The Role of Total Factor Productivity in "Phoenix Miracles": Insights from an Emerging Market Crisis

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THE ROLE OF TOTAL FACTOR PRODUCTIVITY IN "PHOENIX MIRACLES:" INSIGHTS FROM AN EMERGING MARKET CRISIS*

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ABSTRACT

Key macroeconomic variables such as GDP and investment typically display a V-shaped pattern during major emerging market crises. A notable exception to that pattern is intermediated credit, which follows an L-shaped trajectory instead: it declines at first in lockstep with economic activity, but later on it fails to recover while output does. From the vantage point of "credit crunch" theories of crises, it is as if output almost literally "rises from its ashes," prompting the metaphoric characterization of emerging markets post-collapse recoveries as Phoenix Miracles.

This paper reorganizes the evidence for a particular emerging market crisis, the one that Argentina experienced in 2000-01, under the guide of the neoclassical growth model. Under that lens, there is nothing special about the V-shaped trajectory that GDP, investment, and labor input followed during the crisis and its aftermath. That is exactly the pattern, and in the same orders of magnitude, that a neoclassical growth model with TFP taken as exogenous would predict. Furthermore, from the vantage point of that model, there is no Phoenix Miracle: the post-collapse recovery of TFP and GDP was about as strong as the model would have predicted.

1. INTRODUCION

As it is typically the case with phenomena that elude widely accepted scientific explanations, the study of economic crises of "Great Depression" magnitudes continues to captivate the attention of economists.

Economic history makes apparent that no country, big or small, developed or underdeveloped, is exempt from sudden, steep declines in output in a relatively short period of time. However, output collapses of sizable magnitude seem to be far more frequent in the developing world. Given their relative abundance, emerging market crises therefore end up concentrating most of the attention of scholars and researchers eager to understand the nature and causes of crises in general.

There is a sense of urgency in that research program, as the decline in output during emerging market crises is typically several orders of magnitude higher than those observed in run-of-the-mill recessions. According to Calvo, Izquierdo, and Talvi (2006a), the collapse of output in the average emerging market crisis is as high as ten percent from peak to trough. It seems then that societies would obtain large welfare gains from preventing those crises altogether. Unfortunately, that is easier said than done because the economics profession is still debating the causes and factors that trigger such seemingly catastrophic events.

Perhaps for that reason, there is the widespread presumption that well-established theoretical economic frameworks are inadequate to capture the complexities of a yet poorly understood phenomenon. As a consequence, such frameworks have typically been shunned as a valid reference to organize the evidence, in favor of more ad-hoc, atheoretical approaches. That view has no question its merits, but it has the difficulty that it doesn't identify which aspects of economic crises can be read fairly well with existing economic models and which ones still defy explanation. Finding such anomalies seems to be an important, even crucial step, in the scientific endeavor of understanding the nature of severe economic crises and eventually identifying the economic policies capable of preventing them.

For example, as reported in the next section, a regular feature of emerging market crises seems to be that after the collapse, the level of economic activity recovers at a brisk pace, without a corresponding recovery in the flows of intermediated credit. This feature of the aftermath of many emerging market crises has given rise to the speculation that output collapses are followed by Phoenix Miracles, in the sense that the economy seems to “rise from its ashes”, without the support from formal credit markets.

Underlying that assessment is implicitly the view that the most common trigger of crises is a “credit crunch,” an interpretation that by symmetry implies that in order for output to recover, capital intermediation activities must recover as well. However, that prediction is absent from many conventional models, like the representative agent neoclassical growth model, in which financial intermediation is at best a side-show in the capital accumulation process. In the logic of the neoclassical growth model, the main actor is total factor productivity. To qualify as a Phoenix Miracle by the standard of that model, a recovery should exhibit a large increase in GDP without a corresponding recovery in TFP. A legitimate question seems to be then if the post-collapse recoveries observed in emerging markets look still as a “miracle” when examined under the lens of the neoclassical growth model.

In addition, most studies present the evidence for emerging market crises following a cross-country approach, with the obvious goal of identifying common patterns. That is undoubtedly a useful exercise, but to the extent that long run growth features of the economies involved are different, a cross-country methodology has the inherent limitation that it cannot assess whether the dynamic behavior of key macroeconomic variables in a particular episode is consistent or not with underlying long run features and relationships between those variables in a given economy.

For example, investment after a crisis may recover less in some countries than in others. But the reason investment eventually doesn’t go back to its pre-crisis level in some episodes might be that it was already above its long trend value immediately prior to the crisis. Without explicitly taking into account the role that long run features of the economy play on its short-run movements, it is virtually impossible to establish if a particular variable of interest is growing “too fast” or “too slow” during the crisis and/or its aftermath.

That observation readily suggests that the evidence pertaining to emerging market crises (and perhaps to any crisis for that matter) should be examined with a framework that incorporates simultaneously short-run fluctuations and long run features of the economy and that, at the same time, is suitable for quantitative analysis. One such analytical framework that comes to mind is the stochastic neoclassical growth model. The goal of this paper is precisely to complement existing studies by reorganizing with the discipline of that model the evidence for a particular emerging market crisis and subsequent recovery, the one that Argentina experienced in the period 2000-04.

There are two reasons to focus the attention on Argentina's 2000-04 crisis. First, as documented in the next section, severe as it was, that crisis seems to be fairly representative in many dimensions of the typical emerging market crisis. Second, after a 15% collapse in just two years, economic activity recovered quickly without a corresponding recovery of intermediated credit, suggesting a "Phoenix Miracle" of the kind Calvo *et al.* have spotted in the wake of many other emerging market crises. It seems only natural to ask, therefore, what aspects of that alleged "miracle" would remain unexplained once the evidence is examined under the lens of the neoclassical growth model, by now one of the standard instruments in the economists' toolkit.

Needless to say, it would be naive to expect that all aspects of a multifaceted and complex phenomenon such as the extreme bust-boom cycle that Argentina experienced in the period 2000-04 can be adequately captured by such a "simplistic" abstraction of reality as the neoclassical growth model. Nevertheless, that very simplicity has its virtues, as it makes possible to assess in a rather clean fashion, at least on a first pass, which variables seem to behave as expected during a crisis and subsequent recovery and which ones do not, relative to a well-defined quantitative benchmark. This seems to be a useful piece of information to add to the evidence on emerging market crises summarized and documented in the literature in a more atheoretical fashion.

2. A LOOK AT THE EVIDENCE

As stated earlier, the evidence on sharp economic slowdowns in emerging market countries has been documented in several studies. Particularly provocative is the one by Calvo, Izquierdo, and Talvi (2006b) that motivated this paper.

Those authors studied a group of 22 severe emerging market crises ("Systemic Sudden Stops" in their characterization,) that includes most of the high-profile crisis episodes observed in the last thirty years, including the Tequila crises episodes

(Argentina 1995, Mexico 1995, Turkey 1995), East Asian crises episodes (Indonesia 1998, Malaysia 1998,Thailand 1998,) the Russian crises episodes of the late 1990s (Ecuador 1999, Turkey 1999, Argentina 2002), as well as the Latin American Debt Crises episodes of the 1980s (Argentina 1982, Brazil, 1983, Chile 1983, Mexico 1983, Peru 1983, Venezuela 1983, Uruguay 1984).

To give an idea of the severity of the crises included in the sample, the average decline in output across all 22 episodes is 10 percent.

The evidence for emerging market output collapses that qualify as "Systemic Sudden Stops", as documented by Calvo, Izquierdo, and Talvi (2006b), can be summarized in a nutshell as follows:

- Economic activity and total factor productivity follow a sharp V-shaped trajectory: those variables fall precipitously first, but then recover rather swiftly to their pre-crisis levels, typically in less than three years following the output trough.
- A notable exception to that pattern is intermediated credit, which follows an L-shaped trajectory instead. At first, it declines sharply in lockstep with economic activity, seemingly favoring "credit crunch" interpretations of crises. But later, contrary to the predictions of those interpretations, intermediated credit fails to recover as much as economic activity does. In fact, in many instances credit remains flat at its trough level even if output, as reported earlier, returns to its pre-collapse level. From the vantage point of "credit crunch" theories of crises, it is as if output almost literally "rises from its ashes," prompting Calvo *et al.*'s metaphoric characterization of emerging markets post-collapse recoveries as Phoenix Miracles.

