin{aligned}
p^{i} &= \frac{1}{\alpha}\min\left\{w^{best},w^{worst}\right\}, && (60)\\
x^{i} &= \frac{s_n^{i}\alpha\sigma}{\min\left\{w^{best},w^{worst}\right\}}, && (61)\\
\pi^{i} &= s_n^{i}h, && (62)
\end{aligned}
$$

under the assumption that final good prices are normalized so as $E^{best}+E^{worst}=1$.

The FEC is the same as in the case withouth multinational corporations, given by expression (47). With the same procedure we used to get the NAC in equation (51),we get the NAC for the case with multinationals:

$$\frac{\dot{w}^i}{w^i} = \sum_{k=best,worst} s_n^k \gamma^k + \rho - \frac{h}{w^i \Psi^i}. \tag{63}$$

As now the production of intermediate and traditional goods is located wherever the wage is lower, we have that $s^i = s_z^i$, and s_z^i is still defined by equation 27. The LMC can, thus, be written as:

$$s_n^i \gamma^i + \frac{(1-h)\, s_z^i}{\min\{w^{best}, w^{worst}\}} = L. \tag{64}$$

Finally, the steady-state equilibrium characterization remains the same as in equations (53) and (54) in the previous section.

Both Countries Innovate The system that describes the dynamics of wages and blueprint shares is composed of the FEC (47), the NAC (63), and the LMC (64), for both the best and the worst countries. From equation (49), it is clear that $\gamma^{best} = \gamma^{worst}$ in the steady state.

In this setup, there is no FPE equilibrium, as equation (63) cannot hold for both countries when $\dot{w} = 0$ and $w^{best} = w^{worst}$. In the non-FPE equilibrium, equation (63) can be satisfied simultaneously for both countries only if:

$$w^{best} \Psi^{best} = w^{worst} \Psi^{worst}.$$

Therefore, $w^{best} > w^{worst}$, and the worst country will capture all the market of final and intermediate goods. Recall that, in the previous section when intermediate goods had to be produced where invented, this country captured only the traditional good market. As the amount of labor available for innovation is now smaller and the labor supply is the same in the two cases, the share of blueprints invented in the worst country is smaller in the current equilibrium.

The equilibrium allocation is given by:

$$\bar{\gamma} = \frac{2hL - (1-h)\, \Psi^{worst} \rho}{(1-h)\, \Psi^{worst} + h} \tag{65a}$$

$$\bar{w}^{best} = \frac{(1-h)\, \Psi^{worst} + h}{\Psi^{best}\, (2L + \rho)} \tag{65b}$$

$$\bar{w}^{worst} = \frac{(1-h)\, \Psi^{worst} + h}{\Psi^{worst}\, (2L + \rho)} \tag{65c}$$

$$s_n^{best} = \frac{[(1-h)\, \Psi^{worst} + h]\, L}{2hL + (1-h)\, \Psi^{worst} \rho} \tag{65d}$$

and it is feasible if $s_n^{best} \in (0,1)$ and $\bar{\gamma} > 0$, i.e.,

$$\begin{aligned}
\frac{L}{\rho} &< \frac{(1-h)\,\Psi^{worst}}{(1-h)\,\Psi^{worst} - h} \text{ and} \\
\frac{L}{\rho} &> \frac{(1-h)\,\Psi^{worst}}{2h}.
\end{aligned}$$

This equilibrium is only possible for economies where the expenditure on high-tech good is higher than the expenditure on traditional good, and their labor endowments are not too large so as to cope with all demand for labor from R&D, but, at the same time, they are large enough to cope with all manufacturing activities.

Note that the labor endowments must not be as small as before, since the country which devotes less labor to R&D copes with all manufacturing activities, not only with the production of the traditional final good.

The Best Country Always Innovates Note the FEC in this case is the same one as in the case with international spillovers, but no multinationals, in section 3.2. Hence, here there is no equilibrium with only the worst country innovating for the same reason that there was no such equilibrium in that case.

The FPE equilibrium is given by:

$$\bar{\gamma}^{best} = \frac{2h\Psi^{best}(L+\rho) - \left(h + \Psi^{best}\right)\rho}{h + (1-h)\,\Psi^{best}} \tag{66a}$$

$$\bar{w} = \frac{h + (1-h)\,\Psi^{best}}{\Psi^{best}(2L+\rho)} > 0 \tag{66b}$$

$$\bar{s}_z^{best} = \frac{(1-h)\,\Psi^{best}\,(L+\rho) - hL}{(1-h)\,\Psi^{best}(2L+\rho)} \tag{66c}$$

and is feasible if $\bar{\gamma}^{best} > 0$ and $\bar{s}_z^{best} \in [0,1]$, i.e.:

$$\begin{aligned}
\frac{L}{\rho} &\geq \frac{(1-h)\,\Psi^{best}}{(1-h)\,\Psi^{best} - h} \text{ and} \\
\frac{L}{\rho} &> \frac{h + (1-2h)\,\Psi^{best}}{2h\Psi^{best}}.
\end{aligned}$$

On its turn, the non-FPE is given by:

$$\bar{\gamma}^{best} = L, \tag{67a}$$

$$\bar{w}^{best} = \frac{h}{\Psi^{best}(L+\rho)} > 0 \tag{67b}$$

$$\bar{w}^{worst} = \frac{1-h}{L} > 0 \tag{67c}$$

$$\bar{s}_z^{best} = 0 \tag{67d}$$

and is feasible if $\bar{w}^{best} > \bar{w}^{worst}$, i.e.:

$$\frac{L}{\rho} > \frac{(1-h)\,\Psi^{best}}{h-(1-h)\,\Psi^{best}}.$$

This non-FPE equilibrium the best country specializes in R&D ($\bar{\gamma}^{best} = L$), while the worst country produces all final goods.

4 Welfare Analysis

We compare the welfare of the two countries differing only with respect to their credit market in autarky and in free trade. The possibility of knowledge accumulation as new blueprints are invented allows for different impacts of trade opening in the short and in the long run. Hence, the welfare analysis takes into account the environment in these two time frames. As individuals have the same preferences in both countries, comparing welfare is equivalent to comparing their purchasing power. Therefore, we restrict our analysis to investigating the purchasing power of the residents of each country in each of the cases studied.

