Capital Accumulation, Sectoral Productivity and Real Exchange Rate

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ABSTRACT
Kydland and Zarazaga (2001) documented that in the 90s in Argentina huge increases in total factor productivity (TFP) were accompanied by low investment. We try to solve this anomaly by introducing two sectors, tradable and nontradable sector, in an otherwise standard business cycle model. We find that we can not account for the path of aggregate capital. This is mainly because of underinvestment in the tradable sector. Moreover, we find a second and quite robust anomaly: the simulated real exchange rate (the price of the nontradable good in terms of tradable) moves strongly opposite to data. Consequently, we measure the misalignment and we incorporate it as an exogenous state variable. In a new run, we find that the results are completely unrealistic in the magnitudes, though not in the directions of change. We try then different ad-hoc ways of reducing the magnitudes of those effects. Both aggregate capital and real exchange rate paths remain a puzzle.

1 The question
Kydland and Zarazaga (2001) found that a neoclassical dynamic general equilibrium model overestimates the capital stock for Argentina in the 90s, given the productivity levels, measured as Solow residuals (see Figure 1. The figure is based in a replication of the results of KZ(2001) with a slight
difference. This figure presents overestimation of capital after 1994, while KZ found overestimation since 1990. This is due to different coefficients for the autoregressive productivity process: they used a coefficient near 0.85 while we used one near 0.92. This, in turn, is due to different ways of calculating the TFP path. While they calculate TFP before detrending variables, we do it after it. Anyway, using our methodology we found that capital is overestimated by 15% by 2001, while using theirs it would be overestimated by 25%.) That is, capital stock grew in the 90s, but grew too slowly, given the huge increases in measured TFP. Why?

There are some possible explanations related specifically to the financial sector, an important intermediary in the process of capital accumulation: i) frictions in the financial sector, as lack of collaterals; ii) the possibility of default implies a constraint in accumulation of capital; iii) government crowding out of credit.

In this paper we will try to assess the validity of an alternative explanation: low investment is the consequence of the behavior of the real exchange rate. The real exchange rate story of low investment is well described by Calvo (2002):

Another popular view stresses the impact of a fixed exchange rate regime coupled with a devaluation by Argentina’s major trading partners as an important cause of real exchange rate (RER) misalignment, which reduced profitability in the tradable sector. This, in turn, slowed down investment and led the economy into a protracted recession as it deflated away the RER disequilibrium.

This story seems somewhat one-sided, because, with a real appreciation, if investment is reduced in the tradable sector because of low profitability, it will probably be increased in the nontradable sector because of high profitability. Also, the story does not say what would be the behaviour of the consumers given the misalignment. In other words, this story is asking for a quantitative general equilibrium inspection.

Misalignment stories are pervasive in space and history (see, for example, Hinkle and Montiel (1999)). We study the case of Argentina because it seems to be an extreme case. Argentina fixed his currency to the dollar for a long period, from 1991 to 2001, while the dollar appreciated against most currencies, and at the time that most Argentina’s trading partners (Brazil and Western Europe) and competitors (East Asia and East Europe) were devaluing their own. If we do not find signs of misalignment or relevant consequences of misalignment in Argentina’s case in the 90s, we will be taken to think that, in general, misalignment explanations of the performance of economies are not appropriate. The same conclusion can be reached if we
find misalignment, it has relevant consequences, but its consequences fail to accord with the data.

The strategy is to build on Kydland and Zarraga (2001) closed economy model. Ideally we would like to do two things: open the economy in goods and assets and introduce a nontradable sector. To keep things simple we decided to do just the second innovation. Of course, in a closed economy model all goods are nontradable internationally. That does not disqualify the exercise. Mainly we are dividing the aggregate into two sectors which can have different profiles of capital accumulation given changes in sectoral productivities.

The first question we will address is: Can we account for the capital and other variables paths by the mere innovation of disaggregating the economy into two sectors? If not, the second question will be: Can we account better for those paths under some rigidity of the real exchange rate?

Disaggregating into two sectors will make us able to differentiate productivity shocks in each sector as well as calculate a price of nontradable good in terms of the tradable good, that we will call real exchange rate. We will be able to define the real exchange rate overvaluation or undervaluation as the difference between the observed real exchange rate and the one obtained with the model. Finally, we will use this measured misalignment as an exogenous state variable in models where the price is exogenously fix or there is some kind of friction in the markets of goods. We will be in shape then to see if the artificial paths of capital thus generated replicate better the data or not.