For all the reasons offered in the introduction, none of this evidence is at first sight inconsistent with the predictions of the stochastic neoclassical growth model. In particular, critically important for the internal logic of that model is the strong positive association between TFP and GDP. That association eloquently stands out in Figure 1, which following Calvo *et al.* reports an index for those two variables around a five-year window centered on the trough year of the crisis. Figure 2 leaves little doubt that in that regard the particular Argentina's crisis examined in this paper is fairly representative of the emerging market crises studied by Calvo *et al*. Figure 3 reinforces the representative status of the 2000-04 Argentina's crisis, as it documents that the variations that GDP experienced over that period were in the same order of magnitude and followed the same V-shaped pattern as in the average emerging market crises in Calvo *et al*.

Another critical prediction of the neoclassical growth model is that investment is procyclical and more volatile than output. In particular, investment declines or rises in percentage terms more than output does. That prediction of the model seems to have largely materialized in the evidence for emerging market crises documented by Calvo *et al*. and summarized here in Figure 4.[1] That aspect of the evidence for emerging market crises seems to be captured as well by the 2000-04 Argentine crisis, as documented in Figure 5.

The brief description of the evidence seems to suggest that to retain its status as a valid lens to read the evidence pertaining to economic crises, a neoclassical growth model should be capable of replicating a V-shaped pattern for GDP and investment when TFP exhibits that same V-shaped pattern. But before proceeding to establish whether or not that is the case for the particular crisis that Argentina experienced around the year 2000, it is necessary to reorganize the evidence in a manner that is consistent with the methodological approach followed in this paper.

In particular, in the standard version of the stochastic neoclassical growth model the speed of a TFP-induced decline or recovery is influenced in part by the underlying long run growth features of the economy, conceptually corresponding to the balanced growth path in the model economy. For example, the performance of investment at any point in time is determined in part by the size of the deviation of the observed capital-output ratio in that period with respect to the balanced growth value of that ratio. Therefore, to correctly assess if a particular variable is proceeding during a bust or boom at the pace predicted by the neoclassical growth model, it is critical to identify those long run growth features in the data.

[1] Figure 4 reproduces the same information as in Figure 1, panel C, of Calvo, Izquierdo, and Talvi (2006b). It looks different simply because Figure 4 in this paper uses the same scale for both GDP and Investment.

Identifying trends is always a tricky business, particularly in emerging economies (see for example Aguiar and Gopinath, 2007). But the alternative, to ignore trends, is equally dangerous, as it may lead to incorrect interpretations of the evidence. For example, as anticipated in the introduction, in the logic of the neoclassical growth model investment will not necessarily recover to its pre-crisis level if it was immediately before then above its long run value. But this perfectly normal behavior of investment could be incorrectly interpreted as a puzzling weakness when the underlying trend (or balanced growth path) of the relevant variables is ignored.

Accordingly, in part for computational reasons, studies that use the neoclassical growth model as the analytical framework of reference are typically conducted in terms of detrended variables. Consistent with the approach, Figures 6 and 7 display the same variables for Argentina as in Figures 2 and 5, but detrended by TFP and labor force trend growth (see the calibration section below for details). Notice that once trend effects are taken into account, the V-shaped pattern of the bust-boom cycle for GDP is less symmetric than Figure 2 suggested: according to Figure 6, two years after the crisis GDP had not yet fully recovered to the level it had two years prior to the crisis and in fact it was still 10% below that level (which was in turn 10% below the immediately preceding detrended GDP peak, registered in 1998.)

3. ANALYTICAL FRAMEWORK

3.1 - Model

The analytical framework is a bare bones stochastic neoclassical growth model with total factor productivity taken as exogenous.

Household preferences, with variables in per capita terms, can be represented by:

$$E \sum_{t=0}^{\infty} \beta^t (1+\eta)^t \ (c_t^{\alpha} (1-l_t)^{1-\alpha})^{1-\sigma} / (1-\sigma) \qquad (2)$$

where E denotes mathematical expectations, c_t represents consumption, l_t the fraction of the time endowment devoted to work, α the utility-function share parameter, η the population growth rate, and σ the coefficient of constant relative risk aversion (or the reciprocal of the intertemporal elasticity of substitution of the composite commodity.)

Technology is described by

$$c_t + x_t = z_t\, k_t^{\theta}\, [(1+\gamma)^t\, l_t]^{1-\theta} \qquad (3)$$

$$x_t = (1+\eta)\, k_{t+1} - (1-\delta)\, k_t \qquad (4)$$

$$z_{t+1} = (1-\rho)\,\bar{z} + \rho\, z_t + \varepsilon_{t+1} \qquad (5)$$

where k_t is the capital stock, x_t is investment, θ is the capital input share in national income, and z_t is a stochastic total factor productivity shock with mean $\bar{z}$, given that the innovations $\{\varepsilon_{t+1}\}$ are assumed to be an i.i.d. process with zero mean.

The model assumes labor augmenting technological progress at the rate γ. Along the balanced growth path, output, consumption, and capital grow at the rate $(1 + \eta)\,(1 + \gamma)$.

3.2 - Computation

The numerical experiments presented below will exploit the second welfare theorem to compute the solution of the dynamic stochastic general equilibrium neoclassical growth model just presented. Since $\sigma > 1$, $0 \leq \alpha \leq 1$ and $0 \leq \theta \leq 1$, the conditions for the second welfare theorem hold. In particular, the utility function is concave, and the production function defines a convex set for the resource constraint. This will guarantee that the solution to the social planner's problem can be decentralized as a competitive equilibrium. Notice that this problem is a version of the stochastic growth model first developed by Brock and Mirman (1972).

Our strategy to compute the only solution of the model is to find the value function and associated policy (or allocation) functions. Following Kydland and Prescott (1982) we substitute the resource constraint in the utility function and rewrite the resulting expression as a quadratic approximation around the steady state. This defines a linear quadratic problem with well known properties. In particular, the policy (or allocation) functions are linear in the state variables and can be readily computed with standard numerical methods (see Hansen and Prescott (1995)).

Following the convention in that approach, the policy functions and resulting allocations are computed under the assumption that economic agents form expectations about the future rationally, based on the information available at the beginning of each period.

Once the decision rules have been computed, the predicted path of the relevant variables over the period of interest is simulated by simply feeding into the decision rules the initial capital stock and technology level, as well as the residuals for the total factor productivity process (the sequence of ε_t's) actually observed in each year of the simulation period.

3.3 - Calibration

The standard calibration exercise would pick parameter values so that the balanced growth path matches certain balanced-growth path features of the measured economy.

The first step in the calibration, therefore, is to identify a relatively long period during which the economy seems to have been fluctuating around a balanced-growth path. In the case of Argentina, Figure 8 suggests that its economy was substantially derailed from its underlying long run trend by the protracted crisis that it experienced during the so-called lost decade of the 1980s and the more recent one that is the object of analysis of this paper. Therefore, it is fair to conjecture that Argentina's true potential balanced growth path can be best recovered from the growth trends underlying its economic performance during the relatively crisis-free period that preceded the lost decade. Accordingly, the period 1950-79 was adopted as the reference to calibrate the model economy.

Consistent with that choice, the annual growth rate of working-age population, labor augmenting technological progress (TFP factor), and the depreciation rate were set to their average values over 1951-79: 1.55 %, 1.0 %, and 11.14 % respectively. In the case of the depreciation rate, the calibrated value corresponds to a weighted average of the different depreciation rates used for the different components of investment in the process of constructing the capital stock by the permanent inventory method (see appendix).