4.1 Closed economy

The purchasing power of country i's residents in autarky, G^i_{aut}, is given by their total net income, given by equation (14), divided by the price index P_{aut} in autarky:

$$G^i_a = \frac{w^i_{aut}(L - L^i_\gamma) + h}{P^i_{aut}} \tag{68a}$$

Using the definition of the price index in equation (1) and the equilibrium prices of final and intermediate goods in equations (5a), (5b) and (7), we have that the price index in autarky is:

$$P^i_{aut} = \frac{w^i_{aut}}{z\,(n^i)^{\frac{h}{\alpha}}}, \tag{69}$$

where $z \equiv (\alpha\sigma)^\sigma\,(1-\sigma)^{1-\sigma}$. It depends positively on wages and negatively on the number of varieties of the intermediate goods.

Substituting equation (69) into (68a), we have the welfare in autarky:

$$G^i_{aut} = \left[(L - L^i_\gamma) + \frac{h}{w^i_{aut}}\right] zw\left(n^i\right)^{\frac{h}{\alpha}}, \tag{70}$$

where the steady state values of L^i_γ and w^i_{aut} are in equations (23) and (22), respectively. The purchasing power is a decreasing function in investment in R&D and in wages. As, from proposition 3, these two variables are higher in the best country, the welfare of its residents will be lower than that of the worst country when the stock of knowledge is the same across countries. The

reason for this result is that residents of the best country invest a higher share of their income in R&D projects, so that, given the same stock of knowledge, they consume less than residents abroad. Nevertheless, the number of blueprints increases faster in that country, inducing also a faster decreasing price index. If initially both countries have zero blueprints, there will be a moment t^* where the lower price index compensates the higher level of investment in the country. Thereafter, the residents of the best country are better off, and the difference in welfare across countries increases continuously.

Period t^* is implicitly defined as the moment when $G_{aut}^{best} = G_{aut}^{worst}$ as in:

$$\frac{n\left(t^*\right)^{best}}{n\left(t^*\right)^{worst}} = \left[\frac{\Psi^{best}\left(1-\alpha\sigma+h\Psi^{worst}\right)}{\Psi^{worst}\left(1-\alpha\sigma+h\Psi^{best}\right)}\right]^{\frac{\alpha}{h}} \tag{71}$$

As $\frac{\partial t^*}{\partial\left(\frac{\Psi^{worst}}{\Psi^{best}}\right)} < 0$, the higher is the gap of quality in the credit markets, the shorter is the period over which the welfare of the residents of the best country is smaller than the welfare of residents abroad.

4.2 Free Trade

We assume that there is free flow of financial capital when there is international trade, hence all individuals can invest in innovation projects, no matter whether he is resident of the country where the investment project takes place or not. As all individuals have the same logarithmic preferences, all of them devote the same share of income to investment in R&D.

Let us denote $k^i(t)$ the share of the world capital (total number of blueprints) that belongs to residents of country i, and let T be the moment the countries open to trade. We have that:

$$k^i(t) = \frac{n^i\left(T\right)+\frac{w^i}{w^{best}+w^{worst}}\left[n\left(t\right)-n\left(T\right)\right]}{n\left(t\right)}, \text{ for } t \geq T \tag{72}$$

where $n = n^{best} + n^{worst}$. Notice that $k^i\left(T\right) = s_n^i\left(T\right)$. k^i represents the gross national product in the intermediate goods sector, while s_n^i represents the gross domestic product in that sector. When countries are autarkies in goods and asset markets, k^i and s_n^i must be equal.

When there is no trade of intermediate goods, we have seen that all blueprints of the worst country become useless, therefore $k^{best}\left(T\right) = 1$ and $k^{worst}\left(T\right) = 0$. Otherwise, $0 < k^{worst}\left(T\right) < k^{best}\left(T\right) < 1$. In all cases, nevertheless, those shares converge to:

$$\lim_{t\to\infty} k^i(t) = \frac{w^i}{w^{best}+w^{worst}}. \tag{73}$$

It means that, under FPE, residents of both countries share equally the profits of intermediate goods firms in the long run, whereas when non-FPE equilibrium arises residents of the best country have a higher share of profits in the long-run.

The purchasing power of the residents of country i under free trade can be rewritten as:

$$G^i_{free}(t) = \frac{w^i L - w^{best} L_\gamma + hk^i(t)}{P_{free}}, \tag{74}$$

when only the best country innovates, and as:

$$G^i_{free}(t) = \frac{w^i L - \left(\sum_{i=best,worst} s^i_n w^i \right) L_\gamma + hk^i(t)}{P_{free}} \tag{75}$$

when both countries innovate. As we have seen, an equilibrium where both countries innovate is only possible when there are spillovers of knowledge across countries and trade in intermediate goods is allowed.

In all cases studied, the worst country always supplies the traditional goods. Hence, the price index is:

$$P_{free} = \frac{\left(w^{worst}\right)^{1-\sigma} \left(P_y\right)^{\sigma}}{z}, \tag{76}$$

where:

$$P_y = \frac{(n)^{-\frac{1-\alpha}{\alpha}}}{\alpha} \left[\sum_{i=best,worst} s^i_n \left(w^i\right)^{-\frac{\alpha}{1-\alpha}} \right]^{-\frac{1-\alpha}{\alpha}}. \tag{77}$$

Without trade in intermediate goods In this case, $s^{best}_n = 1$, and equation (74), combined with (76) and (77), become:

$$G^i_{free}(t) = \left[\frac{w^i L - w^{best} L_\gamma + hk^i(t)}{\left(w^{worst}\right)^{1-\sigma} \left(w^{best}\right)^{\sigma}} \right] z \left(n^{best}\right)^{\frac{h}{\alpha}}. \tag{78}$$

