# International Real Business Cycles: Are Countercyclical Margins in Banking the Missing Transmission Mechanism?

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**Abstract**

*To study the international transmission of business cycles, I extend a standard two-country RBC model through the introduction of international trade in two different goods and an imperfectly competitive banking sector with endogenously time-varying price-cost margins in the market for loans. Modelling two production sectors generates both demand and terms of trade effects. Using non-competitive behavior in the financial sector to explain the international transmission of aggregate TFP shocks is a novel feature of the model. It also produces a financial accelerator with interesting policy implications. In the calibration exercise I replicate the cross-country comovement of investment, employment and output across the US and other non-OECD countries and I propose a potential solution to the "quantity anomaly".*

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# 1 Introduction

A significant amount of research in international macroeconomics has been devoted to answer the question of what are the channels through which business cycles are transmitted across countries. Unfortunately and despite all this work, there is still no consensus on what determines business cycle comovement.

There are also important discrepancies between the data and what standard models predict regarding the international comovement of macroeconomic aggregates. These discrepancies were first identified by Backus, Kehoe and Kydland (1992) for the OECD countries. They have been labelled "anomalies" when proved robust to various changes to parameter values and model structures. The discrepancies are two. First, in the data, correlations of output across countries are larger than analogous correlations for consumption. With only a few exceptions, previous work obtains consumption cross-country correlations that significantly exceed output correlations. This inconsistency has been labelled the "consumption/output anomaly" or the "quantity anomaly". Second, investment and employment comove across countries in the data, while most models predict negative values for their cross-country correlation. Many candidates have been suggested to propose a solution to these puzzles, but no agreement has been reached on what is the best way to solve them.

The goal of this paper is to study the international transmission of business cycles and to propose a potential solution to these anomalies. To do so, I extend an otherwise standard two-country dynamic stochastic general equilibrium model in two ways: I allow for trade in two different goods, and I model a novel type of friction in the market for bank credit.

Having two goods with each country specializing in the production of one of them provides a *"demand channel"* and a *"terms of trade channel"* to the international transmission of productivity shocks. When a positive shock hits one of the countries, the other faces an increased demand for the good it produces, and some of the benefits spill over to the latter[1]. Also, terms of trade change and imply a positive wealth effect for the country where productivity is not exogenously affected. These features of the model are consistent with the recent empirical results in Baxter and Kouparitsas (2005), who show that bilateral trade is the only robust variable in explaining comovements.

However, previous work[2] has shown that having trade in two goods is not enough to account for the positive correlation of macroeconomic aggregates across countries. In models with perfectly functioning credit markets and no exogenous restrictions to capital mobility, capital would flow from the rest of the world into the country where productivity is relatively higher. This gives rise to the negative cross-country correlations of factors of production, to the very low cross-country output correlations and to the perfect consumption correlations generally obtained in theoretical models. Financial imperfections prevent capital from flowing from the rest of the world into the relatively more productive economy, and help to get cross-country comovement for investment, employment and output. However, it has been shown that modelling incomplete financial markets (by allowing agents to have access to only a risk-free bond) and/or adjustment costs to investment is not enough to replicate the transmission of business cycles observed in the data[3].

Therefore, in this paper I also model a novel type of credit market friction through the introduction of a non-competitive banking sector and en-

[1]Stockman and Tesar (1998) and Heathcote and Perri (2002) show how modelling multiple production sectors can generate cross-country output correlations that are more consistent with the data.

[2]See Stockman and Tesar (1995).

[3]See Baxter and Crucini (1995) and Kollman (1996).

dogenously cyclical price-cost margins in the market for loans. Modelling imperfect competition in the financial sector is something to my knowledge not previously done in the context of the international RBC literature. I argue in this paper that countercyclical price-cost margins in banking are a key missing transmission mechanism in this literature that can explain the comovement of business cycles. Section 5 elaborates on how countercyclical margins become a key transmission mechanism needed to account for business cycle comovement.

This mechanism also has strong empirical support. Aliaga-Díaz and Olivero (2005), Chen, Higgins and Mason (2005) and Mandelman (2005) present empirical evidence on the countercyclical behavior of banks' price-cost margins. Empirical work also provides support to the imperfectly competitive behavior of banks in OECD countries. Nathan and Neave (1989) provide evidence for imperfect competition in the Canadian banking sector. Neven and Roeller (1999) study European loan markets and find significant evidence of market power in both the corporate loan and the household mortgage markets. Bikker and Haaf (2002) and Claessens and Laeven (2003) use the H statistic[4] to measure contestability for a cross-section of countries, obtaining values consistent with imperfect competition[5].

[4]The statistic is used to study the relationship between changes in factor prices and the revenue earned by a specific bank. An H-statistic measures the elasticity of revenues to input prices. H=1 (0) implies perfect competition (perfect collusion). Measures in between indicate imperfect competition.

[5]Worthy of note is the fact that countries with a large (small) number of banks have relatively low (high) H-statistics. Non-competitive behavior might be consistent with not very highly concentrated markets with a large number of banks due to asymmetric information between borrowers and lenders that implies what has been called a "locked-in" effect that gives banks market power and provides barriers to entry. Also, the goods and services supplied by banks can be considered quite heterogeneous. Banks differentiate themselves through reputation, the type of packages offered and the location of their branches among other things. Last, technological considerations like economies of scale

Imperfect competition in banking also produces a novel financial accelerator coming from the supply side of the loans market. Alternative to the Bernanke and Gertler (1989) financial accelerator, here it is the degree of market power in banking changing over the business cycle what can make credit spreads countercyclical. This has interesting policy implications due to its macroeconomic impact. With margins in the market for credit being countercyclical, credit becomes more expensive in bad times relative to standard models. If firms are heavily reliant on credit to finance investment, they may delay their investment and production decisions further and the recession may be made deeper and longer. This in turn may provide additional support to stabilization policies in economies where these margins are countercyclical.

Several papers have looked at various determinants of the international transmission of business cycles and tried to explain the anomalies. They have done this through adjustment costs to investment, imperfect competition in goods markets, household production of non-tradeable goods, government spending entering preferences and shocks to beliefs among others. In general, they have been relatively unsuccessful in finding a solution to all puzzles simultaneously. Among these papers, my work is most closely related to those using credit market frictions and imperfect competition in goods markets to study the anomalies. They are briefly reviewed in Section 2.

In the calibration exercise I obtain positive cross-country correlations for investment, employment and output when banks' margins are countercyclical. For some parameterizations, I propose a potential solution to the "quantity anomaly". I do so while still reproducing the countercyclicality of

might provide incentives for higher concentration, but this does not necessarily imply non-competitive pricing. These are reasons why concentration and contestability are not always directly related, and these reasons seem to be particularly important in the banking sector.

net exports, another important stylized fact in the RBC literature.

Qualitative results are robust to sensibilizations of parameter values and they indicate that an important link to understand the international transmission of economic activity that has been absent from the previous literature is the cyclical behavior of banks' price-cost margins. Results are also indicative of the importance of both the *"demand channel"* and the *"terms of trade channel"*. Having two goods together with credit market frictions is crucial if one wants to replicate both the comovement of macro aggregates and the countercyclicality of the trade balance.

I proceed as follows. In Section 2 I provide a brief literature review. I present the data stylized facts that the model is intended to reproduce in Section 3. In Section 4 I introduce a model of exogenously time-varying banks' price-cost margins. I analyze the intuition about the main transmission mechanisms in Section 5, and present the results in Section 6. In Section 7 I endogenize the cyclical behavior of margins. I conclude in Section 8. Appendix A presents the derivation of the interest rate elasticity of the demand for credit by entrepreneurs. Appendix B shows the results for the sensibilization of the parameter that governs the *"trade channel"*. Appendix C contains some important robustness checks of the model.

## 2 Background Literature

This paper is closely related to two different strands of the literature on the international transmission of business cycles: the work using credit market frictions and restrictions to international capital flows, and the literature on imperfect competition in goods markets as a source for the international propagation of productivity shocks.

The most influential papers within the first strand use a two-country, single-good model where only non-contingent bonds can be traded internationally (Baxter and Crucini (1995) and Kollman (1996)), adjustment costs to investment (Kollman (1996)), financial autarky where risk sharing is completely prohibited (Heathcote and Perri (2002)), or models where market incompleteness is obtained endogenously through the introduction of imperfectly enforceable international loans (Kehoe and Perri (2002)). By restricting international risk sharing and with agents being less able to offset the effects of idiosyncratic shocks, these papers predict lower cross-country correlations for consumption and higher correlations for output.

Gilchrist (2004) explores the role of a financial accelerator à la Bernanke and Gertler (1989) in transmitting shocks from developed to developing economies. Shocks are transmitted internationally due to their effect on the value of foreign assets and on foreign borrowers net worth. He finds that financial leverage provides a strong cross-country propagation mechanism. This is to my knowledge the only paper so far that has looked at time-varying finance premia as an international transmission mechanism. However, financial markets are still imperfectly competitive in their setup. Moreover, Gilchrist (2004) focuses on the effects of one-time shocks only, and does not address the anomalies through model simulations.

My work is also embedded within the literature on imperfectly competitive goods markets as a mechanism for the international transmission of productivity shocks. With imperfect competition in goods markets creating a wedge between wages and the marginal productivity of labor, and with this wedge being countercyclical, a TFP shock to one country triggers an increase in employment smaller than otherwise and hence, a higher correlation with employment in the other country (Schmitt-Grohé (1998) and Ubide (1999)). In Cook (2002) markups are countercylical due to procyclical sequential market entry for final goods producers.

# 3 The Data

In Table 1 I report cross-country correlations between the main macroeconomic aggregates for the United States (US) and other OECD countries, calculated using OECD Quarterly National Accounts and OECD Main Economic Indicators (MEI) data for the period 1960-2002[6]. GDP, investment, employment and consumption are all positively correlated across countries. Also, consumption correlations are lower than output correlations.

As discussed in Heathcote and Perri (2003), worthy of note is the fact that business cycles in the US have become less correlated with those of the other OECD countries over time[7]. Correlations calculated for the period 1970-1990 by Backus, Kehoe and Kydland (1992) are 0.51 for private consumption, 0.66 for output, 0.53 for investment and 0.33 for employment.

The "consumption/output anomaly" and the comovement of investment and employment across countries are still present when looking at data for each OECD country in particular. The cross-country correlations between the macroeconomic aggregates for the US and each of the non-US OECD countries are available from the author upon request.

[6]Data available in Fabrizio Perri's website (http://pages.stern.nyu.edu/ fperri/research.htm). European data refer to the following 15 countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and United Kingdom. Data for employment between 1972.1 and 1983.4 is only for the following subgroup: Austria, Finland, France, Germany, Italy, Norway, Spain, Sweden and United Kingdom. Data for employment between 1962.1 and 1971.4 is only for the following subgroup: Finland, Germany, Italy, Sweden and United Kingdom.

[7]Heathcote and Perri (2003) can account for this through a combination of changes in the nature of real shocks and an increase in US financial integration. The estimated process for TFP shocks changes very little. Increased risk-sharing tends to reduce the international comovement of investment by allowing for intertemporal specialization in production. More integration also leads to decreased cross-country consumption correlations because of lower substitutability between home and foreign goods, a stronger home-bias in consumption and higher willingness to substitute consumption intertemporally.

