# Argentina's Unimpressive Recovery: Insights from a Real Business-Cycle Approach

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ABSTRACT

Argentina's GDP increased 30% between 2002 and 2005, prompting optimistic assessments that the country had finally left behind its secular stagnation. However, this strong performance followed a sharp decline in economic activity and therefore could be the manifestation of a bounce-back effect with no lasting impact on Argentina's mediocre long-run growth rates. The paper examines this conjecture with the quantitative discipline imposed by a Real Business Cycle methodology and concludes that the 2002-05 expansion was not only a rebound, but also considerably weaker than the model predicts, a finding not consistent with upbeat views about the country's long-run prospects.

Argentina's GDP accumulated an impressive 30% gain between 2002 and 2005, giving rise to renewed optimism about the country's prospects. Add the 6% growth widely predicted for 2006, and the future of Argentina as of the beginning of that year indeed looked bright.

However, it is worth reminding those tempted to be carried away that this is not the first time Argentina has posted spectacular growth rates. In fact, at the beginning of the 1990s the country grew at comparable speeds, prompting predictions of a bright future that in the end didn't materialize.

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A legitimate question, therefore, is whether Argentina's current growth spurt is just a rebound from a deep crash that will quickly fizzle out, as have many similar episodes, or whether it reflects, as many believe, an acceleration in the rate of growth that harbingers Argentina's return to the category of "promised land". The purpose of this article is to examine precisely that question in light of the real business cycle methodology developed by Nobel Laureates Finn Kydland and Edward Prescott.

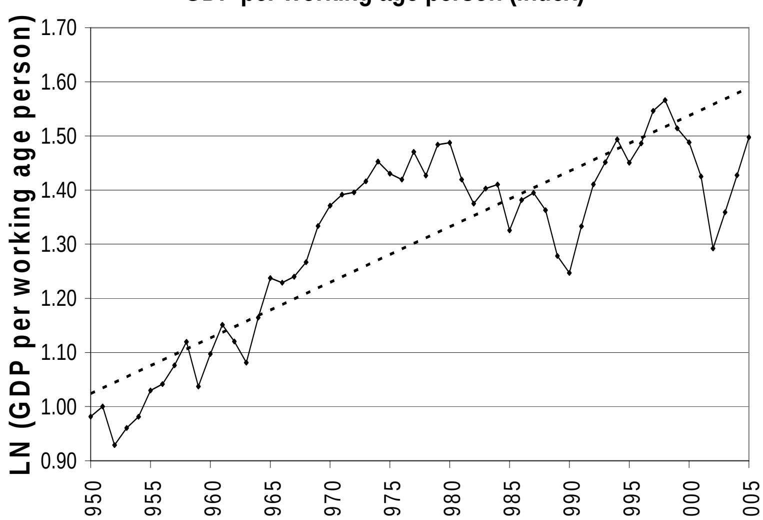
Before proceeding with the analysis, however, it is important to put Argentina's recent growth experience into perspective.

## THE 2002-05 GROWTH PERFORMANCE IN PERSPECTIVE

Figure 1 displays Argentina's GDP per working age person, a variable conceptually similar to the more frequently reported GDP per capita.

**Figure 1**

**GDP per working age person (index)**




The solid line corresponds to actual values, while the broken line identifies the long-run trend, which gro
equal to the value that minimizes over the years 1950-2005 the squared errors

the logarithmic transformation of the stochastic compound growth formula GDP(t) = $GDP_{1950}.(1+\gamma)^t.e^{u(t)}$, where $\gamma$ is TFP trend growth rate, or TFP factor, and u(t) is an i.i.d. innovation with mean zero and variance 1. As is well known from elementary statistics, this minimization criteria implies ln $GDP_{1950}$ = Average [ln $GDP_t$ – ln $(1+\gamma)$ t].

The logarithmic scale on the vertical axis makes it possible to calculate percentage differences between any two observations by simply subtracting their values and multiplying the result by 100. With this method, it can be readily established, for example, that Argentina's GDP per working age person in 2005 was about 7% lower than at the previous GDP peak, in 1998: (1.51 – 1.58) x 100 = - 7%.

The negative number reveals that, despite appearances, the recent pickup in economic activity has not been strong enough to return Argentina's citizens to the standards of living they had before the 1998-2002 recession started.

