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Financial Frictions and Business Cycles in Middle-Income Countries

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Abstract

A standard DSGE small open economy model can not generate the cyclical regularities of middle-income countries. It predicts excessive consumption smoothing, and procyclical, instead of countercyclical, real net exports. Previous studies have solved this problem by increasing the shocks' persistence or by lowering the intertemporal elasticity of substitution. This paper tackles the problem by introducing market imperfections relevant for MICs into an otherwise standard model. More specifically, I build a model with limited access to the foreign capital market, identified as an external borrowing constraint, and asymmetric financing opportunities across nontradable and tradable sectors, identified as a sector-specific labor financing wedge. The key parameters associated to these frictions are deduced to replicate selected data for Chile between 1986 and 2004. I find that both frictions are necessary to replicate the cyclical regularities of middle-income countries as they help the model reproduce different features of the data: The external borrowing constraint makes investment and consumption of tradable goods more procyclical and volatile, and makes real net exports countercyclical, while the sector-specific labor financing wedge makes the model reproduce the cyclical moments of work hours and consumption of non tradable goods.

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Keywords: borrowing constraint, labor financing wedges, procyclical, countercyclical, consumption, real net exports.

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I. INTRODUCTION

Empirical analysis reveals three regularities among middle-income countries: consumption is highly procyclical and more volatile than output, investment is highly procyclical and three to four times as volatile as output, and real net exports are countercyclical and about three times as volatile as output. Standard dynamic stochastic general equilibrium (DSGE) small open economy models have failed to match these regularities, as they predict excessive consumption smoothing, low procyclicality and volatility of investment, and procyclical real net exports. Previous studies have solved these problems by increasing the persistence of shocks (Aguiar and Gopinath, 2007) or by lowering the intertemporal elasticity of substitution, as when using the GHH preferences introduced by Greenwood, Hercowitz, and Hoffman (1988) (Mendoza, 1995, 2001; Neumeyer and Perri, 2005).

This study approaches the problem by considering market imperfections relevant for middle-income countries; a limited access to the foreign capital market, identified as an external borrowing constraint; and asymmetric financing opportunities across tradable and nontradable firms, identified as a sector-specific labor-financing wedge (Caballero, 2002; Tornell and Westermann, 2003). The key parameters associated with these frictions are deduced to match selected data for Chile between 1986 and 2004, narrowing the discussion to whether the cyclical properties of the deduced variables make sense according to previous studies, or whether they could represent some other distortions not identified in the model.

I conclude that a model with an external borrowing constraint can capture the procyclical and volatile path of investment and consumption of tradable goods and produce countercyclical real net exports. However, it generates countercyclical employment and a low volatility of nontradable consumption. Introducing a countercyclical sector-specific labor-financing wedge enables the model to capture the cyclical pattern of these other variables, as well. Moreover, the cyclical properties of the key variables associated with both frictions are consistent with previous studies (Caballero, 2002; Tornell and Westermann, 2003).

An external borrowing constraint may arise from problems of enforceability and risk of default. Atkeson and Rios-Rull (1996) and Caballero and Krishnamurthy (2001) identify this friction as collateral constraints, in which foreign lender can seize part of the export sector's profits or revenues in case of default. Eaton and Gersovitz (1981), Bulow and Rogoff (1989), Atkeson (1991), Kehoe and Levine (1993), Kocherlakota (1996), Alvarez and Jermann (2000), and Jeske (2001) consider exclusion from the foreign capital market as the punishment for defaulting.

Atkeson (1991) derives an external borrowing constraint when foreign lending takes place under moral hazard and risk of repudiation. Foreign lenders cannot observe if borrowers are investing the borrowed funds efficiently or consuming them, and sovereign borrowers can repudiate their debt at any time. With no moral hazard and risk of repudiation, the optimal contract produces full risk sharing between domestic agents and foreign lenders. With these problems, however, foreign lenders can infer the domestic agents' allocations only after output is realized. The optimal contract reduces risk sharing, transferring part of the output risk to the borrowers and thereby inducing them to invest efficiently and repay their loans.

For practical convenience, the constraint is set as the foreign lenders' requirement for domestic households to self-finance a fraction of their expenditures, $0 < \Psi_t < 1$, with their current income at each date t, as in Mendoza (2001). I then deduce Ψ_t to match the path of the real net exports in Chile between 1986 and 2004. Full risk sharing is equivalent to a sufficiently procyclical Ψ_t, so that domestic agents can borrow more relative to income in bad times than in good. Partial risk sharing is equivalent to a less than sufficiently procyclical Ψ_t and less expenditure smoothing. The constraint should always bind to prevent domestic agents from building up savings that would lead them to repudiate their debt.

In the simulations for Chile, the external constraint slackens when the economy receives positive shocks and tightens when it faces negative shocks, but not enough to produce full risk sharing. External financing becomes more (less) expensive during recessions (booms), making investment and tradable goods consumption more procyclical and volatile, and output of export goods less procyclical, as there is less reallocation of production factors across sectors, and it makes real net exports as countercyclical as in the data by construction. However, this friction makes employment countercyclical and does not make nontradable consumption as volatile as in the data. A countercyclical labor-financing wedge can help the model match these moments by making labor demand more procyclical and volatile.

The sectoral labor-financing wedge reflects credit constraints at the firm level. They may arise from informational or enforcement problems, which could be very severe for small and medium-sized firms that lack the collateral to secure loans. Holmström and Tirole (1998) derive credit constraints for firms from moral hazard problems, while Bernanke and Gertler (1989) do it from costly state verification problems. Albuquerque and Hopenhayn (2004) and Medina (2004) derive them from enforcement problems. Kiyotaki and Moore (1997) and Caballero and Krishnamurthy (2001) represent them as collateral constraints. Tornell and Westermann (2003), using firm-level data for twenty-seven middle-income countries, find that financing is a more severe obstacle for firms in the nontradable sector, as they are mostly small and medium-sized firms that lack collateral to secure their loans.

Here, I set this friction as a firm's specific labor-financing wedge that represents the lending spread each firm pays for the credit used to pay wages in advance of production. The spread depends on the firm's available collateral, as in Chari, Kehoe, and McGrattan (2003).[1] The wedges are deduced to make the model replicate the path of output of each sector in the data. As in previous studies, the wedges are countercyclical, particularly in the nontradable sector,

[1]. This specification could be capturing some other distortions in the labor market, such as sticky wages or unions (Chari, Kehoe, and McGrattan, 2003) or labor market regulations (Caballero and others, 2004).

reflecting a lower cost of financing during booms when the collateral's value increases and a higher cost during downturns when the opposite valuation effect occurs. The wedge allows the model to generate procyclical employment, as labor demand becomes more procyclical and volatile, and to increase the volatility of nontradable consumption.

Although this study does not endogenize the source of market imperfections, it presents a simulated scenario for a lower incidence of frictions to show what the economy's cyclical properties would have been if it had better access to external and domestic financing. The self-financing requirement is made more procyclical and volatile to increase the risk sharing between domestic households and foreign lenders, and the volatility of the sector-specific labor-financing wedges are reduced. The cyclical properties of this economy are qualitatively similar to the frictionless case; the volatility of consumption and investment would be smaller, and total work hours and the output of exportable goods would be more procyclical and volatile, resulting in procyclical and less volatile real net exports.

The paper is organized as follows. Section 1 discusses the empirical evidence and related literature. Section 2 presents the model and simulations for a friction-less economy. I then derive variations of the base model: section 3 presents the model and simulations for an externally credit constrained economy, section 4 for an economy with asymmetric financing opportunities, and section 5 for an economy that features both frictions. Section 6 concludes.

II. Empirical Evidence and Related Literature

This section compares the moments of middle-income countries and small developed economies to highlight the particular features of middle-income countries. Table 1 presents statistics for output, consumption, investment, real net exports and the terms of trade for twenty-eight middle-income countries and the average of sixteen small developed economies for annual data between 1980 and 2004. Each variable corresponds to the log deviation from its trend, which was obtained using the Hodrick-Prescott filter with a smoothing parameter of 100. The statistics presented are the first-order autocorrelation and standard deviation of gross domestic product (GDP) and the cross-correlations and relative standard deviations of consumption, investment, real net exports and the terms of trade relative to GDP.

The first distinctive feature is that GDP is almost twice as volatile in the middle-income countries as in the small developed economies, but only slightly less persistent. Second, while investment is as volatile relative to output in both groups of countries, consumption and real net exports are significantly more volatile relative to output in middle-income countries than in small developed economies. Third, all three expenditure items present roughly the same correlation with GDP in the two groups of countries. These findings are robust to different data frequency. Aguiar and Gopinath (2007) present similar evidence at a quarterly frequency for a smaller sample of small developed economies and middle-income countries. They find the same differences in volatility and similarities in correlations with output, except for the ratio of real net exports to GDP, which is more countercyclical in middle-income countries than in small developed economies at quarterly frequency.

One concern with the moments presented in table 1 is whether they are representative of normal business cycles fluctuations in middle-income countries or are biased as a result of crises. Although table 1 does not abstract from periods of crisis, Tornell and Westermann (2002) argue that the typical lending booms that characterize middle-income countries business cycles commonly end in a soft landing with the same moments as in crisis periods, although with less volatility. To avoid this problem, this paper studies the case of Chile between 1986 and 2004, abstracting from its last crisis in 1982.

Earlier studies reproduce the high volatility of consumption and real net exports in middle-income countries by lowering the intertemporal elasticity of substitution, by increasing the shocks' persistence, or by considering frictions in the access to foreign and domestic financing. With regard to the former, Mendoza (1995, 2001) and Neumeyer and Perry (2005), for Mexico and Argentina, respectively, solved the problem by using GHH preferences or by lowering the intertemporal elasticity of substitution. GHH preferences make the labor-leisure decision dependent only on real wages, which makes work hours , consumption, and investment more procyclical and volatile, while real net exports become countercyclical. A lower intertemporal elasticity of substitution produces similar results.

Some empirical studies estimate a lower intertemporal elasticity of substitution for middle-income countries than for developed economies (Ostry and Reinhart, 1992; Barrionuevo, 1993), but Domeij (2006) shows that such estimates would be biased downward if borrowing constraints are ignored in the estimation. He applies standard econometric methods to artificial data constructed for credit-constrained agents, but ignores the constraints in the estimation. This results in an estimated intertemporal elasticity of substitution 50 percent lower than the true elasticity with which the data were built.

With regard to increasing the shocks' persistence, Aguiar and Gopinath (2007) introduce a permanent shock to the trend growth rate of productivity into an otherwise standard DSGE small open economy model, to replicate the cyclical regularities of Mexico. This model could replicate the high volatility of consumption and real net exports observed in middle-income countries, but it relies largely on the strong persistence of the shock to the trend growth rate of productivity, which creates larger procyclical fluctuations in consumption and investment and larger countercyclical fluctuations in real net exports than do shocks to productivity around a trend.

There is no evidence that foreign or domestic shocks are, in fact, more persistent in middle-income countries than in small developed economies. Although there are no data on total factor productivity across countries, the cyclical properties of output and investment offer clues. More persistent productivity shocks would presumably result in more persistent fluctuations in output and investment, as the marginal productivity of capital varies directly with the shock. However, column 1 in table 1 shows that output is slightly less persistent in the middle-income countries than in the small developed economies, while columns 5 and 6 show that investment is less procyclical and persistent in the middle-income countries. For foreign shocks, columns 10 and 11 show that the terms of trade are less persistent, but more volatile in the middle-income countries, while the foreign interest rate shocks should be as persistent and volatile across groups as long as the risk premium is endogenous.

Finally, with regard to frictions in the access to foreign and domestic financing, Caballero (2000) studies the source of volatility in three Latin American middle-income countries: namely, Argentina, Chile, and Mexico. He finds that these economies are weak in their links with the foreign capital market and in the development of their domestic financial markets. These frictions can account for a large share of the fluctuations and crises in modern Latin America, either directly or by leveraging a variety of shocks. Tornell and Westermann (2002) provides evidence of asymmetric financing opportunities across tradable and nontradable firms for a sample of twenty-seven middle-income countries. Estimating an ordered probit model, they find that financing was a more severe obstacle for the nontradable firms, as they were mostly small and medium-sized firms that lack the collateral to secure loans.

Caballero and Krishnamurthy (2001) analyze the interaction of these two frictions in a stylized model with two types of collateral constraints: firms in the domestic economy have limited borrowing capacity from foreign investors and from each other. Their interaction produced two suboptimal allocations. First, disintermediation, by which a fire sale of domestic assets causes banks to fail reallocating resources across firms, resulting in wasted international collateral. Second, a dynamic effect results when firms with limited domestic collateral and a binding international collateral constraint do not take adequate precautions against adverse shocks, thereby increasing their severity

This paper takes Chile as a case study for three reasons. First, it presents roughly the same cyclical moments as other middle-income countries. Comparing table 2 with columns 1 through 9 in table 1 reveals that the first-order autocorrelation of output is roughly the same in Chile as in other middle-income countries, although its output volatility is about half the average of middle-income countries. Consumption and investment are more procyclical in Chile, but as volatile relative to output, while real net exports are more countercyclical and less volatile. Second, Chile is frequently cited in the literature for its disciplined economic policy, which makes it reasonable to abstract from monetary and fiscal policy shocks. This reduces the model to a simple exchange-production economy, similar to that used by Aguiar and Gopinath (2007), Mendoza (1995, 2001), and Neumeyer and Perry (2005). Third, Caballero (2000, 2002) finds an active role of the two financial frictions studied here in Chile’s business cycles in the 1990s. With regard to the limited access to the foreign capital market, he finds that in 1999 consumption and the current account fell more than what could be explained by the negative terms-of-trade shock, in part because of the decline in capital inflows. With regard to domestic financing opportunities, he shows that domestic banks reacted to the shock by slowing down private loans, even though domestic deposits were growing fast. They substituted private domestic loans with public debt and external assets, and they allocated a higher fraction of their credit to large firms, reducing the access to credit of small and medium-sized firms, most of them in the nontradable sector.

This study seeks to evaluate quantitatively, in a DSGE framework, whether considering these two frictions in an otherwise standard small open economy model can replicate the cyclical regularities observed in middle-income countries. The model is calibrated and simulated for shocks to the terms of trade, foreign interest rate, and total factor productivity between 1986 and 2004. I begin with a frictionless version of the model and then incorporate each friction separately into the model to quantify its specific role in the domestic cycles. Finally, a model that features both frictions is simulated.

III. Model 1: Frictionless Small Open Economy

Consider a small open economy that is perfectly integrated to the world in goods, but faces an aggregate upward-sloping supply of external funds:

$$R_t = R_t^* + \eta\left(\overline{b} - b_t\right) \tag{1}$$

where R_t is the domestic rate of return, R_t^* is the foreign rate of return, b_t is the net external assets position, $\overline{b}$ is the level of net external assets at which the risk premium is zero, and η is the elasticity of such premium to the net foreign assets. R_t^* is stochastic according to:

$$R_t^* = \exp\left(\varepsilon_t^R\right) R^* \tag{2}$$

where R^* is its unconditional mean and ε_t^R its first-order autoregressive shock:

$$\varepsilon_{t+1}^R = \rho^R \varepsilon_t^R + v_{t+1}^R \tag{3}$$

with $E\left(v_{t+1}^R\right) = 0$ and $V\left(v_{t+1}^R\right) = \sigma_R^2$.

This model is not exactly a frictionless setup, in which $R_t = R_t^*$ at each date *t*, because when the model is log-linearized around the steady state, it yields a unit root for consumption, work hours, investment, net exports and net foreign assets (see Correia and others, 1995). To have a unique steady state it is necessary to anchor external debt in equilibrium. This can be done by setting an upward-sloping supply of external funds, a cost function of adjusting the external asset portfolio, or an endogenous discount factor. Schmitt-Grohe and Uribe (2003) show that all of these three forms yield the same first and second moments. I chose the first to be consistent with the later specifications, and I kept η small to make the model a good approximation of the frictionless setup.

