Finance and International Business Cycles

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Revised: March 2006†

Abstract

Business cycles are more correlated among countries that have similar financial structures. We first document this empirical regularity using OECD data, and then build a two-country DSGE model with financial frictions that replicates it. Alternative monetary policy regimes and parameter values are explored. Output co-movements increase when the countries involved are linked by a credible exchange rate peg and when they open up to trade; they decrease when their financial openness increases. The model also accounts for a number of stylized facts of international business cycles, such as the positive international correlation of output, investment and employment.

JEL Classification Numbers: E3, E42, E44, E52, F41.

Keywords: financial distance, differential transmission mechanism, international business cycle.

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†For useful comments and discussions I thank Ignazio Angeloni, Fabrice Collard, Thomas Cooley, Dale Henderson, Mark Gertler, Bob King, Tommaso Monacelli and Fabrizio Perri, and seminar participants at the Bank of England, Bank of International Settlements, Duke University, European Central Bank, European University Institute, Federal Reserve Board, Federal Reserve of St. Louis, Federal Reserve of San Francisco, New York University, Stern School of Business, Stockholm School of Economics, Tilburg University, University of Quebec a' Montreal, Universitat Pompeu Fabra, Society for Economic Dynamic Conference in New York, European Economic Association conference in Venice, Konstanz seminar in Monetary Theory and Policy and CEPR conference on Financial Structure and Monetary Policy. I acknowledge financial support from the DSGE grant of the Spanish Ministry of Education and the EU Commission under a Marie Curie grant. All errors are mine.

1. Introduction

Financial structures differ internationally as a result of history, collective preferences, legal frameworks and politics[1]. This well-known fact has often been used, for example, to explain the cross-country differences in the monetary policy transmission mechanisms[2]. Moreover, business cycle correlations also differ across groups of countries: for example, the output co-movements among Anglo-Saxons countries (UK, US) or among continental European countries are higher than those observed e.g. between the US and Europe (see the evidence below in this paper). It is reasonable to conjecture that the financial structures may also influence the international transmission of shocks, hence helping explain why certain clusters of countries co-move more than others. Surprisingly, however, this element has not been considered in the analyses of the international transmission of shocks. This paper does that, and concludes that, indeed, financial factors can contribute to explain the broad patterns of business cycle co-movements in the industrialized world.

The analysis is conducted in three steps. First, OECD data are used to illustrate the correspondence between differences in financial markets and business cycle co-movements. Specifically, a negative relation is shown to exist between pairwise correlations of output and a measure of financial "distance". Second, a standard two country DSGE model with nominal rigidities and a financial accelerator – *a-la* Bernanke, Gertler and Gilchrist (1998)[3] is built and calibrated on OECD data. The model nicely replicates the relation between business cycle co-movements and financial distance found in the data. Intuitively, when the financial distance between two countries is high, the different sensitivity of the external finance premium to collateral induces asymmetric business cycle responses to shocks, hence weakening the co-movement between the two economies. This holds independently of the

[1] See e.g. La Porta, Lopes-de Silanes, Shleifer, Vishny (1997).
[2] Cecchetti (1999).
[3] See also Kiyotaki and Moore (1997) and Carlstrom and Fuerst (1997).

correlation of the underlying shocks, of the degree of trade and financial openness and the monetary policy regime.

Third, the model is shown to possess a number of other features that are consistent with the empirical evidence on international business cycle. First, business cycle synchronization increases under credible exchange rate pegs and with the degree of trade openness, while it decreases with the degree of financial openness[4]. Second, the volatility of real and financial variables is higher under a strict price stability rule than under a Taylor rule. Finally, the model is able to explain the positive international co-movements of output, investment and employment, known in the literature as the "output-investment-employment correlation puzzle"[5].

The paper is organized as follows. Section 2 documents the stylized facts and reviews the literature. Section 3 presents the model economy. In sections 4 the model is augmented with capital formation and a financial sector. Section 5 discusses the calibration. Section 6 presents and comments the results from the model and the matching with the data. Section 7 concludes.

2. Related Literature and Stylized Facts

Within the vast literature on the international business cycles, two main lines of research are related to this paper. The first examines the determinants of the international business cycles. Traditionally, international trade has been considered the main channel of the international transmission mechanism. However extensive recent evidence[6] has shown that the size of bilateral trade is not the sole, or even the most important, determinant of business cycle co-movements. For example, the importance of product structures and of international

[4] This is consistent with the findings of Heatcote and Perri (2004).
[5] Backus, Kehoe and Kydland (1992), Baxter and Crucini (1994) and Stockman and Tesar (1995).
[6] Pioneered by Baxter (1994).

capital movements has been noted [7]. A second line of investigation has tried to explain the discrepancy between the predictions of the traditional models of international business cycle and a series of empirical facts such as the positive co-movements of output, investment and employment[8] and the excess volatility and persistence of the real exchange rate[9].

This paper focuses on the role of financial structures in shaping business cycle co-movements. Table 1[10] shows that large differences exist in financial structures among OECD economies. The table reports some indicators of the structure of the bank and financial systems for a set of OECD countries: the bank return on assets (ROA), the bank loan loss provisions as percentage of total bank liabilities, the firms' external finance as a percentage of GDP and the Thomson rating. The latter is an indicator of bank health: a lower value identifies a more efficient banking system. The data show that there are many similarities between the US and British banking systems, while pronounced differences exists between these countries on one side and the euro area countries and/or Japan on the other. In general, the US and the UK have higher return on assets, lower loan loss provision, higher external finance and lower Thomson rating than the euro area and Japan.

Table 2 shows data on business cycle co-movements. Specifically, the entries in the table are pairwise correlations of output among G7 countries, calculated by the International Monetary Fund[11]. The pairwise correlation between U.S. and U.K. is much higher than the ones between the U.S. and the euro area or Japan. Similarly, correlations between pairs of euro area countries are higher than the ones observed between euro area countries and the U.S. or the U.K.. This happens despite the fact that U.K. trades more with the euro area than with the U.S.

