Argentina's "Missing Capital" Puzzle and Limited Commitment Constraints

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Argentina's "Missing Capital" Puzzle and Limited Commitment Constraints*

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Abstract

Capital accumulation in Argentina was slow in the 1990s, despite high total factor productivity (TFP) growth and low international interest rates. A possible explanation for the "missing capital" is that foreign investors were reluctant to take advantage of the high returns to investment seemingly offered by that small open economy under such favorable conditions, on the grounds that previous historical developments had led them to perceive Argentina as a country prone to external debt "opportunistic defaults." The paper examines this conjecture from the perspective of an optimal contract between foreign lenders and a small open economy subject to limited commitment constraints. Numerical experiments for a deterministic version of that analytical framework show that limited commitment constraints introduce an asymmetry to the capital accumulation process of small open economies: the responses of investment to positive TFP shocks are muted and short-lived, while those to negative TFP shocks are large and persistent. Furthermore, under some circumstances, a lower international interest rate environment can magnify the asymmetry. A quantitative implementation of the model economy to data from Argentina accounts, in line with asymmetry just described, for the rapid decline that that country's capital stock experienced, along with a falling TFP during the 1980s, as well as for the lack of any visible recovery of that stock during the significant surges of TFP observed between 1992-1998 and 2002-2008. In the absence of the limited commitment constraint, Argentina's capital stock in 2008 would have been 50% higher than it actually was.

Keywords: external debt opportunistic defaults, missing capital, optimal contract, limited commitment constraints, capital accumulation, Argentina.

JEL Classification: F34, F41, F42, F43, O19, O54

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1 Introduction

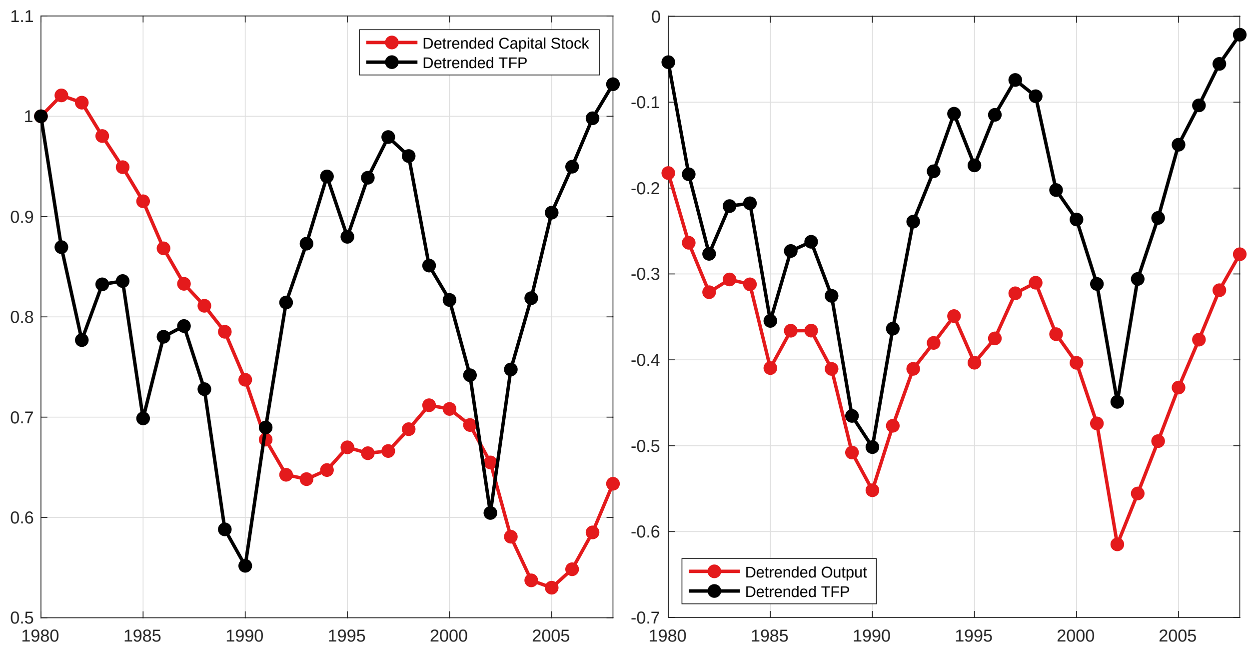
The relegation of Argentina from among the top ten nations in output per capita at the beginning of the 20th century to around the 65th place when the current one began has fascinated researchers in different fields of social sciences and inspired accordingly innumerable studies.

Economists have been attracted by that puzzling performance and naturally devoted great efforts to account for it with different conjectures. A popular one among them is the dismal inefficiency of the Argentine economy, whose total factor productivity (TFP) growth has lagged considerably behind that of developed nations. In this view, after a promising start, Argentina lost its once privileged status in the world economy simply because it failed to keep its productivity growing at the faster rate of that of countries currently at the top of the GDP per capita ranking. There is little doubt that this "total factor productivity problem" is part of the story of Argentina's secular economic decline.

But a more comprehensive examination of the evidence for Argentina during the particularly eventful period covering roughly three decades, from 1980 to 2008, suggests that weak TFP growth cannot be the whole story. The reason for this assessment is that output per working age population grew 26%, about 10% less than TFP, over that period. A standard growth accounting decomposition shows that this differential can be entirely accounted for by a rather dramatic 25% decline of the capital output ratio, from 1.73 in 1980, to 1.32 in 2008. This evidence suggests rather conclusively that, on top of a low average productivity growth rate, Argentina seems to suffer from a severe "capital accumulation problem" as well.

Further insights on the nature of that problem can be gained by examining Figure 1a, which documents the vertiginous "capital shallowing" process just described in terms of the level of the capital stock, detrended by total factor productivity and working–age population growth rates observed on average between 1951 and 1979. In order to highlight one of the key empirical regularities that motivates this paper, the figure displays also the evolution over time of detrended TFP: notice that in the two periods in which that variable exhibits noticeable surges, from 1992 to 1998 and from 2002 to 2008, the detrended capital stock remained rather flat, instead of rising sharply, as it should have according to the predictions of widely used small open economy models. Figure 1b shows a similar lackluster performance in terms of GDP throughout 1990's.

Low capital stock is even more puzzling given that the international interest rates



(a) Capital Stock and TFP. Index, 1980=100.

(b) GDP and TFP. Log index.

Figure 1: TFP, capital stock and GDP for Argentina, 1980-2008, detrended.

were low throughout 1990's. Figure 2 shows the yields from Merrill Lynch's HY175 U.S. bond index , net of expected U.S. inflation[1] The interest rate was about three percentage points lower after 1992 than it was in the 1980's. Yet, capital stock remained almost flat.

The paper investigates the hypothesis, advanced by Kydland and Zarazaga (2007), that that anomaly can be traced to the skepticism of foreign investors about Argentina's commitment to honor its foreign debt obligations. A brief review of the economic developments that took place in the period 1980-2008 will be useful to motivate the conjecture.

One of the most significant events over this period occurred in 1982, when Argentina fell in arrears in its foreign debt obligations, mostly in the form of loans extended by U.S. and European commercial banks. The distress created by the protracted negotiations, with an uncertain outcome to reschedule the payments, created havoc in Argentina's economy. By the time an agreement was finally reached by the end of the 1980s, with a bonds swap sponsored by the U.S. Treasury–the so-called Brady Bonds–output per capita was a dramatic 20% lower than at the beginning of that decade. For obvious reasons, the 1980s earned themselves the well-deserved moniker of the "lost decade," which included among its calamities an outburst of inflation that reached the monthly

[1]Data are taken from Neumeyer and Perri (2005), figure 5.