The persistence parameter ρ, the autoregressive component of the stochastic process describing the evolution over time of total factor productivity, was calibrated to the value of 0.5614, the point estimate resulting from an autoregression over the period

1951-79 on the deviations of the Solow residuals from their mean $\bar{z}$, in turn set equal to the value such that output is equal to 1 in steady-state.

An important but particularly challenging parameter to calibrate for the case of Argentina is the capital share parameter θ of the production function. The National Income accounts typically used to that effect in countries like the US are not available in Argentina, which can therefore estimate its GDP only from the Product accounts. As a result, the labor and capital cost shares in GDP cannot be calculated directly from reported factor incomes. Therefore, we set the capital input share, θ, to 0.40, as if Argentina's production technology were the same as that of the US. While some estimates have the capital share at 60 percent of GDP, most researchers consider that this figure would be closer to 40 percent were it not for the substantial under-reporting of labor income in the informal sector of Argentina's economy.[2]

The utility-function share parameter, α, was set to imply that the average household member spends a fraction 0.3 of its time endowment in the labor market, a standard assumption for the US that casual inspection of the available data suggests reasonable for Argentina as well.

The coefficient of constant relative risk aversion was set at the level used in similar studies for the United States, that is, $\sigma = 2$.

Finally, knowledge of the constant balanced-growth path capital-output ratio would make it possible to pin down the long run investment-output ratio via the balanced growth path version of the law of motion for capital given by (4):

$$x_s = [\delta + (1+\gamma)(1+\eta) - 1]\, k_s$$

where the subscript *s* stands for "steady-state."

Applying the criteria followed earlier, it would be tempting to calibrate the capital-output ratio to its 1950-79 average value. However, as Figure 9 shows, that ratio didn't display over those years the stationary behavior it ought to be expected from an economy moving along a balanced growth path. To the contrary, it rose steadily first, to a

[2] De Gregorio and Lee (1999) find that the labor share could be as large as 0.7, according to the indirect measure proposed by Sarel (1997)

level in the vicinity of 2, from 1950 to the late 1970s, but then it started to retrace its steps around the time of the lost decade, hovering around values closer to 1.6-1.7 than to 2 since then. The absence of an obvious stationary pattern suggests that the average capital-output ratio for the period 1950-79 may be a bad approximation to the underlying balanced growth path capital-output ratio. Accordingly, this variable was calibrated with an alternative procedure. The criteria was to pick the capital-output ratio that minimized the distance (as defined below) between the actually observed investment-output ratios and those predicted by the model in the ten-year period immediately preceding the particular bust-boom cycle studied in this paper.

More precisely, the calibrated capital-output value is the one that solved the following problem

$$\underset{(k/y)_s}{\text{Min}} \quad \sum_{1991}^{2000}\left(\frac{(I_t/Y_t)^{Model}}{(I_t/Y_t)^{Data}}-1\right)^2$$

for capital-output ratios in the interval [1.6-2.0].

The minimization criteria was implemented by calculating the investment-output ratios predicted by the model for the period 1991-2000 for each of the capital-output ratios in the range 1.6 to 2.0, at 0.05 intervals. The resulting calibrated value for the capital-output ratio was 1.7.[3]

Having completed the calibration steps, the next section proceeds to answer the question that motivates this paper: Is the stochastic neoclassical growth model a useful measuring device to organize the evidence regarding the behavior of key macroeconomic variables in Argentina during that country's 2000-2004 economic crisis? More precisely, is that model capable of replicating the V-shaped pattern for GDP and other key macroeconomic variables that Calvo *et al*. have identified as a distinctive feature of emerging market crises?

[3] This value is consistent with the finding in Kydland and Zarazaga (forthcoming) that a capital-output ratio of 2 is too high to account for the low (relative to the model) investment rates observed in Argentina in the 1990s.

4. FINDINGS

Figure 10 provides an eloquent answer to the latter question: the stochastic neoclassical growth model reproduces remarkably well the V-shaped pattern for GDP around the time the Argentine crisis under study bottomed out in the year 2002.[4]

The movements of labor input along the bust-boom cycle are also adequately captured by the model, as shown in Figure 11. It underestimates somewhat the level of labor input during the bust, but the discrepancy may reflect to some extent the lack of precision with which labor input has been measured in the data. Strictly speaking, the variable predicted by the model corresponds to hours worked per household, but due to data limitations (see data appendix), labor input could only be measured by the extensive margin, that is, by the number of workers employed.

The predictions of the model for another important variable, investment, follow rather closely the data as well, as made apparent by Figure 12. The model underestimates investment as a percentage of GDP at the trough, but captures well its performance during the downturn and, especially, during the recovery. Since the path of investment has implications for that of the capital stock, for completion the model predictions vis-à-vis the data for that input are included in Figure 13.[5]

The ability of the model to replicate the V-shaped trajectory of GDP during the crisis window might be dismissed as unsurprising. After all, even if true TFP hadn't changed much during the crisis period, as Calvo *et al*. suggest, that outcome ought to be expected almost mechanically from any model in which TFP enters multiplicatively in the production function and displays a V-shaped pattern merely as a result of misleading measurement errors.

However, that same argument cannot be used to disregard the ability of the model to capture the V-shaped pattern for investment and labor input, because there is nothing "mechanical" about the model predictions for those variables: they are the outcome of decision rules that maximize the representative household's welfare. It is far from

[4] To facilitate comparison with the evidence as presented by Calvo et al., all the results are reported for a five-year window centered at the trough of the crisis, in the year 2002.

[5] The model economy paths were computed setting the initial capital stock equal to its level in the data as of the beginning of 2000. Figure 13 does not reflect that fact because for purposes of comparison with Calvo et al. and the other figures in this paper, the model generated series as well as those in the data have been indexed to 100 in the trough year of the crisis, 2002.

obvious, as some critics of the methodological approach followed here often claim to dismiss it altogether, that feeding those optimally derived decision rules with V-shaped Solow residuals will induce a similar pattern on labor and capital inputs that approximates the data as closely as in Figures 11 and 12.

In particular, recall that the linear-quadratic approximation method used in this paper implies that the optimal decision rules are linear functions of the state variables, TFP and capital in this particular case. Accordingly, the downward trajectory that the capital stock displayed during the five year window (see Figure 13) could have easily induced a similar downward trajectory in investment and labor input. If in the end that is not that case is because the coefficients on the V-shaped TFP and on the downward sloping capital stock have the "right" relative sizes in the decision rules. Since those coefficients are a complicated non-linear function of the calibrated steady-state relationships and utility and production function parameters, that outcome could not have been foreseen without actually computing the decision rules. That is reassuring, both in terms of the model as an adequate abstract representation of reality and of the accuracy with which the Solow residuals measure true TFP.

A legitimate question by those who still remain skeptical of the approach might be if the impressive recovery that TFP experienced after touching bottom in 2002 was not something of a "miracle" even from the standpoint of the neoclassical growth model. As documented in Figure 14, the answer is no: miraculous as it may look, a recovery of TFP as strong as in the data is what an observer standing in 2002 would have predicted based on the estimated AR(1) process from the Solow residuals.[6] This result seems to further validate the use of Solow residuals to measure TFP, as well as the calibration procedure followed to assign values to the relevant parameters.[7]

In summary, examination of the 2000-04 Argentina's crisis under the lens of a parsimonious neoclassical growth model calibrated to long run features of that economy suggests that there is nothing special about the V-shaped trajectory displayed by GDP,

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[6] The forecasts for TFP were computed recursively from the estimated AR(1) process, starting with the TFP level actually observed in 2002 and setting the innovations ε_t for the subsequent years equal to zero.

[7] That is not to say that the Solow residuals measured TFP without measurement errors, just that whatever measurement errors are undoubtedly present do not seem large enough to completely invalidate the quantitative exercise proposed in this paper.

labor input, and investment during that crisis. That is precisely the pattern that the model would have predicted. That output recovered strongly after the bust without a corresponding rebound of intermediated capital poses no puzzle to a parsimonious, representative agent neoclassical growth model that takes TFP as exogenous.