Notice also that despite occasional periods of strong growth, GDP per working age person in 2005 was at the same level as 25 years earlier, in 1980. This suggests that the streaks of sometimes stunning growth displayed since then are nothing but a bounce back from dramatic declines that in the end have left the economy right where it started. In that sense, another feature of Argentina's economy that stands out in Figure 1 is that every period of rapid growth has been preceded by a noticeable, sometimes long-lasting decline in GDP.

For example, between 1990 and 1998 GDP per working age person increased by about 35% (calculated with the simple procedure explained above: [1.58 – 1.23] x 100), which implies a geometric average growth rate of output per working age person of about 4% a year, a rather impressive pace by international standards. But that expansion had been preceded by the deep and protracted recession of the so-called lost decade of the 1980s, during which GDP per working age person declined about 22%. A similar observation applies to the boom years studied in this paper: the 23% increase in GDP per working age person observed between 2002 and 2005 (population growth accounts for the difference with the change in total GDP reported earlier) followed an unprecedented plunge of almost 24% between 1998 and 2002. It is important to point out that half of that steep decline took place in 2002 alone, immediately after Argentina's massive sovereign debt default at the end of 2001 and the two-thirds devaluation of its currency a few days later.

This pattern just reported suggests the presence of a "rubber ball" effect in Argentina's economy: The stronger a rubber ball is thrown against the ground, the stronger the subsequent rebound. Likewise, the more the economy falls from trend, the stronger the subsequent rebound to trend.

In light of the rubber ball effect, Argentina's recent economic performance ceases to be surprising. In fact, a rather strong recovery was due at some point after the 1998-2001 recession and the 2002 crash. The interesting question then, is not why the economy is recovering but rather, if it is doing so at rates commensurate with the depth of the preceding recession.

Quantitative in nature, that question can only be answered with a model. And from the discussion of the evidence above, it seems that any model aspiring to successfully account for Argentina's growth experience must incorporate in its internal dynamics a rubber ball effect.

That rubber ball effect is a key feature of the methodology developed by Edward Prescott and Finn Kydland to study business cycles. The Royal Swedish Academy explicitly mentioned their Real Business Cycle approach (RBC hereafter) in awarding them the 2004 Nobel Prize in Economics.

A particularly useful aspect of the RBC model is that it produces well-defined quantitative relationships between an economy's long-run trend and short-run variables. As a result, the RBC approach makes it possible to calculate, for any economy, the intensity of the bounce back that should follow a given decline in economic activity. In the case of Argentina, the approach makes it possible to answer the question that motivates this article: Is the 23% increase in GDP per working age person observed between 2002 and 2005 in the order of magnitude of the bounce back that should have followed a decline of 24% in that same indicator?

## THE REAL BUSINESS CYCLE APPROACH

Until Kydland and Prescott's seminal paper "Time to Build and Aggregate Fluctuations" was published in 1982, the economics profession had tended to see economic growth and economic fluctuations as separate phenomena that needed to be studied with different, often incompatible models. Kydland and Prescott changed that perception by demonstrating that it is possible to study both phenomena within a unifying analytical framework. Their basic insight was to adapt the neoclassical growth model developed by Solow, meant to address long-run growth issues, in a way that could also be used to address short-run, or economic fluctuation questions.

A full account of the technical and somewhat tedious details of the RBC methodology is beyond the scope of this paper. The appendix contains a brief formal description of the parsimonious RBC model used in this paper. The remainder of this section is devoted to provide non-experts with an intuitive account of the main building blocks of the RBC approach and the interactions between them that play a critical role in delivering quantitative answers to questions like the one that motivates this paper.

The three building blocks of the RBC approach can be described as follows:

1) As with almost any scientific advances, the first building block came from tradition, the well-established economic growth model developed in 1956 by Robert Solow, another winner (in 1987) of the Nobel Prize in Economics.
2) The second building block is the application of the axiomatic principle that the behavior of all economic agents is driven by the maximization of their satisfaction. That behavior is captured in the abstraction of the RBC model by the assumption that households make consumption and labor decisions to maximize some utility function defined over consumption and hours at work (or equivalently, leisure). Firms in turn hire labor and capital to maximize their profits. All economic agents are capable of assessing rationally the consequences of their current actions on their future well-being, in the sense that the probability they assign to future contingencies, conditional on their actions, coincide with the actual relative frequency of such contingencies. Brock and Mirman (1972) captured this optimizing and forward looking behavior by abandoning the assumption of a constant savings rate in Solow's

original formulation and replacing it with a stochastic investment-savings rate which households adjust every period to maximize their welfare.