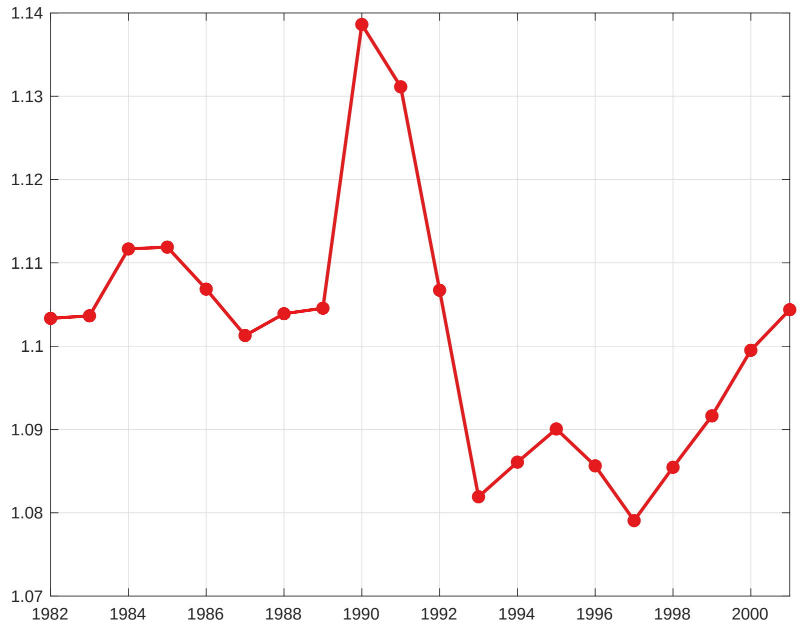


Figure 2: International interest rate: yields from Merrill Lynch's HY175 U.S. bond index minus expected U.S. inflation. Source: Neumeyer and Perri (2005)

rate of 200% in July 1989.

The dire situation forced the new administration elected in 1990 to attempt to turn the country around by launching an ambitious liberalization program, with the ultimate goal of making Argentina a modern, open economy, in position to attract the large amounts of foreign investment needed to reverse the sharp decline that the capital stock had suffered during the lost decade. As implied earlier, inspection of Figure 1 reveals that the program was successful in improving the efficiency of the economy, as measured by TFP, but not in significantly increasing the capital stock. In fact, the program ended in failure, with a deep recession between 1998 and 2002, during which TFP experienced a decline nearly as large as the one observed during the lost decade. As indicated earlier, the subsequent recovery of TFP again failed to have the effect of lifting the capital stock predicted by open economy models.

As already mentioned, Kydland and Zarazaga were the first to notice the anomaly that surges of TFP in Argentina during the 1990s did not seem to have been able to induce investment levels higher than those necessary to just replenish the depreciated capital stock. Importantly, those authors pointed out that the sovereign debt default of the 1980s happened when the capital stock was at a historical high level, as can be verified in Figure 1. It is precisely at the times when the capital stock is high and a large fraction of it has been built up from capital inflows that governments will have the most incentive to seize it and refuse to compensate foreign investors for the services of the confiscated capital.

The empirical plausibility of that "opportunistic default" incentive, established by Kehoe and Perri (2002), and the historic developments briefly summarized above, prompted Kydland and Zarazaga to formulate the conjecture that Argentina's sovereign debt default in the 1980s, when the capital stock was higher than ever before, led international financial markets to place that country in the category of those willing to engage in strategic repudiation of its foreign debt obligations. Aware of this perception, foreign investors subsequently decided to avoid venturing too much of their capital in Argentina, even in periods when a surge in total factor productivity implied that the rate of return on such capital would have been unusually high.

The paper is devoted precisely to explore rigorously the empirical relevance of that conjecture, in the light of a small open economy subject to a limited commitment constraint with respect to its incentives to honor its foreign liabilities, in the spirit of that studied by Kehoe and Perri in a two-country model.

Our paper is also related to Neumeyer and Perri (2005), who investigate the role of interest rate risk in emerging market economies. Besides substantial modelling differences, their paper is not concerned with the question of why capital accumulation was so low in the 1990's.

2 Setup

The economy is deterministic. It consists of a risk neutral lender and a small open economy. The representative agent in the country has a population size N_t in period t, exogenously given. The representative agent consumes $C_t \geq 0$ in period t and evaluates sequences of consumption according to

$$V(\{C_t\}) = \sum_{t=0}^{\infty} \beta^t N_t U\left(\frac{C_t}{N_t}\right), \quad 0 < \beta < 1. \tag{1}$$

The aggregate production function of the country is

$$Y_t = F(A_t, K_t, N_t),$$

where $K_t \geq 0$ is the beginning-of-period capital stock, and $A_t \geq 0$ is total factor productivity parameter in period t. Total factor productivity sequence is exogenously given. The capital stock depreciates at rate δ.

As is standard in open economy models, capital stock adjustments are costly. We assume that the adjustment costs are given by $\phi(K_t, K_{t+1})$, where the function ϕ is non-negative, convex, differentiable (with derivatives ϕ_1 and ϕ_2), and reaches a minimum of zero at some level of capital growth $K_{t+1}/K_t = \omega$. We put no restrioctions on ω now, but will later set it so that, along the balanced growth path, the adjustment costs are equal to zero. Given this normalization, the adjustment cost will modify the model dynamics, but will have the same balanced growth path as a model without adjustment costs.

The country can also borrow from (or save with) the lender. The net transfer from the lender in period t is denoted by B_t, and can be either positive or negative. The resource constraint for the country is

$$C_t + K_{t+1} + \phi\left(K_t, K_{t+1}\right) = F(A_t, K_t, N_t) + (1-\delta)K_t + B_t. \tag{2}$$

The initial capital stock K_0 is given.

The gross interest rate at which the lender discounts cash-flows between periods $t-1$ and t is denoted by R_t, and is exogenous. The lender discounts future cash flows at period discount rates R_t. The implied discount factor between period 0 and t is denoted by $Q_t = \prod_{j=1}^{t} R_j^{-1}$, with $Q_0 = 1$. The lender's present value of its revenue is given by

$$\Pi(\{C_t, K_t\}) = \sum_{t=0}^{\infty} Q_t B_t = \sum_{t=0}^{\infty} Q_t \left[F(A_t, K_t, N_t) + (1-\delta)K_t - C_t - K_{t+1} - \phi\left(K_t, K_{t+1}\right)\right].$$

2.1 Optimal Contract

At time zero, the country and the lender sign a contract that specifies sequences of borrowing, $\{B_t\}$, consumption $\{C_t\}$ and capital stock $\{K_{t+1}\}$. We interpret the present value of lenders' profits as the initial debt of the country to the lenders. We take the initial debt d_0 as given, and require that the contract gives the lender a present value of profits of at least d_0:

$$\Pi(\{C_t, K_t, N_t\}) \geq d_0. \tag{3}$$

While the lender commits to the sequences specified in the contract, the borrowing country can default in any period. If it defaults, it does not repay the debt, but moves into permanent autarky without any access to borrowing or lending in the future. The value of moving to autarky in period t is given by

$$V_t^{\text{aut}}(K_t) = \max_{\{K_{t+j+1}, C_{t+j}\} \geq 0} \sum_{j=0}^{\infty} \beta^j N_{t+j} U\left(\frac{C_{t+j}}{N_{t+j}}\right).$$

subject to the closed economy resource constraint

$$C_{t+j} = F(A_{t+j}, K_{t+j}, N_{t+j}) + (1-\delta)K_{t+j} - K_{t+j+1} - \phi\left(K_t, K_{t+1}\right).$$

Without loss of generality, the contract then requires that, in any period, the value of the contract cannot be smaller than the value of being in autarky:

$$\sum_{j=0}^{\infty} \beta^j N_{t+j} U\left(\frac{C_{t+j}}{N_{t+j}}\right) \geq V_t^{\text{aut}}(K_t). \tag{4}$$

The *optimal contract* is given by feasible sequences $\{B_t, C_t, K_{t+1}\}$ that, given exogenous sequences $\{N_t, A_t, R_t\}$ and initial debt d_0, maximize the country's lifetime utility (1) subject to the resource constraint (2), promise keeping constraint for the lender (3) and the limited commitment constraint (4).