There are also some credit markets stylized facts that the model is intended to reproduce by introducing an imperfectly competitive banking sector. Aliaga-Díaz and Olivero (2005) and Chen, Higgins and Mason (2005) present evidence that banks price-cost margins, defined as the difference between the interest rates on loans and deposits, are countercyclical in the US. Aliaga-Díaz and Olivero (2005) show that this countercyclicality is robust to controlling for the impact on interest margins of countercyclical monetary policy, default and interest rate risk, maturity mismatches between banks' assets and liabilities, banks' liquidity, banks' capital holdings, banking regulations, and changes to market concentration measures, among other factors. Therefore, it seems from these results that there is room for a countercyclical degree of market power to explain the observed behavior of banks' price-cost margins. In this paper, I build a DSGE model that replicates this behavior[8].

Standard international real business cycle two-country models with only one good and complete financial markets fail to reproduce the comovement referred to above. After a country is hit by a positive TFP shock, capital starts flowing into this country from the rest of the world, so that labor productivity and employment fall there. This implies a negative cross-country correlation for investment and employment and a very low cross-country correlation for output, driven mainly by the correlation of the exogenous process assumed for total factor productivity. With perfect risk-sharing across

[8]For the US, additional evidence that market power in banking is inversely related to GDP can be found by looking at the number of banking institutions and branches. They are both procyclical. The correlation of the number of banking institutions (commercial banks branches) to GDP is 0.24 (0.13). Another indicator is given by the inverse relationship between measures of market concentration and GDP. The Herfindahl-Hirschman indexes (HHI) for the deposits and loans markets both have a negative correlation with detrended GDP. However, neither of the last two facts is crucial to the mechanisms at work in the theoretical model of Section 7, where I endogenize the cyclicality of margins but the number of banks and the degree of concentration are fixed at business cycle frequencies.

countries, these standard models also predict a perfect (or close to perfect) correlation for consumption levels. Thus, predicted consumption correlations are always higher than those for output. Also, these models with no financial frictions cannot replicate the existence and the cyclicality of a margin or spread between interest rates on deposits and the cost of credit to investors.

# 4 The Model

I extend a standard two country dynamic, stochastic, general equilibrium model in two ways. First, I introduce international trade in two imperfectly substitutable goods. Second, I model a credit market friction given by the fact that entrepreneurs need to finance capital production with loans. These loans are granted by an oligopolistic banking sector whose degree of market power varies over the business cycle.

In each country there is a continuum of mass one of households, firms operating in a competitive goods market and entrepreneurs producing capital goods in a competitive environment. A "global" oligopolistic banking sector collects deposits from households in both economies and lends to entrepreneurs in both of them.

I present the setup for the home country in this section. Both countries are perfectly symmetric, so that analogous optimization problems apply to all agents in the foreign country. I use stars to denote foreign country variables.

## 4.1 The Households

A continuum of households choose consumption of domestic and imported goods (goods 1 and 2, $x_1$ and $x_2$, respectively), labor ($h$) and bank deposits ($D$) in each of $N$ banks to maximize their expected lifetime utility.

Thus, the representative household's optimization problem is given by

$$\max_{x_{1t}, x_{2t}, h_t, D^i_{t+1}} \quad E_0\left[\sum_{t=0}^{\infty} \tilde{\beta}_t U(C_t, h_t)\right] \tag{1}$$

$$s.t.$$

$$\tilde{\beta}_0 = 1$$

$$\tilde{\beta}_{t+1} = \tilde{\beta}_t \left(1 + \tilde{C}_t - \gamma \frac{\tilde{h}_t^{\omega}}{\omega}\right)^{-\mu} \qquad t \geq 0$$

$$x_{1t} + T_t x_{2t} + \sum_{i=1}^{N} D^i_{t+1} = (1 + r_{t-1}) \sum_{i=1}^{N} D^i_t + w_t h_t + \pi^f_t + \pi^e_t + \frac{1}{2} \sum_{i=1}^{N} \pi^{bi}_t \tag{2}$$

$$C_t = [\varepsilon x_{1t}^{\rho} + (1 - \varepsilon) x_{2t}^{\rho}]^{1/\rho} \tag{3}$$

$$\lim_{j \to \infty} E_t q_{t+j} \sum_{i=1}^{N} D^i_{t+j+1} \geq 0 \quad q_t = \frac{1}{\prod_{k=1}^{t}(1 + r_k)} \tag{4}$$

where $\tilde{\beta}_C < 0$ and $\tilde{\beta}_h > 0$. An endogenous discount factor is needed to generate a stationary distribution of asset holdings between the two countries in this incomplete markets model, where idiosyncratic shocks imply international wealth redistributions. For simplicity, I model the discount factor as a function of average consumption ($\tilde{C}$) and labor ($\tilde{h}$), which the individual household takes as given. This assumption also implies that the FOCs of this problem are not affected by this feature of the model. In equilibrium:

$$\tilde{C}_t = C_t \tag{5}$$

$$\tilde{h}_t = h_t \tag{6}$$

Having an endogenous discount factor to achieve stationarity is a standard approach in the literature. Still, in the numerical simulations the parameter $\mu$ is set to 0.01, the smallest possible amount needed to obtain a stationary distribution of assets. $\tilde{\beta}$ is therefore close to constant and none of the results are driven by the endogeneity of the discount factor.

Preferences are of the Greenwood, Hercowitz, Huffman (GHH) type, with no wealth effects on labor supply

$$U(C,h)=\frac{(C-\gamma\frac{h^{\omega}}{\omega})^{1-\sigma}}{(1-\sigma)} \tag{7}$$

with $\sigma$>1 being the coefficient of relative risk aversion that also pins down the intertemporal elasticity of substitution.

$C$ represents the domestic consumption aggregator over goods produced in the home country (good 1, $x_1$) and in the foreign country (good 2, $x_2$). $\frac{1}{(1-\rho)}$ is the elasticity of substitution between domestic and foreign goods. The foreign aggregator $C^*$ is represented by an analogous expression where $\varepsilon$ is replaced by (1-$\varepsilon$). Notice that if goods were perfect substitutes, agents would consume only the good that is relatively cheaper. Furthermore, there would be no demand spillovers that increase cross-country output correlations.

Equation (2) is the household's budget constraint, where $T_t$ are terms of trade or, equivalently, the relative price of the foreign good in terms of the domestic good (the numeraire), $D^i$ is domestic household's deposits in bank $i$. Domestic (foreign) deposits are denominated in units of good 1 (2). Domestic households own both the domestic firms and entrepreneurs, and earn dividends on them. Domestic households own a fraction $g=\frac{l}{(l+l^*)}$ of banks, where $l$ ($l^*$) denotes loans granted in the domestic (foreign) country[9]. Firms, entrepreneurs and banks profits are all rebated to households in a lump-sum fashion. Households have access to risk-free deposits, where $r$ denotes the interest rate on deposits earned by domestic households[10]. Equation (4) is a borrowing constraint that at all dates prevents households from engaging in Ponzi schemes.

By the first order conditions for the representative household's optimization problem, the marginal utility of consumption equals the shadow value of wealth ($\lambda$).

[9] Foreign households own $g^*=\frac{l^*}{(l+l^*)}$. By symmetry, in steady state, $g=g^*=\frac{1}{2}$.

[10] By the risk free assumption, $r_{t-1}$ is in the information set of period t-1.

$$\frac{\left(C_t-\gamma\frac{h_t^{\omega}}{\omega}\right)^{-\sigma}}{p_t^C}=\lambda_t \tag{8}$$

where:

$$p_t^C=\left[\varepsilon^{1/(1-\rho)}+T_t^{\rho/(\rho-1)}(1-\varepsilon)^{1/(1-\rho)}\right]^{(\rho-1)/\rho} \tag{9}$$

By analogy:

$$p_t^{C*}=\left[(1-\varepsilon)^{1/(1-\rho)}+T_t^{\rho/(\rho-1)}\varepsilon^{1/(1-\rho)}\right]^{(\rho-1)/\rho} \tag{10}$$

$p_t^C$ and $p_t^{C*}$ denote the price of the consumption aggregator in terms of domestic goods (the numeraire) in the home and foreign country, respectively. They are price indices built as weighted averages of the price of the numeraire and the terms of trade ($T_t$).

The intratemporal condition for the allocation of consumption between domestic and foreign goods is given by equations (11) and (12) for the domestic and foreign households, respectively.

$$\frac{\varepsilon}{(1-\varepsilon)}\left(\frac{x_{1t}}{x_{2t}}\right)^{\rho-1}=\frac{1}{T_t} \tag{11}$$

$$\frac{(1-\varepsilon)}{\varepsilon}\left(\frac{x_{1t}^*}{x_{2t}^*}\right)^{\rho-1}=\frac{1}{T_t} \tag{12}$$

The Euler equation for consumption, which governs saving decisions in the domestic country is

$$\lambda_t=\left(1+\tilde{C}_t-\gamma\frac{\tilde{h}_t^{\omega}}{\omega}\right)^{-\mu}(1+r_t)E_t\left(\lambda_{t+1}\right) \tag{13}$$

Equation (14) determines household labor-leisure choices as a function of the real wage.

$$\gamma h_t^{\omega-1}=\frac{w_t}{p_t^C} \tag{14}$$

## 4.2 The Final Good Sector

Competitive firms in the economy produce a final good ($Y$) operating a constant returns to scale Cobb-Douglas technology. They hire labor ($h$) and rent capital ($K$) to maximize profits in each period. Labor is country-specific and it earns a wage rate $w$. Capital is rented at a cost $r^K$ from entrepreneurs who produce the economy's capital stock[11]. The representative firm's problem is given by

$$\max_{h_t, K_t} \pi_t^f = Y_t - w_t h_t - r_t^K K_t \tag{15}$$

$$s.t.$$

$$Y_t = A_t F(K_t, h_t) = A_t K_t^{\alpha} h_t^{1-\alpha} \tag{16}$$

$$log(\mathcal{A}_{t+1}) = \Lambda log(\mathcal{A}_t) + \varepsilon_{t+1} \tag{17}$$

where total factor productivity ($\mathcal{A}_t$) follows an AR(1) in logarithms process and $\mathcal{A}_t \equiv (A_t, A_t^*)$ is part of the state vector of the model. $\Lambda$ is a matrix of coefficients and $\varepsilon_t \equiv (\varepsilon_t,\ \varepsilon_t^*)$. The off-diagonal elements of $\Lambda$ define the spillovers from one country to the other. The elements of $\varepsilon_t$ are serially independent, bivariate, normal random variables with contemporaneous co-variance matrix $V$. TFP processes are related across countries through the off-diagonal elements of both $\Lambda$ and $V$.

The firm's problem gives the standard inverse demand functions for labor and capital:

$$w_t = A_t (1-\alpha) K_t^{\alpha} h_t^{-\alpha} \tag{18}$$

$$r_t^K = A_t \alpha K_t^{\alpha-1} h_t^{1-\alpha} \tag{19}$$

[11] An assumption implicit in this setup that is also standard in the literature is that agents cannot own physical capital in the foreign country.

## 4.3 The Investment Sector

A continuum of mass one of entrepreneurs produce the economy's capital stock. They finance capital production with loans obtained from oligopolistic banks at a risk-free rate $R$, and rent their output to producers of final goods at a rate $r^K$[12].

In period $t$ the representative entrepreneur chooses investment ($I_t$), capital ($K_{t+1}$) and borrowing ($d^E_{t+1}$) to maximize the expected present discounted value of lifetime profits ($\Pi^E$).

$$\begin{aligned}
\max_{I_t, K_{t+1}, d^E_{t+1}} \Pi^E &= E_0\left[\sum_{t=0}^{\infty} \tilde{\beta}_t \frac{\lambda_t}{\lambda_0} \pi^E_t\right] && (20) \\
s.t. & \\
\pi^E_t &= r^K_t K_t - I_t + d^E_{t+1} - (1 + R_{t-1}) d^E_t && (21) \\
d^E_{t+1} &\geq \phi K_{t+1} && (22) \\
K_{t+1} &= I_t + (1-\delta) K_t && (23)
\end{aligned}$$

Entrepreneurs are owned by households and use their intertemporal marginal rate of substitution $\left(\tilde{\beta}_t \frac{\lambda_{t+1}}{\lambda_t}\right)$ as a discount factor. Equation (21) defines the entrepreneur's per-period profits, given by the difference between the sum of capital rental income and current borrowing and the sum of investment expenses and repayment of previous borrowing.