3) The third building block is one of the two key novelties of the RBC approach: the assumption that the efficiency with which firms combine inputs to produce output is subject to random shifts, instead of moving along a deterministic trend at a constant growth rate, as had been assumed in the original formulation of Solow's model. The efficiency level with which an economy combines inputs to produce final goods is referred to as "total factor productivity," or "technology level" in RBC jargon.

The RBC model Kydland and Prescott crafted inherits from each of these three building blocks a feature or property that is important for the ability of that model to account for the data, with respect to both economic growth and to business cycles.

A critical property of the first building block, the neoclassical, or Solow growth model, is the inherent tendency of the economy to converge to the so-called balanced-growth path. Along that path, all main macroeconomic variables (GDP, consumption, investment, capital) grow steadily, year after year, at the rate that results from compounding the population and TFP trend growth rates. This implies that the relevant macroeconomic variables keep constant (balanced) relationships with each other. For example, the share of output devoted to investment remains constant, the capital-output ratio is constant, and so forth.

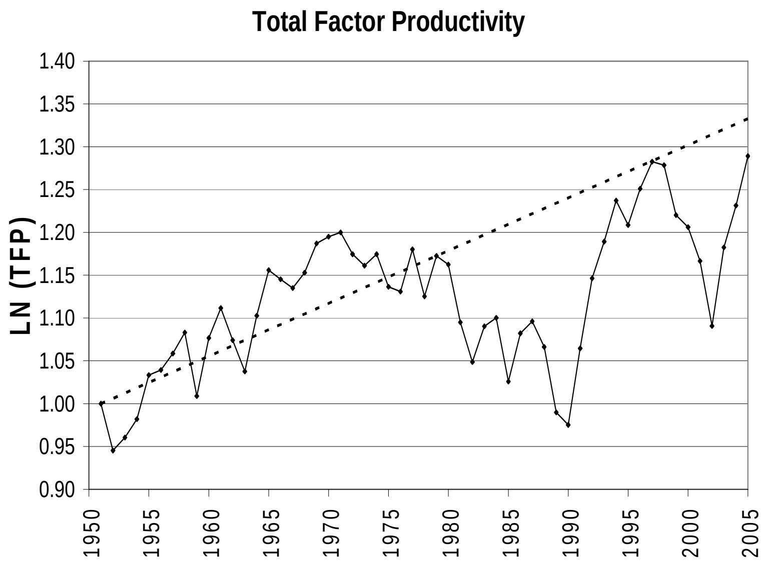
The interesting aspect of the balanced-growth path convergence property is that it is independent of initial conditions. In particular, two economies that start out with different levels of capital but are otherwise identical will converge to the same balanced-growth path over time. This also means that any economy will tend to return to the long- run balanced-growth path if some exogenous force displaces it from that path.

It could be tempting to see in that property the rubber ball effect identified earlier as important to account for Argentina's recent growth experience. That perception is correct only to the extent that it is understood that in the original formulation of the Solow model, the effect is present only in a latent state, as there aren't any external forces that knock the economy off its deterministic balanced-growth track: once it reaches that path, the economy stays there, without ever exhibiting fluctuations around that path. For that reason, the Solow model as originally formulated is ill-equipped to deal with questions about bounce-back effects that are recurrent in nature, judging by the recovery episodes Argentina has experienced in recent years.

That's the role of the random efficiency, or total factor productivity (TFP), Kydland and Prescott introduce in the third building block of their model: to activate the latent rubber ball effect of the Solow model. Recurrent shocks that shift up or down the technology level, or TFP, derail the economy from its balanced-growth track and set in motion the rubber ball effect that puts the economy back on that track. The combination of that rubber ball effect with temporary random shocks to TFP induces the fluctuations of output (or GDP) around its trend that give the RBC approach a shot at accounting quantitatively for business cycles, as well as for the intensity of upswings like the one that is the subject of this paper.

The idea that TFP is subjected to temporary random shifts didn't come to Kydland and Prescott out the blue. It was inspired by evidence like that displayed in Figure 2 for Argentina.