Figure 1 links together these two pieces of evidence, suggesting the existence of a nexus

[7] Ambler, Cardia and Zimmerman (2002), Heathcote and Perri (2004).
[8] Baxter and Farr (2001), Heathcote and Perri (2002).
[9] Kehoe and Perri (2002).
[10] Data are from Cecchetti (1999).
[11] World Economic Outlook (2001). Output data are filtered using Baxter and King (1999).

between financial diversity and business cycle co-movement. The chart plots pairwise correlations of output[12] and a measure of the financial distance, which is the average over the 1989-1999 of the pairwise differences in the return on assets[13] for a set of OECD countries. The interpolating line suggests a negative relation. Table 3 shows that this relation is statistically significant (first column) and is robust to the inclusion of two control variables: bilateral trade and a language dummy (second and third column).

3. A Two-Country Sticky Price Model

The economy is a two-country, two traded-good model with sticky prices *a-la* Rotemberg (1982). Workers-consumers in the domestic economy maximize the following expected discounted sum of utilities[14]:

$$E_t \left\{ \sum_{t=0}^{\infty} \beta^t U\left(C_t\right) - V(N_t) \right\} \tag{1}$$

where N_t denotes total labor hours and $C_t = \left((1-\gamma)^{\frac{1}{\eta}} C_{H,t}^{\frac{\eta-1}{\eta}} + \gamma^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}}$ is a Dixit-Stiglitz consumption aggregator of domestic and imported goods, where $C_{s,t} \equiv \left(\int_0^1 C_{s,t}(i)^{\frac{\varepsilon-1}{\varepsilon}} di \right)^{\frac{\varepsilon}{\varepsilon-1}}$,with s=H,F, are composite aggregates of different varieties of goods i, U is increasing, concave and differentiable and V is increasing, convex and differentiable. The household receives at the beginning of time t a nominal labor income of $W_t N_t$. In order to finance consumption at time t she invests in deposits, D_t, that pay $R_t D_t$ one period later and risk-free international

[12] Data are from the IMF International Financial Statistics. GDP series are quarterly from the 1985 to 2001 and are detrended with a Hodrick-Prescott filter.

[13] Data are from IBCA Bankscope. This measure of the financial distance is chosen for two reasons. First, it is close to the ideal concept incorporated in the model, which is the difference in the external finance premium. Secondly, this index is the only one for which the IBCA Bankscope dataset provides the longest and most uniform series.

[14] Let $s^t = \{s_0, ...s_t\}$ denote the history of events up to date t, where s_t denotes the event realization at date t. The date 0 probability of observing history s^t is given by ρ_t. Henceforth, and for the sake of simplifying the notation, let's define the operator $E_t\{.\} \equiv \sum_{s_{t+1}} \rho(s^{t+1}|s^t)$ as the mathematical expectations over all possible states of nature conditional on history s^t.

bonds, B_t^* ,that pay a return R_t^F. They also receive profits, Θ_t, from owning a monopolistic production sector. The sequence of budget constraints (in units of domestic consumption index) reads as follows:

$$C_t + D_t + e_t^r B_t^* \leq \frac{W_t}{P_t} N_t + R_{t-1} D_{t-1} + R_t^F e_t^r B_{t-1}^* + \frac{\Theta_t}{P_t} \tag{2}$$

where $P_t \equiv [(1-\gamma) P_{H,t}^{1-\eta} + \gamma P_{F,t}^{1-\eta}]^{\frac{1}{1-\eta}}$ is the domestic price index and $e_t^r = \frac{e_t P_t^*}{P_t}$ is the real exchange rate, with e_t being the nominal exchange rate. Households choose the set of processes $\{C_t, N_t, D_t, B_t^*\}_{t=0}^{\infty}$ taking as given the set of processes $\{P_t, W_t, R_t, R_t^F\}_{t=0}^{\infty}$ and the initial wealth D_0, B_0^* so as to maximize (1) subject to (2). First order conditions read as follows:

$$U_{c,t} \frac{W_t}{P_t} = -U_{n,t} \tag{3}$$

$$U_{c,t} = \beta R_t E_t \{U_{c,t+1}\} \tag{4}$$

$$U_{c,t} = \beta R_t^F E_t \left\{ U_{c,t+1} \frac{e_{t+1}^r}{e_t^r} \right\} \tag{5}$$

Equation (3) is the optimality condition with respect to labor supply. Equations (4) and (5) are the optimality conditions with respect to deposits and foreign bonds. Due to imperfect capital mobility and/or in order to capture the existence of country risk domestic workers pay a spread between the interest rate on the foreign currency portfolio, R_t^F, and the interest rate of the foreign country, R_t^*. This spread is proportional to the (real) value of the country's net foreign asset position, $\frac{R_t^F}{R_t^*} = -\zeta\left(e_t^r B_t^*\right)$ where $\zeta > 0$[15], $\zeta' < 0$. It is assumed that all goods are traded and that the *law of one price* holds, $P_H(i) = eP_H^*(i), P_F(i) = eP_F^*(i)$. Foreign agents face a maximization problem similar to the one of the domestic agents. However they do not face any additional cost of portfolio allocation so that they always receive the same

[15] As shown in Schmitt-Grohe and Uribe (2001) this assumption is needed in order to maintain the stationarity in the model and it does not change quantitatively the dynamic of the model compared to the complete market case.

interest rate, R_t^*. The uncovered interest rate parity is obtained using optimality conditions for both, domestic and foreign workers, and applying arbitrage:

$$E_t \left\{ \frac{U_{c,t+1}^*}{U_{c,t}^*} \right\} = E_t \left\{ \frac{U_{c,t+1}}{U_{c,t}} \frac{e_{t+1}^r}{e_t^r} \right\} \zeta \left(e_t^r B_t^* \right) \tag{6}$$

