Dynamics of the Current Account and Interest Differentials

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Abstract

In contrast to earlier work, we study the relation between the current account and the interest rate differential. To do so, we document the relation for international data. We then interpret this relation from a two-country, dynamic, general equilibrium model, where a financial intermediary faces operating costs that are increasing and convex in the volume of internationally intermediated funds. We finally confront the relation predicted by the model to the relation observed in the data. We find that the model correctly predicts that the current account is negatively correlated with current and future interest differentials, but positively correlated with past interest differentials; that the current account is countercyclical; and that the interest differential is procyclical.

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1. Introduction

The analysis of the current account and the interest rate differential have been major, yet separate enterprises. In fact, most studies ignore the relation between the current account and the interest differential. This is surprising since intuition suggests that current accounts and interest rates jointly adjust to ensure the equilibria of both the world capital and good markets.

To fill this gap, we pursue three objectives. First, we document the relation between the business cycle fluctuations of the current account and of the interest differential for 10 developed economies over the post-1975 period. Our measure of the current account is the ratio of the current account to output. Our measure of the interest differential is the spread between country-specific and world interest rates. The country-specific interest rate is the ex-ante, short term, real interest rate, and the world interest rate is a weighted average of the country-specific rates.

Empirically, the correlations between lags of the current account and the interest differential are negative, but the correlations between leads of the current account and the interest differential are positive, with the turning point usually occuring at the two-quarter lead. This asymmetric shape of the cross-correlation function resembles a horizontal S. This S-curve encompasses the negative relation between the current account and the interest differential discussed in Bernhardsen (2000) and Lane and Milesi-Ferreti (2002). In addition, the S-curve is similar to the shape of the cross-correlation function for net exports and the terms of trade documented in Backus, Kehoe, and Kydland (1994). Also, the current account is countercyclical, while the interest differential is procyclical.

Second, we construct a symmetric two-country, dynamic, general equilibrium model with costly financial intermediation. In the environment, countries engage in trade of homogenous goods. This is similar to the specification used in the seminal work of Backus, Kehoe, and Kydland (1992), and thus offers a natural starting point for our analysis. Countries also engage in trade of one-period bonds only. This restriction is similar to the one used in Baxter and Crucini (1995), and allows a straightforward computation of the current account. Finally, trades in the world capital market are costly. This is in the spirit

of the debt-elastic interest rate specification used in Schmitt-Grohé and Uribe (2003), and implies the existence of interest differentials. In particular, we introduce a price-taking financial intermediary that faces operating costs. The costs are increasing and convex in the volume of international funds intermediated. In equilibrium, the intermediary charges a higher rate to borrowers than the rate promised to lenders, and this spread is increasing in the volume of funds borrowed.

For plausible parameter values, our environment generates dynamic responses that hint at prominent predicted features. Specifically, following positive domestic shocks, the responses of the current account are generally negative, whereas the responses of the interest differential and output are positive. The shape of these responses suggests that the current account is negatively correlated with current and future interest differentials, in accord with the S-curve. Also, this suggests that the current account is countercyclical, while the interest differential is procyclical.

Third, we statistically confront the relation between the current account and the interest differential predicted by the model to the relation observed in the data. The confrontation relies on the test procedure developed in Boileau and Normandin (2002). The observed relation corresponds to those found for the United States, an aggregate of the non-US countries, and the average of all 10 countries.

The model predicts an S-curve, with a turning point at the one-quarter lead. This S-curve statistically matches the S-curves of the United States for large values of lags and leads, of the Non-US Aggregate for low values of lags and leads, and of the 10-Country Average for low values of lags and large values of leads. Also, the environment predicts that the current account is countercyclical and that the interest differential is procyclical. These predictions statistically match the observations for the United States, the Non-US Aggregate, and the 10-Country Average.

To some extent, our paper is related to those of Uribe and Yue (2006) and Olivero (2006). Uribe and Yue (2006) also study an international model with financial intermediation. They employ a similar formulation of the financial intermediary, but embed it in a small open economy model. As in our model, this implies a spread between home and foreign interest rates that is increasing in the volume of funds borrowed. They use the

model to study the effects of exogenous world (US) interest rate shocks and country spread shocks on the business cycle of developing economies. In contrast, we study the endogenous relation between the current account and the interest differential for industrialized economies.

Olivero (2006) constructs a two-country model where international non-competitive banks intermediate between consumers and entrepreneurs. In our model, the price taking intermediary intermediates between home and foreign consumers. Also, the model in Olivero (2006) generates an interest differential that, in expectations, depends on movements in the terms of trade. Our model assumes trade in homogenous goods, so that the interest differential does not depend on changes of either the terms of trade or the real exchange rate, but rather on the volume of funds intermediated. Moreover, Olivero (2006) studies the cross-country correlations of consumption, employment, investment, and output for industrialized economies. In contrast, we study the endogenous relation between the current account and the interest differential for industrialized economies.

Finally, our paper is indirectly related to the literature on the failures of uncovered interest parity. We however focus on real rather than nominal interest rates, to generate a real interest differential that resembles a risk premium on uncovered interest parity. That risk premium does not resolve the forward premium anomaly. This anomaly highlights that currencies with high nominal interest rates are expected to appreciate, in contrast to the prediction of uncovered interest parity (e.g. Alvarez, Atkeson, and Kehoe 2005). In our model, purchasing power parity holds because countries trade homogenous goods. Under purchasing power parity, currencies with high expected inflation are expected to depreciate. Then, for given real interest rates, currencies with high expected inflation rates also have high nominal interest rates. Thus, our model predicts that currencies with high nominal interest rates are expected to depreciate, in accord with uncovered interest parity.

The plan of the paper is as follows. Section 2 documents the empirical regularities of the current account and the interest differential. Section 3 presents the economic environment. Section 4 reports test results. Section 5 concludes.

2. Empirical Regularities

We investigate the relation between the business cycle fluctuations of the current account and of the interest differential using postwar quarterly data for 10 developed countries.

2.1 Description of the Data

The data are fully described in Appendix A. The quarterly data covers the post-1975 period. The countries are Australia, Austria, Canada, Finland, France, Germany, Italy, Japan, the United Kingdom, and the United States. These countries are often considered in international real business cycle studies (e.g. Backus, Kehoe, and Kydland 1994), current account studies (e.g. Glick and Rogoff 1995), and interest differential studies (e.g. Lane and Milesi-Ferreti 2002). As a group, they account for 55 percent of the overall 1990 real gross domestic product of the 116 countries for which data are available in the Penn World Tables (Mark 5.6a).

Our definition of the current account is

$$x_t \equiv X_t / Y_t, \tag{1}$$

where X_t is the current account and Y_t is output. This measure is widely used in the current account literature (e.g. Taylor 2002).

Our definition of the interest differential is

$$d_t \equiv R_t - R_t^w, \tag{2}$$

where R_t is the ex-ante country-specific real gross return and R_t^w is the ex-ante world real gross return. The ex-ante real interest rate is the difference between the short-term nominal interest rate and the expected inflation rate. As in Nakagawa (2002), the short-term nominal interest rate is the rate on short lending between financial institutions. As in Barro and Sala-i-Martin (1990), the expected inflation rate is the one-quarter ahead predicted inflation rate from a univariate ARMA(1,1) process. The world interest rate is a weighted average of the country-specific interest rates, where the weights reflect the

country's share of the overall real output of the 10 countries. This measure is useful since it yields one time series per country instead of several bilateral series per country.

Figure 1 plots the two variables for the United States and the Non-US Aggregate (the aggregate of the 9 remaining countries). The United States and the Non-US Aggregate are entities of roughly similar sizes. On average, the United States account for 43 percent of the 10-country output in our data, while the Non-US Aggregate accounts for 57 percent. The decomposition of the 10 countries into the United States and the Non-US Aggregate will prove useful in later sections.

As hoped, the current account of the United States and the Non-US Aggregate mirror each other well (the correlation is -0.70). By construction, the interest differential for the United States and the Non-US Aggregate also mirror each other well (the correlation is -1.00).

2.2 Features of the Data

We report the salient features of the business cycle fluctuations of the current account and of the interest differential. As is standard, we measure the business cycle using the fluctuations of the logarithm of output. The fluctuations of the logarithm of output, the current account, and the interest differential correspond to the series detrended with the Hodrick-Prescott filter with a smoothing parameter of 1,600 (Hodrick and Prescott 1997). In what follows, we report the features for the 10 countries, as well as for the Non-US Aggregate and the 10-Country Average (the mean statistic over the 10 countries).

Figure 2 displays the cross-correlation function. The cross-correlation function is the sample dynamic correlations between the current account and the interest differential. These correlations are useful to summarize the joint behavior of our two variables of interest along the business cycle. In particular, the dynamic correlations capture comovements between leads and lags of the current account and the interest differential, and as such provide information about the shape of the relations between the variables taken at different points in time.

The cross-correlation function shows an asymmetric shape for 9 out of the 10 countries. That is, the correlations between lags of the current account and the interest differential

are negative, but the correlations between leads of the current account and the interest differential are positive, with the turning point usually occuring at the two-quarter lead. The turning point occurs earlier for Italy and later for Germany. The cross-correlation function is flat for the United States, but displays the overall S-shape. The cross-correlation function is also flat for the United Kingdom, but does not exhibit an S-shape. The asymmetric shape occurs with a two-quarter lead for the Non-US Aggregate and for the 10-Country Average. Interestingly, the asymmetric shape is similar to the S-curve documented in Backus, Kehoe, and Kydland (1994). That is, the cross-correlation function between net exports and the terms of trade display an asymmetric shape, where correlations between lags of net exports and the terms of trade are negative, but correlations between leads of net exports and the terms of trade are positive.

Table 1 reports correlation, relative volatility, and autocorrelation. Correlation corresponds to the sample contemporaneous correlation between variables. Relative volatility shows the ratio of the sample standard deviation of a variable to the sample standard deviation of output. Autocorrelation reports the sample first-order serial correlation of a variable. These statistics highlight other interesting features of the business cycle behavior of the current account and the interest differential.

First, the current account is negatively correlated with the interest differential. The correlation between the current account and the interest differential is negative for 9 out of the 10 countries. The correlation is -0.03 for the United States, -0.14 for the Non-US Aggregate, and -0.16 for the 10-Country Average. Note, however, that the estimates of the correlation are imprecise. In addition, the correlation captures only one point of the S-curve, since it entirely ignores the dynamic comovements of the current account and the interest differential.