Other quantities We define trade balance as

$$TB_t = Y_t - C_t - I_t - \phi\left(K_t, K_{t+1}\right).$$

where $I_t = K_{t+1} - (1-\delta)K_t$ is investment. Let also D_t be the debt position of the country at the beginning of period t (including interest payments). It evolves according to the law of motion

$$D_{t+1} = R_{t+1}(D_t - TB_t).$$

Finally, the current account balance CA_t is defined as the sum of trade balance and net investment income on the country's net foreign asset position, $-(1-1/R_t)D_t$:[2]

$$CA_t = TB_t - \left(1 - \frac{1}{R_t}\right) D_t.$$

Solving for the Optimal Contract Let $\lambda > 0$ be the Lagrange multiplier on the promise keeping constraint and $\beta^t M_t \geq 0$ be the Lagrange multiplier on the limited commitment constraint in period t. We will consider the case where the lender is weakly more patient than the borrower:

$$\beta R_t \leq 1. \tag{5}$$

We define the relative discount factor of the lender, relative to the borrower, to be $P_t = Q_t \beta^{-t}$. Assumption (5) implies that $P_t \geq 1$. The first-order conditions in consumption and capital are

$$U'(C_t/N_t)\left(1 + \sum_{s=0}^{t} M_s\right) = \lambda P_t \tag{6}$$

$$\begin{aligned} F_K(A_{t+1}, K_{t+1}, N_{t+1}) + 1 - \delta - \phi_1(K_{t+1}, K_{t+2}) = {} & R_{t+1}\left[1 + \phi_2(K_t, K_{t+1})\right] \\ & + \frac{M_{t+1}}{\lambda P_{t+1}} \frac{dV_{t+1}^{\text{aut}}(K_{t+1})}{dK_{t+1}}. \end{aligned} \tag{7}$$

Relative to a first best allocation, the marginal product of capital is weakly increased, $F_{K,t+1} \geq R_{t+1}$. Increasing capital stock now has an adverse effect of increasing the value of autarky. This makes it more tempting to default. Relative to first best, the optimal capital stock thus decreases.

First best. The solution to the first-best problem, where the country does not have commitment problems and the constraint (4) is not imposed, is simple. The marginal utility of consumption declines at rate $\beta R_t - 1$, $U'(C_{t+1}/N_{t+1}) = (\beta R_{t+1})^{-1} U'(C_t/N_t)$ (with consumption to population ratio being constant if $\beta R_t = 1$). The level of the consumption sequence is chosen to satisfy the promise keeping constraint for the lender. The level of the transfer payments is then computed as a residual from the resource

[2] If one defines debt net of interest payments $\tilde{D}_t = D_t/R_t$, then $\tilde{D}_{t+1} = R_t \tilde{D}_t - B_t$ and $CA_t = TB_t - (R_t - 1)\tilde{D}_t$.

constraint (2).

If the adjustment costs are zero then the capital stock is chosen so as to equalize the marginal product of capital to the gross interest rate, $F_{K,t+1} = R_{t+1}$. In the presence of adjustment costs, the marginal benefit of investment is corrected for tomorrow's change in the marginal cost $\phi_1(K_t, K_{t+1})$ (which can be positive or negative, depending on how K_{t+1} compares to K_t, while the marginal cost of investment is corrected for the current marginal adjustment cost $\phi_1(K_t, K_{t+1})$ (which can again be both positive or negative).

The Euler Equation. We will investigate the extent to which the Euler equation in a standard closed economy is distorted in the optimum. The Euler equation in a closed economy is

$$[1 + \phi_2(K_t, K_{t+1})]\, U'\left(\frac{C_t}{N_t}\right) = \beta\, [F_K(A_{t+1}, K_{t+1}, N_{t+1}) + 1 - \delta - \phi_1(K_{t+1}, K_{t+2})]\, U'\left(\frac{C_{t+1}}{N_{t+1}}\right)$$

Evaluating the first-order condition (6) at two consecutive periods yields the following intertemporal condition that must hold in the optimum:

$$U'\left(\frac{C_t}{N_t}\right) = \beta R_{t+1} \frac{1 + \sum_{s=0}^{t+1} M_s}{1 + \sum_{s=0}^{t} M_s} U'\left(\frac{C_{t+1}}{N_{t+1}}\right)$$

The Euler equation is thus distorted if the promise keeping constraint is binding next period and so $M_{t+1} > M_t$, in which case the future consumption is increased relative to the current consumption to prevent a violation of the promise keeping constraint. We can define the effective interest rate which the country effectively faces to be

$$\hat{R}_{t+1} = R_{t+1} \frac{1 + \sum_{s=0}^{t+1} M_s}{1 + \sum_{s=0}^{t} M_s}.$$

The effective interest rate thus increases above R_{t+1} in periods when the promise keeping constraint binds. In those periods, next period capital is decreased relatively to the first best allocation.

3 Constant Growth

Suppose now that the production function is Cobb-Douglas,

$$F(A_t, K_t, N_t) = A_t K_t^{\theta} N_t^{1-\theta}.$$

The population grows at rate η, $N_t = (1+\eta)^t N_0$, and the total factor productivity grows, on a balanced growth path, at rate ζ. Along the balanced growth path, output, consumption and capital stock grow at rate $(1+\eta)(1+\gamma)$, where $1+\gamma = (1+\zeta)^{\frac{1}{1-\theta}}$ is the growth of variables per capita, while TFP grows at rate $1+\zeta$ and labor grows at rate $1+\eta$. We also assume that the adjustment costs are quadratic in the growth rate of the capital stock, and proportional to the current capital stock:

$$\phi\left(K_t, K_{t+1}\right) = \frac{\kappa}{2}\left(\frac{K_{t+1} - \omega K_t}{K_t}\right)^2 K_t.$$

The parameter κ measures the strength of the adjustment costs. We set $\omega = (1+\gamma)(1+\eta)$, which is the growth rate of capital along the balanced growth path. Finally, we assume that the utility exhibits a constant relative risk aversion:

$$U(C) = \frac{C^{1-\sigma}}{1-\sigma}.$$

This allows us to normalize the model as follows. Let

$$x_t = \frac{X_t}{(1+\eta)^t (1+\gamma)^t}, \quad a_t = \frac{A_t}{(1+\zeta)^t}$$

be the normalized variables, where X_t is either output Y_t, capital stock K_t, consumption C_t, bonds B_t or repayment D_t. We write $f(a_t, k_t) = a_t k_t^{\theta}$. The optimal contract maximizes

$$\sum_{j=0}^{\infty} \hat{\beta}^j U(c_j)$$

subject to the promise keeping constraint

$$\sum_{t=0}^{\infty} Q_t(1+\gamma)^t(1+\eta)^t \left[f(a_t,k_t)+(1-\delta)k_t - c_t - (1+\gamma)(1+\eta)k_{t+1} - \phi\left(k_t,k_{t+1}\right)\right] \geq d_0, \tag{8}$$

where $\hat{\beta} = \beta(1+\eta)(1+\gamma)^{1-\sigma}$, limited commitment constraint

$$\sum_{j=0}^{\infty} \hat{\beta}^j U(c_{t+j}) \geq v_t^{\text{aut}}(k_t), \quad \forall t \geq 0, \tag{9}$$

where the normalized value of autarky is

$$v_t^{\text{aut}}(k_t) = \left[(1+\eta)(1+\gamma)^{(1-\sigma)}\right]^t V_t^{\text{aut}}(K_t),$$

and v_t^{aut} solves

$$v_t^{\text{aut}}(k_t) = \max_{\{c_{t+j},k_{t+1+j}\}\geq 0} \sum_{j=0}^{\infty} \hat{\beta}^j U\left(c_{t+j}\right).$$

subject to

$$c_{t+j} = f(a_{t+j},k_{t+j}) + (1-\delta)k_{t+j} - (1+\eta)(1+\gamma)k_{t+j+1} - \phi(k_{t+j},k_{t+j+1}).$$