**Figure 2**




The solid line plots an index of aggregate TFP, or of the average efficiency of Argentina's economy between 1950 and 2005, calculated from so-called Solow residuals obtained with a standard growth accounting exercise (see details in the technical appendix). The higher the index, the higher the amount of output produced with the same amount of inputs. As mentioned above, the implicit growth rate for trend TFP, identified by the broken line, is the same as that for the trend in Figure 1 and was estimated as reported later. It is obvious from Figure 2 that TFP has not grown at a constant rate. Rather, it seems to have evolved in fits and starts around its long-run trend.

Some streaks of unfavorable TFP shocks, like the one between 1970 and 1990, have been particularly long, to the point of giving the impression that the economy's efficiency was drifting down ever farther from its trend value. But it turned around in 1991, to briefly touch its trend value again in 1998. Similarly, TFP started to climb back to trend in 2003, after having fallen sharply in the immediately preceding years.

This pattern suggests that the economy's efficiency has a tendency to revert to trend, perhaps even after long periods of having drifted away. Statisticians refer to a time series with this property as a "mean-reverting" stochastic process. In practical terms, this property means that favorable or unfavorable shocks to TFP subside over time. The popular saying that there is no evil that lasts 100 years captures this property at an intuitive level.

The trend-reverting property of TFP is an important piece of the mechanism by which Kydland and Prescott generated recurrent busts and booms—that is, business cycles—out of the Solow model, which in its original formulation could not deliver them. In particular, because TFP is a stochastic, rather than a deterministic process, every period there will be a shock to TFP that will displace the economy from its deterministic balanced-growth path. The trend-reverting property of the stochastic process governing the evolution of TFP is necessary to guarantee that shocks to TFP die down over time and, therefore, that the rubber ball effect built into the Solow model brings the economy back to the balanced-growth path until the next favorable or unfavorable strike displaces it from there again.

Notice that shocks that don't shrink over time would permanently shift up or down the efficiency level and with it, the long-run trajectory of the economy. As a result, there wouldn't be a well defined balanced-growth path for the economy to return to and the rubber ball effect would be annihilated. The endogenous growth literature studies economic growth under this alternative assumption.

In light of the reversion-to-trend behavior that TFP exhibits in Figure 2, the evidence appears to favor the hypothesis of temporary rather than permanent shocks to TFP. As mentioned above, it was a plot like this, but for the U.S., that led Kydland and Prescott to ask, What would happen if the constant, determistic rate at which the efficiency of the economy was assumed to improve in the original Solow growth model were replaced with the assumption of a fluctuating, stochastic efficiency level, or TFP, with the statistical "mean-reverting" properties the data suggest?

To their surprise, they found that feeding a neoclassical growth model with a TFP that fluctuates around trend with the same statistical properties as in the data could account for a large fraction, more than two-thirds, of U.S. post-war business cycles. A less rigorous interpretation of this result is that a substantial fraction of U.S. economic fluctuations originate in the supply side of the economy.

As is typically the case with scientific advances, the one made by Kydland and Prescott challenged the then-prevailing wisdom that the bulk of economic fluctuations come from the demand side of the economy. Naturally, a heated debate ensued. That it continues proves how shocking the profession found the revelation that a model designed to address growth questions could, after a seemingly trivial modification, answer business-cycle questions as well.

Nevertheless, in any science, even Nobel Prize caliber contributions are subjected to healthy criticism and scrutiny. An often-heard observation about Kydland and Prescott's 1982 finding is that there isn't anything surprising about it: They fed total factor productivity shocks with certain statistical properties in one end of the model and recovered them at the other end with those same properties. What else could be expected?

This is where the second building block of the RBC approach comes in. Recall that in this building block, intelligent, forward-looking households and firms, well-informed about the state of the economy and its long-run trends, are capable of correctly assessing the probability laws governing the strikes of favorable and unfavorable shocks to TFP. Equipped with that knowledge, households decide every period how much to work, consume, and invest in order to maximize their well-being. It is far from obvious that these intelligent agents' decisions will make consumption, investment, and other relevant variables behave with statistical properties, standard deviations critically among them, that closely resemble those of the data. The second building block is there, therefore, for a reason: to prevent the kind of tautological, mechanical outcomes for which Kydland and Prescott have been paradoxically and mistakenly criticized.