Second, the current account is countercyclical, while the interest differential is procyclical. The correlation between the current account and output is negative for all countries. The correlation is -0.48 for the United States, -0.28 for the Non-US Aggregate, and -0.25 for the 10-Country Average. The correlation between the interest differential and output is positive for 8 out of the 10 countries. The correlation is 0.19 for the United States, 0.04 for the Non-US Aggregate, and 0.10 for the 10-Country Average.

Third, the current account is less volatile than output, and the interest differential is even less volatile than the current account. The current account is less volatile than output in 9 out of the 10 countries. The relative volatility is 0.30 for the United States, 0.49 for the Non-US Aggregate, and 0.62 for the 10-Country Average. The interest differential is less volatile than the current account and much less volatile than output for all countries. The relative volatility is 0.11 for the United States, 0.15 for the Non-US Aggregate, and 0.21 for the 10-Country Average.

Fourth, the current account and the interest differential display a fair amount of persistence, but this persistence is less than that of output. The autocorrelation of the current account is above 0.50 for 6 out of the 10 countries. The autocorrelation is 0.65 for the United States, 0.59 for the Non-US Aggregate, and 0.51 for the 10-Country Average. The autocorrelation of the interest differential is above 0.50 for only 4 out of the 10 countries. The autocorrelation is 0.40 for the United States, 0.38 for the Non-US Aggregate, and 0.44 for the 10-Country Average. In comparison, the autocorrelation of output is above 0.50 for 9 out of the 10 countries. The autocorrelation is 0.90 for the United States, 0.76 for the Non-US Aggregate, and 0.74 for the 10-Country Average.

Finally, although not reported, we find that the features are robust to different aggregations for the world interest rate (e.g. G7 or aggregate of Europe and United States), to different processes to construct expected inflation (e.g. univariate AR(1), AR(4), and ARMA(2,2)), to other detrending methods (e.g. linear quadratic trend), and to whether or not the interest differential is detrended. These results can be obtained from the authors.

3. The Economic Environment

We study a symmetric two-country, dynamic, general equilibrium environment where costly international financial transactions are brokered by an intermediary. Foreign country variables are identified by an asterisk.

3.1 The International Financial Market

The home and foreign consumers trade one-period bonds on the international financial market. The market is operated by a financial intermediary. The intermediary's profits

are given by

$$\Pi_t = \left[q_t B_{t+1} + q_t^* B_{t+1}^*\right] - \left[B_t + B_t^*\right] - \Phi(B_{t+1}, B_{t+1}^*), \tag{3}$$

where Π_t is profits, q_t and B_t are the price and quantity of bonds traded in the home economy, q_t^* and B_t^* are the price and quantity of bonds traded in the foreign economy, and $\Phi(B_{t+1}, B_{t+1}^*)$ are operating costs. The term in the first set of brackets shows the net inflows to the financial intermediary. The net inflows come from the net sell of bonds to the home and foreign consumers. The term in the second set of brackets captures the net outflows. The net outflows come from the net repayment of bonds to the home and foreign consumers.

For tractability, we directly specify the operating costs $\Phi(B_{t+1}, B_{t+1}^*)$. The costs capture the notion that frictions make the international financial market costly to operate. At the bank level, operating costs are increasing and convex in the volume of funds intermediated. At the country level, operating costs are increasing and convex in the net foreign asset position of each country, where the net foreign asset positions correspond to the full volume of intermediation. We specify the operating costs as

$$\Phi(B_{t+1}, B_{t+1}^*) = (\varphi/2)\left(B_{t+1}^2/Y_t + B_{t+1}^{*2}/Y_t^*\right), \tag{4}$$

where $\varphi \geq 0$. Similar costs are sometimes assumed for small open economy models (Schmitt-Grohé and Uribe 2003; Uribe and Yue 2006).

The costs (4) are motivated by theories of portfolio balances and theories of defaults. Portfolio imbalance occurs when a risk-averse financial intermediary is exposed to undesired risk because his portfolio allocation deviates from the desired allocation (Tobin 1969). In that sense, the costs capture the reduction in utility that results from either a purchase or a sale that lead to undesired exposure. The costs are increasing and convex because the risk-averse financial intermediary's utility is increasing and concave. At the bank level, the so called inventory costs to the financial intermediary are increasing and convex in the volume of transactions (Stoll 1978; Ho and Saunders 1981). At the country level, the costs to the financial intermediary are increasing and convex in the net foreign asset positions (Clinton 1998).

Default occurs when a borrower is unable to repay its loans. In that sense, the costs capture the expected loss of inflows to the financial intermediary that results from default. In the debt repudiation literature, the contract between a risk-neutral lender and risk-averse borrower yields a probability of default that is increasing and under mild conditions convex in the amount borrowed. Thus, the costs are increasing and convex because of the property of the default probability. At the bank level, the costs to the financial intermediary are increasing and convex in the size of loans (Eaton and Gersovitz 1981). At the country level, the costs are increasing and convex in the net foreign asset position (Kletzer 1984).

Alternatively, in the agency costs literature, the contract between a risk-neutral lender and risk-neutral borrower yields agency costs. In that sense, the costs capture agency costs. Under certain conditions, the agency costs are akin to increasing and convex adjustment costs in the size of loans (Carlstrom and Fuerst 1997). At the bank level, the costs to the financial intermediary are increasing and convex because of the property of agency costs (Bernanke, Gertler, and Gilchrist 1999). At the country level, the costs are increasing and convex in the net foreign asset position (Cespedes, Chang, and Valesco 2004).

The price-taking financial intermediary chooses the volume of intermediation to maximize profits (3) subject to the costs (4). The first-order conditions of the intermediary's problem yield

$$(q_t - q_t^*) = \varphi \left(B_{t+1}/Y_t - B_{t+1}^*/Y_t^* \right). \tag{5}$$

In equilibrium, the international financial market clears:

$$B_{t+1} + B_{t+1}^* = 0. \tag{6}$$

Condition (6) states that the borrowing of the home country necessarily corresponds to an equal lending by the foreign country. Condition (6) also implies that operating costs can be expressed only in terms of the home net foreign asset position: $\Phi_t = (\varphi/2)(1/\omega_t^*)B_{t+1}^2/Y_t$.

Using conditions (5) and (6), the cross-country spread is

$$(R_{t+1}^* - R_{t+1}) = \varphi R_{t+1} R_{t+1}^* (1/\omega_t^*) B_{t+1}/Y_t, \tag{7}$$

where $R_{t+1} = 1/q_t$ and $R_{t+1}^* = 1/q_t^*$ are the home and foreign gross returns. The resulting cross-country spread states that the financial intermediary charges a higher rate

to borrower than the rate promised to lenders. This spread is a bid-ask spread similar to that predicted by portfolio balance theories (e.g. Stoll 1978; Ho and Saunders 1981). The revenues generated by the spread cover costs and ensure profits. The profits $\Pi_t = (\varphi/2)(1/\omega_t^*)B_{t+1}^2/Y_t$ are assumed to be remitted to the governments of each country. To be consistent, we assume no entry in the intermediation sector, but we obtain similar results if we introduce fixed costs to eliminate profits.

The interest differential used to document the empirical regularities is $d_t = R_t - R_t^w$, where the world return is $R_t^w = \omega_t R_t + \omega_t^* R_t^*$. These definitions and the cross-country spread (7) imply

$$d_t = -\varphi R_t R_t^* \left(\frac{\omega_t^*}{\omega_{t-1}^*} \right) \frac{B_t}{Y_{t-1}}. \tag{8}$$

In the open-economy macroeconomic literature, interest differentials similar to (8) are often imposed, rather than derived. Examples include models where the interest differential is imposed to be inversely related to the level of net foreign assets (Devereux and Smith 2003; Schmitt-Grohé and Uribe 2003), to the ratio of net foreign assets to exports (Senhadji 1997), and to the ratio of net foreign assets to output (Letendre 2004; Nason and Rogers 2002).

At the investor level, a number of empirical studies support the existence of substantial costs that are increasing and convex. These costs imply an increasing spread, as in equations (7) and (8). For example, the bid-ask spread can be decomposed in its different cost components. The components come from the inventory cost, the order processing cost, and the adverse selection cost. Among those, the inventory cost results from the undesired exposure that comes from portfolio imbalances. Using 1992 data on the 19 most actively US traded stocks, Huang and Stoll (1997) document that the average inventory cost component of the traded spread is 28.7 percent, while the order processing cost component is 61.8 percent and the average adverse selection cost component is 9.6 percent. Using Nasdaq stock data for three subsamples, Bollen, Smith, and Whalley (2004) document that the inventory cost component dominates (29.3 percent for March 1996, 32.4 percent for April 1998, and 44.7 percent for December 2001), while the order processing cost component (8.9, 15.8, and 15.3 respectively) pales in comparison. In addition, Huang and Stoll (1997) find that the quoted spread tends to be larger for larger trades.

At the bank level, a number of studies find evidence that the net interest margin (i.e. the spread between loan and deposit rates) is increasing in the size of financial transactions. Using Bank Call Report data for the 1989–1993 period, Angbazo (1997) documents that the average net interest margin is greater for larger US banks, where the bank size proxies for transaction size. The average net interest margin reaches 4.636% for money-center banks, while it is 4.307% and 4.066% for super-regional banks and regional banks. Angbazo (1997) also finds that the sensitivity of the net interest margin to default risk is positive and larger for larger banks. Likewise, using income and balance-sheet data on major US banks for the 1976–1979 period, Ho and Saunders (1981) document that the sensitivity of the net interest margin to interest rate risk is positive and generally larger for larger banks. Interestingly, the sensitivity of the net interest margin to both default risk and interest rate risk is increasing in the transaction size, because of increasing and convex costs associated with exposure risk.

At the country level, a number of studies document an inverse relation between the interest differential and the net foreign asset position. For example, Bernhardsen (2000) uses panel data for the 1979–1995 period to document that the interest differentials of 9 European countries vis-à-vis Germany significantly increase following a deterioration in the current account (which implies a deterioration of the net foreign asset position). Likewise, Orr, Edey, and Kennedy (1995) use panel data for the 1984–1991 period to show a significant negative correlation between the interest differential of 17 OECD countries vis-à-vis the United States and the current account. Moreover, Lane and Milesi-Ferretti (2002) use panel data for the 1970–1998 period to document that the interest differential for 20 industrialized countries vis-à-vis the United States is inversely related to the country's net foreign asset position. The size of the estimates indicates that the interest differential increase by about 2.5 basis points as the foreign debt to output ratio increase by 10 percentage points. Similarly, Edwards (1984) uses data for the 1976-1980 period to show that the cross-country interest differential for 19 developing countries is positively affected by the foreign debt to output ratio. The size of the estimates suggests that the interest differential increase by 5 basis points as the foreign debt to output ratio increase by 10 percentage points.