The Lagrange multiplier on the promise keeping constraint is now $\hat{\beta}^t\mu_t$. We also normalize the effective discount variable P_t by defining

$$p_t = Q_t(1+\gamma)^{\sigma t}\beta^{-t} = P_t(1+\gamma)^{\sigma t}.$$

The first-order conditions now become

$$U'(c_t)\left(1+\textstyle\sum_{s=0}^{t}\mu_s\right) = \lambda p_t \tag{10}$$

$$f_k(a_{t+1},k_{t+1}) + 1 - \delta + \kappa h_{t+1} + \frac{\kappa}{2}h_{t+1}^2 = R_{t+1}\left(1+\frac{\kappa}{(1+\eta)(1+\gamma)}h_t\right) + \frac{\mu_{t+1}}{\lambda p_{t+1}}\frac{dv_{t+1}^{\text{aut}}(k_{t+1})}{dk_{t+1}}. \tag{11}$$

where

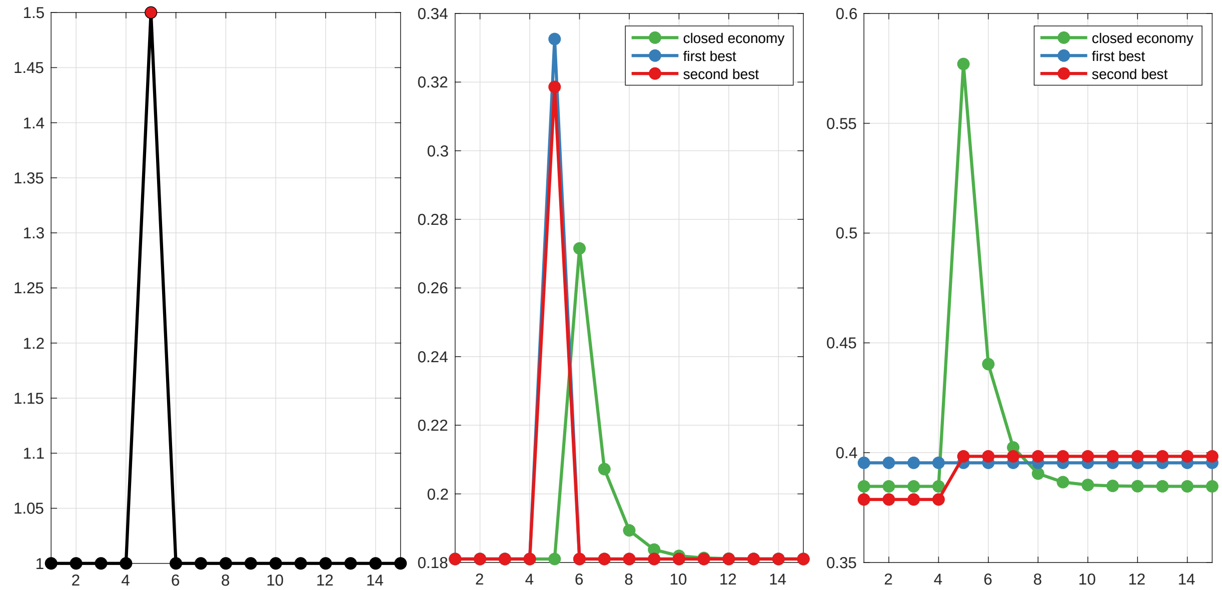
$$h_t = \frac{k_{t+1}-(1+\eta)(1+\gamma)k_t}{k_t}.$$

Numerical Solution We solve the model by solving the corresponding first-order conditions (10) and (11). We iterate on the set of binding limited commitment constraints by dropping the ones that are slack and by adding those that are violated, until convergence. We then iterate on the Lagrange multiplier λ until the model yields initial debt d_0.

4 Inspecting the mechanism

To understand the workings of the model, and the forces that determine capital accumulation as well as the dynamics of consumption and trade balance, we will now consider several simple numerical examples. Unless stated otherwise, all examples assume that the utility is logarithmic, capital share θ is one third, the rate of depreciation δ is 8 percent, there is no population and TFP growth, and the discount factor β equals 0.96.

Transitory changes in productivity. Consider an anticipated one-time increase in the total factor productivity a. The total factor productivity increases in period 5 and then reverts back to its original level. Figure 3 shows the how capital stock (in panel 3b) responds in case there are no adjustment costs, and $\beta R_t = 1$ in all periods. Capital stock in the closed economy decreases in the periods preceding the increase, because the agents increase consumption due to the positive wealth effect, and this effect dominates the fact that capital will have a high rate of return in period 5. The economy then invests more in period 5 when productivity is high, and this results in higher capital stock in period 6. Afterwards, capital stock gradually converges back to its original level, with the rate of convergence driven by the desire to smooth consumption. In the first-best and the second-best economy, capital and consumption decisions are separated, because the economy can borrow and save. In both economies, capital stock is at its steady state level in all periods except in period 5. In the first-best and the second-best economy, capital stock increases when the marginal product of capital is high. The increase in capital stock thus happens one period earlier than in a closed economy, because the mechanism behind the increase in capital stock is different. In a closed economy, the desire to smooth consumption prevents the agents to increase capital stock in period 5, because that would require high investment in period 4, and a drop in consumption. Instead, investment only happens in period 5 when the economy has more resources, and the effect on capital stock is purely transitory.

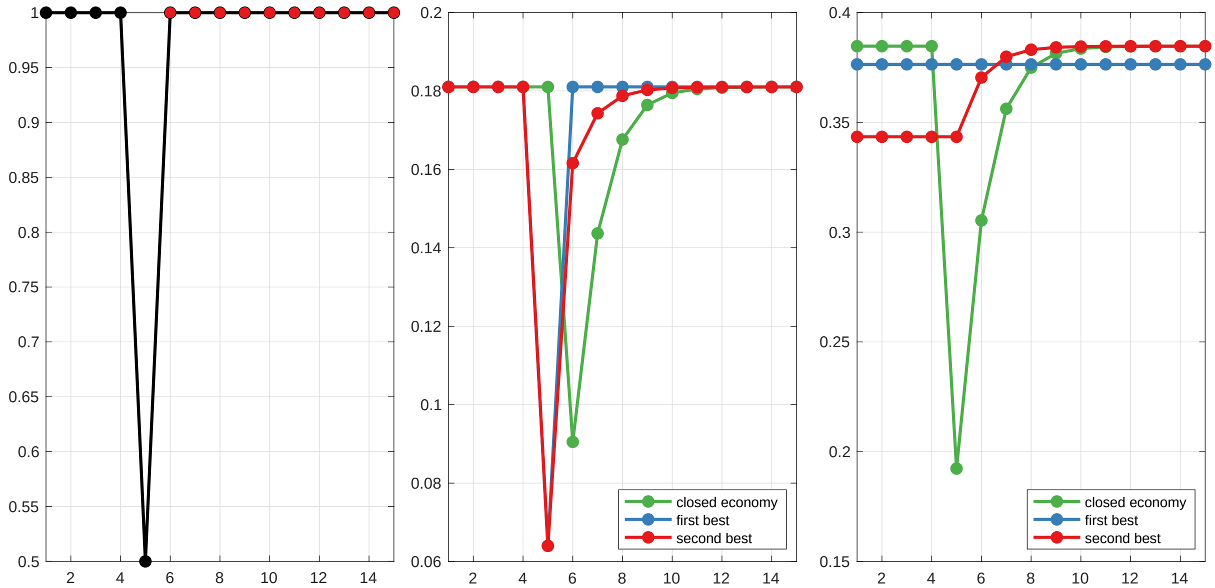


(a) Total Factor Productivity **(b)** Capital Stock **(c)** Consumption

Figure 3: Response to a temporary positive TFP shock without adjustment costs. Red dots in panel (a) denote periods when the limited commitment constraint binds.

In the second best economy, the desire to invest in capital stock is reduced by the limited commitment constraint considerations. As panel 3a shows, the limited commitment constraint binds in period 5. That is, the first-best level of capital stock would prompt the agents to default and move to autarky. This significantly reduces the capital stock in period 5. The level of utility, shown in panel 3c is, however, pushed upward. This stands in contrast to the closed economy, where the lifetime utility decreases after the shock.

Figure 4 shows a response to a one-time decrease in the productivity shock in period 5. The response of the second-best economy is now different in two aspects. First, since the limited commitment constraint does not bind at the time of the negative productivity shock, capital stock decreases by the same amount as in the first-best economy. Second, the limiting commitment constraint now binds in all the periods follow the decrease in productivity. To see why, note that the agents consume more than their production in period 5. Thus, they need to transfer resources back to the lender after period 5. There are no future shocks, and so no benefit from future insurance. If the capital stock immediately reverted back to the first-best level, they would prefer to default. To prevent them from defaulting, the value of autarky needs to be decreased by decreasing the capital stock. The recovery of the capital stock is now sluggish compared to the first-best economy, although the decline in period 5 is identical.