3.1. Production and Pricing of Intermediate Goods

Each domestic worker owns an equal share of the intermediate-goods producing firms. Each firm assembles labor and capital to operate a constant return to scale production function for the variety i of the intermediate good, $Y_t(i) = A_t F(N_t(i), K_t(i))$, with A_t being a productivity shock. Each firm i has monopolistic power in the production of its own variety and therefore has leverage in setting the price. In so doing it faces a quadratic resource cost of adjusting prices equal to $\varkappa_t(i) = \frac{\omega_p}{2} \left(\frac{P_{H,t}(i)}{P_{H,t-1}(i)} - 1 \right)^2$, where the parameter ω_p measures the degree of nominal price rigidity. The problem of each domestic monopolistic firm is the one of choosing the sequence $\{K_t(i), N_t(i), P_{H,t}(i)\}_{t=0}^{\infty}$ in order to maximize expected discounted real profits:

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^t U_{c,t} \frac{P_{H,t}(i) Y_t(i) - (W_t N_t(i) + Z_t K_t(i)) - P_{H,t} \varkappa_t(i)}{P_{H,t}} \right\} \tag{7}$$

subject to the demand constraint: $Y_t(i) = A_t F(N_t(i), K_t(i)) \geq (\frac{P_{H,t}(i)}{P_{H,t}})^{-\varepsilon} (C_{H,t} + C_{H,t}^* + C_t^e + I_t)$, with $C_{H,t} + C_{H,t}^* + C_t^e + I_t$ being the world demand for the domestic intermediate variety i. Since adjustment costs are symmetric across firms all firms will charge the same price. Let's denote by $\{mc_t\}_{t=0}^{\infty}$ the lagrange multiplier on the demand constraint[16], by $\widetilde{p}_{H,t} \equiv \frac{P_{H,t}(i)}{P_{H,t}}$ the relative price of variety i, and by $\pi_{H,t} \equiv \frac{P_{H,t}}{P_{H,t-1}}$ the gross inflation rate. The first order conditions of the above problem read as follows:

$$\frac{W_t}{P_{H,t}} = mc_t A_t F_{n,t}; \frac{Z_t}{P_{H,t}} = mc_t A_t F_{k,t} \tag{8}$$

[16] Notice that mc_t plays the role of the *real* marginal cost of production.

$$0 = U_{c,t} X_t^W \widetilde{p}_{H,t}{}^{-\vartheta} \left((1-\vartheta) + \vartheta mc_t \right) - U_{c,t}\omega_p \left(\pi_{H,t} \frac{\widetilde{p}_{H,t}}{\widetilde{p}_{H,t-1}} - 1 \right) \frac{\pi_{H,t}}{\widetilde{p}_{H,t-1}} + \beta U_{c,t+1}\omega_p \left(\pi_{H,t+1} \frac{\widetilde{p}_{H,t+1}}{\widetilde{p}_{H,t}} - 1 \right) \pi_{H,t+1} \frac{\widetilde{p}_{H,t+1}}{\widetilde{p}_{H,t}{}^2} \tag{9}$$

4. Adding Investment and Finance

To introduce financial frictions in this model we follow Bernanke, Gertler and Gilchrist (1998) and assume the existence of a second set of agents, the entrepreneurs who invest in physical capital. In each period entrepreneurs rent to firms in the competitive unit the existing capital stock that they own and finance investment in new capital, K_{t+1}, which is sold at a price Q_t. To finance the purchase of new capital they use internal funds, NW_t, as well as loans, $L_t = Q_t K_t - NW_t$, obtained from a competitive intermediary that raises funds through deposits. The return on capital is subject to an idiosyncratic shock, ω^j,which is distributed with a log-normal density and can be observed only at a cost μ. For the relationship with the lender is subject to an agency cost problem the entrepreneur needs to pay an external finance premium on the loan. In each period entrepreneurs choose a sequence $\{C_t^e, I_t, K_{t+1}, L_t\}_{t=0}^{\infty}$ to maximize[17] the sum of discounted linear utilities[18]: $E_0 \sum_{t=0}^{\infty} (\varsigma\beta)^t C_t^e$, with ς being the survival probability. In each period wealth is derived from rental income $Z_t K_t$ for production, new loans L_t and a transfer of wealth, Σ_t, with the latter implying that aggregate net wealth is always different from zero. Expenditure is allocated in final good consumption C_t^e, investment I_t and in the service of the predetermined loan debt $R_t^L L_t$. Entrepreneurs' budget constraint (in units of domestic consumption goods) reads as follows:

$$\frac{Z_t}{P_t} K_t + L_{t+1} + \Sigma_t = C_t^e + I_t + R_t^L L_t \tag{10}$$

[17] As we shall see later in the section describing the optimal contract the assumption of a monitoring technology exhibiting constant returns to scale implies *linearity and symmetry* of the relationships which characterize the contracting problem. Hence we can spell out the consumption/investment problem of the entrepreneurs by imposing symmetry ex-ante.

[18] It is assumed that entrepreneurs are risk neutral and finitely lived. This assumption implies that borrowing constraints on loans are always binding.

Capital is accumulated facing adjustment costs in production:

$$K_{t+1} = (1-\delta)K_t + I_t - \Phi\left(\frac{I_t}{K_t}\right)K_t \tag{11}$$

The cost function $\Phi(\cdot)$ is convex and satisfies $\Phi(\delta) = 0$ and $\Phi'(\delta) = 0$, where δ is the depreciation rate of capital. Let's define $\{\lambda_t, Q_t\}_{t=0}^{\infty}$ as the sequence of Lagrange multipliers on the constraints (10) and (11) respectively. The first order conditions of the above problem read as follows:

$$\lambda_t = \varsigma\beta E_t\left\{R_t^L \lambda_{t+1}\right\} \tag{12}$$

$$Q_t\left[1-\Phi'\left(\frac{I_t}{K_t}\right)\right] = \lambda_t \tag{13}$$

$$Q_t = \varsigma\beta E_t\left\{\frac{Z_{t+1}}{P_{t+1}}\lambda_{t+1} + Q_{t+1}\left(1-\delta+\frac{I_{t+1}}{K_{t+1}}\Phi'\left(\frac{I_{t+1}}{K_{t+1}}\right) - \Phi(\frac{I_{t+1}}{K_{t+1}})\right)\right\} \tag{14}$$