Equation (22) imposes the need for banks in the economy[13]. It states that at least a share $\phi$ of capital needs to be externally financed. Given that the

[12] Modelling the production sector and the investment sector separately is innocuous to the model. It will become clear below that I do it to be able to allow for increasing returns to scale just in the investment sector, which is consistent with the empirical evidence that I discuss in Section 7 where I endogenize the cyclical behavior of margins.

[13] By doing this I am implicitly assuming that entrepreneurs face an infinite cost of borrowing directly from the households. An alternative way to interpret this constraint is that if banks provide some sort of services essential for production together with the loans, a fraction $\phi$ of capital has to be financed externally to get those services, even if

interest rate on loans is strictly positive and bigger than the discount rate for the entrepreneur, (22) always binds in equilibrium. If $\phi$ was treated as an endogenous variable, it would optimally be zero. Given that my results do not hinge at all on the way in which I justify the existence of banks, my results should be robust to other ways of imposing the need for banks in the economy, like monitoring costs, liquidity provision, etc..

From the FOCs:

$$(\phi - 1) + E_t \left\{ \Omega_{t+1} \left[ r^K_{t+1} + (1 - \delta) - (1 + R_t)\phi \right] \right\} = 0 \tag{24}$$

where $\Omega_{t+1} \equiv \left(1 + \tilde{C}_t - \gamma \frac{\tilde{h}^{\omega}_t}{\omega}\right)^{-\mu} \frac{\lambda_{t+1}}{\lambda_t}$

The Euler equation for capital (24) states that the user's cost of capital has to equal the marginal revenue obtained by the entrepreneur from the borrowed funds, which is given by the expected future marginal productivity of capital.

## 4.4 The Banking Sector

There are $N$ "global" oligopolistic banks with branches in each of the countries, that take deposits from both domestic and foreign households and lend to both entrepreneurs. As in Cetorelli and Peretto (2000), they affect the price of loans when taking their credit supply decisions. Banks have no oligopsonistic power in the market for deposits.

The behavior of imperfectly competitive banks that are "global" is crucial to one of the transmission mechanisms in the model. There is substantial empirical evidence on the degree of internationalization of commercial banks in the United States. Dahl and Shrieves (1999), Houpt (1999) and Barron and Valev (2000) present evidence for the 1980's and 1990's[14]. More recent

entrepreneurs could finance it with their own current earnings.

[14]Barron and Valev (2000) present evidence on the extent of U.S. bank short-term lend-

empirical evidence is found by looking at data by the Federal Reserve System and the Bank of International Settlements[15].

Each bank $i$ chooses domestic and foreign deposits ($D^i_{t+1}$ and $D^{i*}_{t+1}$) and domestic and foreign loans ($l^i_{t+1}$ and $l^{i*}_{t+1}$) to maximize the expected present discounted value of its lifetime profits ($\Pi^{Bi}$). Its optimization problem is given by[16]

$$\max_{D^i_{t+1},D^{i*}_{t+1},l^i_{t+1},l^{i*}_{t+1}} \Pi^{Bi} = E_0\left[\sum_{t=0}^{\infty}\tilde{\beta}_t\frac{\lambda_t}{\lambda_0}\pi^{Bi}_t\right] \quad (25)$$

$$s.t.$$

$$\pi^{Bi}_t = D^i_{t+1} + T_t D^{i*}_{t+1} - l^i_{t+1} - T_t l^{i*}_{t+1} + (1 + R_{t-1}(l^i_t))l^i_t + \quad (26)$$

ing across 40 countries. Total loans of large and small banks to these countries represented 8.8% of total assets in the period 1982-1994. Dahl and Shrieves (1999) show data on 601 foreign credit extensions by 35 U.S. banks with primarily domestic ownership. Only these 35 banks granted an average of $25.3 billion per year over the period 1988-1994. Of that amount, 40% went to the United Kingdom, 15% to Japan, 9% to Canada, 6% to Brazil, and 4% to each of Belgium and Mexico. Houpt (1999) presents data on international banking assets of U.S. insured commercial banks and bank holding companies by type of office. In both 1997 and 1998, international assets represented around 17% of total assets, and international assets in domestic offices of American banks were 1.7% of total assets. 53% of international assets were held by foreign branches and 36% by foreign subsidiaries.

[15]Bank structure data of the Board of Governors of the Federal Reserve System shows that foreign assets represented 12% of total consolidated assets for insured U.S. large commercial banks for the period 2001-2004. According to the Report of Condition and Income data, in the first quarter of 2001, deposits of non-U.S. addressees represented 38% of total deposits of individuals, partnerships and corporations. In 2004 loans to non-U.S. addressees represented 16% of commercial and industrial loans. This includes loans counted in international banking facilities and loans granted by foreign branches of U.S. banks. Based on the international banking statistics published by the Bank of International Settlements, for U.S. banks external loans vis--vis non-bank sectors represented 2% of GDP in 2000-2002, 2.7% in 2003 and 3.2% in 2004. External deposits represented 1.5% of GDP in 2000, 1.9% in 2001, 2.1% in 2002, 3.6% in 2003 and 4.4% in 2004.

[16]As a simplification, here I assume that the discount factor for banks is given only by the intertemporal marginal rate of substitution of domestic households.

$$+(1+R^*_{t-1}(l^{i*}_t))T_t l^{i*}_t - (1+r_{t-1})D^i_t - (1+r^*_{t-1})T_t D^{i*}_t - \Phi^i$$

$$D^i_{t+1} + T_t D^{i*}_{t+1} = l^i_{t+1} + T_t l^{i*}_{t+1} \tag{27}$$

Equation (26) defines bank $i$'s per-period profits where $R(l^i)$ and $R^*(l^{i*})$ denote the fact that banks internalize the demand for credit that they face. As in Ravn, Schmitt-Grohé and Uribe (2006), fixed costs of production $\Phi$ ensure that banks profits are relatively small in spite of equilibrium price-cost margins being positive[17]. Equation (27) is the balance sheet equation.

The bank's optimization problem results in the pricing equations for domestic and foreign loans:

$$E_t\left\{\Omega_{t+1}\left[(1+R_t(l_t))\left(1-\frac{\varepsilon_{Rt}}{N}\right)-(1+r^*_t)\frac{T_{t+1}}{T_t}\right]\right\} = 0 \tag{28}$$

$$E_t\left\{\Omega_{t+1}\left[(1+R^*_t(l^*_t))\left(1-\frac{\varepsilon^*_{Rt}}{N}\right)T_{t+1}-(1+r^*_t)T_{t+1}\right]\right\} = 0 \tag{29}$$

$$\Omega_{t+1} \equiv \left(1+\tilde{C}_t-\gamma\frac{\tilde{h}^\omega_t}{\omega}\right)^{-\mu}\frac{\lambda_{t+1}}{\lambda_t}$$

where $\varepsilon_R$ is the reciprocal of the interest rate elasticity of the demand for loans by entrepreneurs.

$$\begin{aligned}
\varepsilon_{Rt} &= -\frac{\partial(1+R_t)}{\partial d^E_{t+1}}\frac{d^E_{t+1}}{1+R_t} \\
\varepsilon_{Rt} &= \left[\frac{1}{N}+\frac{1}{\kappa}\left(1-\frac{1}{N}\frac{(1-\alpha)(\omega-1)}{(\alpha+\omega-1)}\right)\right]^{-1} \\
\kappa &\equiv \frac{(r_t+\delta)}{(1+r_t)}\frac{1}{\phi}\left[\frac{(1-\alpha)(\omega-1)}{(\omega+\alpha-1)}\right]
\end{aligned} \tag{30}$$

These conditions equate each bank's marginal revenue to its marginal cost. With the interest rate $r$ being procyclical, it can be seen that $\varepsilon_R$ is procyclical. To replicate the evidence on the countercyclicality of banks'

[17]The assumption is that costs are such that profits are small enough so that no banks enter the industry in the free-entry equilibrium.

price-cost margins, I follow two alternative routes. In Section 6 I model an exogenously procyclical number of banks. In Section 7 I endogenize this behavior through increasing returns to scale in the production of capital.

Equation (31) is the no-arbitrage condition for deposits arising from the bank's problem.

$$E_t \left\{ \Omega_{t+1} \left[ (1+r_t^*) \frac{T_{t+1}}{T_t} - (1+r_t) \right] \right\} = 0 \tag{31}$$

## 4.5 Equilibrium

I restrict attention to the case of symmetric equilibria, so that the $i$ superscripts can be dropped and $\sum_{i=1}^{N} x^i = Nx$ for all variables $x$.

World output of each good is devoted to consumption and investment. Equations (32) and (33) are the market clearing conditions in the goods markets.

$$x_{1t} + x_{1t}^* + I_t = Y_t \tag{32}$$

$$x_{2t} + x_{2t}^* + I_t^* = Y_t^* \tag{33}$$

They are obtained by combining the budget constraints for both households and the definitions for firms', entrepreneurs' and banks' profits. A balance of payments condition for each country stating that the sum of the current and capital accounts must equal zero is implicit in equations (32) and (33).

$$CA_t = (x_{1t}^* - T_t x_{2t}) \tag{34}$$

$$KA_t = N \left( \frac{1}{2}\pi_t^B + l_{t+1} - D_{t+1} - (1+R_{t-1})l_t + (1+r_{t-1})D_t \right) \tag{35}$$

$$CA_t + KA_t = 0 \tag{36}$$

$$CA_t^* = \left(x_{2t} - \frac{x_{1t}^*}{T_t}\right) \tag{37}$$

$$KA_t^* = N\left(\frac{1}{2}T_t\pi_t^B + l_{t+1}^* - D_{t+1}^* - (1+R_{t-1})l_t^* + (1+r_{t-1})D_t^*\right) \tag{38}$$

$$CA_t^* + KA_t^* = 0 \tag{39}$$

These conditions are given by equations (34)-(36) and (37)-(39), where $CA$ and $KA$ stand for the current and the capital account, respectively.

Equations (40) and (41) are the market clearing conditions in the market for bank loans.

$$Nl_{t+1} = d_{t+1}^E \tag{40}$$

$$Nl_{t+1}^* = d_{t+1}^{E*} \tag{41}$$

The recursive equilibrium in this economy is defined by value functions for the home and foreign households, for the home and foreign entrepreneurs and for each of the global banks; decision rules for consumption, labor supply and savings for the home and foreign households; decision rules for labor and capital demand for the home and foreign firms; decision rules for investment and borrowing for the home and foreign entrepreneurs; decision rules for the supply of loans for each of the banks; and prices that satisfy the home and foreign households', entrepreneurs' and firms' first order conditions, the banks' pricing equations, the world resource constraints for both goods, the market clearing conditions for the labor, capital and loans/deposits markets, and the no-Ponzi game constraint on deposits in each country.

# 5 A Discussion of the Model's Transmission Mechanisms

The first mechanism for the transmission of business cycles between the two countries is given by international trade in two goods: the *"trade channel"*. Each country exogenously specializes in the production of one of the goods[18]. This generates a *"demand channel"* to the international transmission of shocks. When one of the countries is hit by a positive TFP shock, its wealth increases and it raises its demand for foreign goods. This *"demand channel"* and the change in relative supply of the two goods (generated by the exogenous TFP shock) together generate a *"terms of trade channel"*. Depending on whether demand or supply forces dominate, the country for which terms of trade end up improving receives a positive wealth effect. Both the *"demand channel"* and the *"terms of trade channel"* are part of the overall *"trade channel"* and contribute to the international synchronization of business cycles.