At the moment T when countries open to trade, the stock of blueprints owned by the residents of the worst country become useless, and we have that $k^{best}(T) = 1$ and $k^{worst}(T) = 0$. Therefore, the purchasing power at that moment equals:

$$G^{worst}_{free}(T) = \left[\frac{w^{worst} L - w^{best} L_\gamma}{\left(w^{worst}\right)^{1-\sigma} \left(w^{best}\right)^{\sigma}} \right] z \left(n^{best}\right)^{\frac{h}{\alpha}}, \text{ and} \tag{79}$$

$$G^{best}_{free}(T) = \left[\frac{w^{best} \left(L - L_\gamma\right) + h}{\left(w^{worst}\right)^{1-\sigma} \left(w^{best}\right)^{\sigma}} \right] z \left(n^{best}\right)^{\frac{h}{\alpha}}. \tag{80}$$

In the no-FPE equilibrium, we can show that $w^{worst} < w^{best} < w^{worst}_{aut} < w^{best}_{aut}$. Clearly, the best country residents are better off than those who live in the worst country. The latter not only lost their accumulated capital (stock of blueprints), but also face lower wages that those in the best country.

Compared to their own situation in autarky, the residents of the best country are clearly better off. Although their nominal wages declined, their purchasing power increased as the decrease in the price index more than compensates their lower wages. The same may not be true for the residents of the worst country. First, they lost part of their wealth when their stock of blueprints lost its value. Second, the effect of opening to trade on the purchasing power in terms of the high tech good is uncertain. On the one hand, those goods are now produced by the best country, which has higher wages. On the other hand, that country has a larger number of varieties of the intermediate goods, which renders production more efficient and less costly. The final effect depends on the difference in the number of varieties both countries had just before starting to trade.

Under the FPE equilibria, equations (79) and (80) become:

$$\begin{aligned} G_{free}^{worst}(T) &= (L - L_\gamma) z \left(n^{best}\right)^{\frac{h}{\alpha}}, \text{ and} \\ G_{free}^{best}(T) &= \left[(L - L_\gamma) + \frac{h}{\bar{w}}\right] z \left(n^{best}\right)^{\frac{h}{\alpha}}. \end{aligned}$$

Now the only difference in the purchasing power between the two countries stems from their difference in wealth. The best country residents have an accumulated capital, which makes them richer.

Similarly to the no-FPE case, the residents of the best country are clearly better off when trade starts, and those of the worst country may be better or worse, depending on the distance between their stock of blueprints and that of the best country at moment T. Intuitively, it may be the case that the best country has so much more blueprints, that the reduction in the price of the high tech goods more than compensates the capital loss that occurs the moment trade starts.

All the analysis so far refers to the comparisons of purchasing power and, therefore, welfare in the short run. Let us now look at the long run impact of opening to trade. In the no-FPE equilibrium, we substitute equation (73) into equations (79) and (80) to get:

$$G_f^{worst}(t) = \left[\frac{w^{worst}L - w^{best}L_\gamma + \left(\frac{w^{worst}}{w^{best}+w^{worst}}\right)h}{\left(w^{worst}\right)^{1-\sigma}\left(w^{best}\right)^{\sigma}}\right] z \left(n^{best}\right)^{\frac{h}{\alpha}}, \text{ and} \quad (81)$$

$$G_f^{best}(t) = \left[\frac{w^{best}(L - L_\gamma) + \left(\frac{w^{best}}{w^{best}+w^{worst}}\right)h}{\left(w^{worst}\right)^{1-\sigma}\left(w^{best}\right)^{\sigma}}\right] z \left(n^{best}\right)^{\frac{h}{\alpha}}, \text{ as } t \to \infty \quad (82)$$

Here, again, the best country residents are clearly better off than the worst country ones. Now, however, differently from the short run, both countries' residents are better off compared to autarky. Note that the terms between brackets are constant in equations (70) and in (81) and (82). The number of varieties, however, increases faster under free trade than in the closed economies. Therefore, the distance between them tends to infinity in the long run.

With trade in intermediate goods, but no international knowledge spillovers We have seen that in this case in all possible equilibria only the best country innovates. Furthermore, in the long run, the equilibria tend to those of the previous case, that is, without trade in intermediate goods. Therefore, the welfare analysis in the long run is equal to the one above.

In the short run, the worst country retains a share of the production of intermediate goods. The purchasing power of each country is obtained by substituting equations (72), (76) and (77) into equation (75). With trade in intermediate goods, the worst country continues producing the varieties it had invented up to the moment of opening to trade. The total number of varieties of intermediate goods used in the production of the high-tech good production is larger than when there is no trade in intermediate goods. This increases productivity, lowering the price of the high-tech good. Welfare should, then, be higher when there is trade in intermediate goods than when there is not such trade. The impact is even larger for the residents of the worst country, because now they do not incur in a capital loss when trade starts.

With trade in intermediate goods and international knowledge spillovers, but no multinational corporations We have seen that the equilibria in the previous case is also possible when there is international knowledge spillovers. In those equilibria, the same analysis from the previous session applies. However, now there is the possibility of an equilibrium where both countries innovate, and in that equilibrium there is no FPE.

The inequality of welfare between residents is strictly increasing in the wage gap, so comparison of wage gaps in both no-FPE equilibria,

$$\left(\frac{\bar{w}^{best}}{\bar{w}^{worst}}\right) = \left\{ \begin{array}{ll} \frac{L}{L+\rho}\frac{\sigma}{1-\sigma}\frac{\left[1+\alpha\left(\Psi^{best}-1\right)\right]}{\Psi^{best}} & \text{where only best country innovates} \\ \left(\frac{\Psi^{worst}}{\Psi^{best}}\right)^{1-\alpha} & \text{where both countries innovate;} \end{array} \right\},$$

shows that residents of the worst country would rather be in equilibrium where both countries innovate if the difference of the quality of credit markets in both countries is small enough to make:

$$\left(\frac{\Psi^{worst}}{\Psi^{best}}\right)^{1-\alpha} < \left(\frac{L}{L+\rho}\right)\left(\frac{\sigma}{1-\sigma}\right)\left(\frac{1+\alpha\left(\Psi^{best}-1\right)}{\Psi^{best}}\right).$$

Otherwise, they would rather be in the equilibrium where only the best country innovates.