There are three goods in this economy: an exportable good (*X*), an importable good (*M*) and a nontradable good (*N*). The two production factors are labor (*h*) and capital (*k*). The home economy produces *X* and *N* goods, using *h* and *k* inputs. Capital is sector specific, and labor moves freely across sectors. The law of one price holds for both tradable goods. The external price of *M* is normalized to one and assumed constant, while the external price of *X* is stochastic, according to the following process:

$$P_t^X = \exp\left(\varepsilon_t^{P^X}\right) P^{X*} \tag{4}$$

where P^{X*} is its unconditional mean and $\varepsilon_t^{P^X}$ is the first-order autoregressive shock:

$$\varepsilon_{t+1}^{P^X} = \rho^{P^X} \varepsilon_t^{P^X} + v_{t+1}^{P^X} \tag{5}$$

with $E\left(v_{t+1}^{P^X}\right) = 0$ and $V\left(v_{t+1}^{P^X}\right) = \sigma_{P^X}^2$.

There are two types of domestic agents: households and firms. Households own the firms, consume the *N* good, buy the *M* good for consumption and investment, and supply *h* and *k* to the firms. They are the only ones with access to the foreign capital market. There are two firms, the export firm and the nontradable firm; both use *h* and *k* to produce their goods. The economy follows a balanced growth path at a growth rate of $(\gamma - 1)$, and population is constant. In the following, the model is set in stationary form.

A. Households

Households maximize their lifetime utility given by equation 6:

$$U = E_0 \left\{ \sum_{t=0}^{\infty} \beta^{*t} \frac{\left[c_t^{\alpha} \left(1 - h_t\right)^{1-\alpha} \right]^{1-\sigma}}{1-\sigma} \right\} \tag{6}$$

where $\beta^* = \beta\gamma^{\alpha(1-\sigma)}$, β is the discount factor, h_t the normalized hours of work, and c_t a constant elasticity of substitution (CES) aggregation of consumption of importable $\left(c_t^M\right)$ and nontradable $\left(c^N\right)$ goods:

$$c_t = \left[\varpi c_t^{M\rho} + \left(1 - \varpi\right) c_t^{N\rho} \right]^{\frac{1}{\rho}} \tag{7}$$

where $1/\sigma$ and $1/1-\rho$ are the intertemporal elasticity of substitution and the elasticity of substitution between *M* and *N*, respectively. The households flow budget constraint is:

$$w_t h_t + q_t^X k_t^X + q_t^N k_t^N + R_t b_t = c_t^M + P_t^N c_t^N + i_t^X + i_t^N + \gamma b_{t+1} \tag{8}$$

where w_t is the wage rate, P_t^N the relative price of *N* to *M* goods, and k_t^j, i_t^j and q_t^j are capital, investment, and the reantal rate of capital in sector *j*, respectively. Investment is used to replace depreciated capital, accumulate new capital, and cover the capital adjustment costs, according to the following law of motion:

$$\gamma k_{t+1}^j = (1-\delta) k_t^j + i_t^j - \frac{\theta}{2}\left(i_t^j\right)^2 \tag{9}$$

For *j* = *X*, *N*, where δ is the depreciation rate and θ the coefficient in the quadratic adjustment costs. Households choose the sequence $\left\{c_t^M, c_t^N, h_t, i_t^X, i_t^N, k_{t+1}^X, k_{t+1}^N, b_{t+1}\right\}_{t=0}^{\infty}$ to maximize equation 6, subject to equations 8 and 9. Their first-order conditions are as follows:

$$\alpha\varpi\left[\varpi c_t^{M\rho} + (1-\varpi) c_t^{N\rho}\right]^{\frac{\alpha}{\rho}(1-\sigma)-1} (1-h_t)^{(1-\alpha)(1-\sigma)} c_t^{M(\rho-1)} = \lambda_t \tag{10}$$

$$\alpha(1-\varpi)\left[\varpi c_t^{M\rho} + (1-\varpi) c_t^{N\rho}\right]^{\frac{\alpha}{\rho}(1-\sigma)-1} (1-h_t)^{(1-\alpha)(1-\sigma)} c_t^{N(\rho-1)} = P_t^N \lambda_t \tag{11}$$

$$(1-\alpha)\left[\varpi c_t^{M\rho} + (1-\varpi) c_t^{N\rho}\right]^{\frac{\alpha}{\rho}(1-\sigma)} (1-h_t)^{\alpha(\sigma-1)-\sigma} = \lambda_t w_t \tag{12}$$

$$\phi_t^X = \lambda_t + \phi_t^X \theta i_t^X \tag{13}$$

$$\phi_t^N = \lambda_t + \phi_t^N \theta i_t^N \tag{14}$$

$$\gamma\phi_t^X = \beta E_t\left[\lambda_{t+1} q_{t+1}^X + \phi_{t+1}^X (1-\delta)\right] \tag{15}$$

$$\gamma\phi_t^N = \beta E_t\left[\lambda_{t+1} q_{t+1}^N + \phi_{t+1}^N (1-\delta)\right] \tag{16}$$

$$\gamma\lambda_t = \beta E_t\left[\lambda_{t+1} R_{t+1}\right] \tag{17}$$

$$E_t\left[\lim_{t\to\infty} \beta^t \lambda_t \left(k_{t+1}^X + k_{t+1}^N + b_{t+1}\right)\right] = 0 \tag{18}$$

where λ_t, ϕ_t^X and ϕ_t^N are the Lagrange multipliers on on equations 8 and 9, respectively.

B. Firms

Both firms have Cobb-Douglas constant-return-to-scale technologies and choose $\left\{h_t^{fj}, k_t^{fj}\right\}_{t=0}^{\infty}$ to maximize profits, with $j = X, N$. The first-order conditions for the nontradable firm are:

$$w_t = \left(1-\alpha_N\right) P_t^N \exp\left(\varepsilon_t^N\right)\left(k_t^{fN}\right)^{\alpha_N}\left(h_t^{fN}\right)^{-\alpha_N} \tag{19}$$

$$q_t^N = \alpha_N P_t^N \exp\left(\varepsilon_t^N\right)\left(h_t^{fN}\right)^{(1-\alpha_N)}\left(k_t^{fN}\right)^{(\alpha_N-1)} \tag{20}$$

while the first-order conditions for the export firm are

$$w_t = \left(1-\alpha_X\right) P_t^X \exp\left(\varepsilon_t^X\right)\left(k_t^{fX}\right)^{\alpha_X}\left(h_t^{fX}\right)^{-\alpha_X} \tag{21}$$

$$q_t^X = \alpha_X P_t^X \exp\left(\varepsilon_t^X\right)\left(h_t^{fX}\right)^{(1-\alpha_X)}\left(k_t^{fX}\right)^{(\alpha_X-1)} \tag{22}$$

Where ε_t^j is the productivity shock in each sector $j = X, N$, respectively. The shocks follow a first-order autoregressive process:

$$\varepsilon_{t+1}^j = \rho^j \varepsilon_t^j + v_{t+1}^j \tag{23}$$

with $E\left(v_{t+1}^j\right) = 0$ and $V\left(v_{t+1}^j\right) = \sigma_j^2$.

C. Competitive Equilibrium

Given b_0, k_0^X, and k_0^N, and shocks' processes $\left(\varepsilon_t^R, \varepsilon_t^{P^X}, \varepsilon_t^X, \varepsilon_t^N\right)$, a competitive equilibrium corresponds to sequences of allocations $\left\{c_t^M, c_t^N, h_t, i_t^X, i_t^N, k_{t+1}^X, k_{t+1}^N, b_{t+1}\right\}_{t=0}^{\infty}$, $\left\{h_t^{fX}, h_t^{fN}, k_t^{fX}, k_t^{fN}\right\}_{t=0}^{\infty}$, and prices $\left\{P_t^X, P_t^N, q_t^X, q_t^N, w_t, R_t\right\}_{t=0}^{\infty}$, such that:

- Given b_0, k_0^X, k_0^N, prices, and shocks' processes, $\left\{c_t^M, c_t^N, h_t, i_t^X, i_t^N, k_{t+1}^X, k_{t+1}^N, b_{t+1}\right\}_{t=0}^{\infty}$ solve the households' problem;

- Given prices and shocks' processes, $\left\{h_t^{fX}, k_t^{fX}\right\}_{t=0}^{\infty}$ solve firm X's problem;

- Given prices and shocks processes, $\left\{h_t^{fN}, k_t^{fN}\right\}_{t=0}^{\infty}$ solve firm N's problem;

- Markets clear: $c_t^N = y_t^N$, $k_t^X = k_t^{fX}$, $k_t^N = k_t^{fN}$, and $h_t = h_t^{fX} + h_t^{fN}$; and

- The resource constraint is satisfied: $R_t b_t + P_t^X y_t^X = c_t^M + i_t^X + i_t^N + \gamma b_{t+1}$

D. Steady State and Calibration

The parameters are calibrated to match Chile's average macroeconomic ratios between 1986 and 2004. Table 3 presents the parameters, together with the ratios in the data and in the model in steady-state. The risk premium elasticity, η, is 0.001 as in Schmitt-Grohé and Uribe (2003), net foreign assets are –19 percent of GDP, and $\bar{b}$ is 8.8 percent of GDP, to yield a spread $R_t - R_t^*$ of 200 basis points in steady state. The parameter γ is equal to 1.056, or one plus the average growth of GDP, while β is 0.94 according to equation 17.

To calibrate the other parameters, it is necessary to construct the sectoral series of output and hours of work. For output, the sectoral series of GDP from national accounts are allocated as exportable or nontradable goods as in Stockman and Tesar (1995) and Mendoza (1995). The export sector's GDP is defined as the sum of GDP in mining, agriculture, forestry, fishery, and manufacturing, equivalent to 36 percent of GDP, while the nontradable sector's GDP corresponds to the sum of GDP in wholesale and retail trade, construction, electricity, gas, and water, financial services, housing, personal services, public administration and transport, storage, and communication, equivalent to 64 percent of GDP. A similar aggregation was used to allocate employment across sectors. Employment in the export sector is the sum of employees in mining, agriculture, hunting and fishery, and manufacturing, equivalent to 33 percent of total employment, while in the nontradable sector it is the sum of employees in construction, electricity, gas and water, trade, transport and communication, financial services, and social services, equivalent to 67 percent of total employment.

Consumption of the nontradable good is equal to nontradable output, while consumption of importable goods is equal to the rest of total consumption. In steady state, the current account balance has to be equal to zero, whereas it is in deficit in the data, so I had to adjust some ratios in the model to calibrate a consistent steady state. The ratio of exportable GDP to total GDP was increased from 0.37 in the data to 0.40 in the model; the ratio of investment was reduced from 0.30 in the data to 0.29 in the model; and the ratio of importable goods consumption was reduced from 0.13 in the data to 0.10 in the model. As a result, the ratio of real net exports to GDP was increased from –0.06 in the data to 0.01 in the model.

In line with the adjustments in output, the share of employment in the export sector was increased from 0.33 in the data to 0.36 in the model, and the nontradable share was reduced from 0.67 in the data to 0.64 in the model. The prices of X and N relative to M were both set equal to one in steady state. Next, σ and ρ were set as in Mendoza (1995) for the industrialized economies[2], while α, $\bar{w}$, λ, φ^X, and φ^N were calibrated from equations 10 to

[2]. I chose the benchmark parameters for industrialized economies because the parameters for the developing economies can be biased as a result of more severe credit constraints ignored in the estimation.

14, respectively. The shares α_X and α_N were calibrated to generate the sectoral allocation of labor in the model and an overall capital income share of 0.46, as estimated by Gallego, Schmidt-Hebbel, and Servén (2005) and García and others (2005). Table 3 shows that the calibration is consistent with the macroeconomic ratios in the data, except for the adjustments made to achieve a zero current account balance in steady state.

E. Simulations

The model is simulated for exogenous shocks to the terms of trade, foreign real interest rate, and productivity in the export and nontradable sectors. The foreign real interest rate is the U.S. federal funds rate minus ex post inflation, and the terms of trade is the ratio of prices of exports to imports of goods and services. Total factor productivity for each sector is the Solow residual, for which I used the sectoral series of output described in the previous section, while the aggregate and sectoral series of work hours and capital were constructed.

Total work hours were built using total employment from the National Institute of Statistics and average hours worked per employee from the International Labor Organization (ILO). They were normalized taking the average hours worked times the number of employees, divided by the potential working time of the working-age population. Its sectoral allocation was built assuming that labor is freely mobile across sectors and that both sectors present Cobb-Douglas production functions with constant return to scale, so that its marginal productivity is equal across sectors according to equation 24:

$$\frac{h_t^N}{h_t^X} = \frac{(1-\alpha_N) P_t^N y_t^N}{(1-\alpha_X) P_t^X y_t^X} \tag{24}$$

The aggregate capital stock (k_t) was estimated using the following law of motion:

$$\gamma k_{t+1} = (1-\delta) k_t + i_t - \frac{\theta}{2} i_t^2 \tag{25}$$

where k_t and i_t are aggregate capital and investment, respectively. For its sectoral allocation, capital was assumed to be sector specific, but investment freely mobile across sectors. I used a three-step procedure. First, the allocation of freely mobile capital was obtained, equating its marginal productivity across sectors (equation 26):

$$\frac{k_t^N}{k_t^X} = \frac{\alpha_N P_t^N y_t^N}{\alpha_X P_t^X y_t^X} \tag{26}$$

Second, the implicit series of investment were derived from these allocations, considering capital as sector specific. Third, a nonnegativity condition for investment in each sector was verified, finding that the freely mobile allocation is consistent with positive investment in both sectors. Then, given that sector-specific capital only creates one-period discrepancies in the sectoral allocation of capital relative to freely mobile capital, I decided to take the latter.[3]

Figure 1, panel A, presents all four shocks in log deviation from their Hodrick-Prescott (HP) trend between 1986 and 2004. Table 4 shows that the autocorrelation of the two productivity shocks and the terms of trade is low, ranging between 0.3 and 0.4. Only the foreign real interest rate is more persistent. The terms-of-trade shocks are the most volatile, about three times as volatile as output, while both productivity shocks and foreign real interest rate are less volatile than output. Finally, the innovations to all four shocks are positively cross-correlated among them, particularly between both productivity shocks and between the terms of trade and the foreign real interest rate.

The model is log-linearized, so the variables represent log deviations from their steady-state values. Table 5 presents the data moments in columns 1–4 and model 1's simulated moments in columns 5–8. Model 1 predicts excessive consumption smoothing of importable and nontradable goods, a lower volatility and procyclicality of investment, and procyclical, instead of countercyclical, real net exports.

Consumption smoothing results in a less procyclical and less volatile nontradable output, but in a more procyclical and more volatile exportable output. In response to the terms-of-trade shocks (the main drivers of the domestic cycles), work hours are reallocated from the nontradable sector to the export sector for positive shocks and vice versa for negative shocks. Thus, hours of work in the export sector are highly procyclical, contrasting with the highly countercyclical employment in the nontradable sector. At the same time, aggregate work hours are more volatile and procyclical than in the data.

Figure 2 presents the data series and model 1 simulations for the same sample. Model 1 predicts a smaller fall in aggregate and nontradable consumption in 1990–91 and 2001–03, and a lower expansion in 1994–98, resulting in the lower procyclicality and volatility relative to the data. For investment, the model also predicts a lower expansion in 1989 and in 1995–98, together with a smaller fall in 1991–92 and 1999–2004. Aggregate and export sector work hours move similarly to the terms of trade. Labor supply is highly procyclical and volatile. Together with the procyclical reallocations of labor from the nontradable to the export sector, this results in highly volatile and procyclical output and employment in the export sector and—when added to the smooth path of consumption and investment—procyclical, rather than countercyclical, real net exports.

Figure 3 presents the real exchange rate, defined as the price of exportable over nontradable goods, and the spread between the domestic and foreign interest rates in the data and in the model. It shows that model 1 does not replicate the real depreciation between 1988 and 1992

[3]. This would be optimal if domestic agents could foresee future shocks and invest accordingly.

and since 2002, nor the decline in the foreign lending spread after 2000. Thus, a frictionless model with standard preferences and a normal intertemporal elasticity of substitution cannot generate the regularities observed in middle-income countries, as it predicts excessive consumption smoothing and procyclical real net exports. The next section explores whether adding an external borrowing constraint to this setup can solve these problems.