The second transmission mechanism is given by time-varying price-cost margins for the oligopolistic banking sector. It will become clear with the simulation results that countercyclical margins are needed to reproduce the positive cross-country correlations for employment, investment and output observed in the data. When a positive productivity shock hits the domestic economy, the trade channel allows for the level of economic activity to increase in the foreign country (even with foreign productivity not being affected on impact). With countercyclical margins, "global" banks start charging lower margins in the foreign country. This drives an increase in investment in the foreign country. Thus, the demand for labor and employ-

[18]The pattern of production specialization is not endogenized through either comparative advantage or Heckscher-Ohlin theories. This simplification is standard in the open economy macro literature.

ment rise there as the capital stock starts increasing, and this has a positive effect on output. This effect works to offset the fall in the foreign capital stock that occurs in a standard model with perfect capital mobility but no financial frictions as capital starts flowing out from the rest of the world into the more productive economy.

Of course this effect is also present in the domestic country, but there the interest rate on loans still increases on impact (as it reflects the increased marginal productivity of capital driven by the exogenous shock). This negatively affects domestic investment and also helps to get increased cross-country correlations more in line with those observed in the data.

# 6 Numerical Solution of the Model

In this section I present the results for a model where the price-cost margins charged by the oligopolistic banking sector are exogenously countercyclical. To do that I assume that the number of banks is exogenously procyclical[19].

I solve the model by log-linearizing it in the neighborhood of the deterministic steady state.

## 6.1 Calibration

I calibrate the model to match some of the post-war stylized facts of the USA and OECD economies. The time period is a quarter. The parameter values are shown in Table 2.

The steady state interest rate on deposits $r$ is set to match the quarterly 20-year inflation-indexed interest rate on Treasury Bills. The parameter $\omega$ is set to match the price elasticity of labor supply, and $\gamma$ to have households

[19]The function $N_t = A_t^{\tau}$ describes how the number of banks changes over the business cycle.

devoting 30% of their time to work. Following standard practice, $\sigma$ is set to 2. In the consumption aggregators, $\varepsilon$ is chosen to match the share of imported goods in total consumption. Following Heathcote and Perri (2002), the parameter $\rho$ is set to reproduce an elasticity of substitution between local and foreign goods in consumption of 0.9. $\mu$, which governs the elasticity of the endogenous discount factor with respect to its argument, is set to the smallest possible value necessary to achieve a stationary distribution of assets across countries.

The depreciation rate is set to 0.025 as standard in the literature. $\phi$ is chosen to match the 0.5 ratio of loans outstanding to assets in the Flows of Funds Accounts of the Federal Reserve System. This is also the value used by Bernanke and Gertler (1989).

The parameters that govern the exogenous process followed by total factor productivity are standard in this literature and taken from Backus, Kehoe and Kydland (1992).

## 6.2 Results

The simulation results for the model with exogenously countercyclical margins are shown in Table 3.

The first column shows moments of the data. All moments are for logged and Hodrick-Prescott filtered series. $R$ is the bank prime loan rate and $r$ is the 20-year inflation indexed T-Bill rate for the period 1979-2005.

Consistent with the intuition discussed before, with countercyclical banks' price-cost margins (i.e. as $\tau$ increases from 2 to 5) the model is able to replicate the positive comovement across countries of consumption, output, employment and investment. Moreover, as $\tau$ increases and margins become more countercyclical, the cross-country correlations for employment, investment and output all increase in magnitude.

After a positive productivity shock hits the domestic economy, the world supply of good 1 increases relative to that of good 2 and works to improve terms of trade for the foreign country. Also, as the sensitivity of margins and of the deadweight loss that they imply increases, terms of trade become less and less procyclical. With this behavior for the terms of trade, the wealth effect that the foreign country enjoys due to this *"terms of trade channel"* becomes weaker. As a result, consumption levels in both countries comove less as $\tau$ rises. For the last calibration shown, $\rho(C, C^{*})$ falls below $\rho(Y, Y^{*})$. However, highly countercyclical margins seem to be needed in the model to address the "quantity anomaly".

Results also match the countercyclicality of net exports, something that previous models with one good cannot achieve. Last, simulations are consistent with the "price-variability anomaly" in Backus, Kehoe and Kydland (1994) and the volatility of the terms of trade is at most 40% of that of output.

# 7 Endogenously Cyclical Banks' Price-Cost Margins

The purpose of this section is to endogenize the cyclical behavior of the margins charged by banks in this model economy.

## 7.1 The Model

Based on empirical evidence documented by Hall (1990), Caballero and Lyons (1992), Paul and Siegel (1999a and 1999b), Jiménez and Marchetti (2002) and others[20], in this section the investment process is characterized by increasing

[20]There is a vast literature dedicated to measuring returns to scale and externalities in industry. Hall (1990) identified scale effects originated in what he labels "thick mar-

returns to scale external to entrepreneurs.

Therefore, the representative entrepreneur's optimization problem of subsection 4.3 changes to:

$$\max_{i_t, k_{t+1}, d^E_{t+1}} \Pi^E = E_0 \left[ \sum_{t=0}^{\infty} \tilde{\beta}_t \frac{\lambda_t}{\lambda_0} \pi^E_t \right] \quad (42)$$

$$s.t.$$

$$\pi^E_t = r^K_t k_t - i_t + d^E_{t+1} - (1 + R_{t-1}) d^E_t - \Psi \quad (43)$$

$$d^E_{t+1} \geq \phi k_{t+1} \quad (44)$$

$$k_{t+1} = z_t i_t + (1 - \delta) k_t \quad (45)$$

$$z_t = f(I_t) \quad f'(I_t) > 0 \quad (46)$$

where lower cases are used to denote individual choice variables. In equilibrium:

$$i_t = I_t \quad (47)$$

kets". Caballero and Lyons (1992) also find evidence for what they call "agglomeration" effects. Paul and Siegel (1999) use a dynamic cost function approach to measure scale economies and external effects. By building a micro-founded model and departing from the Hall/Solow residual approach that characterizes previous studies, they can separately identify some components of the residual: scale economies, cyclical variations in utilization rates and external or agglomeration effects. They find first, that a role still exists for internal long-run scale economies, even after controlling for all these other factors; second, that agglomeration generates cost savings that may be due to external factors, and third, that supply-driven agglomeration externalities appear dominant in both the short and the long run. Sbordone (1997) finds no evidence of external effects and attributes the relationship between aggregate and sectoral productivity to cyclical variations in the rate of labor utilization. However, Jimenez and Marchetti (2002) show that an aggregation bias may be affecting Sbordone's results. They find evidence for external or "thick market" effects by applying Sbordone's methodology to a highly disaggregated dataset and using gross output production instead of value added. Antweiler and Trefler (2000) find evidence of increasing returns to scale for capital intensive sectors like petroleum, pharmaceuticals, electronics, iron and steel basic industries, and non-electrical machinery. Harrison (2003) finds that returns to scale are increasing in the investment sector.

$$k_t = K_t \tag{48}$$

$\Psi$ represents fixed costs of production added in this case so that equilibrium entrepreneur profits are small enough to deter entry[21].

Equation (45) is the capital accumulation equation, now modified to account for increasing returns to scale external to entrepreneurs. The capital production process features an externality not internalized by entrepreneurs when they take their investment decisions[22]. Therefore, increasing returns apply only at the aggregate level and entrepreneurs make positive profits that are distributed to households in a lump-sum fashion.

What is key here is that this provides a channel for the interest rate elasticity of the demand for loans to increase with the equilibrium amount of credit, and for the price-cost margin charged by the banking sector to be countercyclical.

Equation (49) is the Euler equation for capital where the future marginal productivity of capital is affected by increasing returns to scale in its production process.

$$(\phi z_t - 1) + E_t \left\{ \Omega_{t+1} \left[ z_t r^K_{t+1} + (1-\delta)\frac{z_t}{z_{t+1}} - (1+R_t)\phi z_t \right] \right\} = 0 \tag{49}$$

I calibrate the function $z_t$ to the following form:

$$z_t = I_t^{\theta} \tag{50}$$

The parameter $\theta$ pins down the degree of increasing returns. The values used in the simulations are consistent with the evidence by Harrison (2003) for slight increasing returns in the investment sector.

[21]Without these costs, equilibrium profits would be positive when entrepreneurs are subject to external increasing returns to scale.

[22]Notice that $z_t = f(I_t)$ is not a function of the individual investment by each entrepreneur in the economy ($i_t$).

In this extended model, the interest rate elasticity of the demand for credit changes endogenously over the cycle. The reciprocal of this elasticity is given by[23]:

$$\begin{aligned}
\varepsilon_{Rt} &= -\frac{\partial(1+R_t)}{\partial d^E_{t+1}}\frac{d^E_{t+1}}{1+R_t} \qquad (51)\\
\varepsilon_{Rt} &= \left[\frac{1}{N}+\frac{1}{\kappa}\left(1-\frac{1}{N}\frac{(1-\alpha)(\omega-1)}{(\alpha+\omega-1)}\right)\right]^{-1}\\
\kappa &\equiv \frac{(r_t+\delta)}{(1+r_t)}\frac{1}{\phi z_t}\left[-\frac{\theta}{(1+\theta)}\frac{K_{t+1}}{I_t z_t}+\frac{(1-\alpha)(\omega-1)}{(\omega+\alpha-1)}\right]
\end{aligned}$$

It will be shown in the simulation results that increasing returns provide a channel for $\varepsilon_R$ and hence for margins, to be countercyclical. This makes the behavior of margins consistent with the empirical evidence discussed in Section 3.

As in any standard model, an increase in the interest rate on loans lowers the demand for credit and hence, for capital and investment. However, there is another effect present here. A fall in aggregate investment spending lowers $z$, the technology used to produce capital goods becomes worse, and the demand for capital falls by more than in standard models with constant returns to scale. Therefore, the sensitivity of the demand for credit to changes in the interest rate increases with the aggregate level of investment.

When a positive productivity shock hits the domestic economy, both investment and the demand for credit rise. The interest rate elasticity of that demand also increases, and implies a falling degree of market power and lower margins charged by the oligopolistic banks.

## 7.2 Results

In this section I take the problem of the entrepreneurs when they are subject to increasing returns to scale and embed it into the DSGE model of Section

[23]Appendix A shows the derivation of $\varepsilon_{Rt}$.

4.

By looking at equation (51) it can be seen that $\varepsilon_R$ and hence margins are procyclical when the capital production process exhibits constant returns to scale (i.e. in a model with $\theta = 0$ and $z = 1$)[24]. Simulation results in Table 4 show that as the degree of increasing returns rises, the price-cost margin charged by commercial banks becomes less procyclical and investment levels become less negatively correlated across countries. This is consistent with the intuition discussed before. After a productivity shock hits the domestic economy, the cost of credit in the foreign country falls relative to the benchmark model of constant returns in capital production (where margins charged by imperfectly competitive banks are highly procyclical). This allows for foreign investment to increase relative to the benchmark and therefore, for $\rho(I, I^*)$ to increase. With investment being still negatively correlated across countries, the model can reproduce the countercyclicality of net exports. When one of the countries experiences a positive productivity shock, capital starts flowing into it from the rest of the world. This net borrowing is reflected in an increase in imports over that in exports and a fall in the current account. Worthy of note is the fact that in this two-good model the countercyclicality of net exports can be reproduced even with a positive comovement of investment across countries. This is a result of endogenous terms of trade.