With trade in intermediate goods, international knowledge spillovers, and multinational corporations As the previous analysis, all residents are better under free trade in the long run than if they were under autarky because the innovation rate is larger.

Now, we compare welfare distribution between residents under the presence and the absence of multinational corporations. When both countries innovate

the wage gap is given by

$$\left(\frac{\bar{w}^{best}}{\bar{w}^{worst}}\right) = \left\{ \begin{array}{l} \left(\frac{\Psi^{worst}}{\Psi^{best}}\right)^{1-\alpha} \text{ when multinationals are absent;} \\ \frac{\Psi^{worst}}{\Psi^{best}} \text{ when multinationals are present;} \end{array} \right\},$$

so, residents of the worst country is better when multinational corporations do not exist. However, they are better under the presence of multinationals when only the best country innovates because the wage gap is unambiguously smaller under those corporations:

$$\left(\frac{\bar{w}^{best}}{\bar{w}^{worst}}\right) = \left\{ \begin{array}{l} \frac{L}{L+\rho}\frac{\sigma}{1-\sigma}\frac{\left[1+\alpha\left(\Psi^{best}-1\right)\right]}{\Psi^{best}} \text{ when multinationals are absent;} \\ \frac{L}{L+\rho}\frac{(1-\alpha)\sigma}{1-(1-\alpha)\sigma}\frac{1}{\Psi^{best}} \text{ when multinationals are present;} \end{array} \right\}.$$

4.3 When does the free trade benefit all residents?

So far, the welfare analysis has focused on comparisons between residents: 1) under autarky and free trade frames and 2) under equilibria where both countries innovate or only one does. Now, the choice of opening to trade is evaluated as the difference of the present values of being under free trade and under autarky:

$$PV_{eq}^{open,i}(t) = \int_t^\infty e^{-\rho(\tau-t)} \left[G(\tau)_{eq}^i - G(\tau)_{aut}^i\right] d\tau,$$

where eq denotes the equilibrium which arises under free trade given the economic parameters. If the instantaneous rate of growth of $G(\tau)_{eq}^i - G(\tau)_{aut}^i$, which is $\frac{(1-\alpha)\sigma}{\alpha}\left(\bar{\gamma}_{eq} - \bar{\gamma}_{aut}^i\right)$, is greater or equal to the discount rate ρ, then the resident of country i is better if his country opens to trade.

As was shown, no-FPE equilibria which arise when multinationals exist are those in which the world experiences the highest rates of innovation because the best country is free to devote all of its labor resources to R&D. Thus, the presence of multinationals and knowledge spillovers between countries is the setup which dominates all other economic environments in terms of welfare for all residents. In fact, $PV_{eq}^{open,i}(t) > 0$ is more likely to happen in that setup than in others.

5 Concluding Remarks

New ideas pop up at every moment and every place, but it is hard to be accurate about the estimation of *ex-ante* chances of success. Indeed, in many cases, it seems a fortune-teller task. The risk of these projects becomes more dramatic when almost all of their assets are intangible, what is a widespread situation. In the case of failure, the liquidation value is negligible. R&D projects are perfect examples of investments that ask for diversification as a form of risk sharing among economic agents. Thus, when countries engage in technological

competition, financing becomes the main instrument for creating comparative advantage over time.

The model proposed in this article makes the innovation activity the arena where countries compete. Faster innovation in a country renders its high-tech sector more productive than abroad, and moves the economic resources away from the traditional good sector to R&D activity.

When world experiences innovation, in most of the cases innovation is produced by firms located in the country with the best credit market. In all cases, the country with the worst credit market cannot devote the same amount of labor to R&D activity because it has to deal with the whole (or the greater part of) demand for traditional goods. It makes its share of innovating blueprints smaller or null.

In the long run, when FPE (factor price equalization) equilibrium arises, residents of both countries share equally the world capital, whereas when there is no FPE, residents of the country with the best credit market own a higher share. In the long run, all residents are wealthier under free trade than if they were under autarky due to the higher rate of deflation under free trade. However, a decision about open or not open to trade depends on the present value of wealth under both situations. Calculations show that opening to trade is more likely to be worth for all individuals when multinational corporations exist and economies are not too small.

Wealth inequality between residents is strictly increasing in the wage gap, so, under free trade, there is no inequality when FPE equilibria arise. Among all non-FPE equilibria, the largest inequality happens when there are no knowledge spillovers between countries and when there are no multinational corporations, whereas the least inequality arises when these both features exist.

We conclude that, apart from issues related to endowments and exogenous technological differences, institutions, represented in this paper by the credit markets, existence of multinationals corporations and knowledge spillovers, may be an important source of a comparative advantage that is built over the time.

The next steps of this research agenda point to investigating balance sheet effects on firms financing, including the obsolescence of past innovations on production, and changing the accumulation technology of the knowledge stock in order to support increasing or decreasing returns.

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6 Appendix

6.1 Proof of proposition 4

When both countries innovate, the FEC (36) imply:

$$\Psi^{worst} = \frac{v^{worst} n^{worst}}{\bar{w}^{worst}} > \frac{v^{best} n^{best}}{\bar{w}^{best}} = \Psi^{best}. \tag{83}$$

As there is no trade in intermediate goods, both countries would have to produce the high-tech good, and its price would have to be equal in both countries, which, given equations (29b) and (33), implies:

$$\frac{\bar{w}^{best}}{(n^{best})^{\left(\frac{1-\alpha}{\alpha}\right)}} = \frac{\bar{w}^{worst}}{(n^{worst})^{\left(\frac{1-\alpha}{\alpha}\right)}}. \tag{84}$$

We start by investigating the possibility of a FPE equilibrium, that is, $\bar{w}^{best} = \bar{w}^{worst}$. In that case, condition (84) implies $n^{best} = n^{worst}$. With

equal wages and number of blueprints invented across countries, we would have that $\pi^{best} = \pi^{worst}$, which would yield $v^{best} = v^{worst}$.[15] Hence, we would have:

$$\frac{v^{worst} n^{worst}}{\bar{w}^{worst}} = \frac{v^{best} n^{best}}{\bar{w}^{best}},$$

which contradicts the relation (83).