IV. Model 2: Borrowing-Constrained Economy

Consider a small open economy that is perfectly integrated with the world in goods, but faces individual specific external borrowing constraints identified as the external lenders' requirement that domestic households finance at least a fraction, Ψ_t, of their expenditures with their current income at date t (Mendoza, 2001):

$$w_t h_t + q_t^X k_t^X + q_t^N k_t^N \geq \Psi_t \left(c_t^M + P_t^N c_t^N + i_t^X + i_t^N - R_t b_t \right) \tag{27}$$

where the left-hand side is the households' current income and the right-hand side the minimum fraction of expenditures to be self-financed. When equations 27 and 8 are combined and equilibrium conditions imposed, this constraint can re-expressed as

$$b_{t+1} \geq -\frac{1-\Psi_t}{\gamma \Psi_t} \left(P_t^X Y_t^X + P_t^N Y_t^N \right) \tag{28}$$

This constraint can replicate an optimal contract as in Atkeson (1991), in which foreign lending occurs under moral hazard and risk of repudiation. External lenders cannot observe whether borrowers are investing the loans efficiently or consuming them, and sovereign borrowers can repudiate their debt at any time. When there are no informational problems, domestic agents and external lenders share risk fully, but with these problems, the optimal contract reduces risk sharing, transferring part of the output risk to the domestic borrowers to induce them to invest efficiently and repay their loans. Furthermore, the external borrowing constraint should always bind to avoid saving accumulation and debt repudiation.

In this setup, full risk sharing is equivalent to a sufficiently procyclical Ψ_t, which allows domestic agents to borrow more relative to income in bad times than in good, smoothing expenditures over time. Less risk sharing is consistent with a less procyclical Ψ_t and less expenditure smoothing. I assume that the constraint always binds and, given the lack of data on the economy's net foreign asset position, I deduce Ψ_t at each date t to make the model replicate the real net exports in the data as a proxy for the household's net repayment to the foreign lenders.[4] Then, Ψ_t and the borrowing constraint multiplier are analyzed according to previous studies.

[4]. This avoids private agents building up savings that would make the constraint nonbinding again.

The rest of the model is the same. There are three types of agents: domestic households, domestic firms, and foreign lenders. Foreign lenders set the borrowing constraint on the domestic households. Domestic households own firms, consume the *N* good, buy the *M* good for consumption and investment, and supply *h* and *k* to the firms. There are two firms—the export firm and the nontradable firm—that demand *k* and *h* to produce their goods. The economy follows a balanced growth path, and population is assumed to be constant. In the following subsections, the model is set in stationary form.

A. Households

Households choose the sequence $\left\{c_t^M, c_t^N, h_t, i_t^X, i_t^N, k_{t+1}^X, k_{t+1}^N, b_{t+1}\right\}_{t=0}^{\infty}$ to maximize their lifetime utility (equation 6), subject to equations 8, 9, and 27. Their first-order conditions are as follows:

$$\alpha\varpi\left[\varpi c_t^{M\rho}+(1-\varpi)c_t^{N\rho}\right]^{\frac{\alpha}{\rho}(1-\sigma)-1}(1-h_t)^{(1-\alpha)(1-\sigma)}c_t^{M(\rho-1)}=(\lambda_t+\mu_t\Psi_t) \tag{29}$$

$$\alpha(1-\varpi)\left[\varpi c_t^{M\rho}+(1-\varpi)c_t^{N\rho}\right]^{\frac{\alpha}{\rho}(1-\sigma)-1}(1-h_t)^{(1-\alpha)(1-\sigma)}c_t^{N(\rho-1)}=P_t^N(\lambda_t+\mu_t\Psi_t) \tag{30}$$

$$(1-\alpha)\left[\varpi c_t^{M\rho}+(1-\varpi)c_t^{N\rho}\right]^{\frac{\alpha}{\rho}(1-\sigma)}(1-h_t)^{\alpha(\sigma-1)-\sigma}=(\lambda_t+\mu_t)w_t \tag{31}$$

$$\phi_t^X=(\lambda_t+\mu_t\Psi_t)+\phi_t^X\theta i_t^X \tag{32}$$

$$\phi_t^N=(\lambda_t+\mu_t\Psi_t)+\phi_t^N\theta i_t^N \tag{33}$$

$$\gamma\phi_t^X=\beta E_t\left[(\lambda_{t+1}+\mu_{t+1})q_{t+1}^X+\phi_{t+1}^X(1-\delta)\right] \tag{34}$$

$$\gamma\phi_t^N=\beta E_t\left[(\lambda_{t+1}+\mu_{t+1})q_{t+1}^N+\phi_{t+1}^N(1-\delta)\right] \tag{35}$$

$$\gamma\lambda_t=\beta E_t\left[(\lambda_{t+1}+\mu_{t+1}\Psi_{t+1})R_{t+1}\right] \tag{36}$$

$$E_t\left[\lim_{t\to\infty}\beta^t\lambda_t\left(k_{t+1}^X+k_{t+1}^N+b_{t+1}\right)\right]=0 \tag{37}$$

where λ_t, ϕ_t^X, ϕ_t^N, and μ_t are the Lagrange multipliers on equations 8, 9, and 27, respectively.

B. Firms

Firms solve the problem in model 1. Thus, their first-order conditions are equations 19 and 20 for the nontradable firm and equations 21 and 22 for the export firm.

C. Competitive Equilibrium

Given b_0, k_0^X, and k_0^N and shocks' processes $\left(\varepsilon_t^R, \varepsilon_t^{P^X}, \varepsilon_t^X, \varepsilon_t^N, \Psi_t\right)$, a competitive equilibrium corresponds to sequences of allocations $\left\{c_t^M, c_t^N, h_t, i_t^X, i_t^N, k_{t+1}^X, k_{t+1}^N, b_{t+1}\right\}_{t=0}^{\infty}$, $\left\{h_t^{fX}, h_t^{fN}, k_t^{fX}, k_t^{fN}\right\}_{t=0}^{\infty}$, and prices $\left\{P_t^X, P_t^N, q_t^X, q_t^N, w_t, R_t\right\}_{t=0}^{\infty}$ such that:

- Given b_0, k_0^X, k_0^N, prices, and shocks' processes, $\left\{c_t^M, c_t^N, h_t, i_t^X, i_t^N, k_{t+1}^X, k_{t+1}^N, b_{t+1}\right\}_{t=0}^{\infty}$ solve the households' problem;
- Given prices and shocks' processes, $\left\{h_t^{fX}, k_t^{fX}\right\}_{t=0}^{\infty}$ solve firm X's problem;
- Given prices and shocks processes, $\left\{h_t^{fN}, k_t^{fN}\right\}_{t=0}^{\infty}$ solve firm N's problem;
- Markets clear: $c_t^N = y_t^N$, $k_t^X = k_t^{fX}$, $k_t^N = k_t^{fN}$, and $h_t = h_t^{fX} + h_t^{fN}$; and
- The resource constraint is satisfied: $R_t b_t + P_t^X y_t^X = c_t^M + i_t^X + i_t^N + \gamma b_{t+1}$

D. External Lenders

External lenders are risk neutral and face a complete asset market. They maximize the profit function 38 subject to the domestic households' borrowing constraint (equation 27):

$$\Pi^* = E_0 \left\{ \sum_{t=0}^{\infty} Q_t \gamma^t \left[R_t b_t - (1+\Phi) \gamma b_{t+1} \right] \right\} \tag{38}$$

with $Q_t = \left(\prod_{s=0}^{t} R_s^* \right)^{-1}$, where Φ is the constant marginal cost of extending new loans. Their first-order conditions are:

$$Q_t (1+\Phi) = Q_{t+1} R_{t+1} \left(1 - \mu_{t+1} \Psi_{t+1}\right) \tag{39}$$

which yields the following endogenous upward-sloping supply of funds:

$$R_t - R_t^* = R_t^* \Phi + R_t \mu_t \Psi_t \tag{40}$$

This supply of funds depends not only on net foreign assets as in model 1, but also on current expenditures and income, all of which are reflected in the multiplier, μ_t. As before, this functional form allows the model to have a unique steady state.

E. Steady State and Calibration

The calibrated parameters and the implied macroeconomic ratios from the model are the same as in model 1, as μ is small. The only difference is that the parameters associated with the previous upward supply of funds (η and $\bar{b}$ in equation 1) are now replaced by the coefficients associated with the endogenous upward supply of funds (Φ, Ψ, and μ in equation 40), which are presented in table 3.

F. Simulations

The value of Ψ_t is deduced and introduced as a shock, together with the shocks in model 1, to make model 2 replicate Chile's real net exports between 1986 and 2004. Table 6, shows that Ψ_t is highly persistent and more volatile than output. Its innovations are positively correlated with all shocks, but this correlation is higher with the terms of trade than with productivity, which is consistent with a high (low) risk sharing between domestic households and foreign lenders when shocks are observable (unobservable). Figure 1, panel B, shows that Ψ_t was increasing in 1986–95, decreasing in 1996–98, stable until 2003, and increasing again in 2004. The multiplier, μ_t, shows a more binding constraint in 1990–91 and after 1998, when facing negative shocks to productivity and the terms of trade, and a less binding constraint when facing positive shocks (1992–98). This indicates that this constraint may have contributed to the boom in 1995–98 and to the bust in 1999–2003.

Table 7 shows that model 2 captures better the volatilities of export and nontradable output, importable consumption, and investment. It reduces the volatility of export sector's work hours, but increases that of the aggregate and nontradable sector's hours. Figure 4 shows that model 2 can reproduce the path of investment, importable consumption, and export output. Investment is more procyclical and more volatile since Ψ_t is highly persistent and highly correlated to the terms of trade. The less (more) binding constraint in 1992–98 (1999–2003) produced larger and longer-lasting increases (reductions) in investment, respectively.

Households react to positive shocks and a less binding constraint by increasing consumption and reducing their labor effort. The importable goods are obtained abroad, while the nontradable are produced domestically, generating a reallocation of labor from the exportable to the nontradable sector. The lower overall labor effort further reduces employment in the export sector and lowers the increase in employment in the nontradable sector. Thus, the demand for tradable goods increases, but their production falls, generating countercyclical real net exports. Figure 5 shows that model 2 replicates the real exchange rate better than model 1, and it predicts a flat foreign lending spread, as μ_t is small.

Work hours, however, are countercyclical instead of procyclical, and the volatility of nontradable consumption is still low compared to the data. In figure 4, work hours are higher in periods of negative shocks and a tighter constraint (1990–91 and 1999–2003) than in periods of positive shocks and a less binding constraint (1992–98). Since the countercyclical fluctuations in labor supply drive the cyclical path of work hours, the next section explores whether countercyclical labor-financing wedges can produce sufficiently procyclical fluctuations in the labor demand to solve this problem.

V. MODEL 3: ASYMMETRIC FINANCING COSTS

Consider a small economy that is perfectly open to the world in goods, but faces the same upward-sloping supply of external funds as in model 1 (equation 1). Domestic households own firms, consume the *N* good, buy the *M* good for consumption and investment, and supply *h* and *k* to the firms. The export and nontradable firms demand *k* and *h* to produce their goods. They face a specific labor-financing wedge that can capture sector-specific labor market distortions such as labor-financing frictions, sticky wages, or unions (Chari, Kehoe, and McGrattan, 2003) or labor market regulations (Caballero and others, 2004).

The appendix shows that this model is similar to one in which firms face a credit-in-advance constraint when they borrow from domestic banks to pay workers in advance of production. The cost of credit depends on each firm's specific availability of collateral. This is motivated by the evidence found by Tornell and Westermann (2002, 2003) about asymmetric financing opportunities across tradable and nontradable firms for a sample of middle-income countries, and by Caballero (2002) for Chile. Given the lack of data on sectoral financing costs, I deduced the sectoral labor-financing wedge to make the model replicate output of both sectors in the data between 1986 and 2004. The economy follows a balanced growth path, and population is constant. In the following discussion, the model is set in stationary form.

A. Households

Households solve the same problem as in the friction-less economy setup. Their first-order conditions are thus given by equations 10–18.

B. Firms

Each firm's labor-financing wedge is set as augmenting the cost of labor by a fraction, τ_t^j, with $j = X, N$. Their total cost of production is given by equation 41:

$$q_t^j k_t^{fj} + w_t h_t^{fj} \left(1+\tau_t^j\right) \tag{41}$$

for $j = X, N$. The costs associated with the wedges are rebated to the households as a lump sum transfer, such that the resource constraint remains unchanged with respect to the previous specifications. The firms' static problem is to choose the allocation $\{h_t^{fj}, k_t^{fj}\}$ to maximize profits. The first-order conditions for the nontradable firm are

$$w_t\left(1+\tau_t^N\right)=\left(1-\alpha_N\right)P_t^N \exp\left(\varepsilon_t^N\right)\left(k_t^{fN}\right)^{\alpha_N}\left(h_t^{fN}\right)^{-\alpha_N} \tag{42}$$

$$q_t^N=\alpha_N P_t^N \exp\left(\varepsilon_t^N\right)\left(h_t^{fN}\right)^{(1-\alpha_N)}\left(k_t^{fN}\right)^{(\alpha_N-1)} \tag{43}$$

while for the export firm, they are

$$w_t\left(1+\tau_t^X\right)=\left(1-\alpha_X\right)P_t^X \exp\left(\varepsilon_t^X\right)\left(k_t^{fX}\right)^{\alpha_X}\left(h_t^{fX}\right)^{-\alpha_X} \tag{44}$$

$$q_t^X=\alpha_X P_t^X \exp\left(\varepsilon_t^X\right)\left(h_t^{fX}\right)^{(1-\alpha_X)}\left(k_t^{fX}\right)^{(\alpha_X-1)} \tag{45}$$

C. Competitive Equilibrium

Given b_0, k_0^X, and k_0^N and shocks' processes $\left(\varepsilon_t^R,\varepsilon_t^{P^X},\varepsilon_t^X,\varepsilon_t^N,\tau_t^X,\tau_t^N\right)$, a competitive equilibrium corresponds to sequences of allocations $\left\{c_t^M,c_t^N,h_t,i_t^X,i_t^N,k_{t+1}^X,k_{t+1}^N,b_{t+1}\right\}_{t=0}^{\infty}$, $\left\{h_t^{fX},h_t^{fN},k_t^{fX},k_t^{fN}\right\}_{t=0}^{\infty}$, and prices $\left\{P_t^X,P_t^N,q_t^X,q_t^N,w_t,R_t\right\}_{t=0}^{\infty}$ such that:

- Given b_0, k_0^X, k_0^N, prices, and shocks' processes, $\left\{c_t^M,c_t^N,h_t,i_t^X,i_t^N,k_{t+1}^X,k_{t+1}^N,b_{t+1}\right\}_{t=0}^{\infty}$ solve the households' problem;
- Given prices and shocks' processes, $\left\{h_t^{fX},k_t^{fX}\right\}_{t=0}^{\infty}$ solve firm X's problem;
- Given prices and shocks processes, $\left\{h_t^{fN},k_t^{fN}\right\}_{t=0}^{\infty}$ solve firm N's problem;
- Markets clear: $c_t^N=y_t^N$, $k_t^X=k_t^{fX}$, $k_t^N=k_t^{fN}$, and $h_t=h_t^{fX}+h_t^{fN}$; and
- The resource constraint is satisfied: $R_t b_t+P_t^X y_t^X=c_t^M+i_t^X+i_t^N+\gamma b_{t+1}$

D. Steady State and Calibration

Both wedges, τ_t^X and τ_t^N, in table 3 are set to ensure that they are always greater than or equal to zero in the simulations; τ_t^N is about one percentage point above τ_t^X in steady state. This specification only marginally changes the relative allocation of labor across sectors, while the other parameters and macroeconomic ratios remain as in model 1.

E. Simulations

Both wedges are deduced and introduced as shocks to make the model replicate output of exportable and nontradable goods in the data. The model is simulated for these shocks and for the four shocks in model 1. Table 8 shows that the nontradable wedge is more persistent and less volatile than the export wedge. Its innovations are negatively correlated with both productivity shocks and uncorrelated with the terms of trade, while the innovations to the export wedge are highly correlated with the terms of trade and less so with productivity.

Figure 1, panel C, shows a nontradable wedge decreasing continuously between 1991 and 1998 and increasing suddenly in 1999, remaining high until 2004. It mirrors nontradable output, consistent with a lower cost of domestic credit during booms than during recessions. The export wedge mimics the path of the terms of trade, probably reducing the reallocation of labor across sectors rather than measuring changes in domestic financing costs.

Table 9 presents the simulated moments for model 3, which replicates the output moments in both sectors in the data by construction. Relative to model 2, model 3 better reproduces the volatility and procyclicality of consumption and total and sectoral work hours, but not the procyclicality and volatility of investment and consumption of importable goods, nor the countercyclicality of real net exports. Figure 6 shows that model 3 better replicates aggregate consumption, as it replicates the nontradable part by construction. Also, since the wedges generate a procyclical labor demand, it better replicates total and nontradable work hours, in particular their increase between 1994 and 1998 and their fall between 1999 and 2003. It does not, however, capture the path of hours in the export sector.