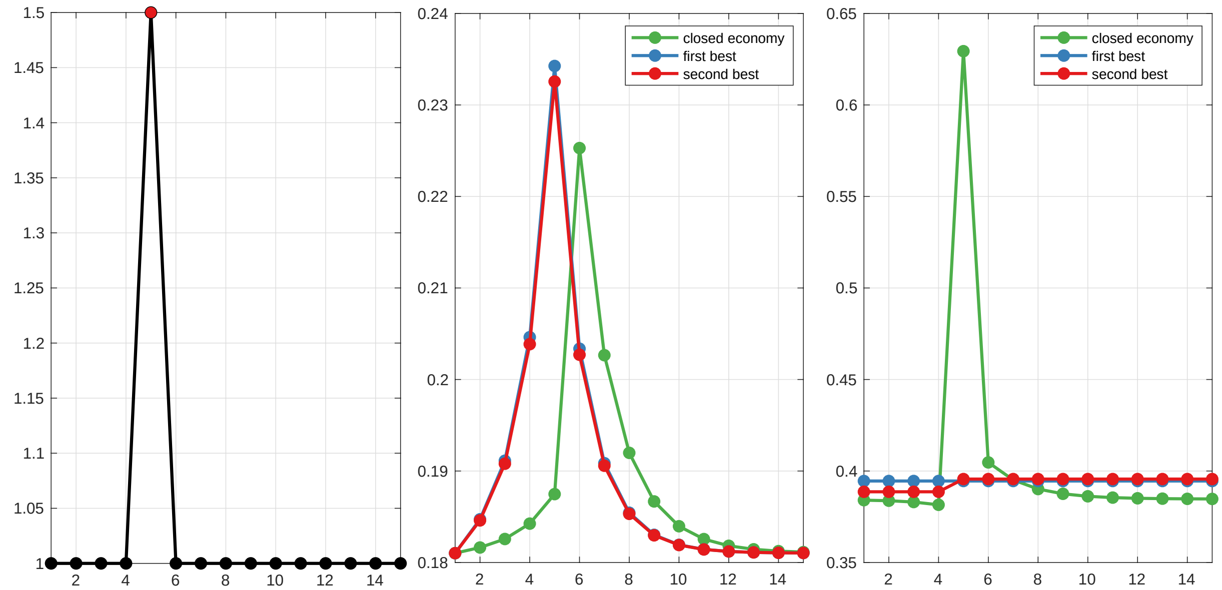
(a) Total Factor Productivity **(b)** Capital Stock **(c)** Consumption

Figure 4: Response to a temporary negative TFP shock without adjustment costs. Red dots in Figure 1 denote periods when the limited commitment constraint binds.

Overall, figures 3 and 4 show that the limited commitment constraints introduced an asymmetry to the capital accumulation process. The response to a positive shock is muted, and the reversal to the steady state level is rapid, while a response to a negative shock is large, and the reversal to the steady state level is slow.

The role of adjustment costs. Figure 5 shows the response to a one-time increase in productivity in the presence of capital adjustment costs. To ensure comparability, adjustment costs are added to both closed and open economy. The dynamics in the closed economy is now very different in the periods preceding the anticipated increase in the capital stock. Capital stock, now increases, rather than decreases, even in those periods, because the build-up of the capital stock must be gradual.[3] In both the first-best and second-best economies, capital stock likewise builds up even before the shock hits. However, the capital stock still peaks one period earlier, just like in the economy without the adjustment costs. In all three economies the capital stock slowly reverts back to its steady state level after the shock hits. The rate at which consumption decreases is the slowest in the closed economy because of an additional concern for consumption

[3]The closed economy thus resembles a closed economy without adjustment costs but with a very high intertemporal elasticity of substitution in consumption.



(a) Total Factor Productivity **(b)** Capital Stock **(c)** Consumption

Figure 5: Response to a temporary positive TFP shock with adjustment costs. Red dots in panel (a) denote periods when the limited commitment constraint binds.

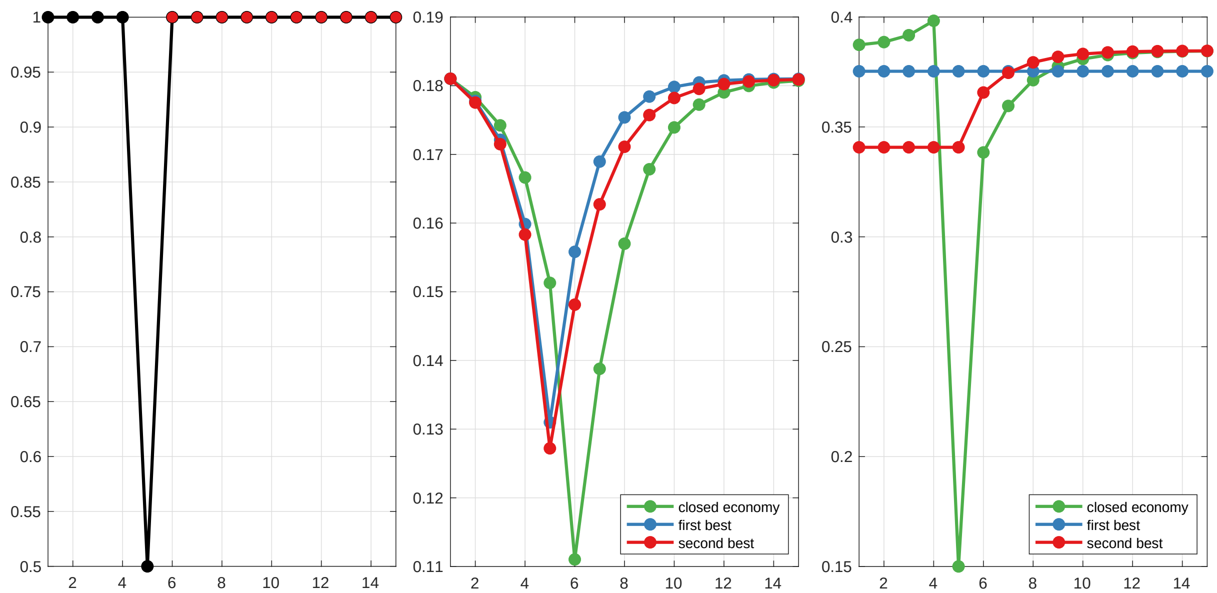
smoothing. Limited commitment constraint again mutes the capital stock response in period 5 in the second-best economy.

Capital stock in the second-best economy peaks again one period earlier, but now increases by about the same amount as in the closed economy. With higher or lower adjustment costs, it is possible to reverse the ordering and have a smaller response in the limited commitment economy. This is due to the fact that the effect of the adjustment costs is asymmetric: it has a relatively smaller effect on the closed economy, where consumption smoothing by itself produces smaller fluctuations in the capital stock.

Figure 6 shows the response to a temporary decrease in productivity in the presence of adjustment costs. Similarly to the experiment without the adjustment costs, the dynamics in periods 1-5 is almost identical in the first-best and second-best economies [4] After the shock, the limited commitment constraints bind, and hinder the speed of reversal to the steady state capital stock in the second-best economy.

The role of interest rates. Previous examples were simulated under the assumption bat $\beta R_t = 1$, and so the required rate of return on capital investment exactly offsets the

[4] But not exactly identical now. Binding limited commitment constraints after the shock push the capital stock in period 5 slightly lower in the second-best economy.



(a) Total Factor Productivity **(b)** Capital Stock **(c)** Consumption

Figure 6: Response to a temporary negative TFP shock with adjustment costs. Red dots in panel (a) denote periods when the limited commitment constraint binds.

discount rate. What happens if the investors require a lower rate of return? Figure 7 shows the capital stock response to a one-time increases in productivity if βR_t is smaller than one, and so the required rate of return is one percent lower than before. Since the closed economy is unaffected by the change in the interest rate, we only compare the responses of the first-best and the second-best economy. As before, there is a one-time increase in total factor productivity in period 5.

In the first-best economy, the response of capital stock to the decrease in the interest rate is unambiguous. Foreign investors require a lower rate of return, and are willing to accepts a lower marginal product of capital. This implies a higher capital stock in every period. Panel 7b shows the capital stock in period 5, which is the period when TFP increases. In the second-best economy, the the capital stock reacts very differently. As one can see from panel 7b, lower interest rates lead to a decrease of the capital stock, not increase. In addition to the direct effect of lower interest rates from the first-best economy, there is now an additional indirect effect of the limited commitment constraints. They are represented by the last term in equation (11). The limited commitment constraint, which binds in period 5, and prevents investors from investing more, is more severe with lower interest rates. It's severity increases because low interest rates put a downward pressure on consumption, and the temptation to default increases. Overall, this effect dominates the direct effect of interest rates, overturning the first-best result.