Due to risk neutrality of the entrepreneurs the marginal utility of additional real income is constant. Equation (12) is the Euler efficiency condition on the loan holding. Equations (13) and (14) are the efficiency conditions on capital investment. Notice that the lagrange multiplier Q_t denotes the real shadow value of installing new capital and thus plays the role of the implicit price of capital (or asset price). By rearranging the above conditions the *return* from holding a unit of capital between t and $t+1$ can be written as $R_{t+1}^k \equiv E_t\{\frac{\mathcal{Y}_{t+1}^k}{Q_t}\}$ with $\mathcal{Y}_t^k \equiv \frac{Z_t}{P_t} + Q_t\left(1-\delta+\frac{I_t}{K_t}\Phi'\left(\frac{I_t}{K_t}\right) - \Phi(\frac{I_t}{K_t})\right)$. Aggregate consumption in this set-up is given by the fraction of entrepreneurs that survive in each period, which by law of large number is equal to the survival probability of entrepreneurs, multiplied by end of period wealth, $NW_t - \Sigma_t$:

$$C_t^e = \varsigma(NW_t - \Sigma_t) \tag{15}$$

4.1. The Financial Intermediary and Differences in Financial Systems

The financial contract between the entrepreneurs and the intermediary assumes the form of an optimal debt contract à la Gale and Hellwig (1983). When the idiosyncratic shock to capital investment is above the cut-off value which determines the default states the entrepreneurs repay an amount R^L_{t+1}[19]. On the contrary, in the default states, the bank monitors the investment activity and repossesses the assets of the firm. Default occurs when the return from the investment activity $\omega^j_{t+1}\mathcal{Y}^k_{t+1}K^j_{t+1}$ falls short of the amount that needs to be repaid $R^L_{t+1}L^j_{t+1}$. Hence the *default space* is implicitly defined as the range for ω such that :

$$\omega^j_{t+1} < \varpi^j_{t+1} \equiv \frac{R^L_{t+1}L^j_{t+1}}{\mathcal{Y}^k_{t+1}K^j_{t+1}} \tag{16}$$

where ϖ^j_{t+1} is a cutoff value for the idiosyncratic productivity shock. Let's define by $\Gamma(\varpi^j) \equiv \int_0^{\varpi^j_{t+1}} \omega^j_{t+1} f(\omega)d\omega + \varpi^j_{t+1}\int_{\varpi_{t+1}}^{\infty} f(\omega)d\omega$ and $1-\Gamma(\varpi^j)$ the fractions of net capital output received by the lender and the entrepreneur respectively. Expected bankruptcy costs are defined as $\mu M(\varpi^j_{t+1}) \equiv \mu\int_0^{\varpi^j_{t+1}} \omega^j_{t+1} f(\omega)d\omega$ with the *net share* accruing to the lender being $\Gamma(\varpi^j_{t+1}) - \mu M(\varpi^j_{t+1})$. The real return paid on deposits is given by the safe rate, R_t, which as such corresponds, for the lender, to the opportunity cost of financing capital. The *participation constraint* for the lender states that the expected return from the lending activity should not fall short of the opportunity cost of finance:

$$\mathcal{Y}^k_{t+1}K^j_{t+1}(\Gamma(\varpi^j_{t+1}) - \mu M(\varpi^j_{t+1})) \geq R_t(Q_tK^j_{t+1} - NW^j_{t+1}) \tag{17}$$

The contract specifies a pair $\left\{\varpi^j_{t+1}, K^j_{t+1}\right\}$ which solves the following maximization problem:

$$Max\ (1-\Gamma(\varpi^j_{t+1}))\mathcal{Y}^k_{t+1}K^j_{t+1} \tag{18}$$

[19] In every period t this amount must be independent from the idiosyncratic shock in order to satisfy incentive compatibility conditions.

subject to the participation constraint (17). Two assumptions make aggregation feasible: 1) A constant fraction ς of entrepreneurs remain alive in every period. 2) The optimal contract linear relations. Using the first order conditions with respect $\left\{\varpi_{t+1}^{j}, K_{t+1}^{j}\right\}$ and aggregating yield a wedge between the return on capital and the safe return paid on deposits, $\rho(\varpi_{t+1}) = \left[\frac{(1-\Gamma(\varpi_{t+1}))(\Gamma'(\varpi_{t+1})-\mu M'(\varpi_{t+1}))}{\Gamma'(\varpi_{t+1})} + (\Gamma(\varpi_{t+1}) - \mu M(\varpi_{t+1}))\right]^{-1}$, which is positively related to the default threshold. By defining $rp_t \equiv \frac{R_{t+1}^k}{R_t}$ as the *premium on external finance* and by combining (17) with the expression for $\rho(\varpi_{t+1})$ it is possible to write a relation between the ex-post external finance premium, rp_t, and the leverage ratio, $\frac{Q_t K_{t+1}}{NW_{t+1}}$:

$$\frac{R_{t+1}^k}{R_t} = rp_t(\frac{Q_t K_{t+1}}{NW_{t+1}}) \tag{19}$$

with $rp_t'(\frac{Q_t K_{t+1}}{NW_{t+1}}) > 0$. An increase in net worth or a decrease in the leverage ratio reduces the optimal cut-off value, as shown by equation (16). By reducing the size of the default space it also reduces the size of the bankruptcy costs and the external finance premium. The relation obtained in equation (19) can also be written in terms of borrowing limit as $L_{t+1} = NW_{t+1}(rp_t^{-1}(\frac{R_{t+1}^k}{R_t}) - 1)$ stating that the higher is the external finance premium the lower is the amount that can be borrowed. As it stands clear the quality of the financial system is determined by the size and the sensitivity to collateral (the net worth) of the external finance premium. In turn the external finance premium depends from the size of the bankruptcy costs and the volatility of the idiosyncratic shock (corporate risk) as from $\rho(\varpi_{t+1})$. In the calibration section the two countries are parametrized by assigning different values to those parameters.