Let us now investigate the possibility of equilibrium with $\bar{w}^{best} \neq \bar{w}^{worst}$. For the price of the high-tech goods to be equal across countries, it would be necessary that $\bar{w}^{best} > \bar{w}^{worst}$, given that $n^{best} > n^{worst}$ when the countries start to trade and equation (84). Furthermore, as $\dot{w}^{best} = \dot{w}^{worst} = 0$ in equilibrium, it must also be the case that $\frac{n^{best}}{n^{worst}}$ remains constant so that equation (84) is always satisfied. Hence, $\bar{\gamma}^{best} = \bar{\gamma}^{worst} > 0$. Using this result, we calculate the high-tech good market shares equalizing the no-arbitrage condition (expression 37) of both countries, and we get that:

$$\bar{s}_y^{best} = \frac{\bar{w}^{best} \Psi^{best}}{\bar{w}^{best} \Psi^{best} + \bar{w}^{worst} \Psi^{worst}}; \text{ and} \tag{85}$$

$$\bar{s}_y^{worst} = \frac{\bar{w}^{worst} \Psi^{worst}}{\bar{w}^{best} \Psi^{best} + \bar{w}^{worst} \Psi^{worst}}. \tag{86}$$

We substitute the high-tech good market-shares (equations 85 and 86) in the labor market clearing conditions of both countries (equation 38) and equalize them. We get:

$$\frac{\Psi^{best}}{\bar{w}^{best} \Psi^{best} + \bar{w}^{worst} \Psi^{worst}} \alpha\sigma = \frac{\Psi^{worst}}{\bar{w}^{best} \Psi^{best} + \bar{w}^{worst} \Psi^{worst}} \alpha\sigma + \frac{(1-\sigma)}{\bar{w}^{worst}}.$$

The above expression holds only if $\Psi^{best} > \Psi^{worst}$, which is a contradiction. Thus, there is no non-FPE equilibrium.

6.2 Proof of proposition 6

When both countries innovate simultaneously, equation (83) must be satisfied. With trade in intermediate goods, we have that $\frac{\partial v^i}{\partial w^i} < 0$, given the definition of v^i in equation (10), the profit function (35) and the definition of the market share s^i in (32). Particularly, under FPE, $v^{best} = v^{worst}$. When countries start to trade $n^{best} > n^{worst}$, hence $\frac{vn^{best}}{w} > \frac{vn^{worst}}{w}$, and equation (83) is not satisfied. Note that it is also true that $\frac{v^{best} n^{best}}{w^{best}} > \frac{v^{worst} n^{worst}}{w^{worst}}$ when $w^{best} < w^{worst}$.

Finally, we show that there is also no equilibrium with $w^{best} > w^{worst}$ and innovation in both countries. Log-differentiating the definition of the market share s^i in equation (32), we get:

$$\dot{s}_x^{best} = s_x^{best} \left(1 - s_x^b\right) \left[\left(\gamma^{best} - \gamma^{worst}\right) - \frac{\alpha}{1-\alpha} \left(\frac{\dot{w}^{best}}{w^{best}} - \frac{\dot{w}^{worst}}{w^{worst}} \right) \right]. \tag{87}$$

[15] Recall that v, defined in equation (10), is the present value of the stream of profits resulted from the sales of an intermediate good variety.

From equation (87), it is clear that $\gamma^{best} = \gamma^{worst}$ in the steady-state with $s_x^{best} \in (0,1)$.

From the NAC for both countries in equation (37), we have, then, that:

$$s_x^{best} = \frac{w^{best}\Psi^{best}}{w^{best}\Psi^{best} + w^{worst}\Psi^{worst}}.$$

Using this result in the LMC (38), and given that $s_z^{best} = 0$ as $w^{best} > w^{worst}$, we get:

$$\frac{\Psi^{best}\alpha\sigma}{w^{best}\Psi^{best} + w^{worst}\Psi^{worst}} = \frac{\Psi^{worst}\alpha\sigma}{w^{best}\Psi^{best} + w^{worst}\Psi^{worst}} + \frac{1-\sigma}{w^{worst}}.$$

The above expression holds only if $\Psi^{best} > \Psi^{worst}$, which is a contradiction. Thus, there is no non-FPE equilibrium.

6.3 Proof of proposition 7

First, we show that the best country will be the innovating one, both under FPE and in the equilibrium with no FPE.

In the equilibrium with FPE, substituting equation (32) into the profits of the firm producing intermediate goods, equation (35), we see that the profits are the same no matter the country where the firm is located, that is, $v^{best} = v^{worst} \equiv v$. Hence, the value of such firms, in equation (10), is also independent of its location. Therefore, given that $n^{best} > n^{worst}$ at the moment countries start to trade, we have that:

$$\frac{vn^{best}}{w} > \frac{vn^{worst}}{w}.$$

Given this inequality, the FEC (36) can only be satisfied simultaneously for both countries if it is the best one that innovates.

If there is no FPE, it must be the case that the non-innovating country has the lower wage to capture the market for the traditional good. In this case profits in intermediate goods production are a decreasing function of wages, as can be seen by substituting equation (46) into the profits equation (35). Let us assume that the worst country is the innovating one. We would have that $w^{worst} > w^{best}$, hence $\pi^{worst} < \pi^{best}$, yielding $v^{worst} < v^{best}$. As $n^{worst} < n^{best}$ when the economies open to trade, we would then have that:

$$\frac{v^{best}n^{best}}{w^{best}} > \frac{v^{worst}n^{worst}}{w^{worst}}$$

The FEC (36) for the innovating (worst) country would imply:

$$\frac{v^{worst}n^{worst}}{w^{worst}} = \Psi^{worst},$$

which, combined with the previous inequality, yields:

$$\frac{v^{best} n^{best}}{w^{best}} > \Psi^{worst} > \Psi^{best}, \tag{89}$$

where the last inequality is an assumption of the model. According to inequality (89), the FEC is not satisfied for the best country. Hence, there is no equilibrium where the worst country is the one that innovates.