Importantly, $\theta$ cannot be increased over 0.0128 because the steady state value of the margin becomes negative then. The last column of Table 4 shows the results for the highest possible calibration for $\theta$ and a positive $\tau$ such that margins are effectively countercyclical and $\rho(I, I^*)$ becomes positive. Again, it is obvious there how countercyclical margins are needed for replicating the comovement of investment across countries and the fact that $\rho(C, C^*) < \rho(Y, Y^*)$.

[24] In such a model the elasticity of the demand for credit and margins would be constant if $\delta = 1$.

As investment becomes less negatively correlated across countries, the same happens to the capital stock and to the demand for labor, so that employment is positively correlated across countries.

Regarding the comovement of consumption, it is still higher than that of output. I take this as an indication that more restrictions to international risk sharing are needed to address the "quantity anomaly" when margins in the financial sector are constant or procyclical.

The qualitative results presented in this section are all robust to changes in most parameter values. Simulations for alternative values of the parameters $\omega, \gamma, \sigma, \alpha, \phi$ and $\mu$ are available from the author upon request.

I have identified two dimensions in which the model does not perform satisfactorily. First, I can provide a potential solution to the "quantity anomaly" only in the case of highly countercyclical price-cost margins. In general though, the cross-country correlation for consumption is bigger than that for output. Second, as in Backus, Kehoe and Kydland (1994) and Schmitt-Grohé (1998), terms of trade are less volatile than output. This is a standard result in two-sector international real business cycle models and it has been labelled the "price-variability anomaly".

### 7.2.1 Impulse Response Analysis

Next I study the response of macroeconomic aggregates to a one standard deviation shock to total factor productivity (TFP) in the domestic economy. Figure 2 shows how foreign TFP is not affected on impact. However, when the productivity shock is transmitted from the domestic economy, it starts increasing and remains above its steady state level for several quarters.

The dynamic responses for most variables are highly persistent. This can be explained by the small elasticity of the endogenous discount factor[25].

[25] The endogenous rate of time preference eliminates the unit root of some of the endogenous variables. However, the short run dynamics are similar to those of a model with

Even though financial markets are not complete, some international risk-sharing is allowed through risk-free international bank deposits. In general, both domestic and foreign consumption rise at the period of impact and stay above their steady state levels for around 40 quarters. Intuitively, the increase in the foreign country is smaller than in the domestic economy.

The computed responses in the period of impact for output and employment are positive in the domestic country and negative in the foreign. Given that this is a two-sector model, labor supply depends not only on the nominal wage, but also on the terms of trade. When the terms of trade increase after the domestic productivity shock, the real wage falls in the foreign country, and employment and output shrink.

Investment and hence the capital stock start increasing in both countries a few quarters after the shock. This drives up the demand for labor, employment and output. Even in a world with perfect capital mobility, foreign capital does not seem to flow out into the domestic economy. For the initial periods after the shock, the interest rate on loans and the cost of investment fall below their steady state values. This offsets the negative effect on the foreign capital stock of higher domestic TFP.

Net exports fall on impact in the domestic economy for the benchmark model. This is in part a reflection of the increase in the relative price of domestic imports.

For the benchmark model, in the domestic country the interest rate on deposits falls and the rate on loans rises on impact. The opposite behavior is observed in the foreign country. As a result of the elasticity of the demand for credit increasing in the foreign country after a domestic TFP shock, the deadweight loss implied by imperfect competition in the banking industry falls abroad. This drives down the cost of credit and capital relative to a standard economy and allows for a smaller fall in investment. Also, the fact

a constant $\beta$ (See Schmitt-Grohé (1998)).

that $R$ exhibits an opposite behavior in both countries helps to get increased cross-country correlations.

As either $\theta$ or $\tau$ increase starting from the model with procyclical banks' price-cost margins (i.e. with $\theta = \tau = 0$), the responses of investment, employment and output all increase in magnitude in both economies. With countercyclical margins, an exogenous increase in domestic productivity derives in an additional positive effect on foreign macroeconomic variables due to the shrinking deadweight loss of imperfect competition in banking in the foreign country. Also, foreign consumption jumps on impact in the model with $\theta = \tau = 0$. The increase in consumption is smaller with a positive value for $\theta$, and it is actually negative for a positive value for $\tau$. With no initial increase in foreign TFP, the bigger response in investment referred to above has to be achieved by transferring resources away from consumption into capital formation.

# 8 Concluding Remarks

To study the international transmission of business cycles, in this paper I extend an otherwise standard DSGE two-country RBC model through the introduction of international trade in two goods and credit market frictions. Imperfect competition in banking and endogenously time-varying price-cost margins in the market for credit are the key novel transmission mechanisms working in the model.

By doing so, I am able to explain the discrepancies between the data and the international RBC literature identified by Backus et al (1992). I obtain positive comovement of consumption, output, investment and employment across countries, and propose a potential solution to the "quantity anomaly". Simulations for a one-good model with and without margins charged by the banking sector are indicative of the importance of the *"trade-channel"*, the *"terms of trade channel"* and countercyclical margins working together to explain the international transmission of business cycles observed in the data. Based on my results, countercyclical price-cost margins in an imperfectly competitive banking sector seem to be an important link that has been missing in the international RBC literature. Moreover, the evidence presented in Section 3 provides empirical support to this transmission mechanism.

A novelty of the paper is to model a financial accelerator coming from the supply side of the loans market, which to my knowledge has not been previously studied. Banks' price-cost margins are endogenously time-varying due to the presence of market power in the market for credit. When they are countercyclical, the cost of credit increases in bad times relative to standard models that lack this friction. As a result, firms may delay their investment and production decisions and the recession may be made even worse and longer. This has interesting policy implications as it may give additional support to stabilization policy in economies with countercyclical price-cost margins. Exploring these implications is an interesting area for further research.

Another avenue for future work is to use this framework to study the implications of banking regulations for the cyclicality of margins and the international transmission of aggregate shocks.

**Table 1: Data on International Comovement**

| | |
|---|---|
| $\rho(C^{US},C^{OECD})$ | 0.3311 |
| $\rho(Y^{US},Y^{OECD})$ | 0.4496 |
| $\rho(I^{US},I^{OECD})$ | 0.4151 |
| $\rho(L^{US},L^{OECD})$ | 0.2167 |

Notes: Correlations between the United States and non-US OECD countries for logged and Hodrick-Prescott filtered quarterly data. The sample period is 1960:I - 2002:II.

*Source: OECD Quarterly National Accounts and OECD MEI data.*

**Table 2: Calibration**

| **Utility Function** | **Consumption Aggregator** |
|---|---|
| $\omega = 2.4$ | $\varepsilon = 0.8$ |
| $\gamma = 5$ | $\rho =$ -1/9 |
| $\sigma = 2$ | |
| $\mu$ (-elasticity of the discount factor) = 0.01 | |
| **Production Function** | |
| $\alpha = 0.36$ | |
| **Capital Accumulation** | **Financing Parameter** |
| $\delta = 0.025$ | $\phi = 0.5$ |
| **TFP Process** | |
| $\lambda_{11} = \lambda_{22} = 0.88$ | $\lambda_{12} = \lambda_{21} = 0.08$ |
| $\sigma^2(\varepsilon_t) = \sigma^2(\varepsilon_t^*) = (0.0085)^2$ | $\rho(\varepsilon, \varepsilon^*) = 0.25$ |

Table 3: **Simulation Results: Exogenously Time-Varying Margins**

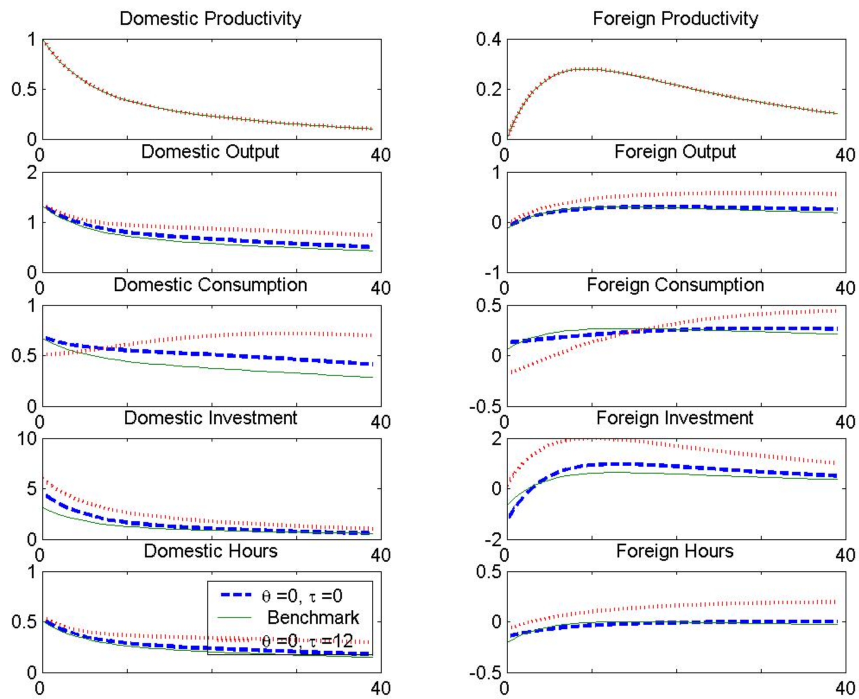
| | **Data** | $\tau$**=0** | $\tau$**=1** | $\tau$**=2** | $\tau$**=5** | $\tau$**=8** | $\tau$**=12** |
|---|---|---|---|---|---|---|---|
| **Domestic** | **Correlations** | | | | | | |
| $\rho(C,Y)$ | 0.8734 | 0.9631 | 0.9652 | 0.9671 | 0.9705 | 0.9689 | 0.9634 |
| $\rho(h,Y)$ | 0.5494 | 0.9967 | 0.9966 | 0.9964 | 0.9961 | 0.9957 | 0.9955 |
| $\rho(I,Y)$ | 0.9245 | 0.9634 | 0.9701 | 0.9754 | 0.9852 | 0.9881 | 0.9874 |
| $\rho(NX/Y,Y)$ | -0.37 | -0.5434 | -0.5897 | -0.6341 | -0.7517 | -0.8419 | -0.8867 |
| $\rho(T,Y)$ | 0.03 | 0.422 | 0.3839 | 0.3454 | 0.2291 | 0.1164 | -0.0456 |
| $\rho(A,Y)$ | 0.96 | 0.6143 | 0.6128 | 0.6113 | 0.6068 | 0.6021 | 0.5989 |
| $\rho(R,Y)$ | 0.29 | 0.9547 | 0.9517 | 0.9429 | 0.8315 | 0.4455 | -0.0972 |
| $\rho(r,Y)$ | 0.40 | 0.9526 | 0.9427 | 0.9296 | 0.8916 | 0.8585 | 0.8329 |
| $\boldsymbol{\rho(R-r,Y)}$ | -0.24 | **0.9579** | **0.908** | **0.4909** | **-0.5635** | **-0.6903** | **-0.7187** |
| **Volatility** | | | | | | | |
| $\sigma(C)/\sigma(Y)$ | 0.8 | 0.5876 | 0.5715 | 0.5558 | 0.5105 | 0.4691 | 0.444 |
| $\sigma(h)/\sigma(Y)$ | 0.88 | 0.4025 | 0.4038 | 0.4051 | 0.4091 | 0.413 | 0.4156 |
| $\sigma(I)/\sigma(Y)$ | 2.61 | 3.3079 | 3.3968 | 3.4888 | 3.7814 | 4.0953 | 4.3146 |
| $\sigma(NX/Y)/\sigma(Y)$ | 0.69 | 0.0692 | 0.0691 | 0.0692 | 0.0708 | 0.0743 | 0.0775 |
| $\sigma(T)/\sigma(Y)$ | 2.88 | 0.3758 | 0.3763 | 0.3775 | 0.3853 | 0.399 | 0.411 |
| $\sigma(A)/\sigma(Y)$ | 0.68 | 0.7438 | 0.7427 | 0.7416 | 0.7380 | 0.7342 | 0.7315 |
| $\sigma(R)/\sigma(Y)$ | 0.85 | 1.3865 | 1.2579 | 1.1359 | 0.8341 | 0.7186 | 0.7893 |
| $\sigma(r)/\sigma(Y)$ | 0.75 | 3.1382 | 3.7588 | 4.4119 | 6.5350 | 8.9952 | 11.1648 |
| $\sigma(R-r)/\sigma(Y)$ | 0.37 | 0.8968 | 0.597 | 0.4593 | 1.2570 | 2.3938 | 3.1886 |
| **CrossCountry** | **Correlations** | | | | | | |
| $\rho(C,C^*)$ | 0.3311 | 0.6594 | 0.6339 | 0.6059 | 0.5046 | 0.3736 | 0.2696 |
| $\rho(h,h^*)$ | 0.2167 | 0.1995 | 0.2119 | 0.224 | 0.2595 | 0.2933 | 0.3149 |
| $\boldsymbol{\rho(I,I^*)}$ | 0.4151 | **-0.1729** | **-0.1135** | **-0.0568** | **0.0966** | **0.2256** | **0.2995** |
| $\rho(Y,Y^*)$ | 0.4496 | 0.2681 | 0.2716 | 0.2752 | 0.2860 | 0.297 | 0.3044 |