In that sense, the second building block in their approach is the "intelligent" piece that bridges in a behaviorally meaningful way the somewhat mechanical features of the first and third blocks. This intelligent connection takes the form of decision rules, which are nothing but quantitative relationships between long-run variables, such as the trend growth of TFP, and short-run variables, such as the shocks that induce temporary, trend-reverting fluctuations in TFP. In practice, these decision rules are the output of a computer program that solves a profit maximization problem for the firms and a welfare maximization problem for the households. For example, households' decisions regarding how much to invest can be summarized by a function that predicts the level of aggregate investment that should be observed in every period as a function of long-run trends and of the short-run, current deviations from those trends of the capital stock, TFP, and other variables that capture the state of the economy in each period.

The decision rules and the quantitative relationships they represent are, therefore, a fundamental component of the measuring device needed to answer quantitative questions like the one this article asks. In particular, knowledge of households' decision rules makes it possible to establish whether a given recovery is of the order of magnitude of the bounce-back effect the RBC model predicts should follow a recession. Obviously, the model predictions will depend critically on the values assigned to the long and short-run variables entering into those decision rules. For that reason, measuring those values correctly is of the utmost importance. The insight that such a delicate task could be accomplished with "calibration" techniques analogous to those used in engineering and physics is the second key innovation of the Kydland-Prescott approach to the study of business cycles.

## CALIBRATING THE MODEL ECONOMY TO ARGENTINA'S ECONOMY

We have already introduced the three building blocks of the RBC model that can be used to address the question about bounce-back effects such as the one that motivates this article. However, it is important to understand that in Kydland and Prescott's view, a model is not just a collection of cleverly combined building blocks but also a carefully crafted measuring device (see Kydland 2005, also available in www.nobelprize.org). As such, a model needs to be calibrated very much like any other precision instrument, be it a scale, a yardstick, or a thermometer.

The basic idea is to calibrate the device so that it delivers the correct answer to a problem whose solution is known, before using it to measure something unknown. For example, it is well-established that the temperature of frozen and boiling water is more or less 32 degrees and 212 degrees Fahrenheit, respectively. A thermometer can be calibrated by exploiting that knowledge, first putting it in contact with ice and then with boiling water. The corresponding marks of 32 and 212 degrees Fahrenheit will provide the benchmark to measure by linear interpolation unknown temperatures, such as that of a patient at a doctor's office.

Likewise, the values of the parameters entering into the decision rules of the different agents in the model economy can be calibrated to known values or, at least, values that can be said with some confidence characterize in the long run the trajectory of the economy under study. It is here that the balanced-growth property of the Solow model becomes handy: since the economy is permanently fluctuating around its trend or balanced-growth path, a good candidate to capture the long-run relationships among variables along that path is the average value of those relationships during a representative, long-enough period.

For example, one of the key balanced-growth path relationships in the Solow model implies the depreciation rate is equal to the investment/output ratio over the capital/output ratio plus 1, minus the product of population and TFP trend gross growth rates. Thus, the average of those ratios and percentages over a long period can be used to calibrate the depreciation rate.

In Argentina's case, the average of the investment/output ratio over the period 1950-79 was 22.65%. The corresponding averages for population and TFP growth were 1.55%

and 1.03%, respectively. The capital/output ratio rose steadily to 2 over the same period. These figures make it possible to calibrate the depreciation rate to the value of 8.73% (obtained from the calculation 0.2265/2 + 1 – 1.0155 x 1.0103 = 8.73).

Most of the other relevant parameters are calibrated in a similar way, replacing in the decision rules the variables representing balanced-growth path relationships with the average value of those relationships in the period 1951-79 (a more thorough justification for the choice of this period, as well as the rest of the details for the calibration of the model to Argentina's economy can be found in Kydland and Zarazaga, 2004).

An important parameter in the model that needs to be calibrated with a different procedure is the persistence parameter of the shocks to TFP. This parameter measures the speed with which shocks to TFP die down or, equivalently, the speed at which the efficiency of the economy reverts to trend after being displaced by a favorable or unfavorable shock.