Now we show that both countries tend to the equilibrium of the case without international trade in intermediate goods. Under FPE, from equation (32) we have that:

$$s_x^{best} = \frac{n^{best}}{n^{best} + n^{worst}}, \tag{90}$$

and from the LMC for the innovating (best) and non-innovating (worst) countries, in equations (38), (44), respectively, we get:

$$w = \frac{1-h}{2L-\gamma}, \tag{91a}$$

$$s_z^{worst} = \frac{wL - s_x^{best} \alpha\sigma}{1-\sigma}, \tag{91b}$$

Equation (91a) yields:

$$\frac{\dot{w}}{w} = \frac{\dot{\gamma}}{2L-\gamma}, \tag{92}$$

which, combined with the NAC in equation (37), implies:

$$\dot{\gamma} = \left[\frac{\gamma+\rho}{2L-\gamma} - \frac{h s_x^{best}}{(1-h)\,\Psi^{best}}\right](2L-\gamma)^2 . \tag{93}$$

When $s_x^{best} = 1$, from equation (93) we have that:

$$\dot{\gamma} = \left[\frac{\Psi^{best}\gamma(1-h) - 2hL + \gamma\left[\Psi^{best}(1-h) + h\right]}{\Psi^{best}(1-h)}\right](2L-\gamma).$$

Substituting the value for γ in equilibrium from equation (40a) into the equation above, we get that $\dot{\gamma} = 0$. From equation (92) we also have that $\dot{w} = 0$, and the economy is steady state, under the same equilibrium values as in the system of equations (40).

When there is no FPE, it must be the case that the worst country, which is the non-innovating one, captures all the market for the traditional good, that is, $s_z^{worst} = 1$. Otherwise, its demand for labor would tend to zero as its share of the intermediate good market tends to zero. Substituting this in the LMC for both countries, in equations (38), (44), we have that:

$$w^{best} = \frac{s_x^{best}\alpha\sigma}{L-\gamma}, \text{ and} \tag{94}$$

$$w^{worst} = \frac{\left(1 - s_x^{best}\right)\alpha\sigma + 1 - \sigma}{L}. \tag{95}$$

Differentiating equation (94), we get:

$$\frac{\dot{w}^{best}}{w^{best}} = \frac{(L-\gamma)\,\dot{s}_x^{best} + s_x^{best}\dot{\gamma}}{s_x^{best}\,(L-\gamma)}, \tag{96}$$

which, combined with the NAC in equation (37), yields:

$$\frac{\dot{\gamma}}{(L-\gamma)} = \gamma + \rho - \frac{(L-\gamma)\,h}{\alpha\sigma\Psi^{best}} - \frac{\dot{s}_x^{best}}{s_x^{best}}. \tag{97}$$

As $t \to \infty$, and $\frac{\dot{s}_x^{best}}{s_x^{best}} \to 0$, equation (97) can be written as:

$$\frac{\dot{\gamma}}{(L-\gamma)} = \rho - \frac{hL}{\alpha\sigma\Psi^{best}} + \gamma\left(\frac{h + \alpha\sigma\Psi^{best}}{\alpha\sigma\Psi^{best}}\right).$$

Substituting the value for γ in equilibrium from equation (42a) into the equation above, we get that $\dot{\gamma} = 0$.From equation (96) we also have that $\dot{w}^{best} = 0$, and the economy is steady state, under the same equilibrium values as in the system of equations (42).

6.4 Proof of proposition 8

Suppose that this steady-state exists, so $\bar{\gamma} \equiv \bar{\gamma}^{best} = \bar{\gamma}^{worst}$. The FEC for both countries imply:

$$\Psi^{worst} = \frac{v^{worst}n}{\bar{w}^{worst}} > \frac{v^{best}n}{\bar{w}^{best}} = \Psi^{best}. \tag{98}$$

Substituting the definition of s_x^i (equation 32) in the profit function (equation 35), we get:

$$\pi^i = \frac{h\left(w^i\right)^{-\frac{\alpha}{1-\alpha}}}{n^{best}\left(w^{best}\right)^{-\frac{\alpha}{1-\alpha}} + n^{worst}\left(w^{worst}\right)^{-\frac{\alpha}{1-\alpha}}},\ i = best, worst. \tag{99}$$

Note that $\bar{w}^{best} = \bar{w}^{worst} \Rightarrow \pi^{best} = \pi^{worst}$. From equation (10), it also means that $v^{best} = v^{worst}$. Hence, equation (98) cannot be satisfied under FPE.

Now, let us consider the case where $\bar{w}^{best} \neq \bar{w}^{worst}$. From equation (99), we have that $\frac{\partial \pi^i}{\partial w^i} < 0$, which implies $\frac{\partial v^i}{\partial w^i} < 0$. Hence, equation (98) can only be satisfied with $\bar{w}^{best} < \bar{w}^{worst}$. This relation, on its turn, implies that $\bar{s}_z^{best} = 0$. The equations (51) and (52) for each country define the equilibrium values for

γ, w^{best}, w^{worst},and s_n^{best}:

$$\bar{\gamma}+\rho = \frac{\bar{s}_x^{best}}{\bar{s}_n^{best}}\frac{h}{\bar{w}^{best}\Psi^{best}} \tag{100a}$$

$$\bar{\gamma}+\rho = \frac{(1-\bar{s}_x^{best})}{(1-\bar{s}_n^{best})}\frac{h}{\bar{w}^{worst}\Psi^{worst}} \tag{100b}$$

$$L = \bar{s}_n^{best}\bar{\gamma}+\frac{\bar{s}_x^{best}\alpha\sigma}{\bar{w}^{best}} \tag{100c}$$

$$L = (1-\bar{s}_n^{best})\bar{\gamma}+\frac{(1-\bar{s}_x^{best})\alpha\sigma}{\bar{w}^{worst}}+\frac{(1-\sigma)}{\bar{w}^{worst}} \tag{100d}$$