Aggregate net wealth accumulation of the economy reads as follows:

$$NW_{t+1} = \varsigma[R_t^k Q_{t-1} K_t - (R_t + rp_{t-1}(\frac{Q_{t-1}K_t}{NW_t}))(Q_{t-1}K_t - NW_t) - \Sigma_t] \tag{20}$$

The presence of financial frictions typically enhances business cycle volatility. To understand the intuition consider a shock that reduces the interest rate. In this case investment raises not only because of the increase in the marginal productivity of capital but also since the cost of lending decreases. Such decrease also induces an increase in the value of net worth which in turn reduces the external finance premium thereby *accelerating* the increase in investment. Clearly the tighter are the financial constraints the higher is the volatility of business cycle.

4.2. Equilibrium Conditions and Monetary Policy Rules

Asset market equilibrium implies that the world net supply of bonds is zero and that deposits are equal to loans in each country. After imposing market clearing for each domestic variety i, aggregating and substituting the relevant demand functions, the resource constraint reads as follows:

$$Y_t = \left(\frac{P_{H,t}}{P_t}\right)^{-\eta}(1-\gamma)\,C_t + \left(\frac{P_{H,t}}{e_t P_t^*}\right)^{-\eta}\gamma^* C_t^* + C_t^e + I_t + \frac{\omega_p}{2}\left(\pi_{H,t}-1\right)^2 + \mu M(\varpi_t) R_t^k Q_{t-1} K_t \quad (21)$$

Three different policy regimes are compared. In the first each monetary authority follows a standard *Taylor type rule* with a coefficient on inflation of 1.5, a coefficient on output of 0.5 and an interest rate smoothing of 0.8. In the second regime each monetary authority follows a strict *price stability rule* and sets inflation to zero. In the third policy regime the domestic monetary authority follows a standard *Taylor type rule* while the foreign monetary authority fixes the exchange rate so as to set its nominal interest rate equal to the one of the domestic country.

5. Calibration

The two countries are assumed to be symmetric in preferences and technologies but not in financial conditions.

Calibrating Preferences, Production and Pricing. The discount factor is set to $\beta = 0.99$; time is measured in quarters, so the annual interest rate is equal to roughly 4 percent. The elasticity of substitution between domestic and foreign goods η is equal to 1.5 as in Backus, Kehoe and Kydland (1992). The parameter on consumption in the utility function is set equal to one to generate a log utility. This value is compatible with a steady state trade balanced growth path. The parameter on labor in the utility is set equal to 3. The steady state balanced growth ratio of exports over GDP is varied between $\gamma = 0.15$ and $\gamma = 0.3$, the first value being compatible with data for US and Europe. The steady state net asset position is symmetric between the two countries. Following Schmitt-Grohe and Uribe (2001) and consistently with Lane and Milesi-Ferretti (2003) the elasticity of the spread on foreign bonds to the net asset position, ζ, is set to 0.000742. Following Basu and Fernald (1997) the value added mark-up of prices over marginal cost is set to 0.2. This generates a value for the price elasticity of demand, ε, of 6. Given the assigned value for μ and consistently with estimates by Sbordone (1998), the cost of adjusting prices ω_p becomes equal to 17.5.

Calibrating Investment and Finance. The share of capital in the production functions, α, is equal to 0.35. The quarterly depreciation rate, δ, is set equal to 0.025. The latter implies an annual depreciation rate of roughly 10%, a value compatible with empirical estimates for the US economy. The elasticity of the price of capital with respect to investment output ratio, $\varphi = [(\Phi(\frac{I}{K})^{-1})'(\frac{I}{K})/(\Phi(\frac{I}{K})^{-1})'']$, is set equal to 0.8. The latter has been chosen so as to generate a volatility of investment higher than the volatility of consumption as observed in the data.

The financial differences between the two countries are obtained by assuming three different types of financial structures ("scenarios") for the foreign country given one scenario for the home country. The parameter values in the three scenarios are summarized in Table 4. The scenarios are obtained calibrating three free parameters: 1) the variance of the idiosyncratic shock, $\sigma_{\overline{\omega}^j}$,(corporate risk), 2) the bankruptcy cost for the bank, μ, 3) the survival rate of firms, ς. The solution of the contract[20] in the steady state leads to values for: 1)

[20]The first order conditions for the contract are three equations in three variables. One needs to specify

the elasticity of external finance premium to the leverage ratio, $rp(\bullet)$, 2) the steady state external finance premium, rp, 3) the optimal cut-off value $\overline{\omega}^j$ and the default probability $F(\overline{\omega}^j)$. In general higher values for the bankruptcy costs or the volatility of the idiosyncratic shock exacerbate borrowing constraints. To illustrate this, figure 2 shows the effects on the contract solution of changes in the bankruptcy cost or in the volatility of idiosyncratic shock (measured at annual rate). An increase in any of the two latter variables induces a decrease in the cut-off value since banks are less willing to monitor. On the other side, banks demand higher external finance premia due to the increase in the default probability.

In table 4[21] the bankruptcy cost is varied in a range consistent with values corresponding to the loan loss provisions in table 1, while the volatility of the idiosyncratic shock is set so as to generate values for the steady state external finance premium consistent with those observed for OECD economies.

The productivity shock has a volatility of 0.008, a persistence of 0.9, and a correlation across countries of 0.3 (see Smets and Wouters (2004)) and the monetary policy shock has a volatility of 0.005, zero persistence and a correlation across countries of 0.6.

6. Properties of the Model

The dynamic properties of the model are now analyzed under technology and monetary policy shocks. The results can be grouped in three broad headings.

1. Under Taylor rules, the correlations of business cycles is a decreasing function of financial diversity.

2. In accordance with earlier studies and empirical evidence, an increase in the degree of trade openness raises the business cycle correlation, while an increase in financial openness lowers it.

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the three free parameters to get the three unknowns.

[21] Values on quarterly basis.

3. The form of the monetary policy rule has consequences for both the volatility of the business cycles within countries and the degree of co-movement across countries.

Table 5 shows bilateral correlations of output between the two countries with different shocks (correlated technology and monetary policy shocks), under Taylor rules and considering the three financial scenarios described in section 5. The domestic country is parametrized as in scenario 1 while the foreign country is parametrized alternatively as in scenarios 1,2,3, hence increasing the financial distance. In all cases the correlation of output decreases when financial distance increases. This occur because different degrees of loan sensitivity to collateral imply different responses to shocks[22].