For the case of exogenously countercyclical price-cost margins, the number of banks is exogenously procyclical and $N_t = A_t^{\tau}$.

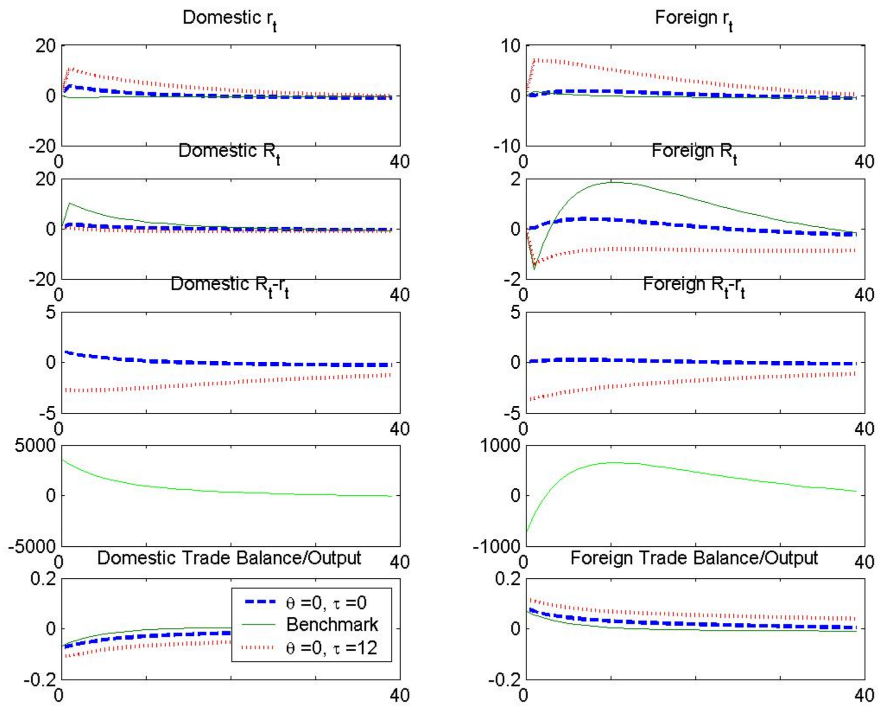
**Table 4: Simulation Results: Endogenously Time-Varying Margins**

| | Data | $\tau = 0$ | | | | | $\tau > 0$ |
|---|---|---|---|---|---|---|---|
| | | | | $\theta$ | | | |
| | | 0.005 | 0.01 | 0.011 | 0.012 | 0.0128 | $\theta = 0.01$ |
| **Domestic** | **Correlations** | | | | | | |
| $\rho(C, Y)$ | 0.8734 | 0.9595 | 0.9532 | 0.9514 | 0.9492 | 0.9469 | 0.9335 |
| $\rho(h, Y)$ | 0.5494 | 0.9967 | 0.9963 | 0.9961 | 0.9959 | 0.9957 | 0.9883 |
| $\rho(I, Y)$ | 0.9245 | 0.9659 | 0.9682 | 0.9687 | 0.9692 | 0.9696 | 0.9931 |
| $\rho(NX/Y, Y)$ | -0.37 | -0.5467 | -0.5466 | -0.546 | -0.5451 | -0.5441 | -0.9758 |
| $\rho(T, Y)$ | 0.03 | 0.459 | 0.4873 | 0.4915 | 0.4952 | 0.498 | -0.5373 |
| $\rho(A, Y)$ | 0.96 | 0.6182 | 0.6223 | 0.6231 | 0.6239 | 0.6247 | 0.6130 |
| $\rho(R, Y)$ | 0.29 | 0.9733 | 0.9761 | 0.9748 | 0.9721 | 0.9671 | 0.6556 |
| $\rho(r, Y)$ | 0.4 | 0.9087 | 0.4165 | 0.1246 | -0.1858 | -0.411 | 0.7687 |
| $\rho(R - r, Y)$ | -0.24 | **0.9745** | **0.9533** | **0.8896** | **0.4626** | **0.0158** | **-0.1824** |
| **Volatility** | | | | | | | |
| $\sigma(C)/\sigma(Y)$ | 0.80 | 0.5939 | 0.6042 | 0.6069 | 0.6098 | 0.6125 | 0.8089 |
| $\sigma(h)/\sigma(Y)$ | 0.88 | 0.4009 | 0.3988 | 0.3982 | 0.3977 | 0.3971 | 0.4664 |
| $\sigma(I)/\sigma(Y)$ | 2.61 | 2.9056 | 2.5082 | 2.4296 | 2.3514 | 2.2829 | 2.9857 |
| $\sigma(NX/Y)/\sigma(Y)$ | 0.69 | 0.0676 | 0.0655 | 0.0649 | 0.0641 | 0.0633 | 0.1768 |
| $\sigma(T)/\sigma(Y)$ | 2.88 | 0.3827 | 0.4113 | 0.4207 | 0.4319 | 0.4434 | 0.9038 |
| $\sigma(A)/\sigma(Y)$ | 0.68 | 0.7458 | 0.7479 | 0.7484 | 0.7489 | 0.7494 | 0.7062 |
| $\sigma(R)/\sigma(Y)$ | 0.85 | 2.1313 | 4.0739 | 4.906 | 6.1365 | 7.8567 | 2.5710 |
| $\sigma(r)/\sigma(Y)$ | 0.75 | 1.8988 | 0.9265 | 0.8773 | 0.9209 | 1.0309 | 5.7545 |
| $\sigma(R - r)/\sigma(Y)$ | 0.37 | 2.2993 | 9.2834 | 18.8563 | 70.4042 | 102.5034 | 11.8776 |
| **Cross-Country** | **Correlations** | | | | | | |
| $\rho(C, C^*)$ | 0.3311 | 0.66 | 0.659 | 0.6593 | 0.6601 | 0.6613 | *0.1940* |
| $\rho(h, h^*)$ | 0.2167 | 0.1894 | 0.1767 | 0.1739 | 0.1708 | 0.168 | 0.5808 |
| $\rho(I, I^*)$ | 0.4151 | **-0.1485** | **-0.1192** | **-0.1126** | **-0.1058** | **-0.0996** | **0.3167** |
| $\rho(Y, Y^*)$ | 0.4496 | 0.265 | 0.2597 | 0.2583 | 0.2567 | 0.2551 | *0.4029* |

**Figure 1: Impulse Response Functions - "Benchmark" Model**



## Impulse Response Functions - "Benchmark" Model (ctd.)



# Appendix A: Derivation of the Interest Rate Elasticity of the Demand for Credit

Starting from equation (49) and working with the equations for labor supply and labor demand (equations (14) and (18), respectively) to replace $r^K_{t+1}$ with $k_{t+1}^{\frac{(\alpha-1)(\omega-1)}{(\alpha+\omega-1)}} A_{t+1}\alpha \left[A_{t+1}(1-\alpha)\frac{1}{\gamma p^C_{t+1}}\right]^{\frac{(1-\alpha)}{(\alpha+\omega-1)}}$, assuming that the discount factor used by entrepreneurs $\Omega_{t+1} = \left(1+\tilde{C}_t - \gamma\frac{\tilde{h}_t^\omega}{\omega}\right)^{-\mu}\frac{\lambda_{t+1}}{\lambda_t}$ is not a function of $k_{t+1}$ and using the approximation $\frac{z_t}{z_{t+1}} = 1$ in the neighborhood of the steady state, I obtain the following expression for the Euler equation for capital which defines the demand for capital and hence, for borrowing by entrepreneurs in this economy.

$$\begin{aligned}\left(1-\frac{1}{\phi z_t}\right) + \frac{1}{\phi}E_t\left[\Omega_{t+1}r^K_{t+1} + \frac{(1-\delta)\Omega_{t+1}}{z_t}\right] &= (1+R_t)E_t\Omega_{t+1}\\ \left(1-\frac{1}{\phi z_t}\right) + \frac{1}{\phi}k_{t+1}^{\frac{(\alpha-1)(\omega-1)}{(\alpha+\omega-1)}}E_t(\Omega_{t+1}\Lambda_{t+1}) + \frac{(1-\delta)}{\phi z_t}E_t\Omega_{t+1} &= (1+R_t)E_t\Omega_{t+1}\end{aligned}$$

where $\Lambda_{t+1} = A_{t+1}\alpha\left[A_{t+1}(1-\alpha)\frac{1}{\gamma p^C_{t+1}}\right]^{\frac{(1-\alpha)}{(\alpha+\omega-1)}}$.