Figure 7 shows that model 3 does not replicate the path of the real exchange rate or the foreign lending spread. The main drawback, however, is that real net exports are procyclical instead of countercyclical, since investment and consumption of importable goods are not sufficiently procyclical and volatile. Thus, the two frictions seem to complement each other: the external borrowing constraint creates countercyclical real net exports, while the labor-financing wedge creates a procyclical and volatile nontradable consumption and employment. The next section considers the two frictions together.

VI. Model 4: External Borrowing Constraint and Asymmetric Financing Costs

Consider a small open economy that is perfectly integrated with the world in goods, but has limited access to the foreign capital market. Foreign lenders set the borrowing constraints on domestic households according to equation 27. Households own firms, consume the *N* good, buy the *M* good for consumption and investment, and supply *h* and *k* to the firms. The export and nontradable firms demand *k* and *h* to produce their goods. They face a specific labor-financing wedge that captures different sources of labor market distortions.

As in models 2 and 3, the self-financing requirement and the labor-financing wedges are deduced to make the model replicate the real net exports and output of exportable and nontradable goods in the data, respectively. Their moments and the moments of the other variables are then compared to those of models 2 and 3. The economy follows a balanced growth path, and population is constant. The model is presented in stationary form.

A. Households

Households solve the same problem as in model 2, so their first-order conditions are given by equations 29–37.

B. Firms

Both firms solve the same problem as in model 3. Their first-order conditions are given by equations 42 and 43 for the nontradable firm and by equations 44 and 45 for the export firm.

C. Competitive Equilibrium

Given b_0, k_0^X, and k_0^N and shocks' processes $\left(\varepsilon_t^R, \varepsilon_t^{P^X}, \varepsilon_t^X, \varepsilon_t^N, \Psi_t, \tau_t^X, \tau_t^N\right)$, a competitive equilibrium corresponds to sequences of allocations $\left\{c_t^M, c_t^N, h_t, i_t^X, i_t^N, k_{t+1}^X, k_{t+1}^N, b_{t+1}\right\}_{t=0}^{\infty}$, $\left\{h_t^{fX}, h_t^{fN}, k_t^{fX}, k_t^{fN}\right\}_{t=0}^{\infty}$, and prices $\left\{P_t^X, P_t^N, q_t^X, q_t^N, w_t, R_t\right\}_{t=0}^{\infty}$ such that:

- Given b_0, k_0^X, k_0^N, prices, and shocks' processes, $\left\{c_t^M, c_t^N, h_t, i_t^X, i_t^N, k_{t+1}^X, k_{t+1}^N, b_{t+1}\right\}_{t=0}^{\infty}$ solve the households' problem;
- Given prices and shocks' processes, $\left\{h_t^{fX}, k_t^{fX}\right\}_{t=0}^{\infty}$ solve firm X's problem;
- Given prices and shocks processes, $\left\{h_t^{fN}, k_t^{fN}\right\}_{t=0}^{\infty}$ solve firm N's problem;
- Markets clear: $c_t^N = y_t^N$, $k_t^X = k_t^{fX}$, $k_t^N = k_t^{fN}$, and $h_t = h_t^{fX} + h_t^{fN}$; and
- The resource constraint is satisfied: $R_t b_t + P_t^X y_t^X = c_t^M + i_t^X + i_t^N + \gamma b_{t+1}$

D. Steady State and Calibration

The self-financing requirement is set as in model 2 and the labor wedges are set as in model 3, with the nontradable wedge about one percentage point above the export wedge. The other parameters and macroeconomic ratios remain as in model 1 (see table 3).

E. Simulations

As before, Ψ_t, τ_t^X and τ_t^N are deduced and introduced as shocks to make the model replicate the real net exports and sectoral output in the data between 1986 and 2004. The model is simulated for these shocks and the ones in model 1. Table 10 shows that the new Ψ_t presents roughly the same moments as in model 2, while the new wedges are slightly less persistent, but more volatile than in model 3, particularly the nontradable one. The innovations to both wedges are highly correlated, suggesting that the export wedge is playing a smaller role in reducing the reallocation of labor across sectors, as the external borrowing constraint does it.

As before, the innovations to the nontradable wedge are negatively correlated to productivity in both sectors, but now they are also negatively correlated to the terms of trade and roughly uncorrelated to Ψ_t. The innovations to the export wedge are no longer as correlated with the terms of trade, but rather with Ψ_t. The lower (but still high) correlation with P_t^X shows that although the external credit constraint reduces the incentive for labor reallocation across sectors, the wedge is still playing some role in the process. There could also be a spurious correlation, as the innovations to Ψ_t and P_t^X are highly cross-correlated.

Figure 8, panel A, shows that the labor-financing wedge does not change how the external borrowing constraint affects households, since Ψ_t and μ_t follow a path similar to model 2. Although the new τ_t^N is more volatile than before, it presents the same path: it falls between 1991 and 1998, rises suddenly in 1999, and remains high until 2004 (see panel B). The new τ_t^X, however, resembles τ_t^N, being more representative of domestic financing costs than in model 3. Furthermore, the two frictions seem to be related as both wedges follow a similar path to μ_t, with a cross-correlation of 0.7. According to the appendix, a high correlation between τ_t^j and μ_t suggests that firm *j*'s cost of financing varies not only with the domestic interest rate, but also with additional direct changes in its specific lending spread.

Table 11 presents the moments for model 4, which match those of the real net exports and sectoral output in the data by construction. Relative to models 2 and 3, model 4 better reproduces the volatility and procyclicality of aggregate consumption and investment and the countercyclicality and volatility of real net exports. However, although it better replicates the volatility and correlation with output of hours of work in the export and nontradable sectors, it does so at the cost of overestimating the volatility and procyclicality of total work hours.

Figure 9 shows that model 4 replicates aggregate consumption better than model 2, as it replicates consumption of nontradable goods by construction. It also better replicates the path of investment and consumption of importable goods, which is required to generate countercyclical real net exports. With regard to total work hours, model 4 underestimates employment in 1991, when the borrowing constraint multiplier and wedges were highest, and overestimates employment in 1997 and 1998, when both were lowest. Since the procyclical labor demand generated by the labor-financing wedge more than offset the countercyclical labor supply generated by the external borrowing constraint, employment becomes more procyclical and volatile than in the data, particularly in the nontradable sector.

Finally, figure 10 shows that model 4 does a better job of replicating the real exchange rate and the external lending spread than the previous specifications. In particular, model 4 better captures the real appreciation between 1995 and 2000, and the real depreciation thereafter, although not before 1995. The fall in the foreign lending spread, however, is much smaller than in the data because the borrowing constraint multiplier, μ_t, is very small in steady state.

This exercise suggests that an adequate characterization of Chile's business cycles since the mid-1980s—and of those of most middle-income countries—should consider both frictions introduced in model 4, namely, limited access to the external capital market and asymmetric financing opportunities across tradable and nontradable sectors. The former can explain the high procyclicality and volatility of investment and importable goods consumption, as well as the countercyclicality of the real net exports, while the latter can explain the high procyclicality and volatility of work hours and nontradable goods consumption.

Lower Incidence of Frictions

This study does not endogenize the source of the market imperfections to draw policy implications, but rather presents a simulated scenario for a lower incidence of frictions to see the cyclical properties of an economy with better access to foreign and domestic financing. The self-financing requirement is made more procyclical and volatile to get a constant μ_t over time, and the standard deviations of τ_t^X and τ_t^N are reduced to 30 percent of its value in the data. Figure 8, panel C, shows that Ψ_t should have been higher than in model 4 during the boom between 1996 and 2001, but lower during the bust between 2002 and 2003.

Table 12 presents the autocorrelations, standard deviations, and correlations of innovations for these shocks. To obtain a higher degree of risk sharing between domestic households and foreign lenders, Ψ_t has to be less persistent, but more volatile, and more correlated to the terms of trade and productivity in both sectors. Figure 11 and table 13 show that with a lower incidence of frictions, the cyclical properties of the economy would be qualitatively similar to the frictionless case. The volatility of consumption and investment would have been smaller, and total work hours and exportable goods output would have been more procyclical and more volatile, resulting in more procyclical and less volatile real net exports. This scenario would have been welfare improving, as households value consumption smoothing.

VII. Conclusions

Business cycles in middle-income countries are characterized by highly procyclical and volatile consumption and by countercyclical real net exports. Standard DSGE small open economy models have failed to reproduce these features, predicting excessive consumption smoothing and procyclical real net exports. Earlier studies approach the problem either by increasing the shocks' persistence or by lowering the intertemporal elasticity of substitution.

This study shows that the problem can be solved without changing preferences or the shocks' persistence, if two market frictions relevant for middle-income countries are considered: an imperfect access to the foreign capital market and asymmetric financing opportunities across tradable and nontradable firms. The former, identified as an external borrowing constraint, generates more procyclical and volatile investment and consumption of importable goods, reduces the reallocation of labor between the export and nontradable sectors, lowers the volatility of exportable output, and produces countercyclical and volatile real net exports. However, it predicts countercyclical rather than procyclical labor supply and employment, and it does not increase enough the volatility of nontradable goods consumption.

The asymmetric financing opportunities across sectors, identified as sector-specific labor-financing wedges, create procyclical fluctuations in labor demand, which increases the procyclicality and volatility of employment, nontradable goods output, and aggregate consumption. However, it does not increase the procyclicality and volatility of investment and importable goods consumption, nor does it produce countercyclical real net exports. The two frictions thus seem to complement each other, as they help the model to reproduce different features of the data. The exercise considering both frictions together suggests that an adequate characterization of Chile's business cycles since the mid-1980s, and probably of the cycles of most middle-income countries, should consider the role played by these two frictions in the origin and amplification of the domestic cycles.

Finally, the simulated scenario for a lower incidence of frictions, in which the self-financing requirement is more procyclical and more correlated to the terms of trade and productivity, to produce more risk sharing between domestic households and foreign lenders shows that the cyclical properties of this economy are qualitatively similar to a frictionless economy. The volatility of consumption and investment are smaller; and employment and exportable goods output are more procyclical and volatile, resulting in procyclical and less volatile real net exports. This would improve welfare since households value consumption smoothing.

Appendix I. Labor Financing Wedges Based on Collateral Constraints

Consider a small economy that is perfectly open to the world in goods, but faces household-specific external borrowing constraints defined as the requirement to self-finance a fraction of their expenditures, Ψ_t, with their current income at date t (equation 27). There are four types of agents: foreign lenders, domestic households, domestic firms, and domestic banks. Foreign lenders set the borrowing constraints on the households. Households own the firms and banks, consume the N good, buy the M good for consumption and investment, and supply h and k to the firms. They supply funds to the domestic banks within the period at the rate of return R_t, and demand funds from the firms within the period at the same rate.

Both the export and the nontradable firms demand h and k for production. They pay wages before production is realized, thus facing a credit-in-advance constraint. The timing is as follows. Firm j gets credit from the banks at the beginning of each period at a rate of return, R_t^{lj}, but it pays wages only at the end of the period, just before production is materialized. It can thus lend its loan to the households within the period at the rate of return, R_t, which results in a net cost of the loan of $R_t^{lj} - R_t \geq 0$.

Banks receive deposits from households within the period at the rate of return, R_t, and lend to the firms subject to collateral constraints. The collateral is the fraction of the firm's output they can seize, which results in a lending rate of $R_t^{lj} \geq R_t$ with $j = X, N$. All the lending costs are rebated to the households in a lump sum, so that the resource constraint does not change. The economy follows a balanced growth path, and population is constant. In the following discussion, the model is set in stationary form.

Households.

The households' problem is the same as in model 2, so their first-order conditions are given by equations 29–37.

Firms.

Both firms get credit from banks at the beginning of each period and repay it at the end of the period. They lend their loans within the period to the households at the rate of return R_t. As $R_t^{lj} \geq R_t$, their optimal decision is to hold just the necessary credit to pay wages in each period, satisfying the credit-in-advance constraint in equality:

$$z_t^{fj} = w_t h_t^{fj} \tag{46}$$

for $j = X, N$, where z_t^{fj} is the credit received by firm j. The firm's total cost of production is given by:

$$w_t h_t^{fj}\left(1+R_t^{lj}-R_t\right)+q_t^j k_t^{fj} \tag{47}$$

for $j = X, N$. Firm j chooses h_t^{fj} and k_t^{fj} to maximize profits. Its first-order conditions are as follows:

$$w_t\left(1+R_t^{lj}-R_t\right)=\left(1-\alpha_j\right)P_t^j \exp\left(\varepsilon_t^j\right)\left(k_t^{fj}\right)^{\alpha_j}\left(h_t^{fj}\right)^{-\alpha_j} \tag{48}$$

$$q_t^j=\alpha_j P_t^j \exp\left(\varepsilon_t^j\right)\left(h_t^{fj}\right)^{\left(1-\alpha_j\right)}\left(k_t^{fj}\right)^{\left(\alpha_j-1\right)} \tag{49}$$

for $j = X, N$.

Banks

The banking industry is perfectly competitive. Banks take deposits from households and lend them to the firms, subject to collateral constraints. The collateral is a fraction, Ω_t^j, of firm j's output that banks can seize at the end of each period. They thus face the following constraint when allocating loans:

$$\Omega_t^j Y_t^j \geq z_t^j \tag{50}$$

for $j = X, N$. The banks' problem is to choose the allocation $\left\{z_t^X, z_t^N\right\}$ in each period to maximize profits. Their first-order conditions are

$$R_t^{lX}-R_t=\eta_t^X \tag{51}$$

$$R_t^{lN}-R_t=\eta_t^N \tag{52}$$

where η_t^X and η_t^N are the Lagrange multipliers on equation 50 for X and N, respectively.

Competitive Equilibrium

Given b_0, k_0^X, and k_0^N and shocks' processes $\left(\varepsilon_t^R,\varepsilon_t^{PX},\varepsilon_t^X,\varepsilon_t^N,\Psi_t,\Omega_t^X,\Omega_t^N\right)$, a competitive equilibrium corresponds to sequences of allocations $\left\{c_t^M,c_t^N,h_t,i_t^X,i_t^N,k_{t+1}^X,k_{t+1}^N,b_{t+1},z_t^X,z_t^N\right\}_{t=0}^{\infty}$, $\left\{h_t^{fX},h_t^{fN},k_t^{fX},k_t^{fN},z_t^{fX},z_t^{fN}\right\}_{t=0}^{\infty}$, and prices $\left\{P_t^X,P_t^N,q_t^X,q_t^N,w_t,R_t,R_t^{lX},R_t^{lN}\right\}_{t=0}^{\infty}$ such that:

- Given b_0, k_0^X, and k_0^N, prices, and shocks' processes, $\left\{c_t^M,c_t^N,h_t,i_t^X,i_t^N,k_{t+1}^X,k_{t+1}^N,b_{t+1}\right\}_{t=0}^{\infty}$ solve the households' problem;

- Given prices and shocks' processes, $\left\{h_t^{fX}, k_t^{fX}, z_t^{fX}\right\}_{t=0}^{\infty}$ solve firm X's problem;
- Given prices and shocks processes, $\left\{h_t^{fN}, k_t^{fN}, z_t^{fN}\right\}_{t=0}^{\infty}$ solve firm N's problem;
- Given prices and shocks processes, $\left\{z_t^{fX}, z_t^{fN}\right\}_{t=0}^{\infty}$ solve bank's problem;
- Markets clear: $c_t^N = y_t^N$, $k_t^X = k_t^{fX}$, $k_t^N = k_t^{fN}$, $h_t = h_t^{fX} + h_t^{fN}$, $z_t^X = z_t^{fX}$, and $z_t^N = z_t^{fN}$;
- The resource constraint is satisfied: $R_t b_t + P_t^X y_t^X = c_t^M + i_t^X + i_t^N + \gamma b_{t+1}$

Equivalence to Labor Financing Wedges

The reduced form of this model is the same as for model 4, with $\tau_t^j = \eta_t^j = R_t^{lj} - R_t$ for *j* = *X*, *N*. Thus, the sector-specific labor-.financing wedges deduced in models 3 and 4 can be interpreted as the spread over the domestic interest rate that each firm pays on its credit from the domestic banks given their specific availability of collateral.