That is not to say that there is nothing "special" about the V-shaped trajectory that according to Calvo *et al*. TFP typically follows in the emerging market crises they studied. The swings that that variable experienced in the particular crisis examined in this paper (see Figure 6) were too wild for any sensible economist to attribute them to technology shocks in the narrow sense of the word. As pointed out by Kydland and Prescott (1990, p.8) the "rate of [technology] change is related to the arrangements and institutions that society uses." In that wide interpretation, there is in principle no reason why shocks that eventually reduce the efficiency with which institutional arrangements (such as financial intermediaries and the banking system) channel capital to its most productive uses should not be treated as aggregate TFP shocks.

In the case of the Argentine crisis studied here, well founded fears of a devaluation of the local currency, deposit freezes, and sovereign debt default initiated a slow motion deterioration of the financial intermediation process that culminated in a full-blown banking panic with suspension of payments at the end of 2001. It is plausible to conjecture that a large fraction of the sharp 14% decline that TFP experienced between 2000 and 2002 was a direct result of that disruption of the financial system. After the initial shock, TFP recovered strongly, suggesting that the Argentine society was able to develop fairly quickly alternatives arrangements to bypass weakened (if not virtually broken) formal financial institutions in the process of channeling capital to productive activities. The representative agent stochastic neoclassical growth model makes abstraction of those details and rationalizes that whole process as temporary, mean-reverting TFP shocks. In the light of the findings of this paper, that doesn't seem to be a particularly bad abstraction to organize the evidence, at least in comparison with alternative interpretations that conjure up metaphoric references to a miracle.

5. CONCLUSION

A recent study by Calvo, Izquierdo, and Talvi (2006b) has examined major emerging market crises and reported that key macroeconomic variables such as TFP, GDP, and investment display a sharp bust-boom V-shaped pattern in a five-year window centered on the year GDP touched bottom. Intermediated credit, however, presents an interesting exception to that pattern, moving instead along an L-shaped trajectory. More precisely, GDP and intermediated credit seem to fall in lockstep during the downturn, but subsequently they decouple and GDP takes off after hitting bottom while intermediated credit remains flat at its trough level. To "credit crunch" accounts of the output collapse, the "creditless" recovery that emerging economies typically witness after a crash is coming out of nowhere. The image of an economy "rising from its ashes" almost immediately springs up to mind, motivating the inspired Phoenix Miracle metaphor with which Calvo *et al*. aptly and eloquently characterize that particular aspect of emerging market crises.

This paper has been motivated however by the observation that Phoenix Miracles might not look as miracles at all from the perspective of a simple representative agent neoclassical growth model if the V-shaped pattern of key macroeconomic variables were induced by a similar V-shaped pattern for TFP, as the data suggests. Accordingly, the paper set out to establish if for a particular emerging market crisis, the one that Argentina experienced over the period 2000-04, the V-shaped pattern that key macroeconomic exhibit in the data is quantitatively in line with that which a parsimonious neoclassical growth model would have predicted. It was argued that the exercise is not as mechanically trivial as commonly believed, because it is far from obvious that a V-shaped TFP will induce a similar pattern in the macroeconomic variables of interest when the decision rules that govern their trajectory are derived from a well defined representative household maximization problem.

By the standard of that quantitative exercise and for the particular crisis examined with it, there is nothing special about the V-shaped trajectory of key macroeconomic variables highlighted by Calvo *et al*. That is precisely the pattern, and in the same orders of magnitude, that a neoclassical growth model would predict for GDP, labor input, and investment when TFP is taken as exogenous.

No Phoenix Miracle either in the post-collapse period: the recovery that TFP experienced in Argentina after hitting bottom in 2002 was about as strong as it should have been according to the statistical representation of that variable in the model, and the associated rebound it induced in GDP as impressive as the model would have predicted. It is "credit crunch" interpretations of output collapses, not the neoclassical growth model, that have trouble accommodating that aspect of the evidence, to the point of inspiring metaphoric references to a Phoenix Miracle.

The real mystery in the light of the evidence for the particular emerging market crisis studied in this paper might be not why GDP recovered without a corresponding recovery in intermediated credit, but why TFP exhibited a wild bust-boom pattern in the short time spanned by a five-year window centered on the year of the crisis trough. Most economists would agree with Calvo *et al*. that it is hard to attribute those swings to purely technological factors. As suggested by Kydland and Prescott (1990), a wider interpretation is needed, such as shocks to the institutional arrangements through which societies channel savings to the production process.

Of course, if TFP is related to developments in the financial system, and those developments are in turn influenced by economic policies, then modeling TFP as an exogenous stochastic process may be an unsatisfactory approach in terms of making policy recommendations to prevent crises. That is a certainly a valid observation, but there are good reasons to suspect that some time will pass before the profession reaches a consensus on some empirically tractable stochastic dynamic general equilibrium model capable of addressing policy questions relevant for the prevention of crises within an analytical framework consistent at the same time with growth theory.

In the meantime, this paper has hopefully provided compelling evidence that measuring TFP with Solow residuals and treating them *as if* they were technology shocks to the production function in a representative agent neoclassical growth model can be a useful abstraction of reality for the purpose of discriminating those features of emerging market crises that defy explanation according to existing theories from those that do not. That lens certainly didn't reveal the presence of any obvious anomaly in the particular crisis examined in this paper, at least none that could be eloquently captured with a metaphoric reference to a miracle. It remains to be seen if that same lens will be equally successful at organizing the evidence for the other, similarly severe emerging market crises documented by Calvo, Izquierdo, and Talvi (2006b) following a more atheoretical approach.

APPENDIX: Data Sources and Methodology

Real GDP

The Real GDP series for the period 1980-97, in 1986 prices, was taken from Heymann (2000). Subsequent years were obtained by applying growth rates from the National Accounts in 1993 prices, as reported by the National Institute of Censuses and Statistics (INDEC). The series was extended back to the year 1950 applying the growth rates of the Real GDP series for the period 1950-70, in 1960 prices, and for the period 1970-80, in 1970 prices, reported in ECLAC-CEPAL (1988).

Population

Total and working-age population series were estimated by geometric interpolation of quinquennial data reported in CELADE (2002).

Labor Input

For most of the period under study, Argentina didn't have reliable statistics on hours worked, except for a few industries. Official statistics on the aggregate level of employment were not available either until 1980. There are, however, partial series of employment that made it possible to measure labor input as number of workers, starting from the aggregate level of employment for the year 1950 reported in Hofman (2000), table 4.4, page 53. The series was extended to the year 2004 by applying to that 1950 level the growth rates of the employment series in Elías (1992) for the period 1951-79, in MECON (2000) for the period 1980-97, and in FIEL (several issues) for subsequent years, excluding recipients of a monthly stipend paid to unemployed head of households under a government welfare program ("Plan jefes y jefas de hogar"), counted as employed for purposes of the official statistics.

The series reported by Elías corresponds to employment of wage earners, constructed using information published by the Central Bank of Argentina, after filling the missing observations by interpolation of labor force participation rates extracted from population censuses run every ten years.[8] This procedure may have underestimated actual employment growth rates, because labor force participation rates include both employed and unemployed workers and unemployment rates experienced a continued decline in Argentina between the year they started to be measured (1963) and the last year of Elías's employment series (1979). As a result, an upward bias may be present in the Solow residuals estimated for that period.

Growth rates for the period 1980-97 were based on annual employment figures, calculated as arithmetic average of all the observations available for each year in MECON (2000). Data from this source correspond to employment in the about 30 urban conglomerates that started to be covered systematically by the Encuesta Permanente de Hogares (Permanent Household Survey) in 1980. The Ministry of Economy uses those surveys to calculate, for each urban center, the fraction of individuals in all households interviewed that have reported some form of employment. It then applies that proportion to the overall population of the corresponding metropolitan conglomerate, to arrive at an estimate of the total number of employed there. The number of employed for urban areas not covered by the survey is estimated by applying to the estimated total population in those areas, the average of the employment coefficient just described, weighted by the population of all urban centers other than the capital of the country, the Buenos Aires Metroplex area. It should be mentioned that one difficulty with those surveys is that it is not clear how well the reporting households represent the characteristics of the whole population, and in particular, of cities and rural areas not covered by the surveys.