3.2 The Incomplete Financial Market Model

The home and foreign economies are each populated by a representative consumer, a representative firm, and a government. We consider economies that are symmetric up to technology and government expenditures shocks. Thus, we only discuss the consumer, firm, and government of the home economy.

The consumer's expected lifetime utility is

$$E_0\left\{\sum_{t=0}^{\infty}\beta^t U\big(C_t, N_t\big)\right\}, \tag{9}$$

where E_t is the conditional expectation operator, C_t is consumption, N_t is employment, and $0 < \beta < 1$. As in Greenwood, Hercowitz, and Huffman (1988), the momentary utility is $U\left(C_t, N_t\right) = \left(C_t - \eta N_t^{\nu}\right)^{(1-\sigma)}/(1-\sigma)$, where $\eta > 0$, $\nu > 1$, and $\sigma \geq 1$. We adopt the Greenwood, Hercowitz, and Huffman (GHH) preferences because it may resolve two important shortcomings of homogenous good multi-country models. As Backus, Kehoe, and Kydland (1992) document, these models incorrectly predict that net exports are procyclical and that consumption is highly correlated across countries. The GHH preferences may alleviate these problems for two reasons. First, Correia, Neves, and Rebelo (1995) show that these preferences promote a countercyclical trade balance in small open economies. This may extend to the current account in one-good two-country models. Second, Devereux, Gregory, and Smith (1992) find that these preferences reduce the cross-country correlation of consumption in one-good two-country models.

The consumer's budget constraint is

$$C_t + I_t + T_t + q_t B_{t+1} = W_t N_t + r_t^k K_t + B_t, \tag{10}$$

where I_t denotes investment, T_t is taxes, W_t is the wage rate, r_t^k is the rental rate of capital, and K_t is the capital stock. Finally, the consumer faces a borrowing constraint $B \geq \bar{B}$, for some large negative number $\bar{B}$.

The capital stock evolves according to

$$K_{t+1} = I_t + (1-\delta)K_t - \left(\frac{\phi}{2}\right)\left[\frac{I_t}{K_t} - \delta\right]^2 K_t, \tag{11}$$

where the last term is an adjustment cost with $\phi \geq 0$ and $0 < \delta < 1$. We add adjustment costs to resolve another shortcoming of one-good two-country models. As Backus, Kehoe, and Kydland (1992) document, these models incorrectly predict a large volatility of investment. Baxter and Crucini (1993), however, show that investment adjustment costs limit the volatility of investment.

The competitive consumer chooses consumption, employment, capital and bonds to maximize expected lifetime utility (9) subject to the constraints (10) and (11). The first-order conditions of the consumer's problem are

$$\lambda_t = U_{ct}, \tag{12.1}$$

$$U_{nt} = -\lambda_t W_t, \tag{12.2}$$

$$q_t \lambda_t = \beta E_t \left\{ \lambda_{t+1} \right\}, \tag{12.3}$$

$$\begin{aligned} \frac{\lambda_t}{\left[1 - \phi\left(\frac{I_t}{K_t} - \delta\right)\right]} = \beta E_t \Bigg\{ & \frac{\lambda_{t+1}}{\left[1 - \phi\left(\frac{I_{t+1}}{K_{t+1}} - \delta\right)\right]} \Bigg(r^k_{t+1} \left[1 - \phi\left(\frac{I_{t+1}}{K_{t+1}} - \delta\right)\right] + (1-\delta) \\ & - \frac{\phi}{2}\left(\frac{I_{t+1}}{K_{t+1}} - \delta\right)^2 + \phi\left(\frac{I_{t+1}}{K_{t+1}} - \delta\right)\frac{I_{t+1}}{K_{t+1}} \Bigg) \Bigg\}, \end{aligned} \tag{12.4}$$

where U_{ct} and U_{nt} are the partial derivatives of $U(C_t, N_t)$ with respect to C_t and N_t, and λ_t is the multiplier associated with the budget constraint (10).

The firm's profits are

$$Y_t - W_t N_t - r^k_t K_t, \tag{13}$$

where Y_t denotes the firm's output. As is standard, output is produced with the constant return to scale technology

$$Y_t = Z_t K_t^{\alpha} N_t^{1-\alpha}, \tag{14}$$

where Z_t is the stochastic, exogenous, level of technology and $0 < \alpha < 1$.

The competitive firm hires labor and capital to maximize profits (13) subject to the production technology (14). The first-order conditions of the firm's problem are

$$W_t = (1-\alpha) Y_t / N_t, \tag{15.1}$$

$$r_t^k = \alpha Y_t / K_t. \tag{15.2}$$

The government runs a balanced budget:

$$\mathcal{G}_t = T_t + \omega_t \Pi_t, \tag{16}$$

where $\mathcal{G}_t$ is government expenditures, $\omega_t = Y_t/(Y_t + Y_t^*)$ is the home share of world output, and Π_t is any redistributed profits from the financial intermediary. Recall that the intermediary is owned by the governments of each country. Also, the ownership shares reflect each country's share of world output. Note that our results are not sensitive to the exact redistribution of the intermediary's profits. In addition, our results are robust to redistributing profits directly to consumers in a lump-sum fashion, as in Uribe and Yue (2006).

Finally, the good market clearing condition is

$$C_t + C_t^* + I_t + I_t^* + G_t + G_t^* = Y_t + Y_t^*, \tag{17}$$

where $G_t = \mathcal{G}_t + \omega_t \Phi_t$ and $G_t^* = \mathcal{G}_t^* + \omega_t^* \Phi_t$. That is, we roll the resources lost in operating the international financial markets with government expenditures, and use G_t and G_t^* as our notion of stochastic, exogenous, government expenditures. Again, our results are not sensitive to the exact redistribution of the resources lost in operating the international financial market. In addition, we obtain similar findings when the resources lost are modeled as output lost in production.

3.3 Calibration

The economic environment does not possess an analytical solution for general values of the underlying parameters. We approximate the solution using the method described in King, Plosser, and Rebelo (2002). That is, we linearize the equations characterizing the equilibrium around the deterministic steady state, and solve the resulting system of difference equations. This requires values for all parameters.

To explain our benchmark calibration, we divide the parameters in three sets. The first set is calibrated on values used in previous studies. As in Backus, Kehoe, and Kydland

(1992), we set the subjective discount factor to $\beta = 0.99$, the share of capital to $\alpha = 0.36$, the depreciation rate to $\delta = 0.025$, and the steady state employment to 30 percent of the time endowment (which requires that $\eta = 3.24$). As in Greenwood, Hercowitz, and Huffman (1988) and Correia, Neves, and Rebelo (1995), we set the coefficient of relative risk aversion to $\sigma = 2$ and the elasticity of labor supply to $1/(\nu - 1) = 1.43$. Finally, as in Nason and Rogers (2002), we set the responsiveness of the interest differential to changes in the net foreign asset position to $\widetilde{\varphi} = 0.0035$. In our model, the linearized version of the interest differential is $d_t \approx -(\varphi/\beta^2)B_t/Y$, where Y and $R = 1/\beta$ are the deterministic steady state values of output and gross return. The calibration requires that we set $\varphi = \widetilde{\varphi}\beta^2$. The linearized interest differential is this simple because the symmetric deterministic steady state implies $B = B^* = 0$. An implication of $B = B^* = 0$ is that reformulating the intermediary's cost as $(\varphi/2)\left(B_{t+1}^2 + B_{t+1}^{*2}\right)$ does not change the linearized interest differential. In that case, the linearized differential is $d_t \approx -\omega^* Y(\varphi/\beta^2)B_t/Y$, where $\omega^* = 1/2$ is the deterministic steady state of the share of world output. The calibration would then require that we set $\varphi = (2/Y)\widetilde{\varphi}\beta^2$. Another implication of $B = B^* = 0$ is that the intermediary's profits Π_t and costs Φ_t vanish in the linearization.

The second set of parameters is calibrated to match observed statistics for the United States. For example, we set $G/Y = 0.163$ to match the average sample output share of government expenditures in the United States. Note that $G/Y = \mathcal{G}/Y$ because $\Phi = \Pi = B = 0$. In addition, we set $\phi = 3.75$ to match the relative volatility of investment in the United States. Also, we have experimented with matching these statistics for the Non-US Aggregate and the 10-Country Average with similar results.

The last set of parameters is calibrated to estimated values for the United States and the Non-US Aggregate. This is in line with our two country symmetrical environment, because the United States and the Non-US Aggregate are of similar size. We calibrate the parameters of the symmetric process that generates the stochastic, exogenous, technology and government expenditures to maximum likelihood estimates. The process is

$$\begin{pmatrix} z_t \\ z_t^* \\ g_t \\ g_t^* \end{pmatrix} = \begin{pmatrix} \gamma_{zz} & \gamma_{zz}^* & \gamma_{zg} & \gamma_{zg}^* \\ \gamma_{zz}^* & \gamma_{zz} & \gamma_{zg}^* & \gamma_{zg} \\ \gamma_{gz} & \gamma_{gz}^* & \gamma_{gg} & \gamma_{gg}^* \\ \gamma_{gz}^* & \gamma_{gz} & \gamma_{gg}^* & \gamma_{gg} \end{pmatrix} \begin{pmatrix} z_{t-1} \\ z_{t-1}^* \\ g_{t-1} \\ g_{t-1}^* \end{pmatrix} + \begin{pmatrix} \epsilon_{zt} \\ \epsilon_{zt}^* \\ \epsilon_{gt} \\ \epsilon_{gt}^* \end{pmatrix}$$

or

$$\mathbf{w}_t = \Gamma \mathbf{w}_{t-1} + \mathbf{e}_t, \tag{18}$$

for $\mathbf{w}_t = (\, z_t \quad z_t^* \quad g_t \quad g_t^* \,)'$, $z_t = \ln(Z_t/Z)$, $z_t^* = \ln(Z_t^*/Z)$, $g_t = \ln(G_t/G)$, and $g_t^* = \ln(G_t^*/G)$, where Z and G are the steady state values of technology and government expenditures. The covariance matrix $E\left[\mathbf{e}_t \mathbf{e}_t'\right] = \Upsilon$ is

$$\Upsilon = \begin{pmatrix} \upsilon_{zz} & \upsilon_{zz}^* & \upsilon_{zg} & \upsilon_{zg}^* \\ \upsilon_{zz}^* & \upsilon_{zz} & \upsilon_{zg}^* & \upsilon_{zg} \\ \upsilon_{zg} & \upsilon_{zg}^* & \upsilon_{gg} & \upsilon_{gg}^* \\ \upsilon_{zg}^* & \upsilon_{zg} & \upsilon_{gg}^* & \upsilon_{gg} \end{pmatrix}. \tag{19}$$