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Table 1. Business Cycles Moments, Annual Data: 1980–2004

Countries[1]	(1) Autocorr Y	(2) St.Dev. Y	(3) Correl. C to Y	(4) SD C/ SD Y	(5) Autocorr Y	(6) Correl. I to Y	(7) SD I/ SD Y	(8) Correl. NE/Y to Y	(9) St.Dev. NE/Y	(10) Autocorr. TOT	(11) SD TOT/ SD Y
Small Developed Countries[2]	**0.672**	**2.308**	**0.789**	**0.863**	**0.547**	**0.832**	**3.985**	**-0.448**	**1.348**	**0.533**	**1.698**
Middle Income Countries[3]											
Argentina	0.552	5.866	0.926	1.215	0.458	0.906	3.270	-0.904	2.168	0.359	1.416
Bolivia	0.816	3.019	0.558	0.881	0.532	0.552	5.586	0.167	2.960	0.239	4.282
Brazil	0.574	3.754	0.912	0.973	0.549	0.906	2.778	-0.407	1.119	0.447	0.548
Chile	0.668	5.698	0.971	1.224	0.513	0.932	3.083	-0.899	2.559	0.331	1.162
Colombia	0.710	2.541	0.864	1.212	0.614	0.714	6.250	-0.560	3.128	0.242	3.177
Costa Rica	0.569	3.533	0.809	1.205	0.411	0.657	4.211	-0.381	3.423	0.477	1.902
Dominican Rep.	0.496	3.317	0.793	1.396	0.419	0.700	3.659	-0.589	3.722	0.317	2.326
Ecuador	0.291	2.971	0.810	1.019	0.217	0.687	5.029	-0.470	3.837	0.371	3.304
El Salvador	0.660	3.048	0.839	1.166	0.359	0.301	3.531	-0.014	2.425	0.211	3.589
Guatemala	0.848	3.067	0.982	0.853	0.435	0.576	4.118	-0.002	1.248	0.353	2.351
Honduras	0.396	2.283	-0.052	1.760	0.313	0.534	7.200	0.051	1.965	0.239	2.326
Hong Kong	0.263	2.959	0.714	1.020	0.557	0.544	3.345	-0.140	2.715	0.195	0.386
Indonesia	0.627	4.682	0.637	1.225	0.618	0.942	3.266	-0.483	3.215	0.564	2.847
Korea, Rep. of	0.504	3.211	0.887	1.116	0.468	0.862	3.356	-0.650	2.868	0.826	1.427
Malaysia	0.686	4.709	0.854	1.464	0.653	0.950	4.292	-0.830	6.729	0.229	0.828
Mexico	0.643	4.280	0.929	1.051	0.441	0.838	3.893	-0.635	3.099	0.629	3.171
Panama	0.648	5.509	0.602	1.103	0.399	0.809	5.886	-0.663	3.402	0.504	1.356
Paraguay	0.764	3.947	0.649	1.293	0.718	0.910	3.109	-0.408	3.435	0.318	2.034
Peru	0.618	6.705	0.890	1.072	0.622	0.762	2.477	-0.641	1.599	0.367	1.723
Philipines	0.696	4.348	0.926	0.563	0.573	0.916	3.998	-0.585	2.466	0.478	1.017
Singapur	0.634	4.179	0.657	0.677	0.544	0.841	3.512	-0.432	2.518	0.568	0.272
Sri Lanka	0.578	1.772	0.773	1.352	0.715	0.592	5.485	-0.335	3.253	0.267	4.704
Taiwan	0.581	2.525	0.728	1.101	0.661	0.792	4.362	-0.379	2.584	0.583	0.980
Thailand	0.748	5.381	0.966	0.916	0.637	0.949	3.876	-0.847	4.400	0.312	0.726
Turkey	0.177	3.417	0.894	1.052	-0.168	0.847	3.669	-0.629	2.726	0.451	2.309
Uruguay	0.680	6.064	0.972	1.207	0.718	0.886	3.705	-0.889	3.786	0.577	0.955
Venezuela	0.373	4.583	0.691	1.175	0.111	0.783	5.389	-0.525	4.058	0.318	3.656
Average	**0.585**	**3.977**	**0.785**	**1.122**	**0.485**	**0.766**	**4.161**	**-0.485**	**3.015**	**0.399**	**2.029**

Source: IMF World Economic Outlook, Author Calculations.

[1] Data are HP filtered.

[2] Simple average of Australia, Austria, Belgium, Canada, Denmark, Finland, Greece, Iceland, Ireland, Netherlands, Norway, New Zealand, Portugal, Spain, Sweden and Switzerland.

[3] Exclude middle-income countries from Africa and the Middle East.

Table 2. Data Moments, Chile: 1986–2004

Variable[1]	x	(1) $\rho(x_t, y_t)$	(2) $\rho(x_t, y_{t-1})$	(3) $\sigma(y)$	(4) $\sigma(x)/\sigma(y)$
Aggregate output	y	1.00	0.59	2.29	1.00
Output exportables	y^x	0.84	0.39	1.78	0.78
Output non tradables	y^n	0.98	0.61	2.80	1.22
Aggregate consumption	c	0.95	0.69	2.66	1.16
Consumption importables	c^m	0.25	0.45	4.98	2.17
Consumption non tradables	c^n	0.98	0.61	2.80	1.22
Investment	i	0.80	0.44	8.50	3.71
Investment exportable	i^x	n.a.	n.a.	n.a.	n.a.
Investment non tradable	i^n	n.a.	n.a.	n.a.	n.a.
Real net exports	nx	-0.74	-0.41	--	2.55
Nominal net exports	nnx	--	--	--	--
Hours of work	h	0.40	0.12	1.78	0.78
Hours of work exportable	h^x	-0.09	-0.30	2.05	0.89
Hours of work non tradable	h^n	0.53	0.25	1.96	0.85
Aggregate capital	k	0.33	0.68	2.88	1.26
Capital exportable	k^x	0.43	0.75	3.06	1.34
Capital non tradable	k^n	0.24	0.60	2.80	1.22

Source: Central Bank of Chile, Author calculations.

[1] Data are HP filtered.

n.a. Not available.

Table 3. Calibration and Macroeconomic Aggregates

Parameter	Value	Macroeconomic Ratios Variable	Data	Model
Model 1: Friction-Less Economy				
Preferences		Aggregate Demand		
β	0.943	c/y	0.762	0.696
ρ	-0.350	c^N/y	0.634	0.600
ϖ	0.079	c^M/y	0.128	0.096
σ	1.500	i/y	0.297	0.292
α	0.323	tb/y	-0.059	0.012
		b/y	n.a.	-0.190
Technology				
		Production		
α_X	0.523			
α_N	0.435	y^N/y	0.634	0.600
θ	0.028	y^X/y	0.366	0.400
δ	0.080			
		Inputs		
Supply of External Funds				
		k/y	n.a.	1.700
$\bar{b}$	0.088	k^N/k	n.a.	0.555
η	0.001	k^X/k	n.a.	0.445
		h	0.267	0.267
Long Term Growth		h^N/h	0.670	0.640
		h^X/h	0.330	0.360
γ	1.056			
Models 2 and 4: Credit Constraint				
Ψ	0.833			
μ	3.35E-08			
Φ	0.019			
Models 3 and 4: Labor Financing Wedges				
τ^X	0.162	h^N/h	0.670	0.638
τ^N	0.171	h^X/h	0.330	0.362

Source: Central Bank of Chile and National Institute of Statistics
n.a. Not available.

Table 4. Shock Processes in Model 1

Shocks	Statistic	ρ	SD Shock/ SD GDP	Cross correlation of innovations with P^X	r*	z^X	z^N
Terms of Trade	P^X	0.287	3.16	1.000	0.456	0.202	0.140
Foreign Interest Rate	r*	0.774	0.76	0.456	1.000	0.242	0.274
Productivity Exportable	z^X	0.409	0.71	0.202	0.242	1.000	0.985
Productivity Non Tradable	z^N	0.357	0.68	0.140	0.274	0.985	1.000

Table 5. Data and Model 1 Simulations: Frictionless Economy

		HP-Filtered data				Model 1			
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variable	x	ρ(xt ,yt)	ρ(xt ,yt-1)	σ(y)	σ(x)/σ(y)	ρ(xt ,yt)	ρ(xt ,yt-1)	σ(y)	σ(x)/σ(y)
Aggregate output	y	1.00	0.59	2.29	1.00	1.00	0.31	2.28	1.00
Output exportables	y^x	0.84	0.39	1.78	0.78	0.92	0.17	5.35	2.35
Output non tradables	y^n	0.98	0.61	2.80	1.22	0.35	0.40	1.51	0.66
Aggregate consumption	c	0.95	0.69	2.66	1.16	0.45	0.38	1.31	0.58
Consumption importables	c^m	0.25	0.45	4.98	2.17	0.38	0.01	2.64	1.16
Consumption non tradables	c^n	0.98	0.61	2.80	1.22	0.35	0.40	1.51	0.66
Investment	i	0.80	0.44	8.50	3.71	0.02	-0.40	3.37	1.48
Investment exportable	i^x	n.a.	n.a.	n.a.	n.a.	-0.11	-0.53	3.84	1.69
Investment non tradable	i^n	n.a.	n.a.	n.a.	n.a.	0.13	-0.25	3.14	1.38
Real net exports	nx	-0.74	-0.41	--	2.55	0.83	0.30	--	2.20
Nominal net exports	nnx	--	--	--	--	0.78	0.13	--	4.57
Hours of work	h	0.40	0.12	1.78	0.78	0.68	0.09	2.84	1.25
Hours of work exportable	h^x	-0.09	-0.30	2.05	0.89	0.77	0.08	9.77	4.29
Hours of work non tradable	h^n	0.53	0.25	1.96	0.85	-0.63	-0.04	1.94	0.85
Aggregate capital		0.33	0.68	2.88	1.26	0.23	0.11	0.54	0.24
Capital exportable	k^x	0.43	0.75	3.06	1.34	0.34	0.11	0.58	0.25
Capital non tradable	k^n	0.24	0.60	2.80	1.22	0.13	0.11	0.54	0.24

Table 6. Shock Processes in Model 2

Shocks	Statistic	ρ	SD Shock/ SD GDP	Cross correlation of innovations with P^X	r^*	z^X	z^N	Ψ
Terms of Trade	P^X	0.287	3.16	1.000	0.456	0.202	0.140	0.754
Foreign Interest Rate	r^*	0.774	0.76	0.456	1.000	0.242	0.274	0.157
Productivity Exportable	z^X	0.409	0.71	0.202	0.242	1.000	0.985	0.306
Productivity Non Tradable	z^N	0.357	0.68	0.140	0.274	0.985	1.000	0.192
Self Financing Requirement	Ψ	0.709	1.75	0.754	0.157	0.306	0.192	1.000

Table 7. Data and Model 2 Simulations: Credit Constraint

		HP-filtered data				Model 2			
		(1)	(2)	(3)	(4)	(9)	(10)	(11)	(12)
Variable	x	ρ(xt ,yt)	ρ(xt ,yt-1)	σ(y)	σ(x)/σ(y)	ρ(xt ,yt)	ρ(xt ,yt-1)	σ(y)	σ(x)/σ(y)
Aggregate output	y	1.00	0.59	2.29	1.00	1.00	0.02	1.26	1.00
Output exportables	y^x	0.84	0.39	1.78	0.78	0.57	-0.41	2.99	2.37
Output non tradables	y^n	0.98	0.61	2.80	1.22	0.51	0.41	1.91	1.51
Aggregate consumption	c	0.95	0.69	2.66	1.16	0.54	0.39	1.42	1.12
Consumption importables	c^m	0.25	0.45	4.98	2.17	-0.12	-0.18	4.82	3.82
Consumption non tradables	c^n	0.98	0.61	2.80	1.22	0.51	0.41	1.91	1.51
Investment	i	0.80	0.44	8.50	3.71	-0.29	-0.16	7.42	5.88
Investment exportable	i^x	n.a.	n.a.	n.a.	n.a.	-0.35	-0.16	8.67	6.87
Investment non tradable	i^n	n.a.	n.a.	n.a.	n.a.	-0.23	-0.16	6.54	5.18
Real net exports	nx	-0.74	-0.41	--	2.55	0.53	-0.01	--	2.55
Nominal net exports	nnx	--	--	--	--	0.34	-0.50	--	2.88
Hours of work	h	0.40	0.12	1.78	0.78	0.34	-0.18	2.95	2.34
Hours of work exportable	h^x	-0.09	-0.30	2.05	0.89	0.29	-0.50	6.23	4.94
Hours of work non tradable	h^n	0.53	0.25	1.96	0.85	0.16	0.27	3.40	2.69
Aggregate capital		0.33	0.68	2.88	1.26	0.16	-0.06	1.06	0.84
Capital exportable	k^x	0.43	0.75	3.06	1.34	0.16	-0.10	1.26	0.99
Capital non tradable	k^n	0.24	0.60	2.80	1.22	0.16	-0.01	0.92	0.73
Borr. constraint multiplier	μ	n.a.	n.a.	n.a.	n.a.	0.46	0.00	460	365

Table 8. Shock Processes in Model 3

			SD Shock/	Cross correlation of innovations with					
Shocks	Statistic	ρ	SD GDP	P^X	r*	z^X	z^N	τ^X	τ^N
Terms of Trade	P^X	0.287	3.16	1.000	0.456	0.202	0.140	0.935	0.070
Foreign Interest Rate	r*	0.774	0.76	0.456	1.000	0.242	0.274	0.509	-0.323
Productivity Exportable	z^X	0.409	0.71	0.202	0.242	1.000	0.985	0.399	-0.407
Productivity Non Tradable	z^N	0.357	0.68	0.140	0.274	0.985	1.000	0.342	-0.435
Labor Wedge Exportable	τ^X	0.337	3.14	0.935	0.509	0.399	0.342	1.000	-0.024
Labor Wedge Non Tradable	τ^N	0.584	1.45	0.070	-0.323	-0.407	-0.435	-0.024	1.000

Table 9. Data and Model 3 Simulations: Labor Wedges

		HP-filtered data				Model 3: Labor Wedges			
		(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Variable	x	ρ(xt ,yt)	ρ(xt ,yt-1)	σ(y)	σ(x)/σ(y)	ρ(xt ,yt)	ρ(xt ,yt-1)	σ(y)	σ(x)/σ(y)
Aggregate output	y	1.00	0.59	2.29	1.00	1.00	0.58	2.29	1.00
Output exportables	y^x	0.84	0.39	1.78	0.78	0.86	0.40	1.78	0.78
Output non tradables	y^n	0.98	0.61	2.80	1.22	0.98	0.62	2.80	1.22
Aggregate consumption	c	0.95	0.69	2.66	1.16	0.97	0.58	2.45	1.07
Consumption importables	c^m	0.25	0.45	4.98	2.17	0.08	-0.24	2.64	1.15
Consumption non tradables	c^n	0.98	0.61	2.80	1.22	0.98	0.62	2.80	1.22
Investment	i	0.80	0.44	8.50	3.71	-0.20	-0.50	3.61	1.57
Investment exportable	i^x	n.a.	n.a.	n.a.	n.a.	-0.19	-0.50	4.00	1.74
Investment non tradable	i^n	n.a.	n.a.	n.a.	n.a.	-0.20	-0.49	3.36	1.47
Real net exports	nx	-0.74	-0.41	--	2.55	0.51	0.56	--	1.51
Nominal net exports	nnx	--	--	--	--	0.32	-0.02	--	3.23
Hours of work	h	0.40	0.12	1.78	0.78	0.69	0.82	2.22	0.97
Hours of work exportable	h^x	-0.09	-0.30	2.05	0.89	0.07	0.31	2.65	1.16
Hours of work non tradable	h^n	0.53	0.25	1.96	0.85	0.78	0.80	2.93	1.28
Aggregate capital		0.33	0.68	2.88	1.26	0.38	0.26	0.62	0.27
Capital exportable	k^x	0.43	0.75	3.06	1.34	0.43	0.30	0.67	0.29
Capital non tradable	k^n	0.24	0.60	2.80	1.22	0.33	0.23	0.58	0.25