The actual employment variable used for the computations was $E_t h/W_t$, where E_t his the number of persons employed, W_t is the population in working age, and h is a normalizing constant, chosen so that the mean of the variable $E_t h/W_t$ for the period under study, 1980-2004, is equal to 0.3, the fraction of total available time that it was assumed households devote to work in steady-state. The constant h is a synthetic variable that stands in for the missing information in hours worked and can be interpreted as the fraction of the total individual available time that each household member devotes to work when employed. Taking into account that on per person basis a household has about

[8] As documented by Elías in personal correspondence with the authors.

100 hours of productive time per week (see Prescott, 2004) the calibrated value for h, 0.44, implies a workweek of approximately 44 hours.

Capital and Investment

Given the lack of official series, the capital stock was calculated by applying the permanent inventory method to the investment series for different type of assets, discriminated in residential structures, nonresidential structures, and machinery and equipment.

Following accepted practice, (see Hofman (1992) and ECLAC-CEPAL (1996)), each asset class i was assumed to be completely worn out, that is, to have no scrap value, after T(i) years of service, with a useful lifetime of fifty years for residential structures, forty years for nonresidential structures, and fifteen years for machinery and equipment.[9] Depreciation in the meantime is assumed to proceed at geometric rate δ_i. Taking into account the time-to-build assumption that the services from investment in period t become available at t+1, this truncated geometric depreciation scheme implies that the residual value at period t of productive capital of type *i* installed n periods before is given by $I_{i,\,t-n}\,(1-\delta_i)^n$, where δ_i is the depreciation rate and $I_{i,\,t-n}$ the investment in asset type i in period t-n, $n \le T(i)$. The implicit depreciation rate δ_i was chosen so that the residual value of the asset type i at the last year of its useful life is given by $I_{i,\,t-T(i)} / T(i)$, that is, to satisfy the equation $(1-\delta)^{T(i)} = 1/T(i)$. This condition implied annual depreciation rates of 7.53 percent for investment in residential structures, 8.81 percent for investment in nonresidential structures, and 16.52 percent for investment in machinery and equipment.[10]

The permanent inventory method with the assumptions just discussed was applied to the investment series, available or constructed as follows:

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[9] Capital stock estimates for the United States assume asset life spans that are roughly in line with the ones used in this paper.

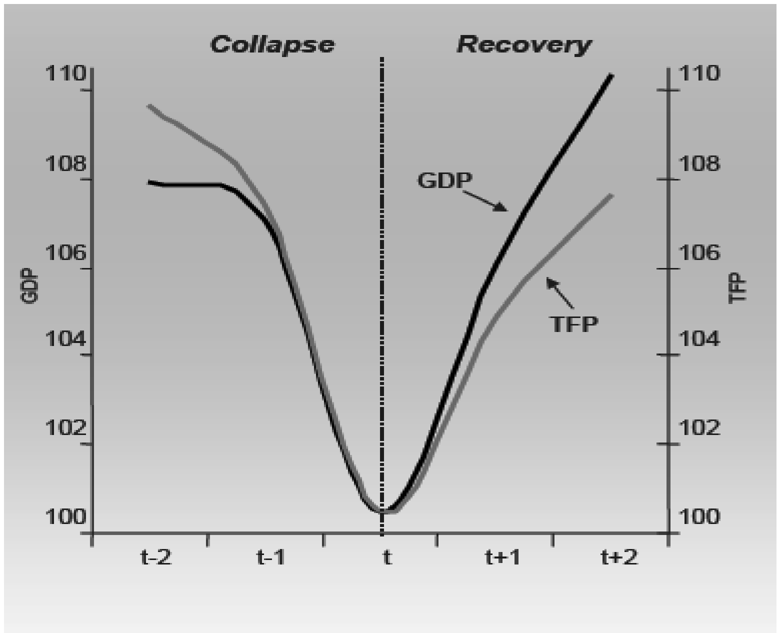
[10] The truncated geometric depreciation scheme used here may underestimate steady-state capital stock by a fraction $(1-\delta_i)^{T(i)+1}$ of the capital stock calculated with the perpetual geometric depreciation scheme assumed by the neoclassical growth model. The potential underestimation is relatively minor for the particular depreciation parameter values used here (around 5 percent for the machinery and equipment component and 2 percent for the structures component.)

Investment in machinery and equipment series: for the period 1980-97, obtained as the difference between Gross Total Fixed Investment and Investment in Structures in 1986 prices, as reported in Heymann (2000). Subsequent years were estimated by applying annual rates of growth for the machinery and equipment component of investment according to the National Accounts in 1993 prices, as reported by the National Institute of Censuses and Statistics (INDEC.) As with the case of Real GDP, this series was spliced with previous periods by applying the growth rates of the machinery and equipment investment series reported in ECLAC-CEPAL (1958) for the period 1900-50, in 1950 prices, and in ECLAC-CEPAL (1988), for the period 1950-70, in 1960 prices, and for the period 1970-80, in 1970 prices.

Investment in nonresidential and residential structures series: Argentina's national accounts report investment in total structures, but the discrimination between the nonresidential and the residential component is available only for certain periods. A possible option to confront this difficulty is to ignore any distinction between non-residential and residential components of investment in structures.[11] An alternative followed here, based on standard practice by other researchers, was to assume that the nonresidential component is a fixed percentage of overall investment in structures. To that end, based on the considerations in Hofman (1992, see comments section in data diskette), for the period 1980-2004 it was assumed that 54 percent of investment in structures went to its nonresidential component and the remainder to its residential component. For the period 1900-79, residential investment was assumed to grow at the same rates as the non-residential investment series reported in Hofman (1992). This assumption, implied by the fixed coefficient allocation approach applied by Hofman (1992) to the period 1955-69, was applied here as well for methodological consistency to all years prior to 1955.

[11] This was implicitly the procedure adopted in Kydland and Zarazaga (2002).

Figure 1
EMERGING MARKET CRISES (Average)
TFP and Real GDP



Source: Calvo, Izquierdo, and Talvi (2006b)