The estimates for Γ are $\gamma_{zz} = 0.720$, $\gamma_{zz}^* = 0.069$, $\gamma_{zg} = 0.108$, $\gamma_{zg}^* = -0.006$, $\gamma_{gg} = 0.722$, $\gamma_{gg}^* = 0.017$, $\gamma_{gz} = 0.022$, and $\gamma_{gz}^* = -0.085$. The estimates for Υ are $\upsilon_{zz} = 5.390 \times 10^{-5}$, $\upsilon_{zz}^* = 1.085 \times 10^{-5}$, $\upsilon_{zg} = 1.363 \times 10^{-5}$, $\upsilon_{zg}^* = 1.110 \times 10^{-5}$, $\upsilon_{gg} = 4.370 \times 10^{-5}$, and $\upsilon_{gg}^* = 2.529 \times 10^{-6}$.

Our numerical method requires that the linearization of the model yields a stationary system of difference equations. Fortunately, this is ensured for our benchmark calibration. To be more specific, the model has three predetermined (state) variables (B_t, K_t, and K_t^*). With the benchmark calibration, the system of difference equations has three roots that are strictly inside the unit circle (0.894, 0.992, 0.994). It also yields as many roots strictly outside the unit circle as their are nonpredetermined variables. This occurs because the intermediary's cost plays the same role as the quadratic costs on bond holdings used in Heathcote and Perri (2002). Boileau and Normandin (2006) provide a detailed discussion of these issues.

To highlight the role played by the financial intermediary, we compute the features predicted by an alternative calibration that eliminates the intermediary. We refer to this calibration as the no cost calibration. For this, we retain the benchmark calibration, but set

$\varphi = 0.000001$. This setting virtually eliminates the intermediary's cost and substantially reduces the size of the interest differential. In that case, the system has three roots strictly inside the unit circle (0.944, 0.992, 0.999), and as many roots strictly outside the unit circle as their are nonpredetermined variables.

Some popular variants of the model, however, do not yield a stationary system of difference equations. For example, fully eliminating the cost (i.e. setting $\varphi = 0$) yields a standard two-country model with incomplete international financial market (e.g. Baxter and Crucini 1995). Linearization of that model yields a nonstationary system of difference equations. Another example would be to reformulate the intermediary's cost as an increasing function of the current account $(B_{t+1} - B_t)$. Linearization of the resulting model also yields a nonstationary system of difference equations.

4. Test Results

We gauge whether the benchmark calibration of the economic environment explains the features of the current account and the interest differential documented for our post-1975 sample of international data. To highlight the contribution of financial intermediation, we also compare the predictions to those obtained from the no cost calibration of the model.

4.1 Dynamic Responses

Figures 3 and 4 display the dynamic responses of various domestic variables to orthogonal, domestic, technology and government expenditures shocks. The responses are predicted by the economic environment with the benchmark and no cost calibrations. The key variables are output, the current account, and the interest differential. The current account is decomposed into the national saving to output ratio and the investment to output ratio.

As a useful starting point, we document the responses predicted by the benchmark calibration. An increase in technology raises output, and stimulates both savings and investment. Savings, however, does not rise enough to fully fund the investment boom, such that the current account deteriorates. The deterioration in the current account worsens the country's net foreign asset position and pushes up the interest differential. Also, an

increase in government expenditures eventually raises output, reduces savings, but raises investment. This implies a deterioration of the current account. The deterioration worsens the net foreign asset position and raises the interest differential.

The responses associated with the benchmark calibration hint at prominent predicted features. First, the responses of the current account are generally negative, whereas the responses of the interest differential are positive. This suggests that the current account is negatively correlated with contemporaneous and future interest differentials. This accords with the S-curve, although it is difficult to deduce the entire shape of cross-correlation functions from response functions. Second, the responses of output are positive. Combining this feature with the signs of the responses of the current account and of the interest differential suggests that the current account is countercyclical, while the interest differential is procyclical. Third, the responses of the current account are smaller than those of output, and the responses of the interest differential are even smaller. This suggests that the current account is less volatile than output, and that the interest differential is even less volatile. Fourth, the responses of the current account appear slightly less persistent than those of output, while the hump-shaped responses of the interest differential are more persistent. This suggests that the current account is less persistent than output, while the interest differential is more persistent. Interestingly, these hinted features appear consistent with most of the empirical regularities.

A comparison of the responses computed from the benchmark calibration with those computed from the no cost calibration provides some intuition on the role played by financial intermediation. In general, the responses are similar across the two calibrations. There are two important exceptions. First, the benchmark calibration is the only one to generate non-zero responses for the interest differential. Consequently, only the benchmark calibration may explain the joint behavior of the current account and the interest differential. Second, the benchmark calibration produces a more important deterioration of the current account than that produced by the no cost calibration, whereas the two calibrations generate similar responses for output. This suggests that the benchmark calibration generates a more pronounced relative volatility of the current account, and this may imply a better explanation of the cyclical fluctuations of the current account.

4.2 Features of the Current Account and the Interest Differential

We now proceed to the central part of our analysis. That is, we perform challenging statistical tests to confront the predicted features of the current account and the interest differential to the observed features. The tests are based on the approach described in Boileau and Normandin (2002).

Figure 5 compares the predicted dynamic cross-correlation function between the current account and the interest differential to the sample cross-correlation functions. The predicted cross-correlation function is computed from the benchmark calibration only, because the no cost calibration does not generate fluctuations in the interest differential. The sample cross-correlation functions are those of the United States, the Non-US Aggregate, and the 10-Country Average. In each case, the figure also presents the p-value from a $\chi^2(1)$ distributed test that the difference between predicted and sample cross-correlations is null. The test uses the variance of the difference, which is computed as $D'\Sigma D$— where D is the vector of numerical derivatives of the difference with respect to the estimated parameters, and Σ is the covariance matrix of these estimates.

The economic environment with the benchmark calibration predicts a sharp S-curve. The correlations between lags of the current account and the interest differential are negative, and the correlations between leads of the current account and the interest differential are positive, with the turning point occuring at the one-quarter lead. The sample cross-correlation function for the United States is flatter, but displays the overall shape. The predicted cross-correlations statistically match the sample correlations for large values of lags and leads. The sample cross-correlation function for the Non-US Aggregate also displays the S-curve, but with a turning point at the two-quarter lead. The predicted cross-correlations statistically match the sample correlations for low values of lags. The sample cross-correlation function for the 10-Country Average displays the S-curve with a turning point at the two-quarter lead. The predicted cross-correlations statistically match the sample ones for low values of lags and large values of leads. Overall, these findings reveal that the benchmark calibration provides a good explanation of the joint behavior of the current account and the interest differential.

Table 2 compares predicted statistics to sample statistics. The predicted statistics

are computed from the benchmark calibration, and whenever defined from the no cost calibration. The sample statistics are those of the United States, the Non-US Aggregate, and the 10-Country Average. In each case, the table also presents the p-value from a $\chi^2(1)$ distributed test that the difference between predicted and sample statistics is null.

To start with, we document the statistics generated by the benchmark calibration. First, the benchmark calibration correctly predicts the frequently observed negative correlation between the current account and the interest differential. The predicted correlation between the current account and the interest differential is -0.07. In comparison, the sample correlation (p-value) is -0.03 (0.00) for the United States, -0.14 (0.01) for the Non-US Aggregate, and -0.16 (0.00) for the 10-Country Average.

Second, the benchmark calibration correctly predicts that the current account is countercyclical and that the interest differential is procyclical. The predicted correlation between the current account and output is -0.22. The sample correlation (p-value) is -0.48 (0.01) for the United States, -0.28 (0.55) for the Non-US Aggregate, and -0.25 (0.77) for the 10-Country Average. Also, the predicted correlation between the interest differential and output is 0.18. The sample correlation (p-value) is 0.19 (0.97) for the United States, 0.04 (0.55) for the Non-US Aggregate, and 0.10 (0.73) for the 10-Country Average.

Third, the benchmark calibration correctly predicts the relative volatility of the current account, but underpredicts the relative volatility of the interest differential. The predicted relative volatility of the current account is 0.27. The relative volatility (p-value) observed in the data is 0.30 (0.82) for the United States, 0.49 (0.17) for the Non-US Aggregate, and 0.62 (0.04) for the 10-Country Average. The predicted relative volatility of the interest differential is 0.01. The relative volatility (p-value) observed in the data is 0.11 (0.00) for the United States, 0.15 (0.00) for the Non-US Aggregate, and 0.21 (0.00) for the 10-Country Average.

Fourth, the benchmark calibration numerically and statistically predicts the persistence of the current account. The predicted autocorrelation of the current account is 0.70 for the benchmark calibration. The sample autocorrelation (p-value) is 0.65 (0.42) for the United States, 0.59 (0.09) for the Non-US Aggregate, and 0.51 (0.00) for the 10-Country Average. The benchmark calibration overpredicts the persistence of the interest differen-

tial. The predicted autocorrelation of the interest differential is 0.99, while the sample autocorrelation (p-value) is 0.40 (0.00) for the United States, 0.38 (0.00) for the Non-US Aggregate, and 0.44 (0.00) for the 10-Country Average.

As before, a comparison between the features predicted by the benchmark and no cost calibrations is useful to understand the importance of financial intermediation. The features are similar across both calibrations, but there are two important exceptions. First, only the benchmark calibration generates fluctuations in the interest differential. As a result, only the benchmark calibration explains the co-movements of the current account and the interest differential found in the data. Second, the benchmark calibration produces a much larger (in absolute value) correlation between the current account and output, a larger relative volatility of the current account, and a smaller autocorrelation of the current account. As a result, the benchmark calibration provides a better explanation of the cyclical fluctuations of the current account.