From equations (100a) and (100b) we have that:

$$\bar{s}_x^{best} = \frac{\bar{s}_n^{best}\bar{w}^{best}\Psi^{best}}{\bar{s}_n^{best}\bar{w}^{best}\Psi^{best}+(1-\bar{s}_n^{best})\bar{w}^{worst}\Psi^{worst}} \tag{101}$$

Using the definition of market share in equation (32) and that of s_n^i, we have that the wage gap across countries is:

$$\frac{\bar{w}^{best}}{\bar{w}^{worst}} = \left(\frac{\Psi^{worst}}{\Psi^{best}}\right)^{1-\alpha} > 1. \tag{102}$$

Substituting this relation into equation (101), we get the relation between the market share of intermediate goods and the share of inventions:

$$\bar{s}_x^{best} = \frac{\bar{s}_n^{best}\left(\Psi^{best}\right)^{\alpha}}{\bar{s}_n^{best}\left(\Psi^{best}\right)^{\alpha}+\left(1-\bar{s}_n^{best}\right)\left(\Psi^{worst}\right)^{\alpha}} \tag{103}$$

Substituting $\bar{\gamma}$ from equations (100a) and (100b) into equations (100c) and (100d), respectively, we get:

$$L = \frac{\bar{s}_x^{best}h}{\bar{w}^{best}\Psi^{best}}-\bar{s}_n^{best}\rho+\frac{\bar{s}_x^{best}\alpha\sigma}{\bar{w}^{best}}, \text{ and} \tag{104}$$

$$L = \frac{\left(1-\bar{s}_x^{best}\right)h}{\bar{w}^{worst}\Psi^{worst}}-\left(1-\bar{s}_n^{best}\right)\rho+\frac{\left(1-\bar{s}_x^{best}\right)\alpha\sigma}{\bar{w}^{best}}+\frac{(1-\sigma)}{\bar{w}^{worst}}. \tag{105}$$

Using equations (102), (103), (104) and (105), we get an equation that implicitly defines $\bar{s}_n^{best}$:

$$A\rho\left(\bar{s}_n^{best}\right)^2+B\bar{s}_n^{best}+LC^w=0,$$

where:

$$\begin{aligned}
A &= (1-\sigma)\left(\Psi^{worst}\right)^{1-\alpha}\left[\left(\Psi^{best}\right)^{\alpha}-\left(\Psi^{worst}\right)^{\alpha}\right]+\alpha\sigma\left(\Psi^{best}-\Psi^{worst}\right) \\
B &= L\left\{(1-\sigma)\left(\Psi^{worst}\right)^{1-\alpha}\left[\left(\Psi^{best}\right)^{\alpha}-\left(\Psi^{worst}\right)^{\alpha}\right]-\alpha\sigma\left(\Psi^{best}+\Psi^{worst}\right)-2h\right\}+ \\
&\quad +\rho C+h+\alpha\sigma\Psi^{best} \\
C &= \left[h+(1-h)\Psi^{worst}\right]
\end{aligned}$$

6.5 Proof of proposition 9

First, we show that the worst country cannot be the only one to innovate in equilibrium. Assume it is in order to obtain a contradiction. From the proof of proposition 8, we know that $\frac{\partial v^i}{\partial w^i} < 0$. Hence, if $w^{worst} \geq w^{best}$, the FEC in equation (47) would imply:

$$\Psi^{worst} = \frac{v^{worst}n}{w^{worst}} \leq \frac{v^{best}n}{w^{best}},$$

given that the FEC is satisfied with equality for the worst country. As $\Psi^{worst} > \Psi^{best}$, we would have that $\frac{v^{best}n}{w^{best}} > \Psi^{best}$, and the FEC would not be satisfied for the best country.

If $w^{worst} < w^{best}$, then $s_z^{best} = 0$ and the LMC (equation (52)) for the best and the worst countries would be:

$$L = \frac{s_x^{best}}{w^{best}}\alpha\sigma, \tag{106a}$$

$$L = (1 - s_n^{best})\gamma^{worst} + \frac{(1 - s_x^{best})}{w^{worst}}\alpha\sigma + \frac{(1-\sigma)}{w^{worst}}, \tag{106b}$$

respectively. As only the worst country innovates, s_x^{best} and s_n^{best} tend to zero. Also given that $w^{worst} < w^{best}$, there would be a moment where:

$$\frac{s_x^{best}}{w^{best}} < \frac{(1 - s_x^{best})}{w^{worst}},$$

and, consequently, equations (106a) and (106b) could hold simultaneously. Therefore, there is no equilibrium with only the worst country innovating.

Now we investigate the equilibria where the best country innovates. In proposition 8 we have already seen that there is an equilibrium with both countries innovating. Here we study the equilibria with only the best country innovating.

We start with the non-FPE equilibrium. Using an analogous argument to the one used above to show that there is no equilibrium with $w^{worst} < w^{best}$ and with only the worst country innovating, it is straightforward to show that there is also no equilibrium with $w^{best} < w^{worst}$ and where only the best country innovates.

There is an equilibrium with $w^{best} > w^{worst}$ and with only the best country innovating. The FEC in equation (47) for the best country become:

$$\Psi^{best} = \frac{v^{best}n}{w^{best}} < \frac{v^{worst}n}{w^{worst}},$$

where the inequality is due to the fact that $\frac{\partial v^i}{\partial w^i} < 0$, and it is compatible with the FEC for the worst country, as $\Psi^{worst} > \Psi^{best}$ by assumption.