The characterization of the international transmission mechanism so far proposed is reinforced by the observation of the patterns of volatilities across the three scenarios. Table 6 shows that the second moments of output, investment and asset price tend to diverge when the financial distance increases. In particular, volatilities increase for the country with higher external finance premium[23].

Note that the values of the correlations of output are positive in all cases[24]; this suggests that the introduction of financial frictions helps resolve the well-known output correlation puzzle, consisting in the fact that the empirical co-movements of output, investment and employment across countries are positive, contrary to the predictions of standard real business cycle models[25]. The model generates positive co-movements of output, investment and employment due to a sort of *financial spillover* effect; to understand this, figure 3 shows impulse responses of domestic and foreign variables to a 1% domestic technology shock under

[22] This happens independently from the correlations of the underlying shocks; the evidence is not reported here but is available on request.

[23] This result is consistent with evidence provided by Mihov (2002) who shows that volatilities of de-trended output across countries is an increasing function of the leverage ratio.

[24] The same is true of the cross-correlations of investment and employment which follow the same patterns as the ones of output. They are positive in all cases and tend to decrease when financial distance increases.

[25] Backus, Kehoe and Kydland (1992), Baxter and Crucini (1994) and Stockman and Tesar (1995), among others.

the assumption that both countries are in scenario 2. Intuitively, when a positive technology shock hits the home country we observe an increase in domestic output and investment as well as a demand shift between domestic and foreign goods which induces a decrease in foreign inflation and a decrease of foreign output and investment. This effect, coupled with capital flows toward the home country, would normally produce negative correlations of output, investment and employment between the two countries contrary to what observed in the data. However, in this model the fall in foreign inflation induces a fall in foreign interest rates, due to the response of monetary policy coupled with sticky prices. As a result, the foreign economy experiences a fall in the cost of loans that boosts investment and asset prices[26]. The positive financial effect tends to offset the negative impact of the demand shift on the foreign country business cycle. The magnitude of the financial spillover depends on the financial distance and on the sensitivity of the foreign external finance premium to collateral conditions, thus generating the link between financial structures and international business cycle co-movements.

The numerical experiments have been repeated varying the degree of trade openness (measured by the parameter γ) and of financial openness (obtained assuming that loans are denominated in foreign currency); see table 5. An increase in the degree of trade openness tends to raise the correlations of cycles since, by reducing the home bias, it reduces the magnitude of the switching expenditure effect. An increase in the financial openness, on the contrary, enhances business cycle divergence. This is because movements in the exchange rates impact the cost of the loans and the value of collateral, implying a wealth transfer across countries, which exacerbates the differential response[27].

[26] It is worth noticing that in the present model an increase of domestic TFP produces an increase of foreign asset prices. The recent open economy literature does not provide explanation of the link between total factor productivity shocks in the US and asset prices in Europe. This link is examined in other areas of macroeconomics – see Greenwood and Jovanovic (1999).

[27] This is consistent with empirical evidence of Heathcote and Perri (2004) showing that financial globalization leads to more asymmetric cycles.

Finally, we focus on the impact of the monetary policy regimes on business cycle volatilities and co-movements. Table 6 shows that under a strict price stability rule (i.e. when inflation enters the central bank's instrument rule with a very high weight) the volatility of the home and foreign variables is higher; intuitively, under a rigid inflation target the nominal interest rate becomes very volatile, thereby increasing financial instability. Table 7 shows that under credible pegs business cycle correlations tend to increase. This is so because when the foreign interest rate is set equal to the domestic interest rate the impact of financial differences is mitigated and cycles are more synchronized.

7. Conclusion

Financial structures are often invoked to explain the transmission of monetary policy or other domestic shocks, but so far they have not been used in the analysis of international interdependence. This paper fills this gap by examining the role that financial market differences play in the international transmission of shocks.

It is shown that a negative empirical relation exists between the degree of business cycle co-movement among the OECD economies and a measure of financial difference. A two country DSGE model with sticky prices and financial frictions is built and shown to be able to replicate this relation. The robustness of this finding is explored under different monetary policy regimes and alternative model parameter values. Output co-movements increase under credible exchange rate pegs and when trade openness increases; on the contrary, they decrease under financial openness. Finally, the model is able to replicate other key international business cycle facts. For these reasons, I believe that the framework I propose is promising for conducting further research, particularly on the welfare effects of alternative policy regimes in presence of financial diversity.

References

Ambler, Steve, Emanuela Cardia, and Christian Zimmermann. (2002) "International Transmission of the Business Cycle in a Multi-Sectoral Model." *European Economic Review*, 46(2), pages 273-300.

Backus, David K., Patrick J. Kehoe, and Finn E. Kydland. (1992) "International Real Business Cycles." *Journal of Political Economy,* 101, 745-775.

Basu, Susanto, and John Fernald. (1997) "Returns to Scale in U.S. Production: Estimates and Implications." *Journal of Political Economy*, 105-2, 249-83.

Baxter, Marianne. (1994) "International Trade and Business Cycle." NBER w.p. 5025.

Baxter, Marianne, and Mario Crucini. (1994) "Business Cycles and the Asset Structure of Foreign Trade." *International Economic Review* 36, 821-854.

Baxter, Marianne, and Robert King. (1999) "Measuring Business Cycle: Approximate Band Pass Filters for Economic Time Series." *Review of Economic and Statistics*, 81:4.

Baxter, Marianne, and D. Farr. (2001) "Variable Factor Utilization and International Business Cycles." mimeo.

Bernanke, Ben, Mark Gertler, and Simon Gilchrist. (1999) "The Financial Accelerator in a Quantitative Business Cycle Framework", in J.B. Taylor, and M. Woodford, eds., *Handbook of Macroeconomics*, Amsterdam: North-Holland.

Carlstrom, Charles, and Timothy Fuerst. (1997) "Agency Costs, Net Worth and Business Fluctuations: A Computable General Equilibrium Analysis." *American Economic Review,* 87, 893-910.