Considering that by equation (13), $E_t\Omega_{t+1} = \frac{1}{(1+r_t)}$,

$$\left(1-\frac{1}{\phi z_t}\right)(1+r_t) + \frac{1}{\phi}k_{t+1}^{\frac{(\alpha-1)(\omega-1)}{(\alpha+\omega-1)}}\frac{E_t(\Lambda_{t+1}\Omega_{t+1})}{E_t\Omega_{t+1}} + \frac{(1-\delta)}{\phi z_t} = (1+R_t)$$

Now, using the fact that $\frac{\partial(1+R_t)}{\partial d^E_{t+1}}\frac{d^E_{t+1}}{(1+R_t)} = \frac{\partial(1+R_t)}{\partial K_{t+1}}\frac{K_{t+1}}{(1+R_t)}$ and considering that $\frac{\partial z_t}{\partial K_{t+1}} = \frac{\theta}{(1+\theta)}I_t^{-1}$,

$$\frac{\partial(1+R_t)}{\partial K_{t+1}}\frac{K_{t+1}}{(1+R_t)} = \frac{\theta}{(1+\theta)}\frac{1}{\phi}\frac{K_{t+1}}{I_t z_t^2}\frac{(r_t+\delta)}{(1+R_t)} + \frac{E_t(\Lambda_{t+1})}{\phi}\frac{(\alpha-1)(\omega-1)}{(\alpha+\omega-1)}\frac{K_{t+1}^{\frac{(\alpha-1)(\omega-1)}{(\alpha+\omega-1)}}}{(1+R_t)}$$

From before: $\frac{E_t(\Lambda_{t+1})}{\phi}\frac{K_{t+1}^{\frac{(\alpha-1)(\omega-1)}{(\alpha+\omega-1)}}}{(1+R_t)} = 1 - \frac{(1-\delta)}{\phi z_t(1+R_t)} - \frac{(1+r_t)}{(1+R_t)}\left(1-\frac{1}{\phi z_t}\right)$, then

$$\varepsilon_{Rt} = -\frac{\partial(1+R_t)}{\partial K_{t+1}}\frac{K_{t+1}}{(1+R_t)}$$
$$= \frac{-(r_t+\delta)}{\phi z_t^2}\frac{\theta}{(1+\theta)}\frac{K_{t+1}}{I_t}\frac{1}{(1+R_t)} + \frac{(1-\alpha)(\omega-1)}{(\alpha+\omega-1)}\left[1-\frac{(1-\delta)}{\phi z_t(1+R_t)} - \frac{(1+r_t)}{(1+R_t)}\left(1-\frac{1}{\phi z_t}\right)\right]$$

Considering that $\frac{(1+r_t)}{(1+R_t)} = \left(1-\frac{\varepsilon_{Rt}}{N}\right)$ and denoting $\frac{(r_t+\delta)}{(1+r_t)}\frac{1}{\phi z_t}\left\{-\frac{\theta}{(1+\theta)}\frac{K_{t+1}}{z_t I_t} + \frac{(1-\alpha)(\omega-1)}{(\alpha+\omega-1)}\right\} = \kappa$, I get to equation (51).

$$\varepsilon_{Rt} = -\frac{\partial(1+R_t)}{\partial d^E_{t+1}}\frac{d^E_{t+1}}{1+R_t}$$
$$\varepsilon_{Rt} = \left[\frac{1}{N}+\frac{1}{\kappa}\left(1-\frac{1}{N}\frac{(1-\alpha)(\omega-1)}{(\alpha+\omega-1)}\right)\right]^{-1}$$
$$\kappa \equiv \frac{(r_t+\delta)}{(1+r_t)}\frac{1}{\phi z_t}\left[-\frac{\theta}{(1+\theta)}\frac{K_{t+1}}{I_t z_t} + \frac{(1-\alpha)(\omega-1)}{(\omega+\alpha-1)}\right]$$

# Appendix B: The "Trade Channel"

To study the effects of the *"trade-channel"* on the transmission of business cycles, in Table B.1 I show simulation results for alternative values of the parameter $\varepsilon$ that governs the share of domestic goods in the households consumption baskets.

The countries become increasingly "closed" economies as $\varepsilon$ rises and the share of imported goods in the consumption basket falls. Therefore, as the magnitude of the current account falls, so does that of the capital account, and macroeconomic aggregates become increasingly correlated across countries even in a world with free capital mobility. Actually, in a model of essentially two closed economies with no capital mobility and no opportunities for international risk sharing (i.e. when $\varepsilon = 1$), consumption, output, employment and investment all comove across countries, and the cross-country correlation for consumption falls below that of output as in the data. Also, terms of trade become procyclical in that model[26]. With $\varepsilon = 1$ and only supply forces affecting the relative price of the good produced by the foreign country, increases in domestic productivity and output raise this price. Last, notice that the non-monotonicity in the behavior of the cross-country correlations when $\varepsilon$ changes from 0.9 to 1 can be explained because international capital mobility is suddenly and completely restricted when doing so.

[26]Actually there is no trade in this model, so that $T$ becomes just the relative price of good 2 in terms of good 1.

**Table B.1: The Effects of the "Trade Channel"**

| $\theta = 0.01; \tau > 0$ | $\epsilon = 0.7$ | $\epsilon = 0.8$ | $\epsilon = 0.9$ | $\epsilon = 1$ |
|---|---|---|---|---|
| **Domestic** | **Correlations** | | | |
| $\rho(C, Y)$ | 0.9327 | 0.9335 | 0.9314 | 0.9854 |
| $\rho(h, Y)$ | 0.988 | 0.9883 | 0.9864 | 0.9998 |
| $\rho(I, Y)$ | 0.9917 | 0.9931 | 0.9936 | 0.9953 |
| $\rho(NX/Y, Y)$ | -0.9986 | -0.9758 | -0.9175 | -0.5631 |
| $\rho(T, Y)$ | -0.1836 | -0.5373 | -0.7255 | 0.502 |
| $\rho(A, Y)$ | 0.6136 | 0.613 | 0.6121 | 0.6114 |
| $\rho(R, Y)$ | 0.6355 | 0.6556 | 0.6828 | 0.6494 |
| $\rho(r, Y)$ | 0.7511 | 0.7687 | 0.7921 | 0.7645 |
| $\rho((R - r), Y)$ | -0.1639 | -0.1824 | -0.2089 | -0.1878 |
| **Volatility** | | | | |
| $\sigma(C)/\sigma(Y)$ | 0.7101 | 0.8089 | 0.9759 | 0.439 |
| $\sigma(h)/\sigma(Y)$ | 0.4334 | 0.4664 | 0.5158 | 0.4158 |
| $\sigma(I)/\sigma(Y)$ | 3.1088 | 2.9857 | 2.8225 | 2.935 |
| $\sigma(NX/Y)/\sigma(Y)$ | 0.1898 | 0.1768 | 0.1784 | 0.0008 |
| $\sigma(T)/\sigma(Y)$ | 0.5054 | 0.9038 | 3.1636 | 0.1888 |
| $\sigma(A)/\sigma(Y)$ | 0.7274 | 0.7062 | 0.6757 | 0.7341 |
| $\sigma(R)/\sigma(Y)$ | 2.6827 | 2.571 | 2.4304 | 2.5538 |
| $\sigma(r)/\sigma(Y)$ | 5.8483 | 5.7545 | 5.6565 | 5.7776 |
| $\sigma(R - r)/\sigma(Y)$ | 12.8641 | 11.8776 | 10.8957 | 12.3569 |
| **Cross-Country** | **Correlations** | | | |
| $\rho(C, C^*)$ | 0.0877 | 0.194 | 0.6649 | 0.097 |
| $\rho(h, h^*)$ | 0.4436 | 0.5808 | 0.7761 | 0.1576 |
| $\rho(I, I^*)$ | 0.2511 | 0.3167 | 0.4479 | 0.3536 |
| $\rho(Y, Y^*)$ | 0.3416 | 0.4029 | 0.5577 | 0.2638 |

# Appendix C: Robustness Checks

In this section I present the results of some robustness checks performed on the benchmark model. The first subsection presents a model with only one production sector (the "One-Good Model"). The last subsection studies the model with perfectly competitive banks and one good. Thus, the results presented in the last subsection correspond to a "standard" model along the lines of Baxter and Crucini (1995) and Kollman (1996), one-sector models, with perfect international capital mobility and incomplete markets where agents only have access to a risk-free asset.

## The "One-Good" Model

The results for a one sector model in which both countries produce the same good are presented in Table C.1. The first column corresponds to a model where margins in the market for credit are procyclical (i.e. a model with constant returns to scale in capital production and a constant number of banks). The second corresponds to the calibration chosen in Section 6 to obtain exogenously countercyclical margins. The last corresponds to the calibration chosen in Section 7 for the model with endogenously time-varying margins.

For the first and the second case, the cross-country correlations of consumption, output, employment and investment are all smaller than in a two-good economy with the same parameterization of $\theta$ and $\tau$. Actually, employment and output are negatively correlated across countries now. I take these results as evidence of the importance of the *"trade-channel"*. For the third case, macroeconomic aggregates exhibit a bigger comovement than in the two-sector model. However, notice that margins are less procyclical when only one good is traded in the world market.

Consistent with the findings of previous work, with no endogenous vari-

**Table C.1: Simulation Results: The "One-Good" Model**

| | $\theta = 0; \tau = 0$ | | $\theta = 0; \tau = 12$ | | $\theta = 0.01288; \tau = 0$ | |
|---|---|---|---|---|---|---|
| | **Bench.** | **One-Good** | **Bench.** | **One-Good** | **Bench.** | **One-Good** |
| **Domestic** | **Correlations** | | | | | |
| $\rho(C,Y)$ | 0.9631 | 0.9445 | 0.9634 | 0.9703 | 0.9469 | 0.9691 |
| $\rho(h,Y)$ | 0.9967 | 0.9998 | 0.9955 | 0.9998 | 0.9957 | 0.9999 |
| $\rho(I,Y)$ | 0.9634 | 0.0911 | 0.9874 | 0.1078 | 0.9696 | 0.8957 |
| $\rho(NX/Y,Y)$ | -0.5434 | 0.0163 | -0.8867 | 0.0105 | -0.5441 | 0.3418 |
| $\rho(A,Y)$ | 0.6143 | 0.564 | 0.5989 | 0.5521 | 0.6247 | 0.6245 |
| $\rho(R,Y)$ | 0.9547 | 0.6121 | -0.0972 | -0.5881 | 0.9671 | 0.8858 |
| $\rho(r,Y)$ | 0.9526 | 0.6103 | 0.8329 | 0.5882 | -0.411 | 0.627 |
| $\rho(R-r,Y)$ | 0.9579 | 0.6151 | -0.7187 | -0.6291 | 0.0158 | 0.0083 |
| **Volatility** | | | | | | |
| $\sigma(C)/\sigma(Y)$ | 0.5876 | 0.5184 | 0.444 | 0.3974 | 0.6125 | 0.6297 |
| $\sigma(h)/\sigma(Y)$ | 0.4025 | 0.416 | 0.4156 | 0.4156 | 0.3971 | 0.4162 |
| $\sigma(I)/\sigma(Y)$ | 3.3079 | 44.7227 | 4.3146 | 44.9389 | 2.2829 | 2.0277 |
| $\sigma(NX/Y)/\sigma(Y)$ | 0.0692 | 4.4906 | 0.0775 | 4.4719 | 0.0633 | 0.2326 |
| $\sigma(A)/\sigma(Y)$ | 0.7438 | 0.5935 | 0.7315 | 0.591 | 0.7494 | 0.7365 |
| $\sigma(R)/\sigma(Y)$ | 1.3865 | 0.9683 | 0.7893 | 0.3251 | 7.8567 | 7.5758 |
| $\sigma(r)/\sigma(Y)$ | 3.1382 | 2.1898 | 11.1648 | 8.8049 | 1.0309 | 0.2261 |
| $\sigma(R-r)/\sigma(Y)$ | 0.8968 | 0.6262 | 3.1886 | 2.556 | 102.5034 | 101.6567 |
| **Cross-Country** | **Correlations** | | | | | |
| $\rho(C,C^*)$ | 0.6594 | 0.465 | 0.2696 | -0.0693 | 0.6613 | 0.6988 |
| $\rho(h,h^*)$ | 0.1995 | -0.1413 | 0.3149 | -0.1366 | 0.168 | 0.2987 |
| $\rho(I,I^*)$ | -0.1729 | -0.5482 | 0.2995 | -0.5445 | -0.0996 | -0.0603 |
| $\rho(Y,Y^*)$ | 0.2681 | -0.1414 | 0.3044 | -0.1367 | 0.2551 | 0.2985 |

Table C.2: Simulation Results: The "Standard" Model

| | $\theta = 0; \tau = 0$ |
|---|---|
| **Domestic Correlations** | |
| $\rho(C, Y)$ | 0.9713 |
| $\rho(h, Y)$ | 0.9999 |
| $\rho(I, Y)$ | 0.0862 |
| $\rho(NX/Y, Y)$ | -0.0141 |
| $\rho(A, Y)$ | 0.5672 |
| $\rho(r, Y)$ | 0.6168 |
| **Volatility** | |
| $\sigma(C)/\sigma(Y)$ | 0.5019 |
| $\sigma(h)/\sigma(Y)$ | 0.4161 |
| $\sigma(I)/\sigma(Y)$ | 44.4988 |
| $\sigma(NX/Y)/\sigma(Y)$ | 6.7776 |
| $\sigma(A)/\sigma(Y)$ | 0.594 |
| $\sigma(r)/\sigma(Y)$ | 2.1961 |
| **Cross-Country Correlations** | |
| $\rho(C, C^*)$ | 0.2909 |
| $\rho(h, h^*)$ | -0.1419 |
| $\rho(I, I^*)$ | -0.5523 |
| $\rho(Y, Y^*)$ | -0.1421 |

ation in the terms of trade, a one-sector model cannot reproduce the countercyclicality of net exports.