Overall, costly financial intermediation appears to explain the joint behavior of the current account and the interest differential. It also improves the explanation of the fluctuations of the current account. Costly intermediation, however, only provides a partial explanation of the cyclical fluctuations of the interest differential. That is, the benchmark calibration correctly predicts a procyclical interest differential, but underpredicts the interest differential volatility.

It should also be noted that the benchmark calibration explains the standard international business cycle statistics as well as the no cost calibration — see Appendix Table B1. In this sense, our explanation of the relation between the current account and the interest differential does not come at the cost of a deterioration in the standard statistics. That is, our benchmark calibration generates standard statistics that are similar to those in Backus, Kehoe, and Kydland (1992), Baxter and Crucini (1995), and Kehoe and Perri (2002).

4.3 Robustness

We finally verify the robustness of our results for the benchmark calibration, and pay particular attention to the predicted features of the interest differential. For this purpose,

we conduct several experiments with alternative calibrations of the key parameters. The different experiments are reported in Table 3 and Figure 6 — also see Appendix Table B2.

The first experiment verifies the effects of changing the coefficient of relative risk aversion. Intuition suggests that an increase in the coefficient magnifies the volatility of the marginal utility of consumption. This should raise the volatility of the interest differential. We lower the coefficient to $\sigma = 1$ (the logarithmic utility) and raise it to a high of $\sigma = 10$. These values are consistent with the range studied in Mehra and Prescott (1985). Unfortunately, raising the coefficient of relative risk aversion has only negligible effects on the relative volatility and persistence of the interest differential. In addition, it makes the interest differential countercyclical and flattens the cross-correlation function. Finally, it has only small effects on the statistics of the current account.

The second experiment verifies the effects of changing the elasticity of labor supply. Raising the elasticity should make employment and the marginal utility of consumption more volatile. This should raise the volatility of the interest differential. We lower the elasticity to $1/(\nu - 1) = 0.2$ and raise it to $1/(\nu - 1) = 2.5$. These values are consistent with the range discussed in Greenwood, Hercowitz, and Huffman (1988). Unfortunately, changing the elasticity of labor supply has negligible effects on the statistics and cross-correlation function of the interest differential and current account.

The third experiment verifies the effects of changing the cost of adjusting the capital stock. A reduction of the cost should raise the volatility of international capital flows, and thus the volatility of the interest differential. For this experiment, we lower the cost by setting $\phi = 0$ and raise it by setting $\phi = 7.5$. These values either eliminate the cost or double it (for a given investment). As expected, lowering the cost raises the relative volatility of the interest differential and lowers its persistence. It also makes the cross-correlation function steeper around the turning point. Unfortunately, lowering the cost unreasonably raises the relative volatility of the current account and makes it procyclical.

The fourth experiment verifies the effects of changing the responsiveness of the interest differential to the ratio of net foreign assets and output. An increase in the responsiveness should raise the volatility of the interest differential. We lower the responsiveness to $\varphi/\beta^2 = 0.001$ and raise it to $\varphi/\beta^2 = 0.01$. These values are consistent with those found

in Lane and Milesi-Ferretti (2002) and used in Devereux and Smith (2003). The increase slightly raises the relative volatility of the interest differential and lowers its persistence. It also raises the steepness of the cross-correlation function and makes the interest differential more procyclical. Finally, it has only small effects on the statistics of the current account.

The fifth experiment verifies the effects of changing the parametrization of the stochastic process for technology shocks. Intuition suggests that removing spillovers should make economic conditions more different across countries, and thus magnify the volume of trade in bonds and raise the volatility of the interest differential. We report two cases without government expenditures shocks. The No Spillovers parametrization is that of Baxter and Crucini (1995). For this, we set $\gamma_{zz} = 0.999$ and $\gamma^*_{zz} = 0$, but keep the estimated values for υ_{zz} and υ^*_{zz}. The Spillovers parametrization is that of Backus, Kehoe, and Kydland (1992). For this we set $\gamma_{zz} = 0.906$ and $\gamma^*_{zz} = 0.088$, and keep the estimated values for υ_{zz} and υ^*_{zz}. For both cases, we also set $\gamma_{zg} = \gamma^*_{zg} = \gamma_{gz} = \gamma^*_{gz} = \gamma_{gg} = \gamma^*_{gg} = 0$ and $\upsilon_{zg} = \upsilon^*_{zg} = \upsilon_{gz} = \upsilon^*_{gz} = \upsilon_{gg} = \upsilon^*_{gg} = 0$ to remove government expenditures shocks. The absence of spillovers in technology shocks raises the volatility of the interest differential, and makes it too procyclical.

The last experiment verifies the effects of changing the parametrization of the stochastic process for government expenditures shocks. Again, intuition suggests that removing spillovers should make economic conditions more different across countries, and thus magnify the volume of trade in bonds and raise the volatility of the interest differential. We report two cases without technology shocks. Both parametrizations adapt the technology shocks parametrization to government expenditures. That is, the No Spillovers parametrization sets $\gamma_{gg} = 0.999$ and $\gamma^*_{gg} = 0$, and keeps the estimated values for υ_{gg} and υ^*_{gz}. The Spillovers parametrization sets $\gamma_{gg} = 0.906$ and $\gamma^*_{gg} = 0.088$, and keeps the estimated values for υ_{gg} and υ^*_{gg}. For both cases, $\gamma_{zg} = \gamma^*_{zg} = \gamma_{gz} = \gamma^*_{gz} = \gamma_{zz} = \gamma^*_{zz} = 0$ and $\upsilon_{zg} = \upsilon^*_{zg} = \upsilon_{gz} = \upsilon^*_{gz} = \upsilon_{zz} = \upsilon^*_{zz} = 0$ to remove technology shocks. The absence of spillovers in government expenditures shocks raises the volatility of the interest differential, but makes it more countercyclical.

In sum, the various experiments confirm that our results are robust. They also suggest that matching the anomalous volatility of the interest differential without deteriorating

other statistics is a difficult task.

5. Conclusion

In contrast to earlier work, we document the business cycle fluctuations of the current account and interest differentials. We find that our two-country, dynamic, general equilibrium environment correctly predicts that the current account is negatively correlated with current and future interest differentials, but positively correlated with past interest differentials. It also correctly predicts that the current account is countercyclical and that the interest differential is procyclical. Unfortunately, the environment underpredicts the volatility of the interest differential.

Future work should aim at resolving the discrepancies between facts and predictions. Promising extensions should consider the effects of the real exchange rate (terms of trade) and government budgets. For example, Sachs (1981) finds evidence that the exchange rate affects the current account, and Baxter (1994) finds evidence that it affects the interest differential. Also, Normandin (1999) shows that government budgets impact the current account, while Bernhardsen (2000) shows that they impact the interest differential.

Appendix A: Data

The quarterly seasonally adjusted measures are constructed for 10 developed countries and a Non-US Aggregate over the post-1975 period. The measures are computed from the International Financial Statistics (IFS) released by the International Monetary Funds, as well as the Main Economic Indicators (MEI) and the Quarterly National Accounts (QNA) published by the Organization for Economic Cooperation and Development. The individual countries (common samples for all measures) are Australia (1975-I to 2001-II), Austria (1975-I to 1998-IV), Canada (1975-I to 2001-II), Finland (1978-I to 2001-II), France (1975-I to 1999-I), Germany (1975-I to 2001-II), Italy (1975-I to 2001-II), Japan (1977-I to 2001-II), the United Kingdom (1975-I to 2001-II), and the United States (1975-I to 2001-II). Germany refers to West Germany and Unified Germany for the pre- and post-1990 periods. The Non-US Aggregate covers the 1975-I to 2001-II period.

A.1 Output

For each country, output is measured by the weighted nominal gross domestic product (GDP) in national currency (source: QNA), deflated by the all-item consumer price index (CPI) for the base year 1995 (source: MEI). The output weights are country-specific constants that convert the values of output into comparable units. Following Backus, Kehoe, and Kydland (1992), the constants are chosen to match the averages of our quarterly values of output in 1985 to the yearly data on real GDP obtained from the international prices for 1985, reported by Summers and Heston (1988) (source: variables 1 and 2 in their Table 3). The published data for Germany and Austria are not seasonally adjusted. Thus, German and Austrian output is regressed (by OLS) on quarter dummies to remove seasonality. For the Non-US Aggregate, output is constructed by summing over all countries, except the United States.

A.2 Current Account

For each country, the current account is the product of the output weight, the nominal current account in US dollars (source: IFS), and the nominal exchange rate of national currency units per US dollar (source: IFS), divided by the CPI. The current account is further regressed on quarter dummies to remove seasonality. For the Non-US Aggregate, the current account is constructed by summing over all countries, except the United States. In doing so, the few missing values for Japan (from 1975-I to 1976-IV) are replaced by zeros.

A.3 Interest Differential

For each country, the interest differential is the difference between the country-specific interest rate and the world interest rate. The country-specific interest rate is the nominal interest rate minus the expected inflation rate. The nominal interest rate is the one-quarter interbank rate (source: IFS). The expected quarterly inflation rate is the one-quarter ahead forecast formed from a univariate ARMA(1,1) process. The world interest rate is the sum of the country-specific interest rates weighted by the country's share of the total output of the 10 countries. The few missing values for Austria (from 1999-I to 2001-II), Finland (from 1975-I to 1977-IV), and France (from 1999-II to 2001-II) are replaced by zeros, and the shares of output are recomputed to exclude these countries. For the Non-US Aggregate, the interest rate is computed similarly to the world interest rate, but excludes the United States.

A.4 Consumption, Investment, and Government Expenditures

For each country, consumption is the output weight times nominal private final consumption expenditures in national currency (source: QNA), deflated by the CPI. Investment is the output weight times nominal gross fixed capital formation in national currency (source: QNA), deflated by the CPI. Government expenditures are the output weight times nominal government final consumption expenditures in national currency (source: QNA), normalized by the CPI. For consumption, investment, and government expenditures, German and Austrian data are regressed on quarter dummies to remove seasonality. For the Non-US Aggregate, consumption, investment, and government expenditures are constructed by summing over all countries, except the United States.

A.5 National Saving

For each country, national saving is the current account plus investment. For the Non-US Aggregate, national saving is constructed by summing over all countries, except the United States.