The standard practice is to measure the changes in TFP by the so-called Solow residuals. As their name suggests, these residuals represent the rate of growth or decline of GDP that cannot be accounted for by changes in inputs, which in Kydland and Prescott's analytical framework are capital and labor. The initial value of the technology level is normalized to satisfy some criteria, for example, that output in some reference year be equal to one. Starting from that initial value, the rest of the TFP series is constructed by recursively applying the growth rates of TFP, as measured by the Solow residuals. Therefore, a researcher with a long time series of observations for those residuals at hand can calibrate the persistence parameter by running a regression with the

TFP series as the dependent variable (the left side variable) and that same TFP series lagged one period as the independent (or right side) variable.

That is the procedure used in this paper for calibrating the persistence parameter for Argentina, again using the period 1951-79 as representative of long-run trends. The point estimate of the persistence parameter produced by the autoregression described above is 0.5715. This figure implies that each year the efficiency of the economy inherits only 60% of the shock it experienced in the immediately preceding period. This suggests that in Argentina shocks to TFP are relatively short lived, as their effects practically disappear after five years.

The important thing to remember is that the ultimate purpose of the calibration procedure is to produce reliable numbers for the parameters that link long-run with short-run variables in the decision rules that guide the actions of households and firms. This will guarantee the decision rules provide a reliable device with which to measure, for example, the strength of the recovery that should follow a recession of a given intensity.

Equipped with those decision rules, calibrated as described above, it is possible to travel back in time to 2002 and answer the question in the introduction, that we are now in position to rephrase more precisely as follows: If TFP had not been hit by favorable or unfavorable shocks from 2003 onwards, by how much should GDP and investment have recovered from the deep 1998-2002 recession?

The next section answers that question with the aid of Kydland and Prescott's RBC "measuring device".

## ARGENTINA'S RECENT RECOVERY: NOT ALL THAT GLITTERS IS GOLD

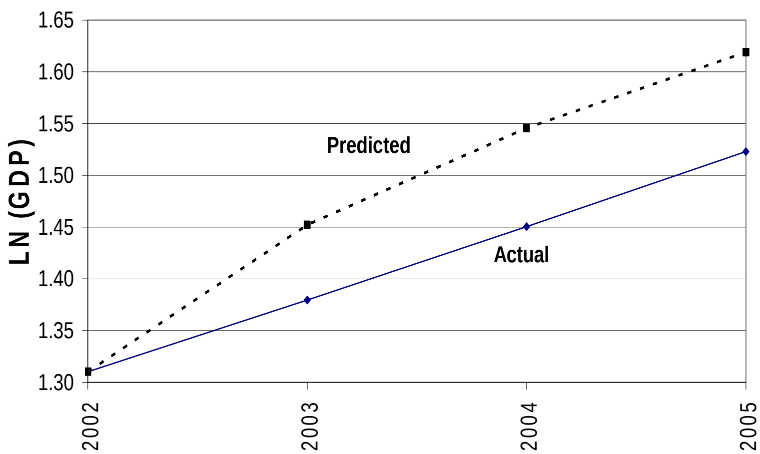
As mentioned earlier, by 2005 Argentina's GDP per working age person had posted a 23% gain from the 2002 trough of the immediately preceding recession. Once sifted through an RBC model calibrated to Argentina's economy, that figure ceases to be as impressive as it may appear to the uninformed observer.

Figure 3 plots the values for GDP per working age adult actually observed between 2002 and 2005 (solid line), along with those predicted by the model for the same period (broken line).

**Figure 3**

**GDP per working age person**

**Actual and Predicted**



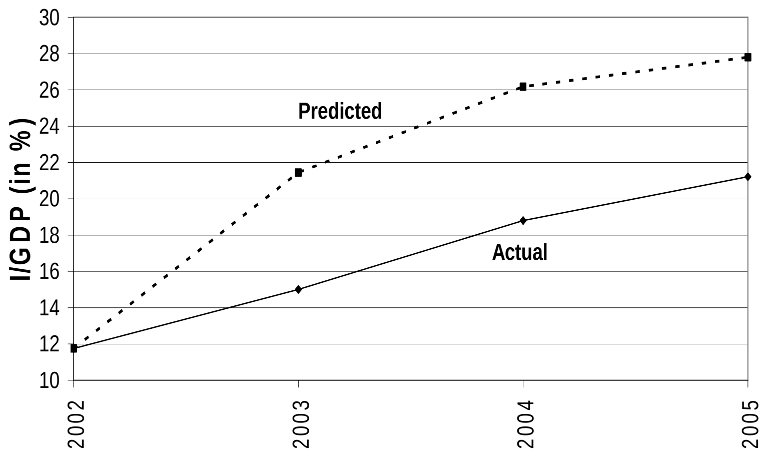

Given the depths to which the economy had fallen in 2002, the rubber ball effect should have induced a particularly strong rebound. In fact, Figure 3 shows that according to the model, GDP per working age person should have recovered by about 35% since 2002. The actual gain was instead about 23%, more than a third lower than the model predicted.