The dynamics of the one-good model are compared to those of the benchmark economy in Figure C.1.

## The "Standard" Model

Results for a model with perfectly competitive banks and where only one good is traded in the world market are shown in Table C.2. I label this the "standard" model, as it is along the lines of Baxter and Crucini (1995) and Kollman (1996) where only risk-free debt contracts are traded in world financial markets.

As expected, employment, investment and output are now negatively correlated across countries. With free capital mobility, when one of the economies is hit by a positive productivity shock, capital starts flowing into this country from the rest of the world. Thus, investment falls in the country where TFP has not been affected. As the capital stock starts falling (after the initial period when it is fixed) and with no wealth effects on labor supply, labor demand falls and employment and output shrink there. Even with only one production sector, the highly negative cross-country correlation for investment allows the model to replicate a mildly countercyclical trade balance. These results are comparable to those by Baxter and Crucini (1995) and Kollman (1996).

The dynamics of the standard model are compared to those of the benchmark economy in Figure C.2.

I now turn to discuss the behavior of the main macro variables after a one standard deviation shock to total factor productivity in the domestic country. When the productivity shock is transmitted across countries, total factor productivity in the foreign economy starts increasing and remains above its steady state level for several quarters given the high persistence in the exogenous process assumed for TFP.

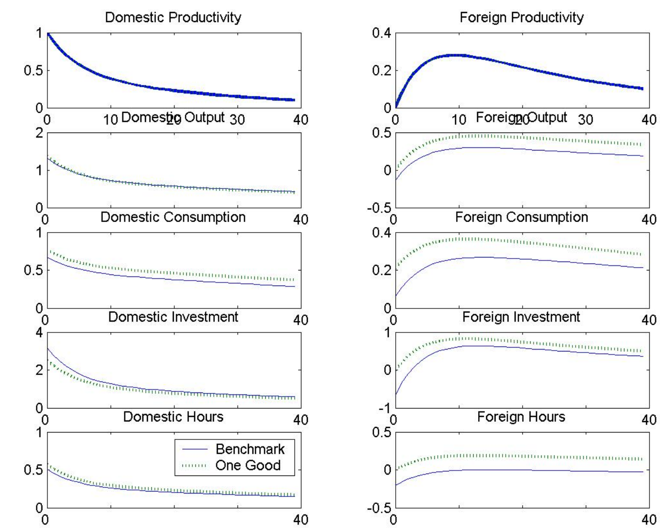
*Consumption:* Foreign consumption increases significantly less in the model with imperfectly competitive banks and two goods (the "benchmark") than in the one sector model. Two factors work together to explain this behavior: With two goods, employment falls in the foreign country and the increase in the rate of return on deposits is bigger there. Last, the positive wealth effect on the foreign country coming from the *"terms of trade channel"* improves investment and negatively affects consumption as resources are transferred from consumption to investment.

*Employment and Output:* In the model with one good, a positive shock to domestic productivity results in an increase in foreign output only with a lag. Labor demand does not change in the period of impact because the capital stock is predetermined. Labor supply depends only on the real wage and does not change either. Therefore, the model predicts no initial response of foreign employment and output. In the two-good model labor supply depends also on the terms of trade (through $p_C^*$). When the terms of trade increase after the domestic productivity shock, the real wage falls and labor supply falls in the foreign country. Therefore, employment and foreign output fall there on impact. In the "standard" model, foreign hours are still not affected on impact but start falling afterwards as capital flows out of the country and the marginal productivity of labor starts falling.

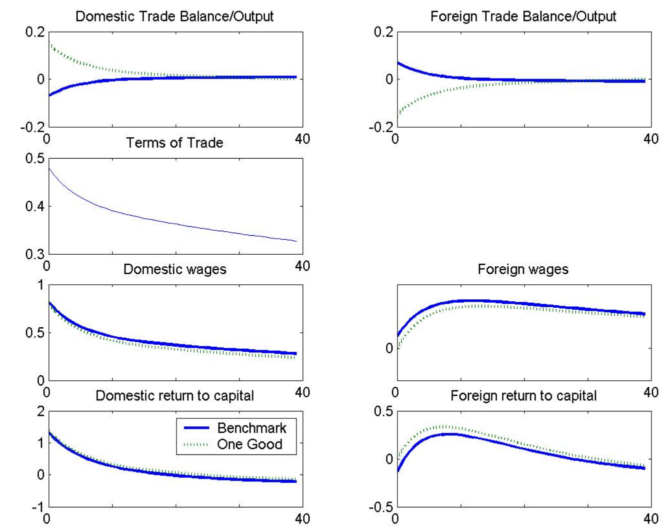
*Investment:* For both the "benchmark" and the "one-good" model, investment and hence the capital stock start increasing in both countries a few quarters after the shock. This drives up the demand for labor, employment and output. This effect is strongest in the economy with countercyclical margins, where the cost of credit to finance capital purchases falls relative to standard models that lack this friction. Worthy of note is the fact that foreign capital never falls below its steady state value as in the standard two-country model with no financial frictions depicted by Figure 4. In that model foreign investment falls on impact by close to 50%, while domestic investment increases by a similar proportion. With perfect capital mobility and no financial frictions other than just having incomplete markets where agents can smooth consumption only through a risk-free asset, capital starts flowing out of the foreign country as soon as the domestic economy is hit by a positive shock.

*Trade Balance and Terms of Trade:* With no *"terms of trade effect"*, in the one-good model net exports increase for the domestic country on impact. The behavior of the trade balance here is opposite to that in the "benchmark" model. The qualitative response of the trade balance in the "standard" model is similar to that of the benchmark. This is true even with only one good, and can be explained through the international reallocation of capital and its impact on the capital account. Right after the shock the domestic country starts borrowing from abroad and running a current account deficit.

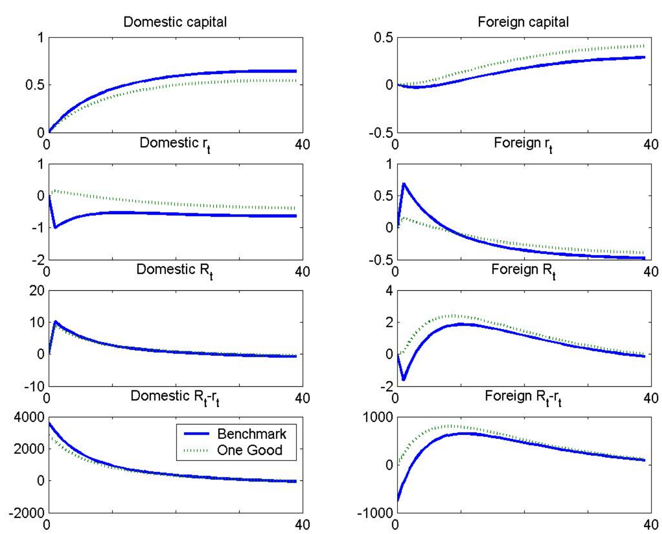
**Figure C.1: Impulse Response Functions - "One-Good" Model**



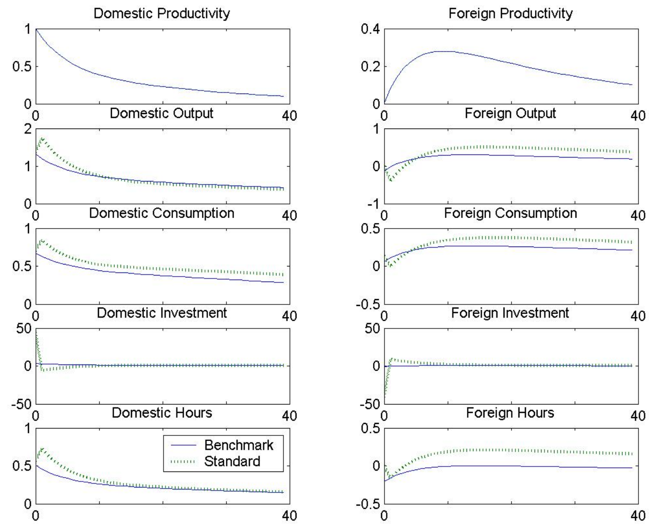
## IRFs "One-Good" Model (ctd.)



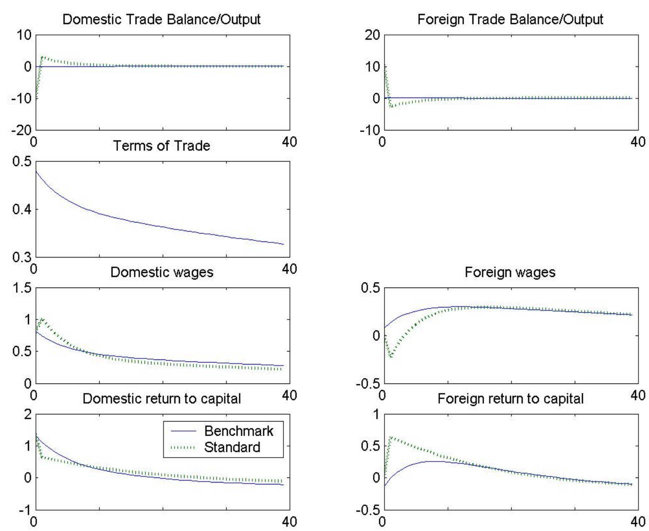

## IRFs "One-Good" Model (ctd.)



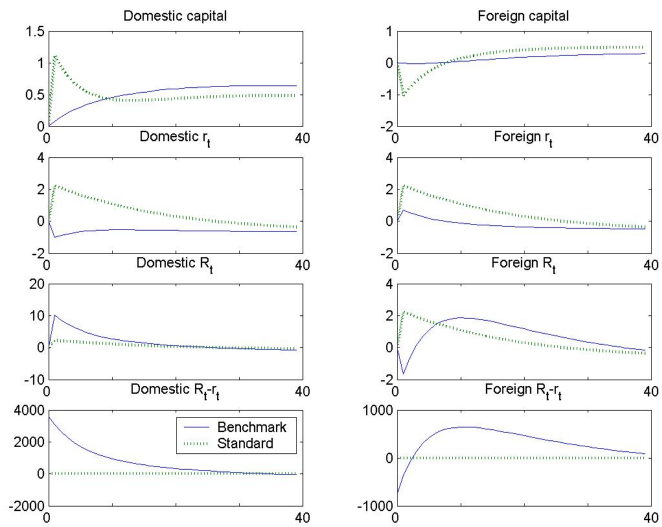
## Figure C.2: Impulse Response Functions - "Standard" Model




## IRFs "Standard" Model (ctd.)



## IRFs "Standard" Model (ctd.)



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