A.6 Technology

For each country, technology is constructed from the production function (8) using the calibrated capital share $\alpha = 0.36$, and measures of output, capital, and employment. Capital is computed from the capital accumulation equation (5), the calibrated depreciation rate $\delta = 0.025$ and adjustment costs parameter $\phi = 3.75$, the steady state value of capital

(for the initial period), and investment. Employment is calculated as the civilian employment index for the baseyear 1995 (source: MEI) times the population in 1985 reported by Summers and Heston (1988) (source: variable 1 in their Table 3). For the Non-US Aggregate, technology is constructed similarly using the Non-US Aggregate measures of output, investment, and employment. The Non-US Aggregate's employment is constructed by summing weighted employment over all countries except the United States, where the weights reflect each country's share of the Non-US Aggregate total population.

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Table 1. Empirical Regularities: Baseline Statistics

	Relative Volatility		Autocorrelation			Correlation		
Country	x	d	y	x	d	(x,y)	(d,y)	(x,d)
Australia	0.55	0.19	0.77	0.67	0.64	-0.30	0.24	-0.32
	(0.05)	(0.02)	(0.07)	(0.06)	(0.09)	(0.07)	(0.10)	(0.08)
Austria	1.02	0.19	0.30	0.35	0.63	-0.08	0.16	-0.29
	(0.10)	(0.03)	(0.11)	(0.09)	(0.07)	(0.10)	(0.09)	(0.09)
Canada	0.53	0.17	0.90	0.55	0.32	-0.15	0.52	-0.13
	(0.05)	(0.02)	(0.05)	(0.09)	(0.12)	(0.10)	(0.06)	(0.09)
Finland	0.60	0.15	0.87	0.23	0.58	-0.00	-0.25	-0.08
	(0.06)	(0.02)	(0.05)	(0.09)	(0.09)	(0.10)	(0.08)	(0.10)
France	0.66	0.25	0.85	0.43	0.48	-0.06	0.01	-0.08
	(0.06)	(0.03)	(0.05)	(0.09)	(0.13)	(0.11)	(0.10)	(0.10)
Germany	0.43	0.11	0.66	0.53	0.29	-0.48	0.21	-0.22
	(0.03)	(0.01)	(0.16)	(0.09)	(0.10)	(0.10)	(0.09)	(0.10)
Italy	0.88	0.30	0.78	0.59	0.33	-0.28	-0.22	-0.09
	(0.09)	(0.03)	(0.06)	(0.08)	(0.11)	(0.08)	(0.10)	(0.14)
Japan	0.61	0.24	0.63	0.73	0.67	-0.31	0.11	-0.44
	(0.07)	(0.05)	(0.07)	(0.07)	(0.10)	(0.07)	(0.08)	(0.08)
United Kingdom	0.60	0.34	0.78	0.40	0.04	-0.37	0.07	0.04
	(0.05)	(0.04)	(0.07)	(0.09)	(0.13)	(0.09)	(0.13)	(0.11)
United States	0.30	0.11	0.90	0.65	0.40	-0.48	0.19	-0.03
	(0.04)	(0.02)	(0.06)	(0.11)	(0.15)	(0.06)	(0.11)	(0.12)
Non-US Aggregate	0.49	0.15	0.76	0.59	0.38	-0.28	0.04	-0.14
	(0.05)	(0.02)	(0.07)	(0.08)	(0.15)	(0.10)	(0.09)	(0.12)
10-Country Average	0.62	0.21	0.74	0.51	0.44	-0.25	0.10	-0.16

Note: Entries under relative volatility, autocorrelation, and correlation refer to the sample standard deviation of the variable relative to the sample standard deviation of y, the sample first-order autocorrelation of the variable, and the sample contemporaneous correlation between variables. The variables are the detrended logarithm of output (y), the detrended ratio of the current account to output (x), and the detrended interest differential (d). The detrending method is the Hodrick-Prescott filter. The interest differential is constructed from ex-ante real interest rates, using a one-quarter ahead predicted inflation rate from an ARMA(1,1) process. The Non-US Aggregate is an aggregate of the 10 countries except the United States. The 10-Country Average is the mean statistic over all 10 countries. Entries in parentheses are the standard errors computed by the generalized method of moments.

Table 2. Test Results: Baseline Statistics

	Relative Volatility		Autocorrelation			Correlation		
	x	d	y	x	d	(x, y)	(d, y)	(x, d)
Benchmark	0.27	0.01	0.87	0.70	0.99	-0.22	0.18	-0.07
No Cost	0.21		0.86	0.76		-0.05		
United States	0.30	0.11	0.90	0.65	0.40	-0.48	0.19	-0.03
	(0.82)	(0.00)	(0.47)	(0.42)	(0.00)	(0.01)	(0.97)	(0.00)
	[0.48]		[0.33]	[0.12]		[0.01]		
Non-US Aggregate	0.49	0.15	0.76	0.59	0.38	-0.28	0.04	-0.14
	(0.17)	(0.00)	(0.01)	(0.09)	(0.00)	(0.55)	(0.55)	(0.01)
	[0.03]		[0.03]	[0.02]		[0.18]		
10-Country Average	0.62	0.21	0.74	0.51	0.44	-0.25	0.10	-0.16
	(0.04)	(0.00)	(0.00)	(0.00)	(0.00)	(0.77)	(0.73)	(0.00)
	[0.00]		[0.01]	[0.00]		[0.24]		

Note: Entries under relative volatility, autocorrelation, and correlation refer to the predicted and sample standard deviations of the variable relative to the predicted and sample standard deviations of y, the predicted and sample first-order autocorrelations, and the predicted and sample contemporaneous correlations. The predicted statistics are constructed from the benchmark and no cost calibrations. The variables are the detrended logarithm of output (y), the detrended ratio of the current account and output (x), and the detrended interest differential (d). Entries in parentheses (brackets) are the p-values of the test that the difference between the predicted statistic generated by the benchmark (no cost) calibration and the sample statistic is null.

Table 3. Robustness: Baseline Statistics

	Relative Volatility		Autocorrelation			Correlation		
	x	d	y	x	d	(x, y)	(d, y)	(x, d)
Benchmark	0.27	0.01	0.87	0.70	0.99	-0.22	0.18	-0.07
Risk Aversion								
Low($\sigma = 1$)	0.28	0.01	0.85	0.70	0.99	-0.24	0.28	-0.08
High($\sigma = 10$)	0.21	0.01	0.92	0.70	0.99	-0.17	-0.12	-0.04
Labor Supply Elasticity								
Low($\frac{1}{\nu-1} = 0.2$)	0.28	0.01	0.84	0.68	0.99	-0.17	0.15	-0.07
High($\frac{1}{\nu-1} = 2.5$)	0.25	0.01	0.89	0.70	0.99	-0.22	0.15	-0.07
Investment Adjustment Costs								
Low($\phi = 0$)	11.63	0.06	0.79	-0.10	0.78	0.34	0.79	-0.33
High($\phi = 7.5$)	0.13	0.01	0.86	0.66	0.99	-0.05	-0.06	-0.05
Interest Differential Responsiveness								
Low($\varphi/\beta^2 = 0.001$)	0.23	0.01	0.86	0.73	0.99	-0.16	-0.02	-0.03
High($\varphi/\beta^2 = 0.01$)	0.32	0.02	0.87	0.65	0.98	-0.24	0.35	-0.10
Technology Shocks Only								
No Spillovers	0.20	0.07	0.99	0.89	0.99	-0.03	0.99	-0.01
Spillovers	0.18	0.01	0.98	0.72	0.99	-0.12	0.16	-0.07
Government Expenditures Shocks Only								
No Spillovers	0.12	0.05	0.99	0.89	0.99	-0.07	-0.07	-0.01
Spillovers	0.01	0.01	0.99	0.97	0.99	0.01	-0.05	-0.01

Note: Entries under relative volatility, autocorrelation, and correlation refer to the predicted standard deviation of the variable relative to the predicted standard deviation of y, the predicted first-order autocorrelation, and the predicted contemporaneous correlation. The variables are the detrended logarithm of output (y), the detrended ratio of the current account and output (x), and the detrended interest differential (d). The predicted statistics are constructed from the benchmark calibration and alternative parametrizations.

Table B1. Test Results: Business Cycle Statistics

	Relative Volatility		Within-Country Correlation			Cross-Country Correlation	
	c	i	(c, y)	(i, y)	$(s/y, i/y)$	(c, c^*)	(y, y^*)
Benchmark	0.93	2.23	0.99	0.88	0.70	0.41	0.35
No Cost	1.17	2.01	0.77	0.91	0.72	-0.06	0.42
United States	0.88	2.23	0.91	0.92	0.43		
	(0.18)	(0.99)	(0.00)	(0.69)	(0.23)		
	[0.00]	[0.47]	[0.06]	[0.92]	[0.16]		
Non-US Aggregate	0.85	2.62	0.87	0.79	0.39	0.20	0.38
	(0.01)	(0.30)	(0.00)	(0.27)	(0.16)	(0.42)	(0.88)
	[0.00]	[0.04]	[0.18]	[0.10]	[0.11]	[0.42]	[0.86]
10-Country Average	0.90	2.59	0.79	0.74	0.30	0.17	0.29
	(0.39)	(0.34)	(0.00)	(0.12)	(0.06)	(0.37)	(0.83)
	[0.00]	[0.06]	[0.80]	[0.02]	[0.04]	[0.48]	[0.57]