In this numerical example, the limited commitment constraint always binds in period 5. In other periods shown in figure 7, the limited commitment constraint does not bind, and the capital stock is at its first best level. In the presence of incomplete capital stock depreciation or adjustment costs, capital stock in other periods will be affected as well, stretching the impact of low interest rates to other periods. We have, also constructed examples, where lower interest rate increase the set of binding incentive constraints. In such case, lower interest rates generate an additional downward pressure on capital stock in other periods.

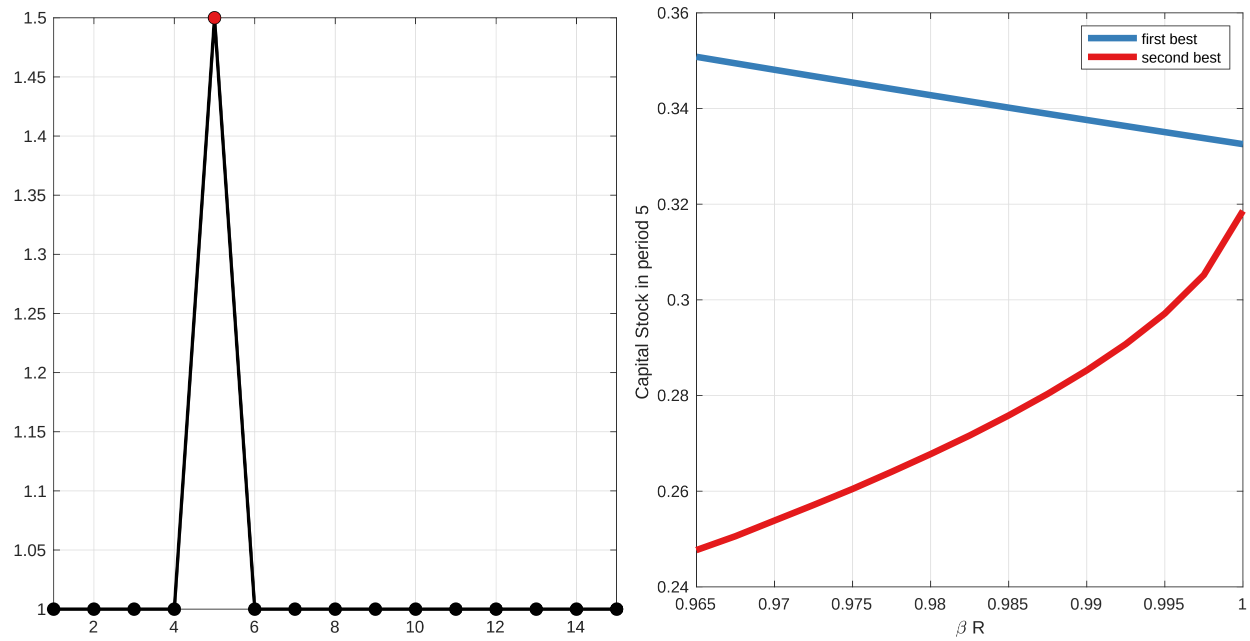
The first-best and second-best economy also have different implications in the long run. While capital stock in the first-best economy remains at its first-best level, capital stock in the second-best economy converges to the closed economy level. Moreover, borrowing constraints prevent consumption from falling, and it also settles at a closed economy level in the long run. this implies that there is no effect of lower interest rates on capital stock in the long run.[5]

5 Argentina

We calibrate the model for Argentinian economy as follows. We set the coefficient of relative risk aversion $\sigma = 2$. We set capital share $\theta = 0.4$. Based on the 1951-1979 period when the Argentinian economy can be considered closed, we compute the depreciation rate $\delta = 0.111$, net growth rate of technology $\gamma = 0.010$ and population growth rate $\eta = 0.016$. We calibrate the discount factor β to yield the steady state capital to output ratio of 1.6. This yields $\beta = 0.896$. To model a period of low interest rates in the 1990's, we assume that investors are more patient than the Argentinians, and set $R = 0.975$ times $(1+\gamma)^{\sigma}/\beta$. This yields $R = 1.110$. The benchmark parameters are summarized in Table 1. Finally, we set the adjustment cost parameter $\kappa = 1$.

We run the experiment for the 1980-2008 period. We set the initial level of debt d_0 in 1980 to be zero, which is close to 3.2 percent of GDP, as computed by Lane and Milesi-Ferretti (2007). We feed in the actual time series for TFP, $\{a_t\}$ and assume that, after 2008, it reverts back to its mean value.

[5] To prove those results, note that in a steady state, p_t converges to $((1+\gamma)^{\sigma}/(\beta R))^t$, that μ_t/p_t converges to a constant, say ρ, and that, since the limited commitment constraints bind, consumption converges to consumption in autarky c^{aut}. This implies that $U'(c^{\text{aut}}) = (1 - \beta R/(1+\gamma)^{\sigma})/\rho$ and that



(a) Total Factor Productivity

(b) Capital Stock

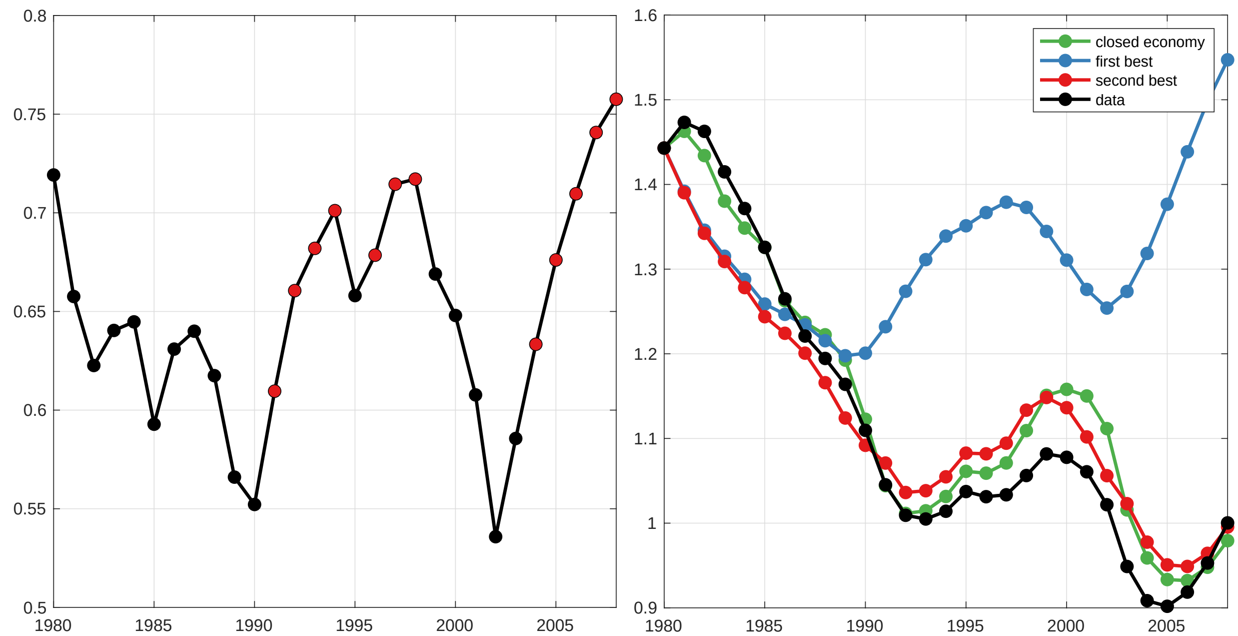
Figure 7: Capital stock and interest rate. Left panel: Total factor productivity. Right panel: Capital stock in period 5 as a function of βR, no adjustment costs.

Table 1: Benchmark Parameters

σ	β	δ	γ	η	R	κ	d_{1980}/y_{1980}
2.000	0.896	0.111	0.010	0.016	1.110	1.000	0

Figure 8a shows total factor productivity in Argentina for 1980-2008. After a relatively rapid decrease in the 1980's, Argentinian TFP recovered for most of 1990's, with a mild exception in 1995, when TFP temporarily declined. The crisis between 1998 and 2002 is visible by another drastic decline in TFP. After that, TFP recovered again. Red dots in figure 8b show periods when the limited commitment constraints bind: between 1991 and 1998, with the exception of 1995, and then after 2004. Those are periods when TFP is relatively high. As figure 8b shows, binding limited commitment constraints imply that capital stock is relatively low. In fact, the capital stock is comparable to the one in a closed economy, and in some periods even lower than that. In contrast, in the first-best economy, investors take advantage of low interest rates, and accumulate a large amount

$f_k = R + \rho U'(c^{\text{aut}}) f_k$. Combining, one gets $f_k = 1/\beta$, i.e. closed economy level of capital stock.