Table 10. Shock Processes in Model 4

Shocks	Statistic	ρ	SD Shock/ SD GDP	Cross correlation of innovations with P^X	r^*	z^X	z^N	Ψ	τ^X	τ^N
Terms of Trade	P^X	0.287	3.16	1.000	0.456	0.202	0.140	0.756	0.418	-0.257
Foreign Interest Rate	r^*	0.774	0.76	0.456	1.000	0.242	0.274	0.175	-0.255	-0.523
Productivity Exportable	z^X	0.409	0.71	0.202	0.242	1.000	0.985	0.340	-0.152	-0.508
Productivity Non Tradable	z^N	0.357	0.68	0.140	0.274	0.985	1.000	0.222	-0.232	-0.518
Self Financing Requirement	Ψ	0.735	1.67	0.756	0.175	0.340	0.222	1.000	0.655	0.064
Labor Wedge Exportable	τ^X	0.257	3.30	0.418	-0.255	-0.152	-0.232	0.655	1.000	0.693
Labor Wedge Non Tradable	τ^N	0.531	3.43	-0.257	-0.523	-0.508	-0.518	0.064	0.693	1.000

Table 11. Data and Model 4 Simulations: Credit Constraint and Labor Wedges

		HP-filtered data				Model 4: Credit Const. and Labor Wed.			
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variable	x	ρ(xt ,yt)	ρ(xt ,yt-1)	σ(y)	σ(x)/σ(y)	ρ(xt ,yt)	ρ(xt ,yt-1)	σ(y)	σ(x)/σ(y)
Aggregate output	y	1.00	0.59	2.29	1.00	1.00	0.58	2.29	1.00
Output exportables	y^x	0.84	0.39	1.78	0.78	0.86	0.40	1.78	0.78
Output non tradables	y^n	0.98	0.61	2.80	1.22	0.98	0.62	2.80	1.22
Aggregate consumption	c	0.95	0.69	2.66	1.16	0.98	0.60	3.06	1.34
Consumption importables	c^m	0.25	0.45	4.98	2.17	0.86	0.47	5.52	2.41
Consumption non tradables	c^n	0.98	0.61	2.80	1.22	0.98	0.62	2.80	1.22
Investment	i	0.80	0.44	8.50	3.71	0.81	0.44	8.50	3.71
Investment exportable	i^x	n.a.	n.a.	n.a.	n.a.	0.80	0.43	10.87	4.75
Investment non tradable	i^n	n.a.	n.a.	n.a.	n.a.	0.82	0.44	6.78	2.96
Real net exports	nx	-0.74	-0.41	--	2.55	-0.74	-0.42	--	2.55
Nominal net exports	nnx	--	--	--	--	-0.58	-0.67	--	2.88
Hours of work	h	0.40	0.12	1.78	0.78	0.76	0.59	2.23	0.97
Hours of work exportable	h^x	-0.09	-0.30	2.05	0.89	0.23	0.02	2.07	0.91
Hours of work non tradable	h^n	0.53	0.25	1.96	0.85	0.79	0.66	3.03	1.33
Aggregate capital		0.33	0.68	2.88	1.26	0.04	0.54	1.34	0.58
Capital exportable	k^x	0.43	0.75	3.06	1.34	0.02	0.52	1.75	0.77
Capital non tradable	k^n	0.24	0.60	2.80	1.22	0.07	0.56	1.01	0.44
Borr. constraint multiplier	μ	n.a.	n.a.	n.a.	n.a.	-0.76	0.00	55.87	24.40

Table 12. Shock Processes in Reduced-Frictions Model

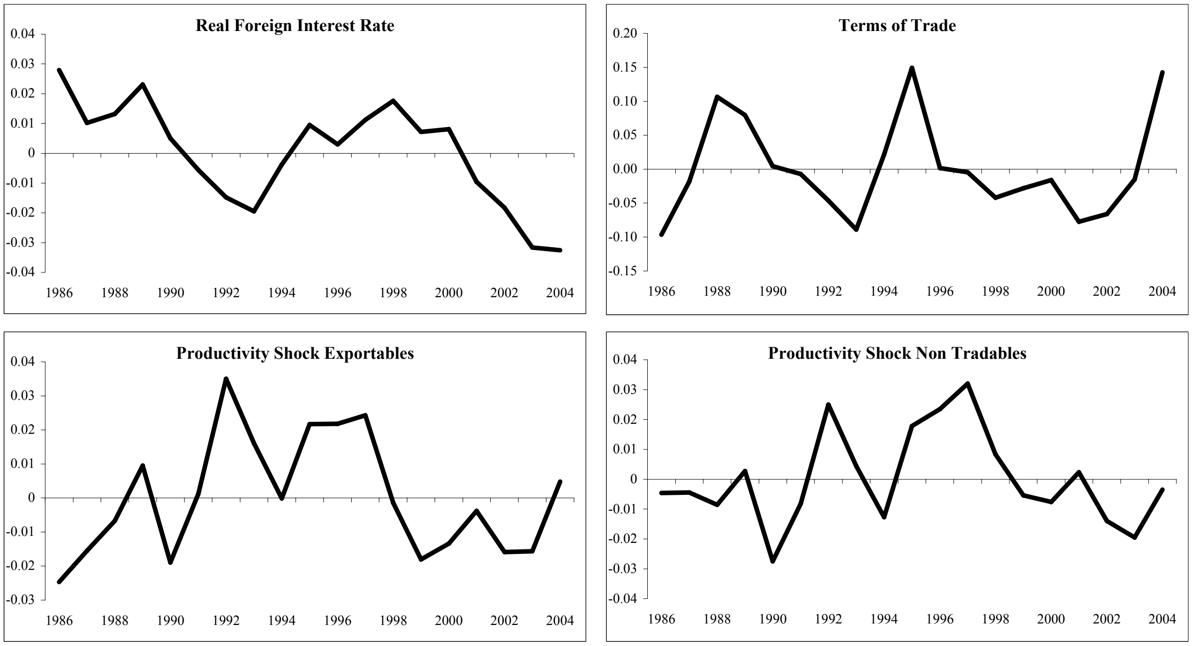
Shocks	Statistic	ρ	SD Shock/ SD GDP	Cross correlation of innovations with P^X	r^*	z^X	z^N	Ψ	τ^X	τ^N
Terms of Trade	P^X	0.287	3.16	1.000	0.456	0.202	0.140	0.835	0.418	-0.257
Foreign Interest Rate	r^*	0.774	0.76	0.456	1.000	0.242	0.274	0.715	-0.254	-0.523
Productivity Exportable	z^X	0.409	0.71	0.202	0.242	1.000	0.985	0.439	-0.152	-0.507
Productivity Non Tradable	z^N	0.357	0.68	0.140	0.274	0.985	1.000	0.427	-0.232	-0.518
Self Financing Requirement	Ψ	0.639	1.82	0.835	0.715	0.439	0.427	1.000	0.043	-0.471
Labor Wedge Exportable	τ^X	0.257	0.99	0.418	-0.254	-0.152	-0.232	0.043	1.000	0.693
Labor Wedge Non Tradable	τ^N	0.530	1.03	-0.257	-0.523	-0.507	-0.518	-0.471	0.693	1.000

Table 13. Data and Reduced-Frictions Model Simulations

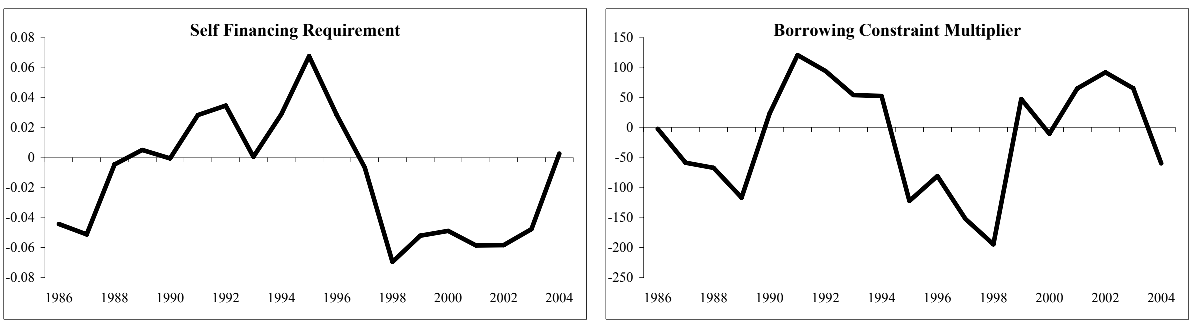
		HP-filtered data				Reduced-Frictions Model			
		(1)	(2)	(3)	(4)	(9)	(10)	(11)	(12)
Variable	x	ρ(xt ,yt)	ρ(xt ,yt-1)	σ(y)	σ(x)/σ(y)	ρ(xt ,yt)	ρ(xt ,yt-1)	σ(y)	σ(x)/σ(y)
Aggregate output	y	1.00	0.59	2.29	1.00	1.00	0.45	2.40	1.00
Output exportables	y^x	0.84	0.39	1.78	0.78	0.89	0.24	4.27	1.78
Output non tradables	y^n	0.98	0.61	2.80	1.22	0.75	0.56	1.97	0.82
Aggregate consumption	c	0.95	0.69	2.66	1.16	0.84	0.57	1.84	0.77
Consumption importables	c^m	0.25	0.45	4.98	2.17	0.67	0.29	2.86	1.19
Consumption non tradables	c^n	0.98	0.61	2.80	1.22	0.75	0.56	1.97	0.82
Investment	i	0.80	0.44	8.50	3.71	0.43	-0.08	3.01	1.26
Investment exportable	i^x	n.a.	n.a.	n.a.	n.a.	0.33	-0.24	3.24	1.35
Investment non tradable	i^n	n.a.	n.a.	n.a.	n.a.	0.49	0.06	2.95	1.23
Real net exports	nx	-0.74	-0.41	--	2.55	0.75	0.33	--	1.23
Nominal net exports	nnx	--	--	--	--	0.59	0.04	--	3.51
Hours of work	h	0.40	0.12	1.78	0.78	0.74	0.38	2.59	1.08
Hours of work exportable	h^x	-0.09	-0.30	2.05	0.89	0.69	0.15	7.22	3.01
Hours of work non tradable	h^n	0.53	0.25	1.96	0.85	0.11	0.57	1.90	0.79
Aggregate capital		0.33	0.68	2.88	1.26	0.29	0.48	0.46	0.19
Capital exportable	k^x	0.43	0.75	3.06	1.34	0.40	0.54	0.47	0.19
Capital non tradable	k^n	0.24	0.60	2.80	1.22	0.19	0.42	0.47	0.19
Borr. constraint multiplier	μ	n.a.	n.a.	n.a.	n.a.	-0.36	-0.23	0.00	0.00

Figure 1. Chile: Domestic and External Shocks, and Financial Frictions

Panel A: Exogenous Shocks for Models 1, 2, 3 and 4



Panel B: Self Financing Requirement and Extenal Borrowing Constraint Multiplier for Model 2



Panel C: Labor Financing Wedges for Model 3

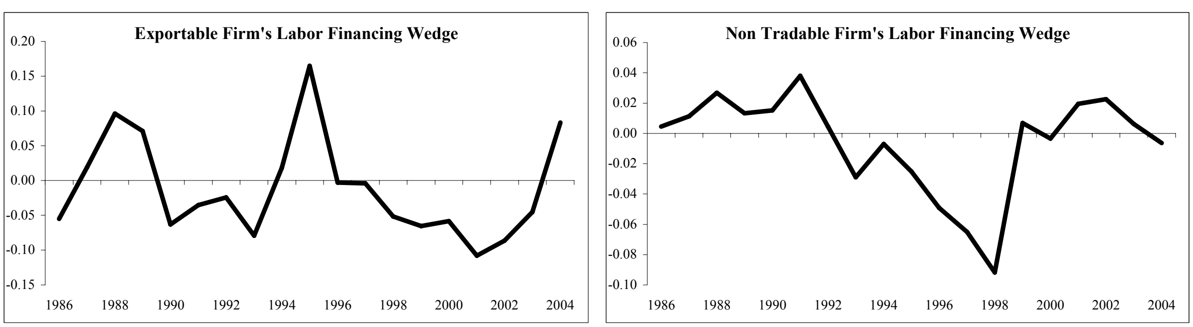


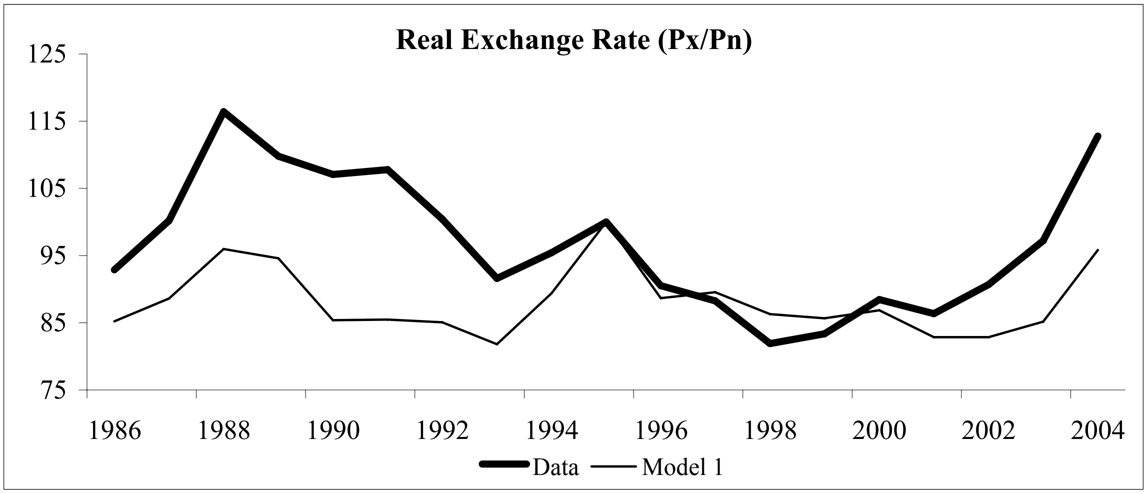
Figure 2. Data and Model 1 Simulations: Frictionless Economy

Figure 2. Data and Model 1 Simulations: Frictionless Economy (Concluded)

Figure 3. Real Exchange Rates and Foreign Lending Spreads in Model 1

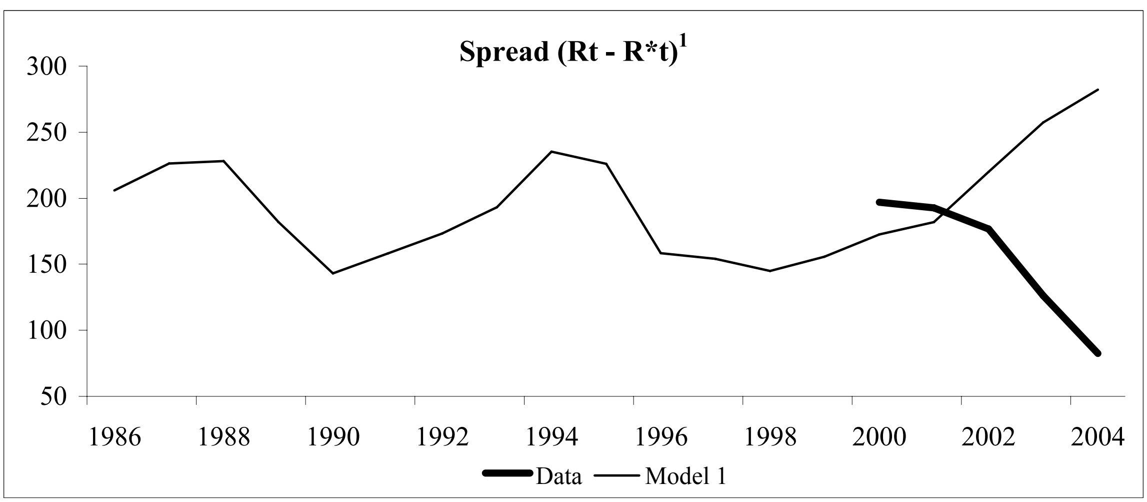
Real Exchange Rate

(Price of Exportable Goods over Price of Non Tradable Goods)



Foreign Lending Spread

(Domestic Interest Rate Minus Foreign Interest Rate)



[1] The data corresponds to the EMBI Global for Chile, JP Morgan.