Cecchetti, Stephen G. . (1999) "Legal Structure, Financial Structure, and the Monetary Policy Transmission Mechanism." NBER Working Papers 7151, National Bureau of Economic Research, Inc.

Gale, Douglas, and Martin Hellwig. (1985) "Incentive-Compatible Debt Contracts: The One-Period Problem." *Review of Economic Studies,* 52, 647-663.

Greenwood, Jeremy, and Boyan Jovanovic. (1999) "The IT Revolution and the Stock Market." RCER Working Papers 460, University of Rochester - Center for Economic Research (RCER).

Heathcote, Jonathan, and Fabrizio Perri. (2004) "Financial Globalization and Real Regionalization." *Journal of Economic Theory,* 199(1), 207-243.

Heathcote, Jonathan, and Fabrizio Perri. (2002) "Financial Autarky and International Business Cycle." *Journal of Monetary Economics,* 49(3), 601–627.

Kehoe, Patrick, and Fabrizio Perri. (2002) "International Business Cycle and Endogenous Incomplete Markets." *Econometrica,* 70(3), 907-928.

Kiyotaki, Nobu, and John Moore. (1997) "Credit Cycles." *Journal of Political Economy,* 105, April , 211-48.

Lane, Philip R., and Gian M. Milesi-Ferretti. (2003) "International Financial Integration." CEPR d.p. 3769.

La Porta, Rafael, Florencio Lopez-de-Silanes, Andrei Shleifer, and Robert Vishny, (1997), "Legal Determinants of External Finance," NBER w.p. 5879.

Mihov, Ilian. (2001) "Monetary Policy Implementation and the Transmission in the European Monetary Union." *Economic Policy,* 33.

Smets, Frank, and Raf Wouters. (2005) "Comparing Shocks and Frictions in US and Euro Area Business Cycles: A Bayesian DSGE Approach." *Journal of Applied Econometrics,* 20(1).

Rotemberg, Julio. (1982), "Monopolistic Price Adjustment and Aggregate Output." *Review of Economics Studies,* 44, 517-531.

Sbordone, Argia. (1998) "Prices and Unit Labor Costs: A New Test of Price Stickiness", *Journal of Monetary Economics.*

Schmitt-Grohe, Stephanie, and Martin Uribe. (2003) "Closing Small Open Economy Models", *Journal of International Economics,* 61,

163-185.

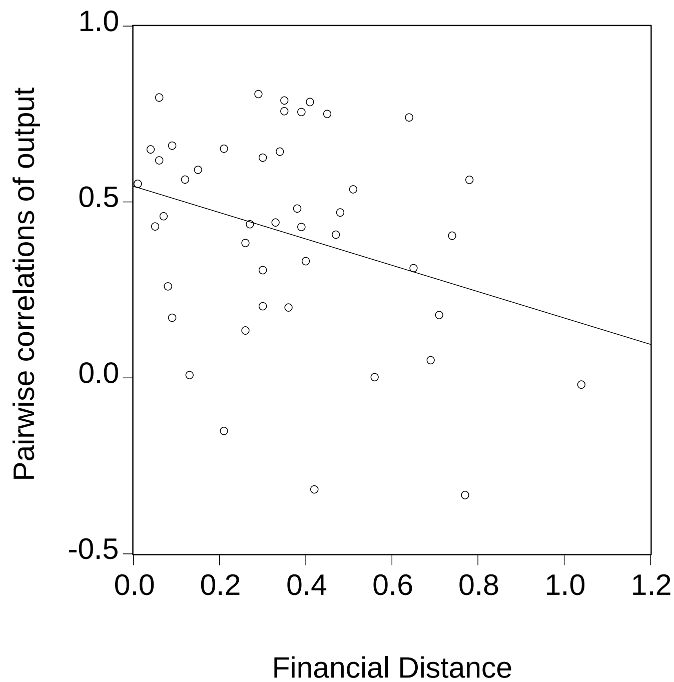

Figure 1: **Pairwise correlations of de-trended output and financial distance.**

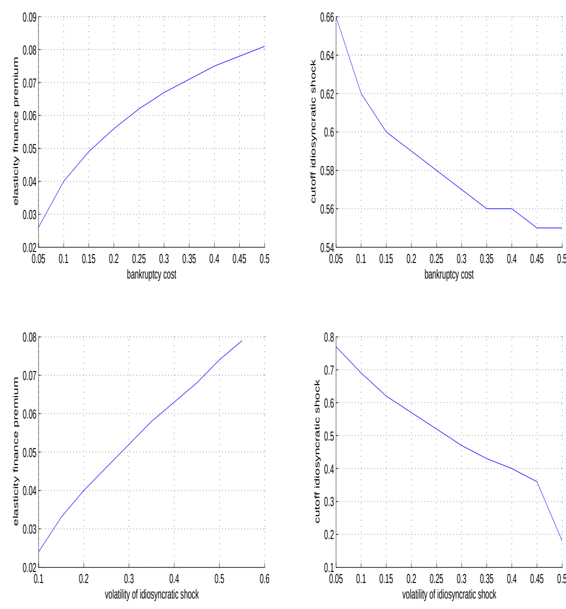

Figure 2: **Properties of the contract solution.**

Table 1: **Indicators of bank industry health and importance of external finance for a set of OECD countries.**

Countries	Return on assets	Provisions	External Finance	Thomson Rating
Austria	0.38	0.59	46	2.38
Belgium	0.52	0.17	60	2.00
Finland	0.50	0.78	34	2.83
France	0.36	0.24	49	2.28
Germany	0.44	0.18	58	1.97
Greece	1.11	0.18	3	2.50
Ireland	1.57	0.17	13	1.83
Italy	0.33	0.62	37	2.57
Netherlands	0.75	0.26	48	2.10
Portugal	0.91	0.42	19	2.30
Spain	0.76	0.32	11	1.79
Euro area	0.50	0.32	41	2.16
UK	1.28	0.18	45	2.04
US	1.42	0.10	64	1.73
Japan	0.01	0.75	39	3.32

Return on assets: ratio between gross bank profits and the stock of bank assets.