Literature:
Depression papers
Stockman and Tesar
Mendoza

In section 2 I introduce the data and highlight some facts. In section 3 I present the model with two sectors. In section 4 I calibrate the model. In section 5 I present the main results. In section 6 I conclude.

2 The data

The data we use for aggregate output, capital and employment was elaborated by Maia and Nicholson (2001) and spans from 1960 to 2001. This
data differs slightly from the one used by KZ(2001). We have done the same
simulations for both data sets and the results are almost identical.

The main data issue is to separate output, employment and capital in
tradable and nontradable sectors. We considered that agriculture, mining
and manufacturing were tradables and the rest (construction, transportation
and public utilities, wholesale trade, retail trade, finance, insurance and real
estate, services and government) were nontradables during all the period.
We used data by sector to separate aggregate output and employment into
tradable and nontradable. The case for capital was different. As we do
not have long series of investment for each sector, we used data on use of
electrical energy by sector (mainly two sectors: industry and commerce)
to attribute capital to tradables and nontradables. The correlation between
total electrical energy use and aggregate capital is high (0.95). Many studies
(see, for example, ...) obtain for other economies a high correlation between
energy use and capital stock for the manufacturing sector (the main tradable
sector). So it seems natural to think that it will be high for the nontradable
sector too.

For the relative price I used the real exchange rate between Argentina
and U.S. computed with CPI series. The correlation between this and the
relative price is 0.85 for the period 1981-2001 and 0.95 for the 90s.

In the appendix A I describe more carefully the data sources and elab-
oration.

We have not seen before growth accounting divided into tradable and
nontradable sector, so we present the data in the figures 2 to 5 and in table
1 and describe it in the next few paragraphs. I report facts from 1976 to the
present because that is the time period for which I obtained sectoral energy
data.

The main facts are the following:

i) (Figure 2) Tradable output has decreased from 1976 to the present
while nontradable output increased drastically in the 90s. (We present the
data for US to try to distinguish worldwide tendencies from Argentina’s
facts. In the US the increase in nontradable was huge in the last 25 years
and the tradable, unlike the case of Argentina, slightly increased).

ii) (Figure 3) Until the end of the eighties capital in both sectors increased
similarly. From then on, capital in the nontradable sector increases sharply
while capital in the tradable sector diminishes.

iii) (Figure 4) More labor is used in the nontradable sector than in the
tradable sector (the double in 1976; the triple in 2001). Employment did
not change in the whole period in the tradable sector while it increased in
iv) (Figure 5) TFP in the nontradable sector increased by 20% while it decreased by 35% in the tradable sector in the period 1976-2001. For the US, the equivalent numbers are steady increases of 25% and 15%. For Argentina, the variability in both series have been huge. In particular, observe the decrease of 30% of tradable TFP in just five years, from 1976 to 1981. To try to explain that decline seems to be an interesting challenge.

v) Figure 6 shows the relative TFP (the ratio of TFP in tradable sector to TFP in nontradable) and the real exchange rate (price of nontradable in terms of tradables). The "mirror" movement is striking. Note that the relationship goes in the opposite direction that the one emphasized in the literature (for example, Obstfeld and Rogoff (1996), p. 210-214, or De Gregorio and Wolf (1994)): higher growth of productivity in tradable sector than in nontradable is accompanied by a depreciation of the real exchange rate. This graph induces the question: what is the causality (if any) between the relative productivity and the real exchange rate?

Table 1 presents a growth accounting exercise for aggregate, tradable and nontradable output per capita. There are many curious episodes: the huge decrease in tradable TFP in the period 1976-1981 with an important increase in capital intensity; a similar situation, though not so drastic, in 1996-2001 for nontradables; or the important increase in nontradable TFP in 1991-1996 with a decrease in employment intensity. None of these seem to be consistent with neoclassical growth theory.

In the following sections we will present two models, one with perfectly flexible RER and the other with some type of intervention in the goods markets. The stylized facts of the 90s by which we would like to judge the appropriateness of these models are the following (note that all variables in the model are detrended by both population growth rate and per capita income growth rate, so the following quantity variables have been also de-trended).