Figure 2
ARGENTINA
TFP and Real GDP

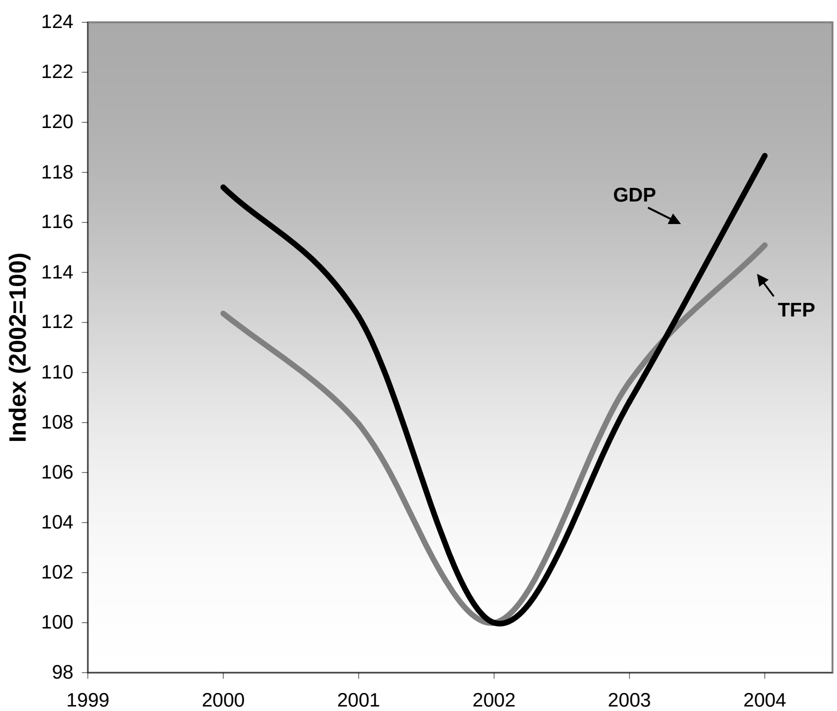
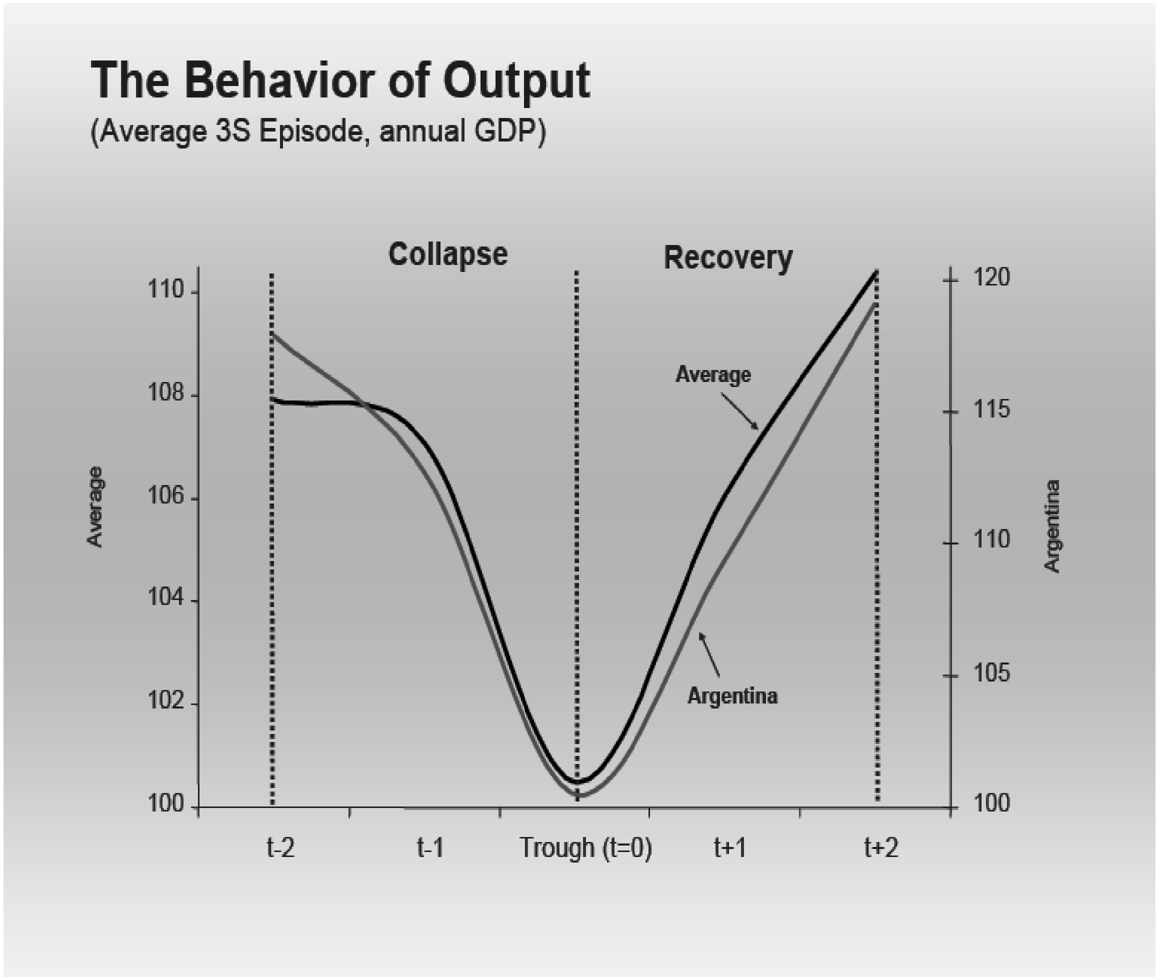
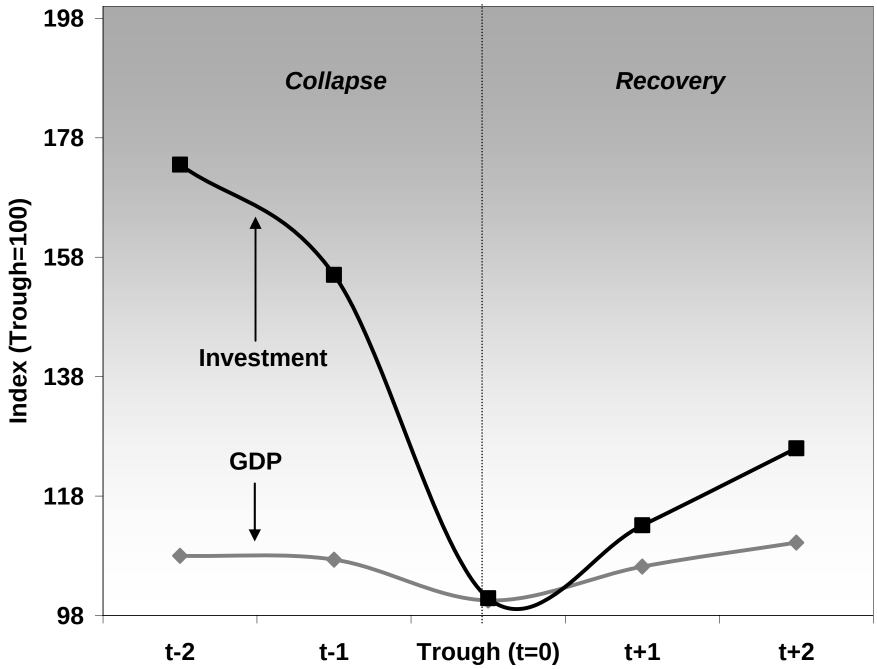


Figure 3
Real GDP
Argentina vs. Emerging Market Crises (Average)



Source: Calvo, http://www.bis.org/events/conf060619/calvo.pdf

Figure 4
EMERGING MARKET CRISES (Average)
Real Investment and GDP



Source: Calvo, Izquierdo, and Talvi (2006b)

Figure 5
ARGENTINA
Real Investment and GDP

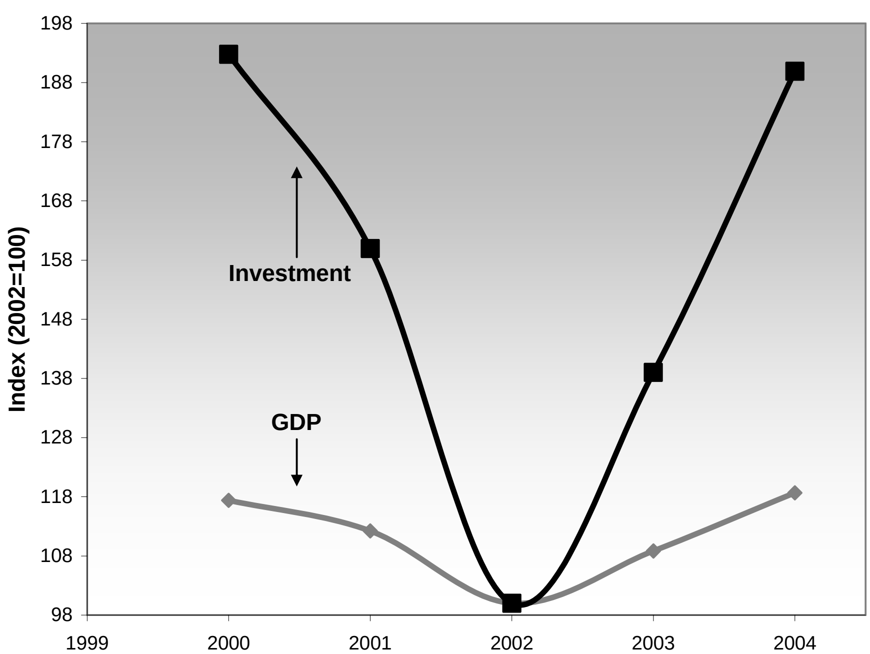


Figure 6
ARGENTINA
TFP and Real GDP (detrended)