Figure 4 reveals one of the main reasons for the poor performance (relative to the model): a substantially lower than predicted share of GDP devoted to investment.

**Figure 4**

**Investment as a percentage of GDP**

**Actual and Predicted**




The Figure suggests that the 2002-05 recovery was not only weaker than it should have been, but also that it was standing more on dangerously volatile TFP gains than on solid-rock capital. Indeed, investment as a percentage of GDP remained substantially below the long-run value of 23% used to calibrate the economy. This contrast between actual and predicted performance should serve as a sobering note about Argentina's long-run prospects.

It is true that according to Figure 2 that by the end of 2005 TFP remained below trend and could therefore, by virtue of its mean-reverting property, keep driving the 2002-05 recovery for a while. But as Figure 2 also suggests, efficiency is a volatile creature. Trusting inherently unreliable inertial forces to pull Argentina's economy out of the hole is a risky strategy.

The low fraction of their income Argentines have devoted on average to investment during the 2002-05 recovery—about 19% as opposed to the historical average of 23%—suggests they still have serious doubts about keeping their savings in a country that has repeatedly confiscated them, indirectly through hyperinflations or—more recently—through outright bank deposit confiscations and sovereign debt defaults.

It may be tempting for the poor to think that it's the rich who mostly suffer the consequences of mistreating investors. Unfortunately, the majority of victims are likely to come from the ranks of the poor. This is because, as Figure 5 reveals, Argentina's capital stock per working age person in 2005 was about 25% lower than a generation before and the 2002-05 low rates of investment are barely enough to replace the capital stock that becomes obsolete each year.

**Figure 5**


Figure 5 in fact sends a rather discouraging message to the nonskilled workers of Argentina, because the neoclassical growth model predicts that a lower level of capital is inevitably associated with lower labor productivity and, therefore, with lower real wages and a worse income distribution. This suggests that the future of nonskilled workers and of the poor segments of the population they typically belong to may not be as bright as a naive observer of Argentina's economy might conclude from the deceptively strong 2002-05 recovery.

## CONCLUSION

By the end of 2005, Argentina's economy had posted impressive growth after having fallen into an abyss during the 1998-2002 recession. That chronology of events, however, suggests that the seemingly strong recovery still under way at this writing was just a natural rebound from that unusually deep recession, rather than the result of a sustainable acceleration of the growth rate.

This paper has shown that this conjecture can be examined with the rigor of the Real Business Cycle approach developed by Finn Kydland and Edward Prescott. Under the RBC lens, Argentina's seemingly stellar growth performance between 2002 and 2005 was not as bright as it may initially appear.

First, a parsimonious RBC model calibrated to Argentina's economy doesn't rule out the interpretation that the strong growth observed during those three years was nothing but the manifestation of a bounce-back effect from the previous, deep recession.

Second, contrary to widespread belief, the recovery has been rather weak. Given the magnitude of the preceding recession, and in view of the rubber ball effect built into the RBC model, GDP per working age person should have rebounded about 35% in 2002-05, when its actual increase was 23%, about a third less than the model predicted.

Third, a major source of concern is that the reason for GDP's weak performance relative to the model's predictions is unusually low investment, barely enough to keep the capital stock at its 2005 level, which was already 25% lower than 25 years earlier. This suggests the recovery still under way at this writing was flying more on TFP circumstantial tailwinds than on the fuel of capital. And it certainly implies that the lowest real wages Argentines have seen in a generation are likely to persist for some time and, along with them, lingering poverty and income distribution skewed in favor of land and capital owners.