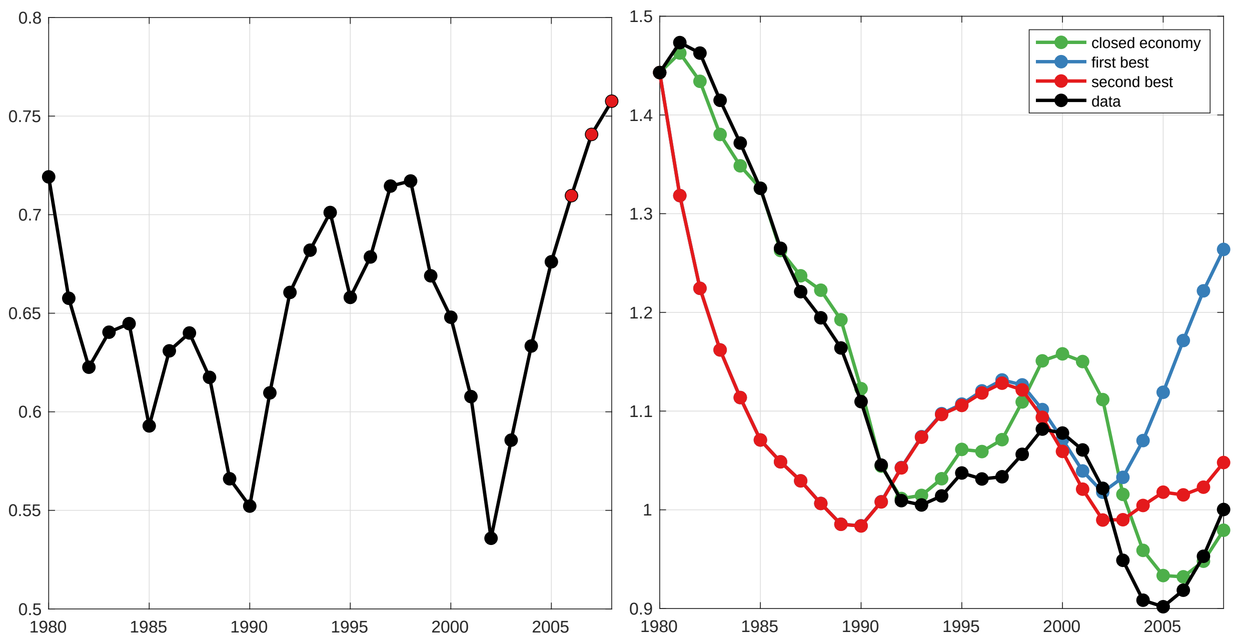


(a) Total Factor Productivity **(b)** Capital Stock

Figure 8: TFP and capital stock for Argentina, 1980-2008, benchmark calibration. Red dots in panel (a) denote years when the limited commitment constraint binds.

of capital: in the absence of limited commitment constraints, capital stock would be about 30% higher. This is consistent with the intuition given in the example above: when the investors are relatively patient, the first-best economy responds by increasing capital stock, but the second-best economy responds in the opposite direction, and the gap between both economies widens.

This finding is confirmed in figure 9b that shows the results when the investors are equally patient as the Argentinians and so $R = 1\beta$. The limited commitment constraint is slack throughout 1990's and binds only after 2006. As a result, there is there is almost no difference between the first-best and the second-best economy before 2000. The capital stock is significantly lower in the first-best economy. In the second-best economy, however, higher international interest rate leads to higher capital stock between 1991 and 1996, and then again after 2003.



(a) Total Factor Productivity **(b)** Capital Stock

Figure 9: TFP and capital stock for Argentina, 1980-2008, equal patience. Red dots in panel (a) denote years when the limited commitment constraint binds.

6 What if Argentina gains commitment?

Suppose now that Argentina, magically, counterfactually and unexpectedly, obtains the commitment technology in 2003. What would be the response of the economy? The results on the capital stock are shown in Figure 10. There would be a gradual buildup of capital stock after 2000. The build-up would be substantial but, due to the adjustment cost, it would take about 15 years to get to the new steady state. Th new steady state would have about 40 percent more capital stock than it would be in the presence of limited commitment constraints. If the limited commitment constraints were relaxed in 1991 then, similarly, the capital stock over the 1990's would accumulate rapidly and would be about 20 percent higher, before the gap increases even more after 1998.

7 Conclusions

This paper has been motivated by an anomaly that Kydland and Zarazaga (2007) detected in Argentina in the process of studying the severe economic depression that that country experienced during the 1980s, known for that reason as Argentina's lost decade.

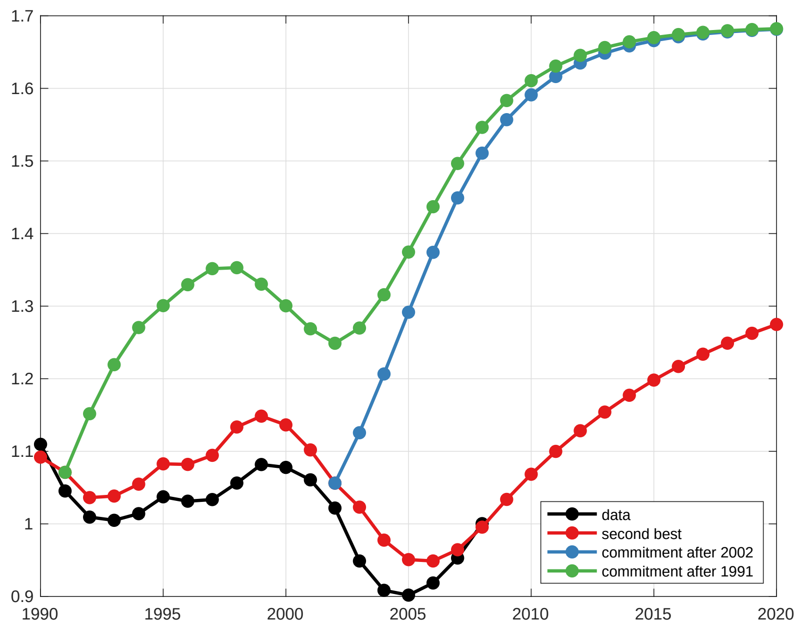


Figure 10: Capital stock in a second best economy, and in an economy where the limited commitment constraints are unexpectedly relaxed either in 1991 or in 2002.

Those authors showed that a standard neoclassical growth closed economy model can account for the capital shallowing process that the country suffered over that period, given that total factor productivity declined sharply at the same time.

It was investigating the implications of the model for the subsequent decade that those authors discovered, however, that the same model failed to account for the lack of recovery of the capital stock during the period 1992-1998, despite the strong rebound that TFP registered then. In other words, the anomaly suggested by the closed economy model was that a lot of capital was missing from Argentina during 1990's, despite the surge of TFP and the unusually low international interest rates observed during most of that decade. It turns out that this pattern of an unresponsive capital stock to a strongly rising TFP repeated itself in the period 2002-2008.

In the study just mentioned, Kydland and Zarazaga conjectured that the anomaly for the 1990s described above could eventually be explained away with an open economy model in which the capital accumulation process is impaired by foreign investors' skepticism about Argentina's commitment to honor its foreign debt obligations. Theoretical, empirical, and historical considerations justified the conjecture.

The theoretical argument is that governments have incentives to default on their respective countries' external debt obligations when the capital stock, at least partially built up with investment flows from abroad, is at its peak. Kehoe and Perri (2002) demonstrated the empirical relevance of this opportunistic default incentive, by showing that the introduction of limited commitment constraints in a two-country model resolved several puzzles in the international business cycle first reported by Backus et al. (1992). Finally, the historical justification for the conjecture advanced by Kydland and Zarazaga is that Argentina defaulted on its external debt obligations in 1982, when the capital stock had reached its peak according to the available data. This development may have led foreign investors to perceive Argentina as a country prone to opportunistic defaults, that is, to defaults not prompted by particularly adverse economic conditions. Accordingly, international capital markets started to treat Argentina thereafter as an economy operating under the same kind of limited commitment constraints considered by Kehoe and Perri.