Figure 4. Data and Model 2 Simulations: Credit Constraint

Figure 4. Data and Model 2 Simulations: Credit Constraint (Concluded)

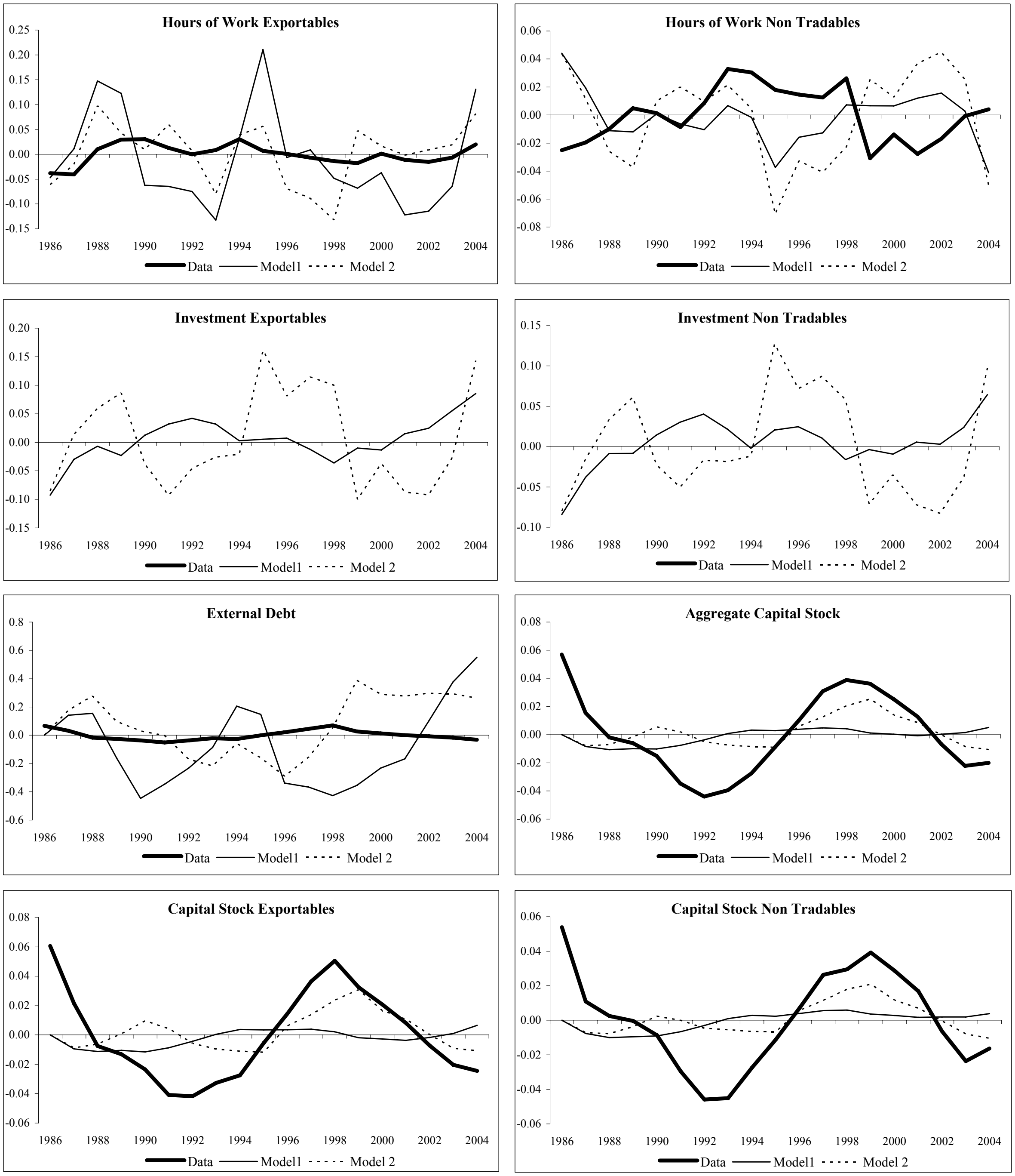
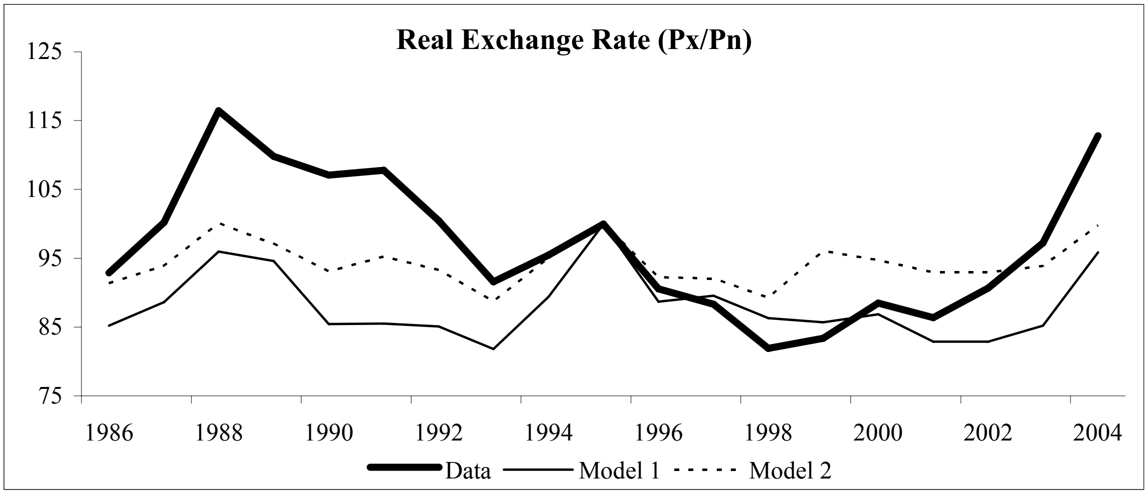
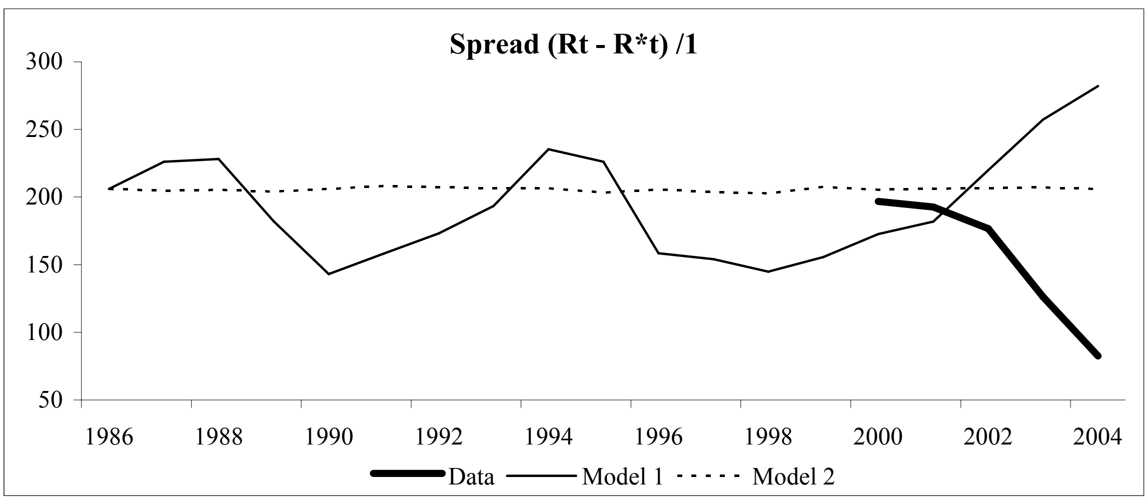


Figure 5. Real Exchange Rates and Foreign Lending Spreads in Model 2

Real Exchange Rate
(Price of Exportable Goods over Price of Non Tradable Goods)



Foreign Lending Spread
(Domestic Interest Rate Minus Foreign Interest Rate)



[1] The data corresponds to the EMBI Global for Chile, JP Morgan.

Figure 6. Data and Model 3 Simulations: Labor Wedges

Figure 6. Data and Model 3 Simulations: Labor Wedges (Concluded)

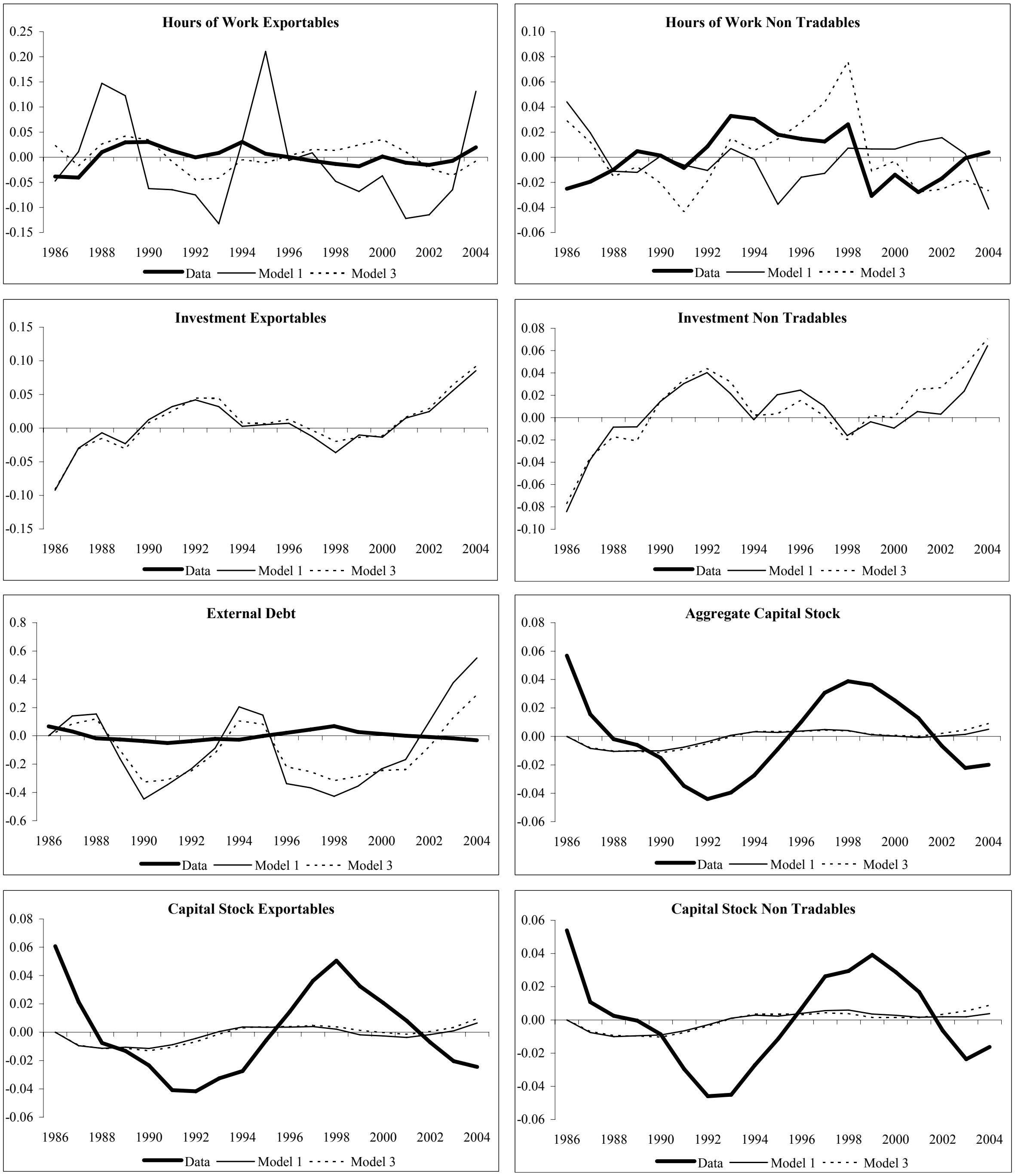
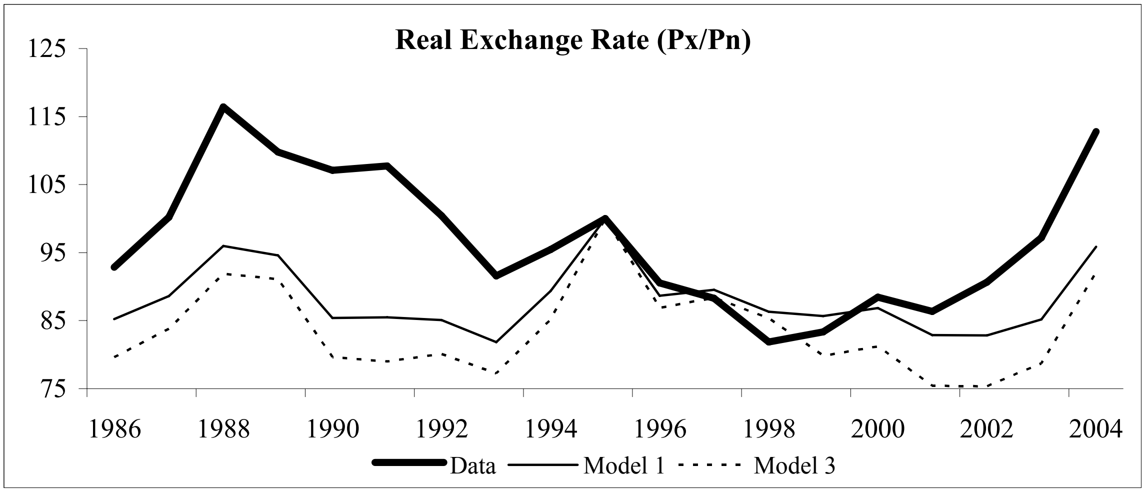
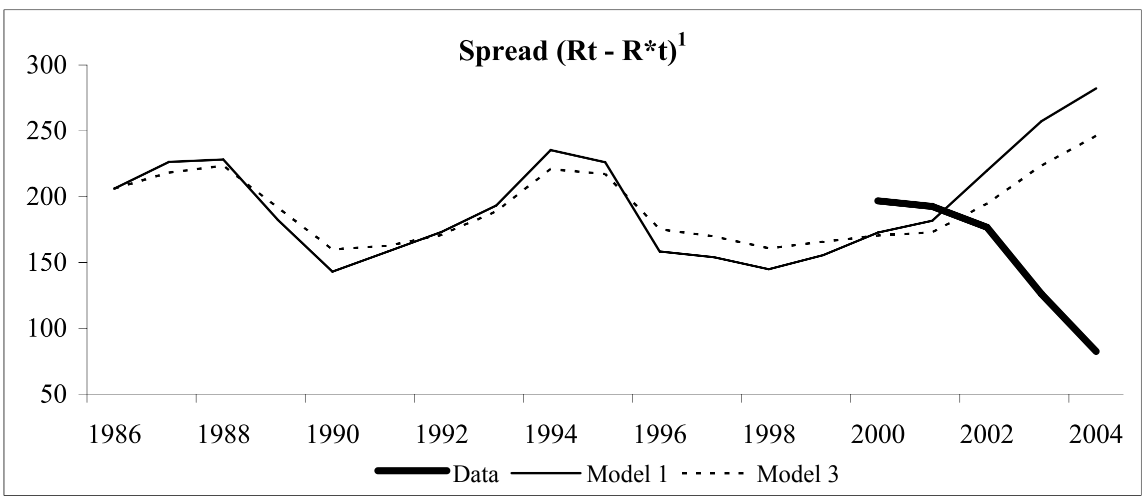


Figure 7. Real Exchange Rates and Foreign Lending Spreads in Model 3

Real Exchange Rate
(Price of Exportable Goods over Price of Non Tradable Goods)



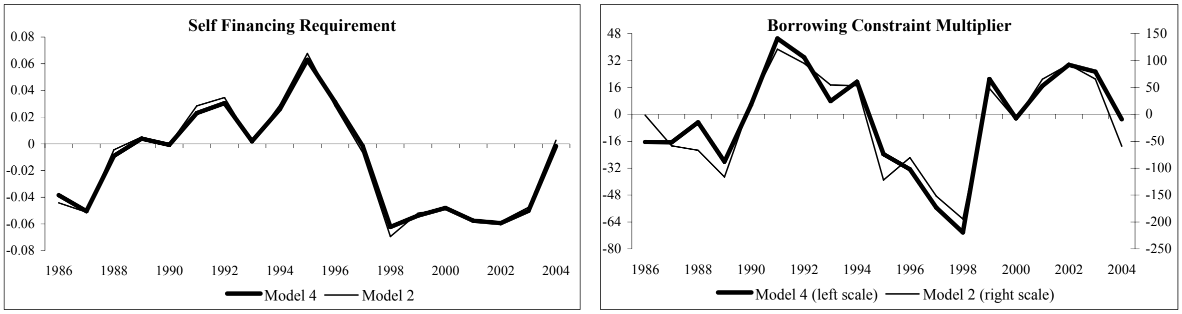
Foreign Lending Spread
(Domestic Interest Rate Minus Foreign Interest Rate)



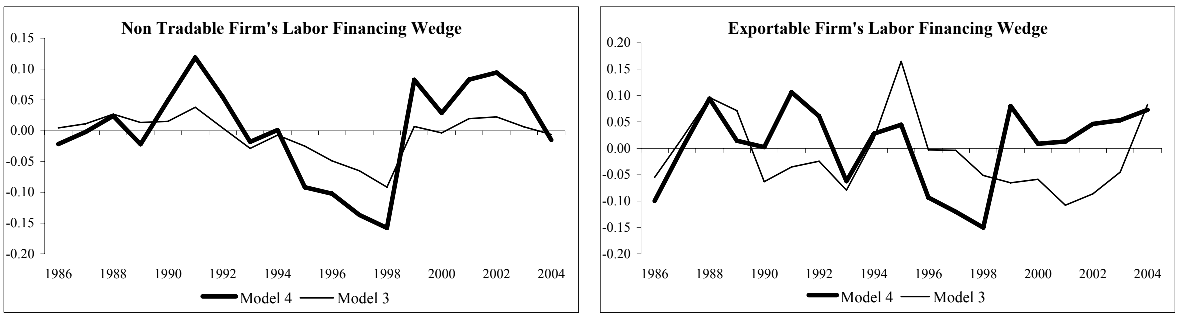
[1] The data corresponds to the EMBI Global for Chile, JP Morgan.