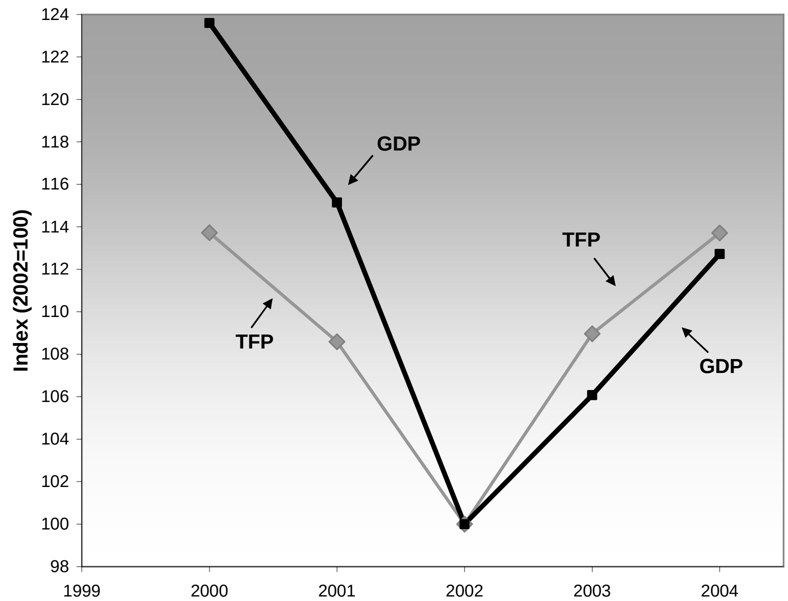


Figure 7
ARGENTINA
Real Investment and GDP (detrended)

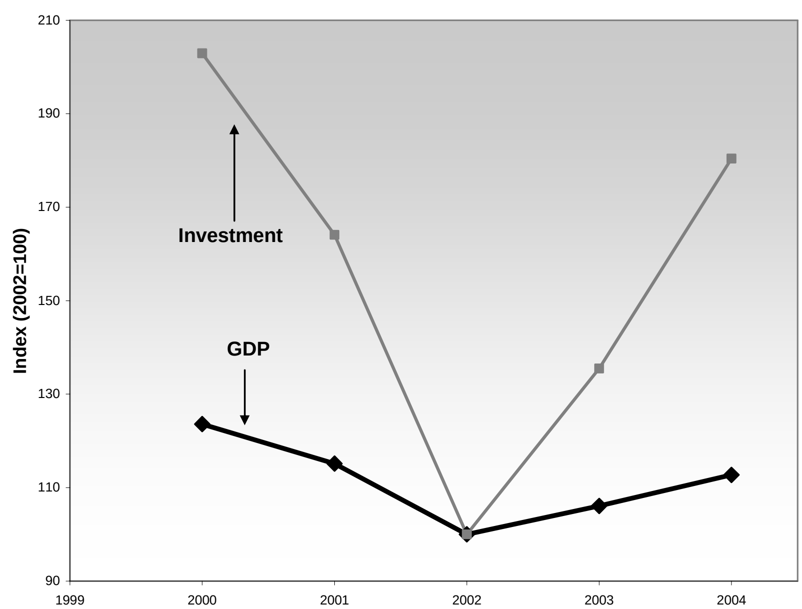


Figure 8
ARGENTINA
GDP per working age person (index)

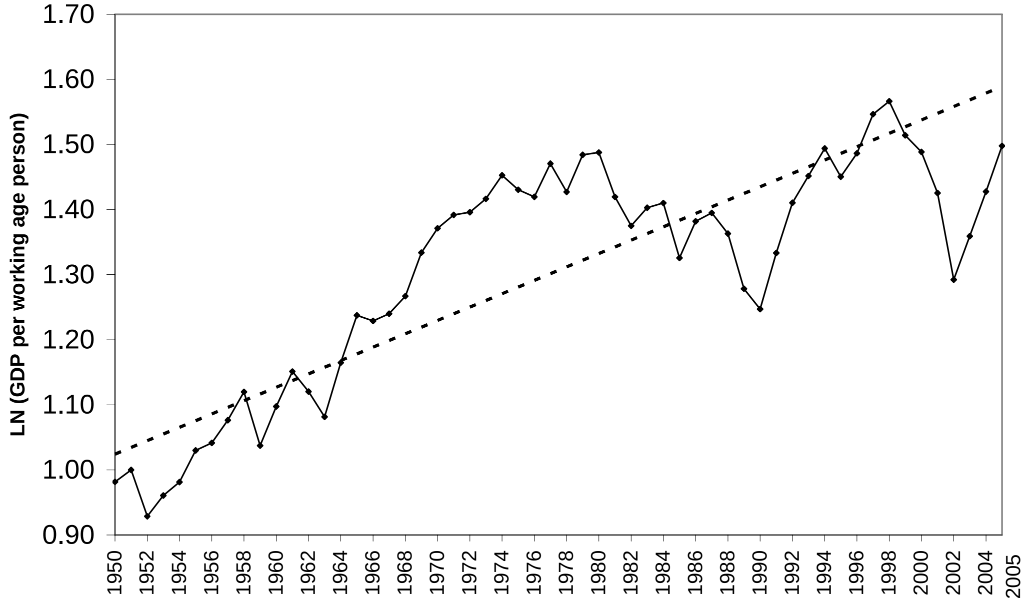


Figure 9
ARGENTINA
Capital-Output Ratio

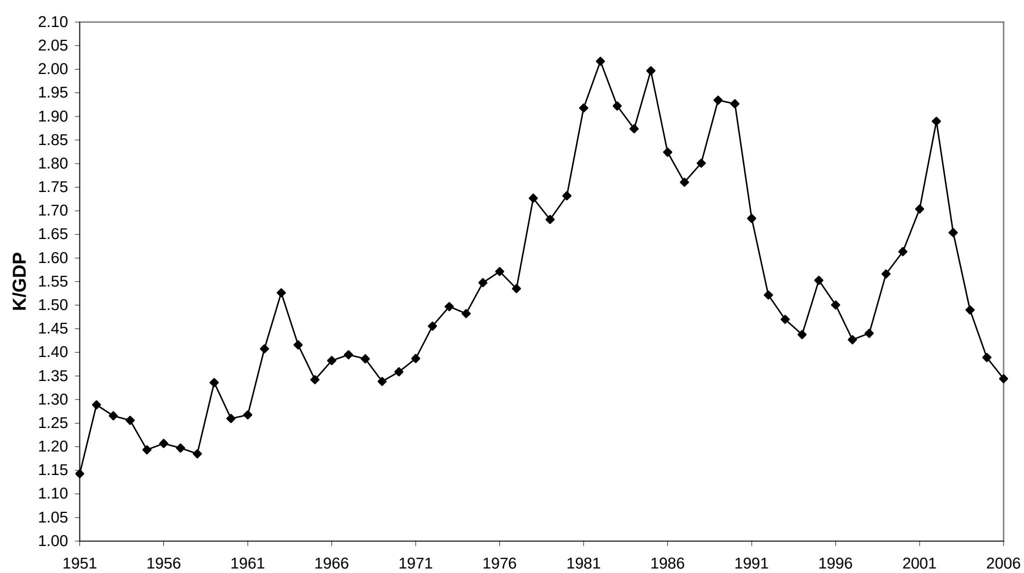


Figure 10
ARGENTINA
GDP (detrended)