Provisions: loan loss provisions as percent of total loans.

External finance: external finance of corporate sector as percent of GDP.

Thomson rating: indicator of bank health (a lower value indicates a sounder banking system).

Data are for the 1997 and are taken from Cecchetti (1999).

Table 2: **Pairwise output correlations in the G7.**

	US	Japan	Germany	France	Italy	UK	Canada
United States							
Japan	-0.60						
Germany	-0.57	0.53					
France	-0.10	0.05	0.72				
Italy	-0.28	0.38	0.75	0.74			
United Kingdom	0.68	-0.36	-0.38	-0.14	0.15		
Canada	0.79	-0.66	-0.38	0.15	0.08	0.82	

Source: IMF World Economic Outlook (2001).

Table 3: **Regressions of the pairwise correlations of output on financial distance and other control variables in the OECD.**

Dep var: Corr of output	Regression 1	Regression 2	Regression 3
Constant	0.55	0.55	1.02
	(5.26)*	(5.62)	(3.67)
Financial Distance	-0.37	-0.37	-0.30
	(-2.07)	(-2.047)	(-1.61)
Trade		-0.02	-0.05
		(-0.19)	(-0.57)
Language dummy			-0.09
			(-1.79)

∗t-statistic in parenthesis.

Table 4: **Calibration of the financial parameters.**

Free Parameters	Mnemonics	Scenario 1	Scenario 2	Scenario 3
Volatility of idiosyncratic shock	$\sigma_{\bar{\omega}_j}$	0.26	0.28	0.28
Bankruptcy cost	μ	0.07	0.12	0.3
Survival probability	ς	0.98	0.975	0.97
General equilibrium parameters				
Steady state bankruptcy threshold	$\bar{\omega}_j$	0.53	0.52	0.47
Elasticity of finance premium	$rp_t(.)$	150	370	420
Finance premium in steady state	rp^{ss}	0.02	0.05	0.08

The home country is always parametrized as in the column labelled scenario 1.

The foreign country is parametrized alternatively as in columns labelled scenario 1, 2 and 3.

Table 5: **Model based output correlations under different shocks and degrees of trade and financial openness.**

	Scenario 1	Scenario2	Scenario3
Taylor rules			
Productivity shocks, $\gamma^{*} = 0.15$	0.30	0.24	0.16
Productivity shocks, $\gamma = 0.3$	0.31	0.24	0.14
Productivity shocks**, $\gamma = 0.15$	0.29	0.23	0.15
Monetary policy shocks, $\gamma = 0.15$	0.62	0.55	0.48
Monetary policy shocks, $\gamma = 0.3$	0.64	0.58	0.49
Monetary policy shocks**, $\gamma = 0.15$	0.61	0.54	0.47

∗Trade openness (ratio of exports to GDP)

∗∗Financial openness (loans are denominated in foreign currency)

Table 6: **Model based second moments with productivity shocks and under different monetary policy rules.**

	Scenario 1	Scenario 2	Scenario3
Taylor rule			
Domestic output σ_y^2	1.34	1.34	1.34
Foreign output σ_{y*}^2	1.34	1.36	1.47
Domestic investment σ_I^2	0.83	0.84	0.85
Foreign investment σ_{I*}^2	0.83	2.36	3.68
Domestic asset price σ_q^2	0.48	0.49	0.5
Foreign asset price σ_{q*}^2	0.48	1.46	2.57
Price stability rule			
Domestic output σ_y^2	2.13	2.12	2.12
Foreign output σ_{y*}^2	2.13	2.89	4.20
Domestic investment σ_I^2	1.42	1.41	1.39
Foreign investment σ_{I*}^2	1.42	2.42	3.18
Domestic asset price σ_q^2	0.96	0.95	0.93
Foreign asset price σ_{q*}^2	0.96	1.57	2.20
Credible pegs			
Domestic output σ_y^2	1.31	1.33	1.33
Foreign output σ_{y*}^2	1.71	2.11	3.08
Domestic investment σ_I^2	0.62	0.62	0.66
Foreign investment σ_{I*}^2	1.14	2.45	3.49
Domestic asset price σ_q^2	0.45	0.46	0.49
Foreign asset price σ_{q*}^2	0.76	1.55	2.39

Table 7: **Model based correlations of output between the two countries under both productivity and technology shocks: Taylor rule versus credible pegs.**

	Scenario 1	Scenario2	Scenario3
Taylor rules	0.42	0.38	0.31
Credible pegs	0.42	0.42	0.34

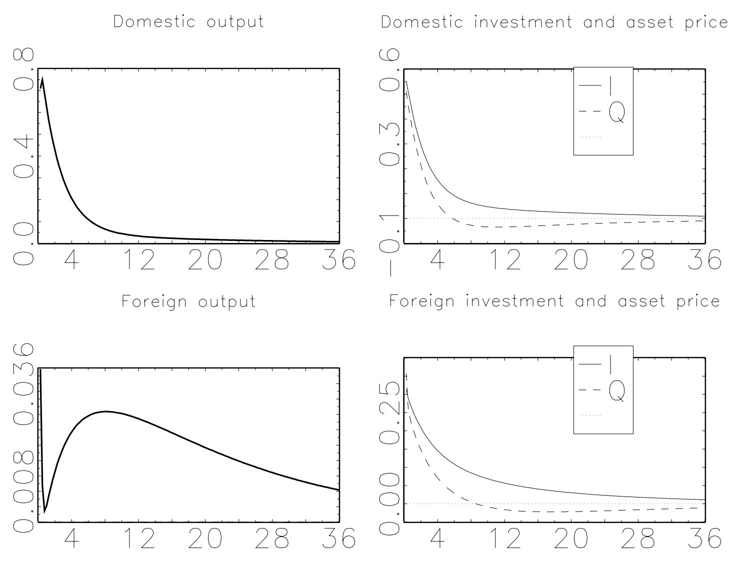

Figure 3: **Impulse responses of domestic and foreign variables to 1% domestic productivity shock.**