Fourth, the RBC model calibrated to Argentina's economy predicts that the average life of a favorable TFP shock is about five years. That suggests that barring any large new shocks, the TFP tailwinds that started to blow at the end of 2002 will have likely died down by 2007, when TFP will be approaching its trend value. Afterwards, GDP growth rates will tend to settle in the range of 2-3% per year determined by population and TFP historical growth rates. Such mediocre rates are certainly insufficient to reduce the distance that separates Argentina's GDP per capita from that of Canada, Australia, or South Korea, not to mention that of even more developed nations, such as the United States.

In the end, when examined with the quantitative discipline imposed by the Real Business Cycle methodology developed by Kydland and Prescott, Argentina's seemingly impressive 2002-05 recovery offers plenty of reasons to remain unimpressed.

## TECHNICAL APPENDIX

A.1 - Model

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

Household preferences, with all variables expressed in terms of per working age person, can be represented by:

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

where $E$ denotes mathematical expectations, β the discount factor, $c_t$ consumption, $l_t$ the fraction of its time endowment the household devotes to work, $\alpha$ the utility-function share parameter, $\eta$ the population growth rate, and $\sigma$ the coefficient of constant relative risk aversion (or the reciprocal of the intertemporal elasticity of substitution of the composite commodity).

Technology is described by the constant returns production function:

$$y_t = z_t \ k_{t-1}^{\theta} \ [(1+\gamma)^t \ l_t]^{1-\theta} \tag{2}$$

where $y_t$ represents GDP per working age person, $z_t$ a stochastic total factor productivity or technology level, $k_t$ the capital stock, and θ the capital input share in national income. This specification makes apparent that the model assumes labor augmenting technological progress at the rate $\gamma$. Therefore, along the balanced growth path, output, consumption, investment, and capital grow at the rate $(1 + \eta) (1 + \gamma)$.

For this simple economy, without government and external sector, the resource constraint can be represented as:

$$c_t + x_t = y_t = z_t \ k_{t-1}^{\theta} \ [(1+\gamma)^t \ l_t]^{1-\theta} \tag{3}$$

where $x_t$ denotes gross fixed investment.

The law of motion of capital,

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

captures the standard time-to-build assumption that it takes one period to turn investment goods into productive capital, which depreciates at rate δ.

The stochastic process governing total factor productivity is assumed to be an AR(1) process with mean 1 and persistence parameter ρ:

$$z_t = 1 - \rho + \rho\, z_{t-1} + \varepsilon_t \tag{5}$$

where the shocks $\varepsilon_t$ are assumed to be an i.i.d. process with mean zero and standard deviation $1/(1-\rho)^2$.

A.2 - Computation

The decision rules used to generate the predicted paths for GDP and investment reported in the text were computed by exploiting the equivalence result between a competitive equilibrium allocation and the solution to a social planner's problem established by the second welfare theorem.

Since by assumption, $\sigma > 1$, $0 \le \alpha \le 1$ and $0 \le \theta \le 1$, the conditions for that theorem to hold are met by the neoclassical growth model described in the previous section. In particular, the utility function is concave, and the production function defines a convex set for the resource constraint. This guarantees 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).

The strategy was to compute the only solution of the model by finding the value function and associated decision (or allocation) functions. Following Kydland and Prescott (1982) the resource constraint (3) was replaced in the utility function and the resulting expression rewritten as a quadratic approximation around the steady state. This defines a linear quadratic problem with well known properties. In particular, the decision (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 decision rules 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. The technology level, $z_t$, is assumed to be known at the beginning of period t. Under this information structure, the two decision rules that emerge from this model, one for investment and another one for labor supply, are time-invariant linear function of the two state variables, the beginning-of-period capital stock and that same period's technology level.

The predicted paths for GDP and investment in the period 2003-05 reported in the text were computed by first setting the shocks $\varepsilon_t$ equal to zero for those years and then using equation (5) to calculate the predicted technology levels for 2003 through 2005 as of the end of 2002, from knowledge of the technology level for 2002. Next, gross fixed investment for each year in the period 2003-05 was computed sequentially by feeding the corresponding decision rule with that year's predicted technology level and with the beginning-of-period capital, computed recursively from the law of motion (4) and knowledge of the capital stock at the beginning of 2003. The labor supply was computed likewise, by feeding the corresponding decision rule with each period's predicted technology level and beginning-of-period capital stock. Predicted GDP levels for the period 2003-05 were then calculated using equation (2).

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