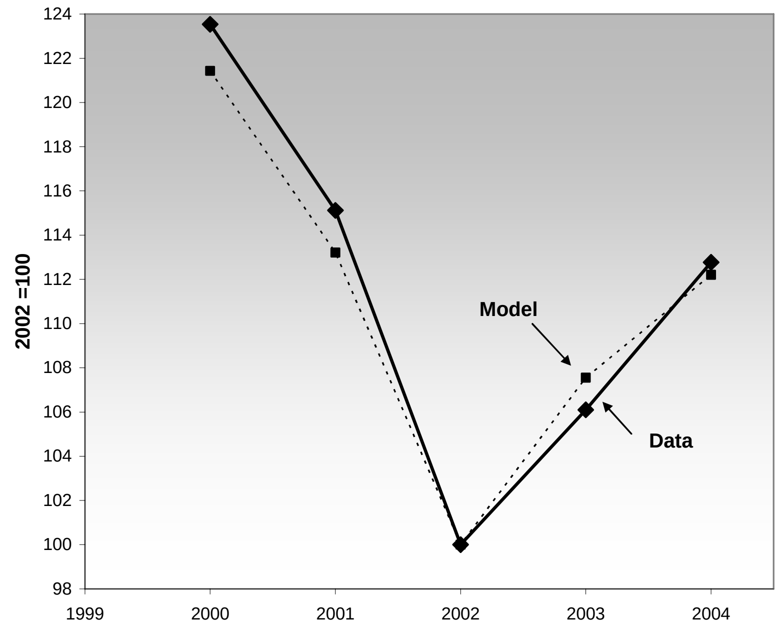


Figure 11
ARGENTINA
Labor Input (detrended)

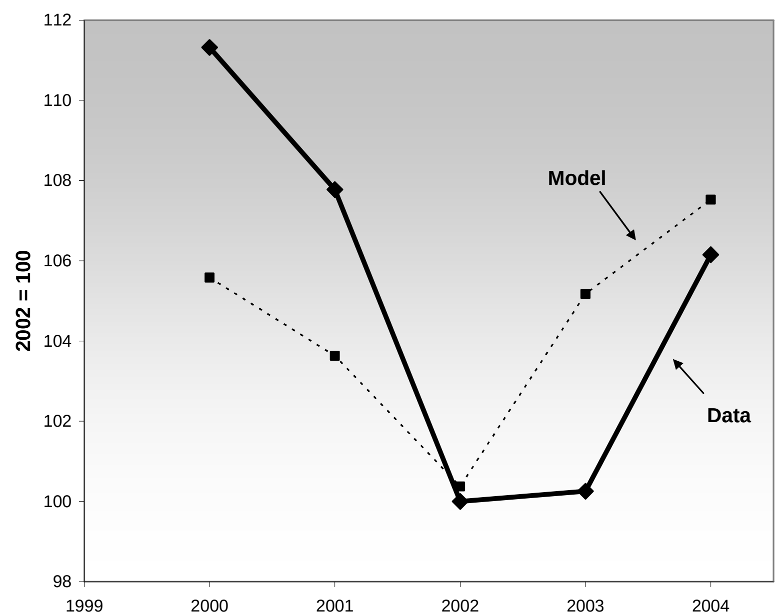


Figure 12
ARGENTINA
Investment as a percentage of GDP

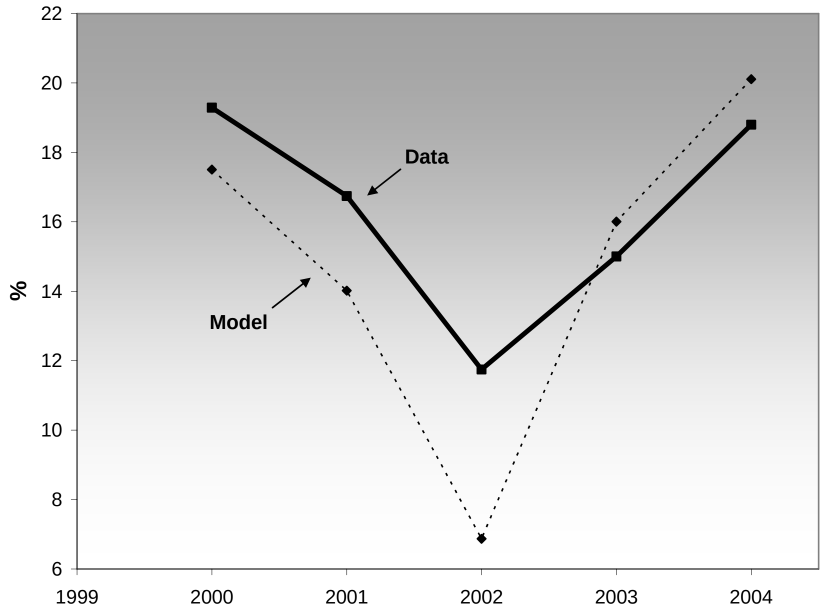


Figure 13
ARGENTINA
Capital Input (detrended): Data and Model

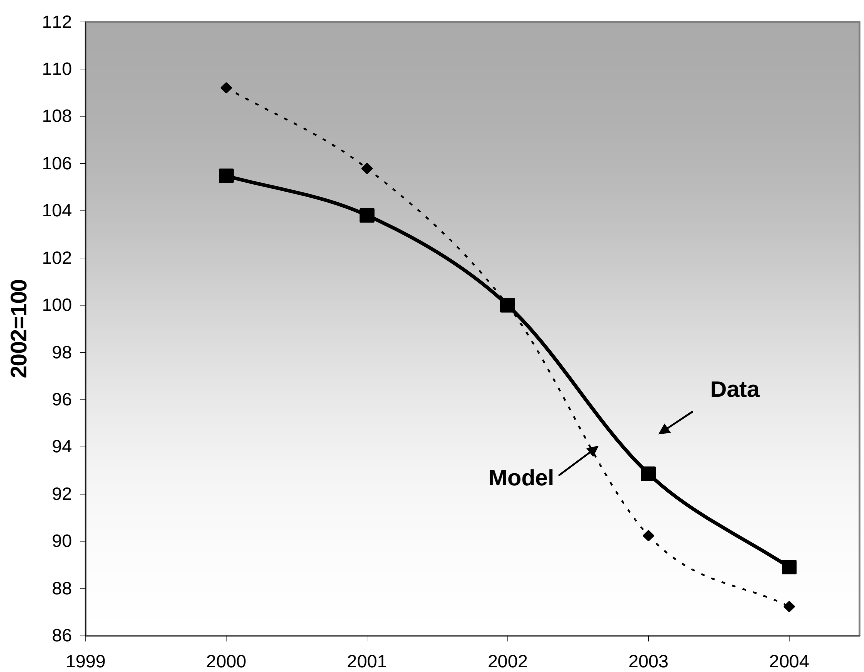
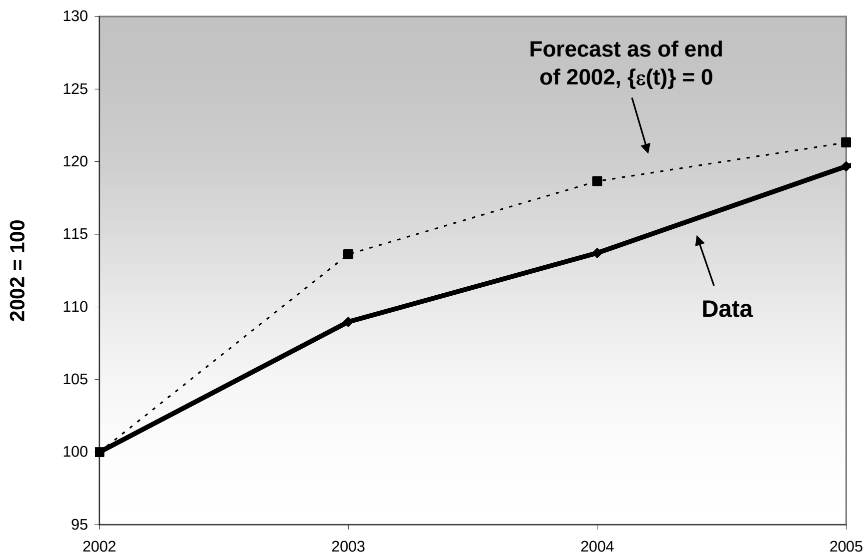


Figure 14
ARGENTINA
TFP (detrended) - Actual and Predicted



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