Figure 8. Chile: Self Financing Requirement and Labor Financing Wedges

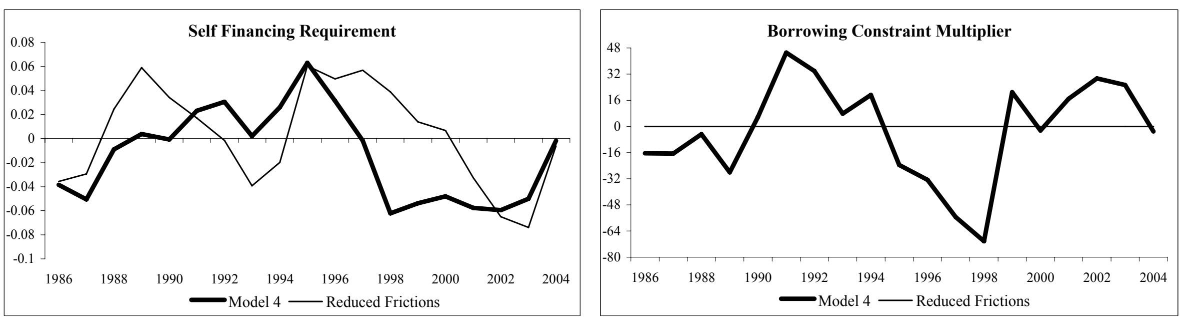
Panel A: Self Financing Requirement and Extenal Borrowing Constraint Multiplier for Models 2 and 4



Panel B: Labor Financing Wedges for Models 3 and 4



Panel C: Self Financing Requirement and Extenal Borrowing Constraint Multiplier for Models 4 and Reduced Frictions



Panel D: Labor Financing Wedges for Models 4 and Reduced Frictions

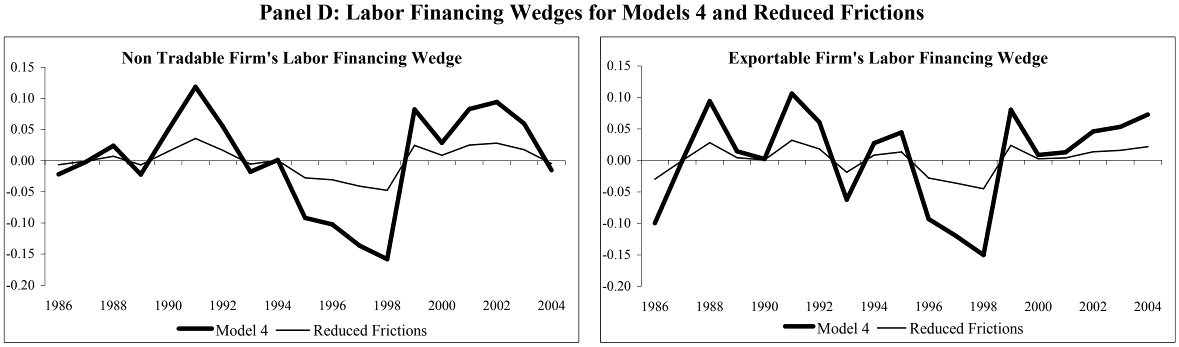


Figure 9. Data and Model 4 Simulations: Credit Constraint and Labor Wedges

Figure 9. Data and Model 4 Simulations: Credit Constraint and Labor Wedges (Concluded)

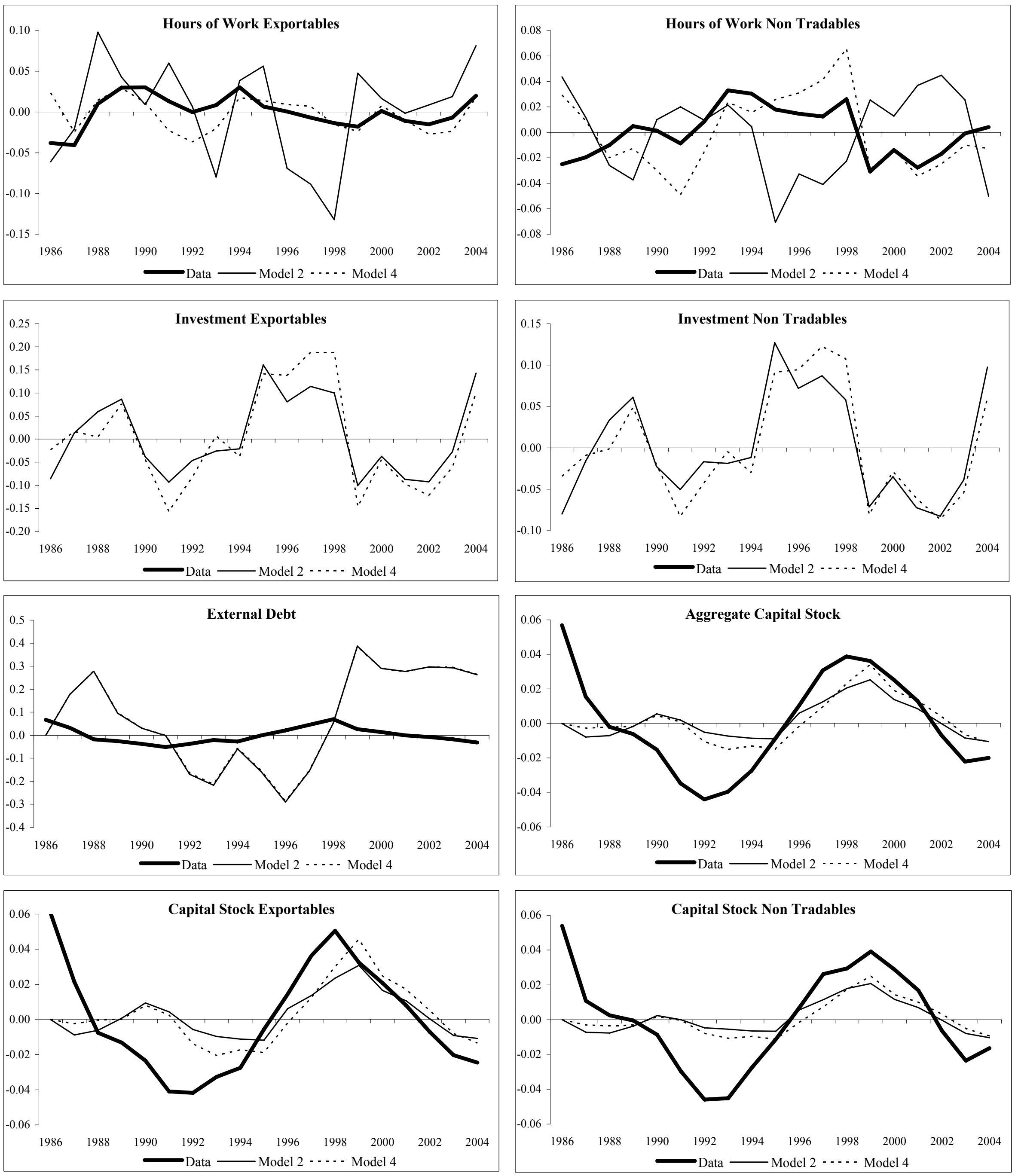
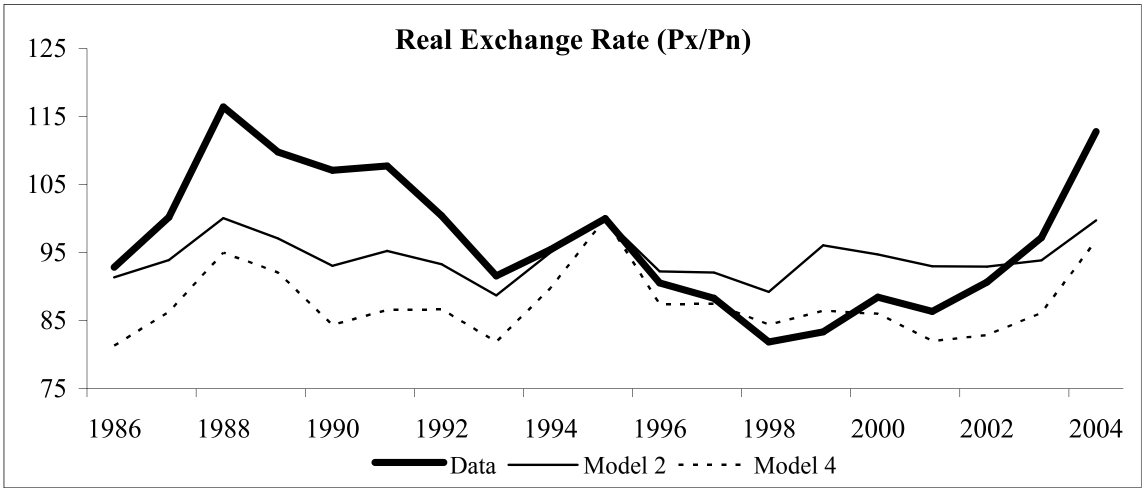
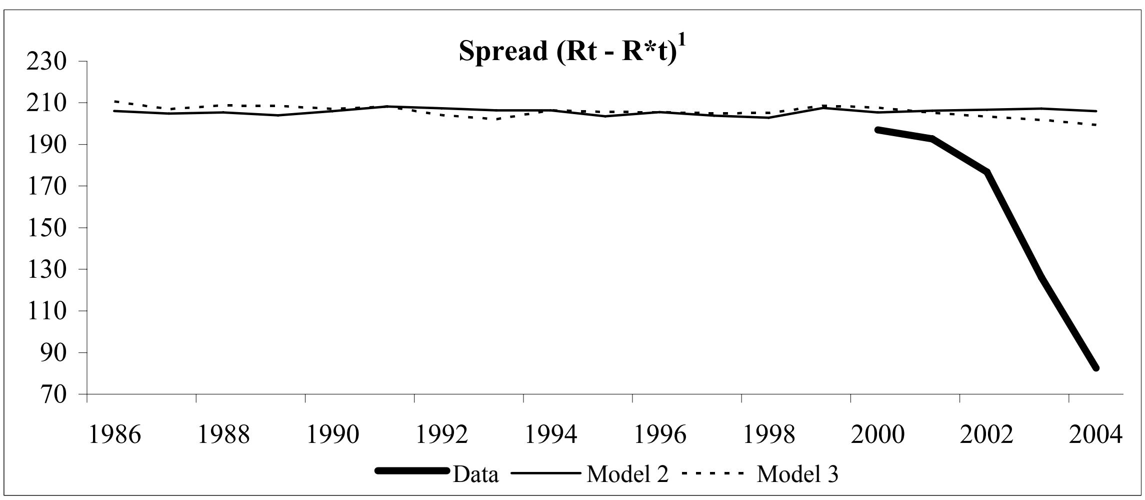


Figure 10. Real Exchange Rates and Foreign Lending Spreads in Model 4

Real Exchange Rate
(Price of Exportable Goods over Price of Non Tradable Goods)



Foreign Lending Spread
(Domestic Interest Rate Minus Foreign Interest Rate)



[1] The data corresponds to the EMBI Global for Chile, JP Morgan.

Figure 11. Data and Reduced-Friction Model Simulations

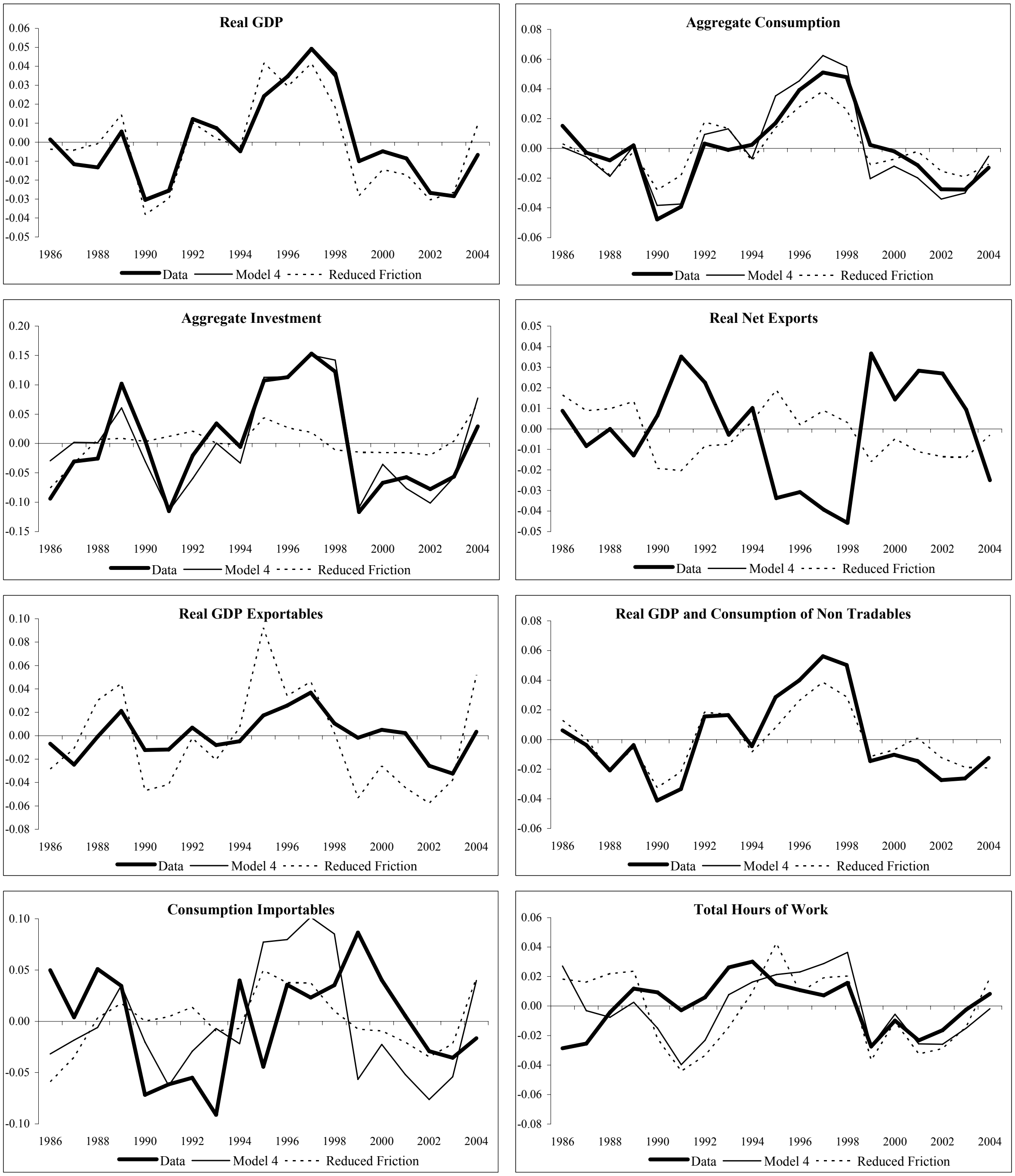


Figure 11. Data and Reduced-Friction Model Simulations (Concluded)