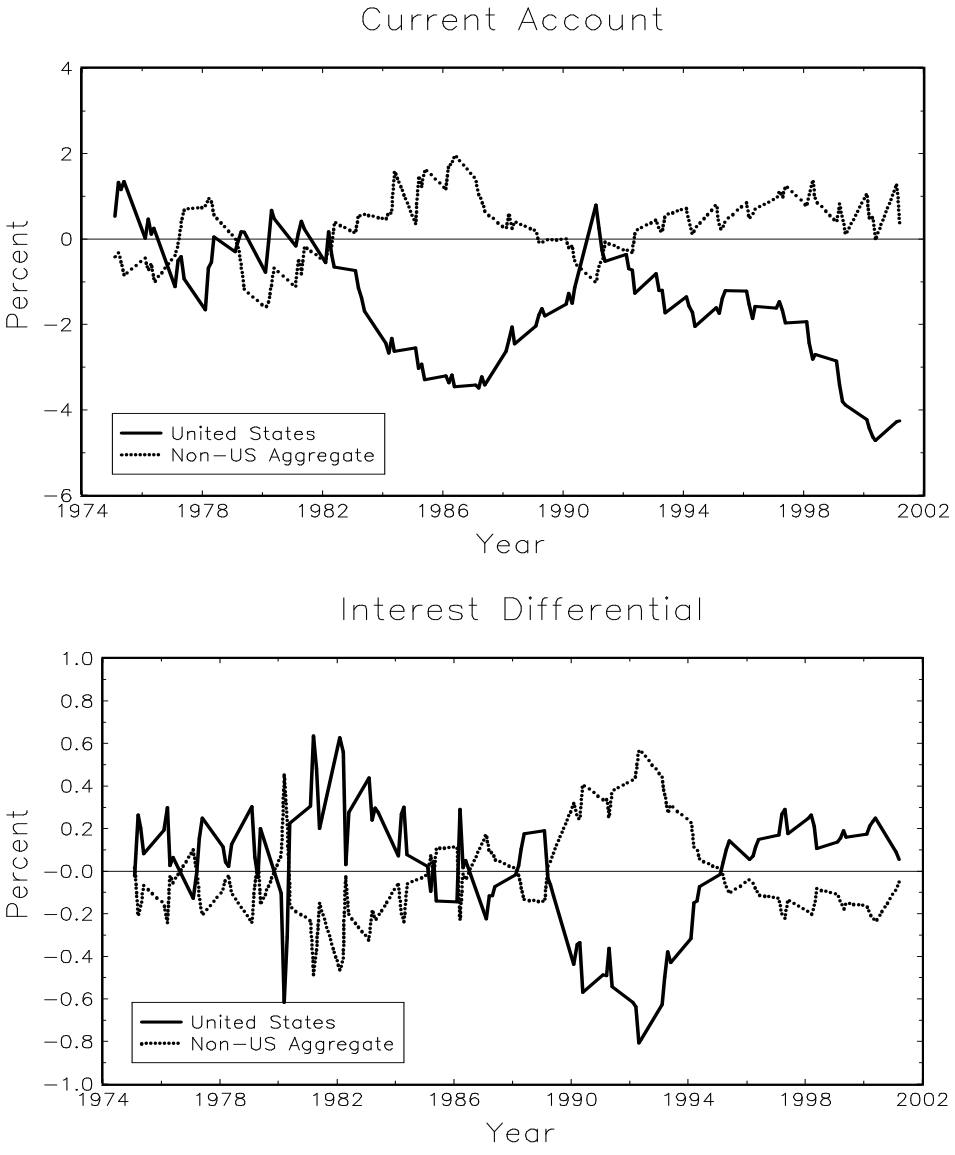
Note: Entries under relative volatility, within-country correlation, and cross-country correlation refer to the predicted and sample standard deviations of the variable relative to the predicted and sample standard deviations of y, the predicted and sample contemporaneous correlations between home variables, and the predicted and sample contemporaneous correlations between international variables. The predicted statistics are constructed from the benchmark and the no cost calibrations. The variables are the detrended logarithm of output (y), the detrended logarithm of consumption (c), the detrended logarithm of investment (i), the detrended ratio of national savings and output (s/y), and the detrended ratio of investment and output (i/y). The cross-country statistics refer to United States versus the Non-US Aggregate and to the average of all the bilateral statistics for the 10 countries. Entries in parentheses (brackets) are the p-values of the test that the difference between the predicted statistic generated by the benchmark (no cost) calibration and the sample statistic is null.

Table B2. Robustness: Business Cycle Statistics

	Relative Volatility		Within-Country Correlation			Cross-Country Correlation	
	c	i	(c, y)	(i, y)	$(s/y, i/y)$	(c, c^*)	(y, y^*)
Benchmark	0.93	2.23	0.99	0.88	0.70	0.41	0.35
Risk Aversion							
Low($\sigma = 1$)	0.95	2.22	0.98	0.88	0.67	0.39	0.32
High($\sigma = 10$)	0.93	2.23	0.99	0.91	0.75	0.47	0.45
Labor Supply Elasticity							
Low($\frac{1}{\nu-1} = 0.2$)	0.69	2.72	0.93	0.91	0.81	0.51	0.34
High($\frac{1}{\nu-1} = 2.5$)	1.02	2.01	0.99	0.87	0.63	0.41	0.36
Investment Adjustment Costs							
Low($\phi = 0$)	0.65	44.83	1.00	-0.29	-0.39	-1.00	-1.00
High($\phi = 7.5$)	0.95	1.80	0.99	0.96	0.83	0.45	0.39
Interest Differential Responsiveness							
Low($\varphi/\beta^2 = 0.001$)	0.93	2.10	0.98	0.90	0.72	0.45	0.38
High($\varphi/\beta^2 = 0.01$)	0.93	2.40	0.99	0.85	0.65	0.39	0.33
Technology Shocks Only							
No Spillovers	0.71	1.74	0.99	0.89	0.57	-0.95	0.97
Spillovers	0.99	1.51	0.97	0.26	0.93	0.96	0.81
Government Expenditures Shocks Only							
No Spillovers	0.80	1.79	0.96	0.97	0.83	0.65	0.88
Spillovers	0.80	1.80	0.74	0.96	0.99	0.99	0.99

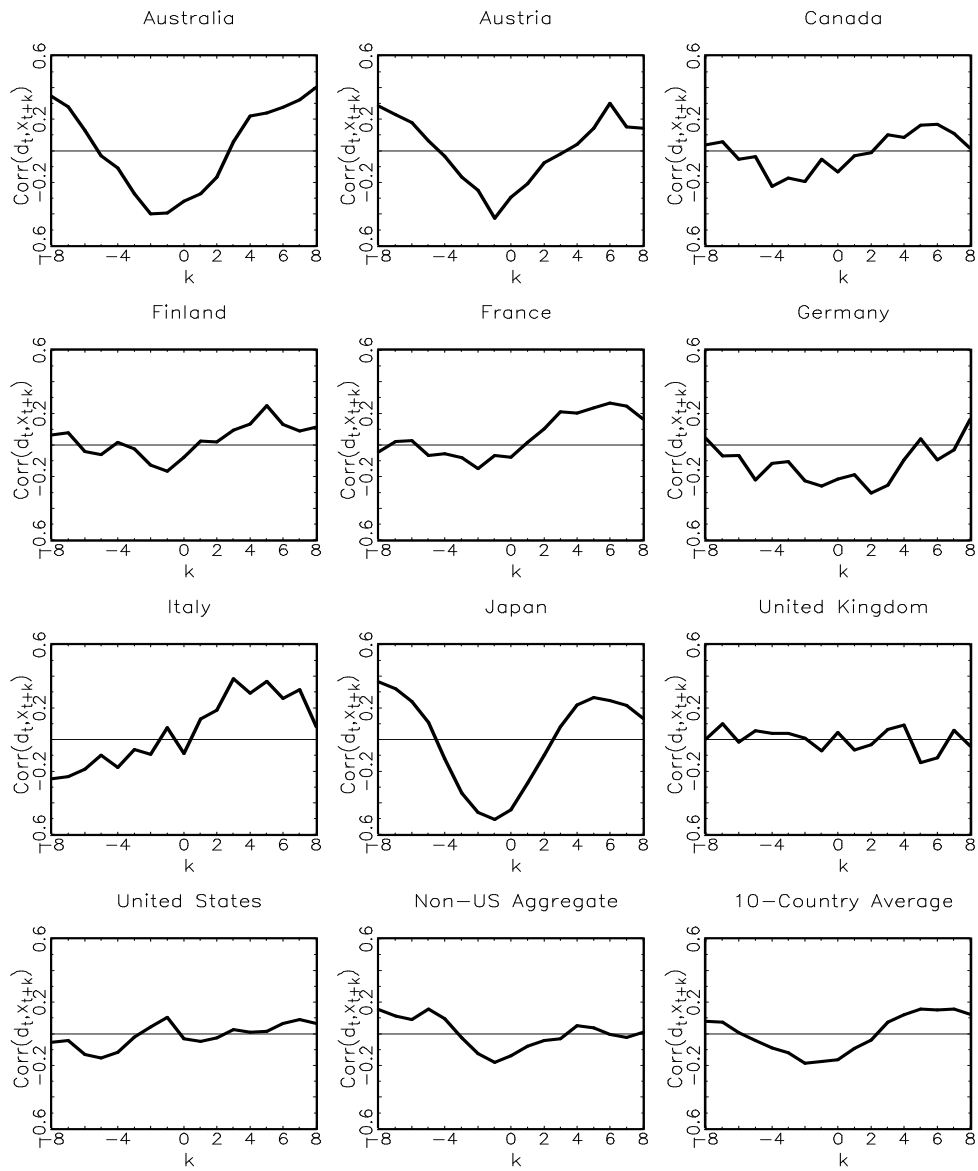
Note: Entries under relative volatility, within-country correlation, and cross-country correlation refer to the predicted standard deviation of a variable relative to the predicted standard deviation of y, the predicted contemporaneous correlation between home variables, and the predicted contemporaneous correlation between international variables. The variables are the detrended logarithm of output (y), the detrended logarithm of consumption (c), the detrended logarithm of investment (i), the detrended ratio of savings and output (s/y), and the detrended ratio of investment and output (i/y). The predicted statistics are constructed from the benchmark calibration and alternative parametrizations.

Figure 1. Current Account and Interest Differential



Note: The figure shows the current account to output ratio and the interest differential for the United States and an aggregate of non-US countries.