The paper set out to rigorously investigate that conjecture, with the analytical framework of a small open economy that cannot commit to honor its foreign debt obligations, because it may find more convenient to default on them and switch to autarky after the capital stock increases above certain endogenous time-varying threshold. To that effect, the paper studied the dynamics of capital accumulation implied by an optimal contract between the lenders and a small open economy, whose known propensity to engage in strategic defaults is captured in the formality of the model by the presence of limited commitment constraints.

Several numerical experiments performed with a deterministic version of the model revealed that the dynamics of capital accumulation in that limited commitment constraint environment is very different from the one that would be observed in small open economies committed to honor their external debt. In particular, in economies lacking that commitment, the responses of investment to positive TFP shocks are rather muted and short-lived, while those to negative TFP shocks are large and fade away slowly over time. An interesting, and somewhat counterintuitive finding suggested by those numerical experiments, is that persistently low international interest rates can reduce even more the level of the small open economy's capital stock the optimal contract can support, because they have the effect of making the limited constraint to bind even more tightly than in a high real interest rate environment.

A calibration of the model with data from Argentina shows that, indeed, the limited commitment constraints can account not only for that country's capital shallowing in the lost decade, but also for the failure of its capital stock to show any significant recovery between 1992-1998 and 2002-2008, when TFP grew strongly and international interest rates were low by historical standards.

Given the apparent empirical success of the model in accounting for the dynamics of Argentina's capital stock, future research should establish the decentralized mechanism that could have implemented the allocation implied by the optimal contract. One possibility is that credit report agencies monitor the level of capital stock of economies operating under limited commitment constraints and that their assessments, reflected in changes in the country risk premium, mimic the quantitative effects of the Lagrange multipliers on the effective real interest rate such economies face in international financial markets. Another possibility is that the small open economy implements state-contingent capital income taxes, limits to capital flows, or exchange rate controls with a similar effect. Finally, it remains to be seen to which extent the theoretical and quantitative findings obtained under the assumption of deterministic exogenous variables apply to a more realistic stochastic model economy.

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Appendix: Computational Details

This section s concerned with numerical computations of the lifetime utility and profits under the assumption that all the exogenous variables are constant after some time period t_0. This implies that the sequence $\{p_t\}$ equals p in and after t_0. The consumption can be written as

$$c_{t_0+j} = c_{t_0} \left(\frac{1}{p}\right)^{\frac{j}{\sigma}}.$$

If $p = 1$ then the solution is easy. Consumption is constant, and the lifetime utility is

$$V_{t_0+j} = \max \left(V^{\text{aut}}, \frac{U(c_{t_0})}{1-\hat{\beta}} \right)$$

where V^{aut} is the steady state value of autarky.

The situation is more complicated when $p > 1$. In that case, consumption monotonically declines after t_0. Since V^{aut} is constant, there will be some period s such that the limited commitment constraint will start binding at s and will bind forever after. To find s, we need to compute the value of the optimal contract at each period in the future. We have two cases, one with $\sigma = 1$ (log utility), and one with $\sigma \neq 1$, and they must be treated separately.

Case I, $\sigma = 1$. Suppose first that the utility is logarithmic. Then $\ln c_{t_0+j} = \ln c_{t_0} - j \ln p$ and one can compute the lifetime utility without taking into account the possibility that the limited commitment may bind in the future as

$$V_{t_0+j} = \frac{1}{1-\hat{\beta}} \left(\ln c_{t_0+j} - \frac{\hat{\beta}}{1-\hat{\beta}} \ln p \right) = \frac{1}{1-\hat{\beta}} \left(\ln c_{t_0} - j \ln p - \frac{\hat{\beta}}{1-\hat{\beta}} \ln p \right) = V_{t_0} - \frac{j}{1-\hat{\beta}} \ln p.$$

The lifetime utility is monotonically decreasing. The limited commitment will start binding when the lifetime utility drops below the value of autarchy. We compute the binding period s as a solution to[6]

$$V_{t_0+s} = V^{\text{aut}},$$

or, rearranging,

$$s = (1-\hat{\beta})(V_{t_0} - V^{\text{aut}}) \frac{1}{\ln p}.$$

[6]Round it to the next natural number.

If the limited commitment constraint starts binding at s then we can rewrite, after some algebra, the value function as

$$V_{t_0} = \frac{1-\hat{\beta}^s}{1-\hat{\beta}} \ln c_{t_0} - \left[\frac{\hat{\beta}}{(1-\hat{\beta})^2}(1-\hat{\beta}^{s-1}) - (s-1)\frac{\hat{\beta}^s}{1-\hat{\beta}} \right] \ln p + \hat{\beta}^s V^{\text{aut}}.$$

Note that as p goes to one then s goes to infinity, and the value function goes to $\ln c_{t_0}/(1-\beta)$, as expected.

Case II, $\sigma \neq 1$. In all other cases, the lifetime utility, not taking into account the limited commitment constraint, is

$$V_{t_0+j} = \frac{c_{t_0+j}^{1-\sigma}}{1-\sigma} \frac{1}{1-\hat{\beta}p^{-\frac{1-\sigma}{\sigma}}} = \left(\frac{1}{p}\right)^{\frac{1-\sigma}{\sigma}j} V_{t_0}.$$

We can now compute the binding period s similarly to the previous case to obtain

$$s = \frac{\sigma}{1-\sigma}(\ln V_{t_0} - \ln V^{\text{aut}})\frac{1}{\ln p}.$$

The lifetime utility is now

$$V_{t_0} = \frac{c_{t_0+j}^{1-\sigma}}{1-\sigma} \frac{1-\left(\hat{\beta}p^{-\frac{1-\sigma}{\sigma}}\right)^s}{1-\hat{\beta}p^{-\frac{1-\sigma}{\sigma}}} + \hat{\beta}^s V^{\text{aut}}.$$

As p goes to one, then the lifetime utility again goes to its expected limit.

Profit function. The time period s is also relevant for the profit function. We decompose the profits into the first t_0 periods, and the remaining part, where we have to distinguish between periods before s and after s. Let

$$\Pi_0^{t_0-1} = \sum_{t=0}^{t_0-1} Q_t(1+\gamma)^t(1+\eta)^t \left[f(a_t, k_t) - c_t - (1+\gamma)(1+\eta)k_{t+1} \right]$$

be the profits in the first t_0 periods. Then we write

$$\begin{aligned}
\Pi_0 &= \Pi_0^{t_0-1} + Q_{t_0} \sum\nolimits_{j=0}^{\infty} R^{-j}(1+\gamma)^j(1+\eta)^j \left[f(a,k) - (1+\gamma)(1+\eta)k - c_{t_0+j}\right] \\
&= \Pi_0^{t_0-1} + Q_{t_0} \frac{f(a,k) - (1+\gamma)(1+\eta)k}{1 - \frac{(1+\gamma)(1+\eta)}{R}} - Q_{t_0} \sum\nolimits_{j=0}^{s-1} R^{-j}(1+\gamma)^j(1+\eta)^j c_{t_0+j} \\
&- Q_{t_0} \sum\nolimits_{j=s}^{\infty} R^{-j}(1+\gamma)^j(1+\eta)^j c_{t_0+j} \\
&= \Pi_0^{t_0-1} + \frac{Q_{t_0}}{1 - \frac{(1+\gamma)(1+\eta)}{R}} \left[f(k) - (1+\gamma)(1+\eta)k\right] - Q_{t_0} \frac{1 - \left[\frac{(1+\eta)(1+\gamma)}{Rp^{\frac{1}{\sigma}}}\right]^s}{1 - \frac{(1+\eta)(1+\gamma)}{Rp^{\frac{1}{\sigma}}}} c_{t_0} \\
&- Q_{t_0} \frac{\left[\frac{(1+\gamma)(1+\eta)}{R}\right]^s}{1 - \frac{(1+\gamma)(1+\eta)}{R}} c^{\text{aut}},
\end{aligned}$$

where c^{aut} is the value of consumption in autarchy.