The NAC (equation (51)) for the best country becomes:

$$\frac{\dot{w}^{best}}{w^{best}} = s_n^{best}\gamma^{best} + \rho - \frac{s^{best}h}{s_n^{best}w^{best}\Psi^{best}}, \tag{107}$$

while the LMC for each countries are:

$$L = s_n^{best}\gamma^{worst} + \frac{s_x^{best}}{w^{best}}\alpha\sigma, \text{ and} \tag{108}$$

$$L = \frac{(1-s_x^{best})}{w^{worst}}\alpha\sigma + \frac{(1-\sigma)}{w^{worst}}. \tag{109}$$

From equation (109), we have that:

$$w^{worst} = \frac{1-\sigma+\left(1-s_x^{best}\right)\alpha\sigma}{L}. \tag{110}$$

Combining equations (107) and (108), we get:

$$w^{best} = \frac{h + s_n^{best}\alpha\sigma\Psi^{best}}{s_n^{best}\left(L+\rho-\frac{\dot{w}^{best}}{w^{best}}\right)\Psi^{best}}, \tag{111}$$

which, substituted back into equation (107), yields:

$$\begin{aligned} s_n^{best}\gamma^{best} = & \frac{s_x^{best}hL + \left(s_x^{best}-1\right)\rho - s_n^{best}\alpha\sigma\rho\Psi^{best}}{h+s_n^{best}\alpha\sigma\Psi^{best}} + \\ & + \frac{\dot{w}^{best}}{w^{best}}\left(\frac{h+s_n^{best}\alpha\sigma\Psi^{best}-s_x^{best}}{h+s_n^{best}\alpha\sigma\Psi^{best}}\right) \end{aligned} \tag{112}$$

Let us now derive the system which represents the dynamics of the world economy. Combining equations (108), (109), and (32), we get:

$$\dot{w}^{best} = (L+\rho)\,w^{best} - \frac{\left(w^{best}\right)^{-\frac{\alpha}{1-\alpha}}\left[1+\alpha(s_n^{best}\Psi^{best}-1)\right]\sigma}{\left[s_n^{best}\left(w^{best}\right)^{-\frac{\alpha}{1-\alpha}} + \left(1-s_n^{best}\right)\left(w^{worst}\right)^{-\frac{\alpha}{1-\alpha}}\right]\Psi^{best}} \tag{113}$$

The differentiation of s_n^{best} combined to equation (108) yields:

$$\dot{s}_n^{best} = (1-s_n^{best})\left[L - \frac{s_n^{best}\left(w^{best}\right)^{-\frac{1}{1-\alpha}}}{s_n^{best}\left(w^{best}\right)^{-\frac{\alpha}{1-\alpha}} + \left(1-s_n^{best}\right)\left(w^{worst}\right)^{-\frac{\alpha}{1-\alpha}}}\alpha\sigma\right] \tag{114}$$

Equations (113), (114), (108) and (109) determine the equilibrium dynamics of the world economy. Solving that system, equilibrium arises when $s_n^{best} = s_x^{best} = 1$. Equations (110), (111) and (112) tend to equilibrium values in equations (42), which is the allocation of the non-FPE equilibrium with no international knowledge spillovers and no trade of intermediate goods. The feasibility conditions for this equilibrium is the same as the ones in equations (43a) and (43b).

We now consider the FPE equilibrium. Given the profit equation (99), we have that profits are equal across countries when $w^{best} = w^{worst} \equiv w$, hence

$v^{best} = v^{worst}$. Combining this information with the FEC for the best country and the fact that $\Psi^{best} < \Psi^{worst}$, we get that:

$$\frac{v^{worst} n}{w} = \frac{v^{best} n}{w} = \Psi^{best} < \Psi^{worst}.$$

The FEC is then also satisfied for the worst country, with $\gamma^{worst} = 0$. Under FPE $s_x^i = s_n^i$, for $i = best, worst$, then the LMC (equation (52)) for the best and worst countries are, respectively:

$$L = s_n^{best} \gamma^{best} + \frac{s_n^{best}}{w} \alpha\sigma + s_z^{best} \frac{(1-\sigma)}{w}, \text{ and} \tag{115a}$$

$$L = \frac{(1 - s_n^{best})}{w} \alpha\sigma + (1 - s_z^{best}) \frac{(1-\sigma)}{w}. \tag{115b}$$

Adding up equations (115a) and (115b), we get:

$$s_n^{best} \gamma^{best} = 2L - \frac{(1-h)}{w}. \tag{116}$$

The wages is obtained by substituting the equation above in the NAC (51):

$$w = \frac{h + (1-h)\,\Psi^{best}}{\Psi^{best} \left(2L + \rho - \frac{\dot{w}}{w}\right)}, \tag{117}$$

which, substituted back into equation (116), yields the innovation rate:

$$s_n^{best} \gamma^{best} = \frac{2Lh - (1-h)\left(\rho - \frac{\dot{w}}{w}\right) \Psi^{best}}{h + (1-h)\,\Psi^{best}}. \tag{118}$$

Finally, substituting equation (117) into (115b), we get the best country share of the traditional good market:

$$\begin{aligned} s_z^{best} = & \frac{\Psi^{best} (1-\sigma) \left(L + \rho - \frac{\dot{w}}{w}\right) - L \left(\alpha\sigma\Psi^{best} + h\right)}{\Psi^{best} \left(2L + \rho - \frac{\dot{w}}{w}\right) (1-\sigma)} + \\ & + \frac{\alpha\sigma \left(1 - s_n^{best}\right)}{(1-\sigma)}. \end{aligned} \tag{119}$$

The dynamics of the economy is characterized by equation (117), which can be written as:

$$\dot{w} = (2L + \rho)\, w - \frac{h + (1-h)\,\Psi^{best}}{\Psi^{best}}, \tag{120}$$

and by:

$$\dot{s}_n^{best} = (1 - s_n^{best}) \left[2L - \frac{(1-h)}{w}\right], \tag{121}$$

which is obtained by substituting the equation (116) in the log-differentiation of s_n^{best}.

The equations (120) and (121) above describe the dynamics of wages and blueprint. Wages and blueprint sharesare constant when $s_n^{best} = 1$. Equations (117), (118) and (119) tend to equilibrium values in equations (40), which is the allocation of the non-FPE equilibrium with no international knowledge spillovers and no trade of intermediate goods. The feasibility conditions for this equilibrium is the same as the ones in equations (41a) and (41b).