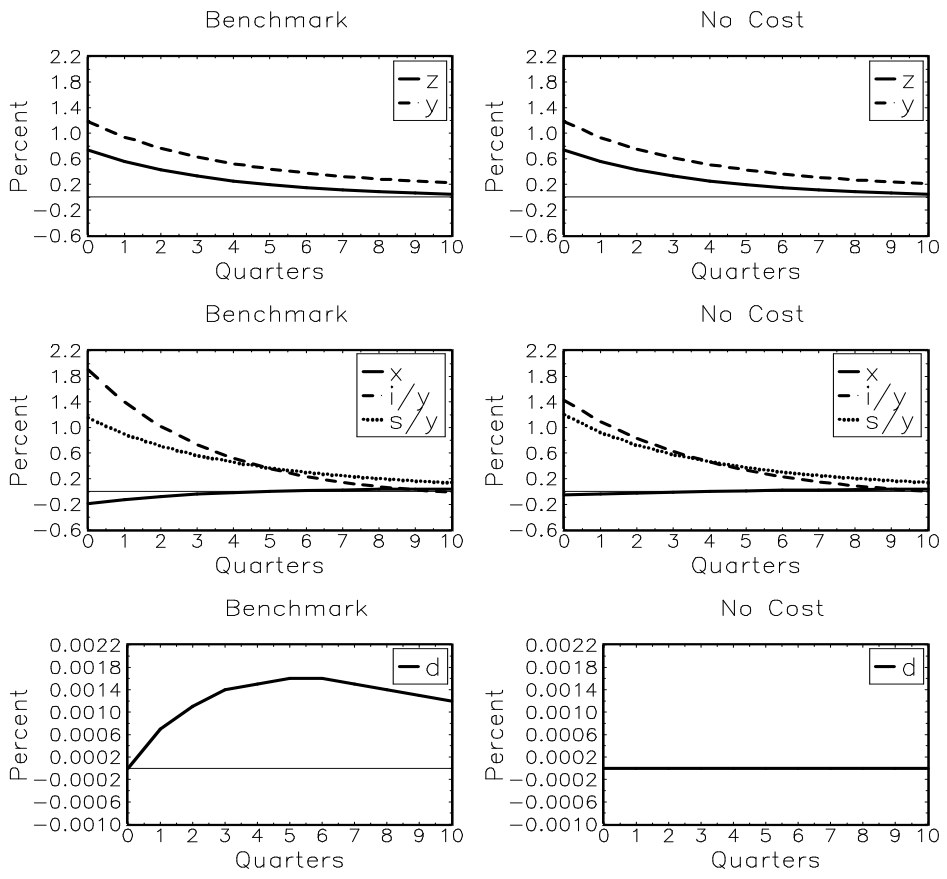
Figure 2. Empirical Regularities: Cross-Correlation Functions



Note: The figure shows the cross-correlation functions between the current account to output ratio (x) and the interest differential (d).

Figure 3. Theoretical Properties:

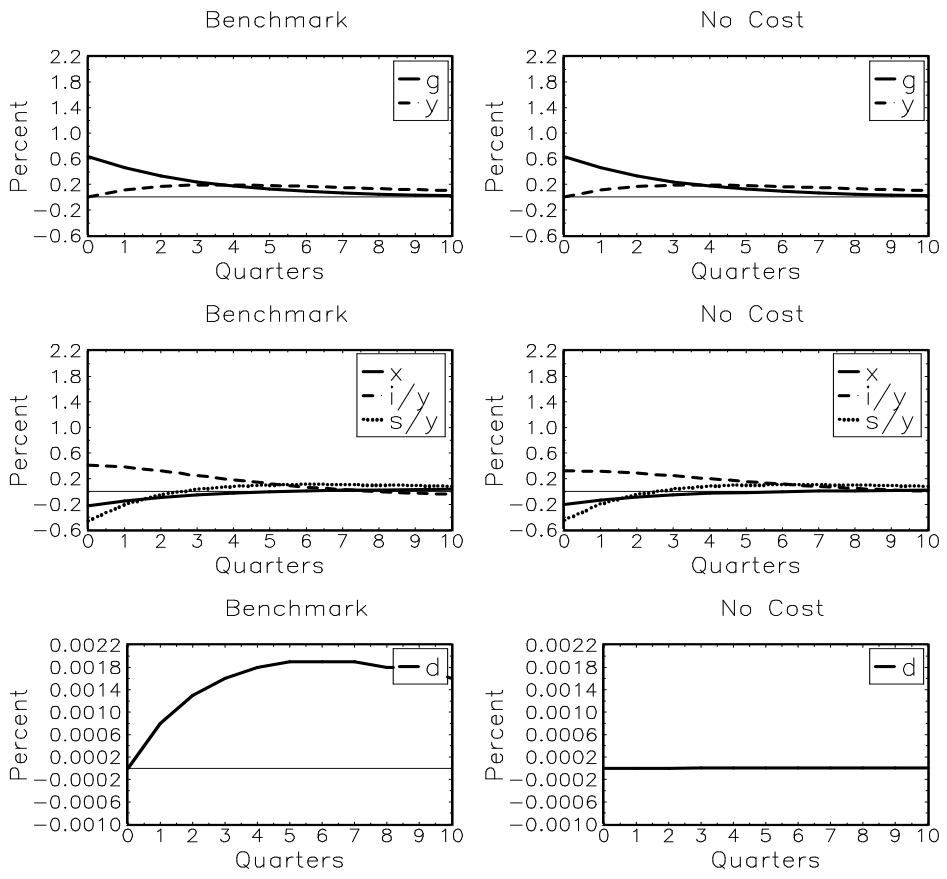
Dynamic Responses to Home Technology Shock



Note: The figure shows the dynamic responses of home variables to a one-standard deviation shock to home technology. The variables are technology (z), output (y), the current account to output ratio (x), the investment to output ratio (i/y), the savings to output ratio (s/y), and the interest differential (d).

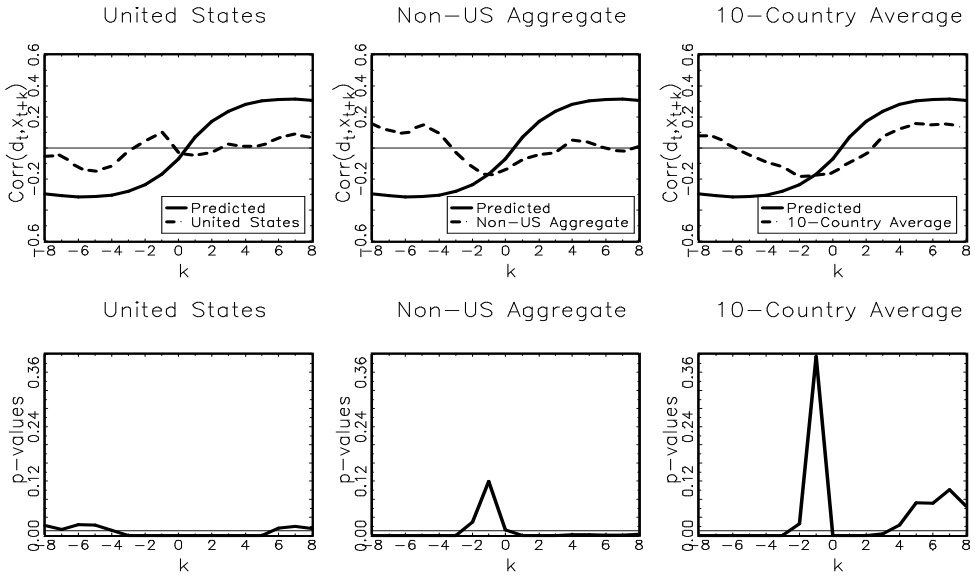
Figure 4. Theoretical Properties:

Dynamic Responses to Home Government Expenditure Shock



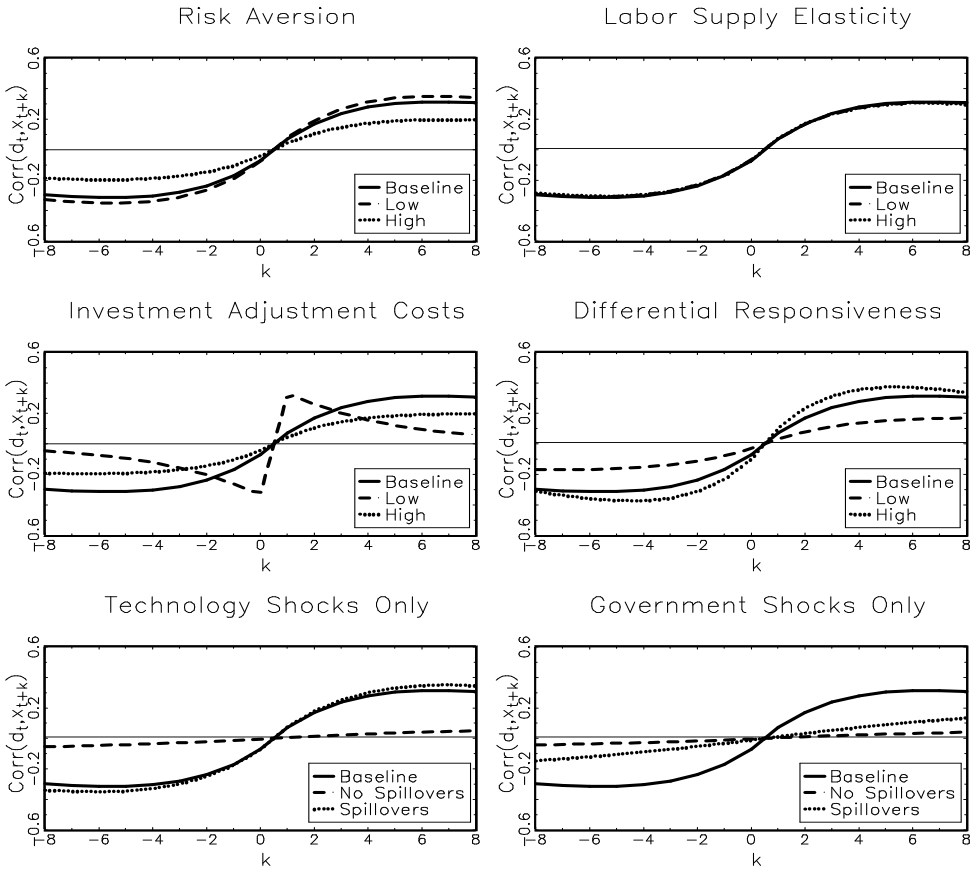
Note: The figure shows the dynamic responses of home variables to a one-standard deviation shock to home government expenditures. The variables are government expenditures (g), output (y), the current account to output ratio (x), the investment to output ratio (i/y), the savings to output ratio (s/y), and the interest differential (d).

Figure 5. Test Results: Cross-Correlation Functions



Note: The upper panels show the predicted and observed cross-correlation functions between the current account to output ratio (x) and the interest differential (d). The lower panels show the p-values of the test that the difference between the predicted cross-correlation generated by the benchmark calibration and the sample cross-correlation is null.

Figure 6. Robustness: Cross-Correlation Functions



Note: The figure shows the predicted cross-correlation functions between the current account to output ratio (x) and the interest differential (d). The predicted cross-correlation functions are constructed from the benchmark calibration and alternative parametrizations