1. Total capital slightly diminishes (despite increases in total productivity) (KZ(2001) anomaly);
2. Total product increases;
3. Total employment is roughly constant;
4. Capital increases in the nontradable sector, while it decreases dramatically in the tradable sector;
5. Employment slightly increases in the nontradable sector, while it slightly decreases in the tradable sector;
6. Production increases in the nontraded sector, while it decreases dramatically in the tradable sector;

7. The real exchange rate appreciates drastically in the first years of the 90s.

3 The model

There are three type of agents in the economy: consumers, producers of tradable goods and producers of nontradable goods. We assume that there are many so that they take prices as given.

We consider an economy with constant deterministic population and income per capita growth. Therefore all variables are in per-capita, per-efficiency units terms, except for employment, that is in per-capita terms. These transformations are done to obtain a stationary solution.

In what follows $T$ and $N$ indicate tradable and nontradable sector respectively.

*Households*

The representative consumer chooses tradable consumption, $c^T$, nontradable consumption, $c^N$, leisure, $l$, labor, $h$, and investment, $x$, to maximize his expected infinite lifetime utility:

$$\max E[\sum_{t=0}^{\infty} \beta^t U(c^T_t, c^N_t, l_t)]$$

Here $\beta$ is equal to $(1 + \nu)^{1 - \sigma} (1 + \gamma)^{\alpha(1 - \sigma)} \beta$.

We assume the momentary utility form

$$U(c^T, c^N, l) = [(ac^T + (1 - a)c^N l)^{\alpha/\eta}l^{1 - \alpha}]^{1 - \sigma} / (1 - \sigma).$$ (1)

The consumer faces a number of constraints. First he is entitled to one unit of time each period so that labor in each sector, $h^T$ and $h^N$, must satisfy

$$h^T_t + h^N_t + l_t = 1.$$ (2)

Second, he accumulates capital separately in each sector following the laws of motion

$$(1 + \nu)(1 + \gamma)k^T_{t+1} = (1 - \delta^T)k^T_t + x^T_t.$$ (3)
\[(1 + \nu)(1 + \gamma)k_{t+1}^N = (1 - \delta^N)k_t^N + x_t^N \tag{4}\]

where \(k^T, k^N\) are capital in each sector, \(\delta^T, \delta^N\) are depreciation in each sector, and \(\nu\) and \(\gamma\) are the deterministic constant population and income per capita growth.

In some warm-up exercises we found that a key decision is the classification of investment as tradable or nontradable. (Note: In a recent paper Burstein, Neves and Rebelo (2003) suggest that modelling open economies with a nontradable component of investment “may be a better approach to generate plausible investment dynamics”. Our dataset indicates that near 45% of investment is nonresidential construction, which we consider a nontradable.) If we classify investment as a tradable, we can replicate quite well the declining aggregate capital. If we classify it as a nontradable, then we missed it, as simulated capital grows during the period. These results are not surprising. The meager performance of productivity in the tradable sector constrains the increase of investment as a tradable; the good performance of productivity in the nontradable sector gives space to increase of investment as a nontradable. These considerations led me to define a more realistic investment sector. Now, investment in each sector has both tradable and nontradable components, with the following functions:

\[x_t^T = G^T(x_t^{TT}, x_t^{NT}) = (\omega_1 x_t^{TT \rho_1} + \omega_2 x_t^{NT \rho_1})^{1/\rho_1} \tag{5}\]

\[x_t^N = G^N(x_t^{NN}, x_t^{TN}) = (\omega_3 x_t^{NN \rho_2} + \omega_4 x_t^{TN \rho_2})^{1/\rho_2} \tag{6}\]

where \(x_t^{ij}\) represents investment produced in sector \(i\) and used in sector \(j\).

Third, the consumer satisfies his budget constraint

\[c_t^T + x_t^{TT} + x_t^{TN} + p_t(c_t^N + x_t^{NT} + x_t^{NN}) \leq \]

\[w_t x_t^{TT \lambda} k_t^T + w_t x_t^{NN \lambda} k_t^N + r_t^T k_t^TT + r_t^N k_t^NN \leq \tag{8}\]

where \(p, w\) and \(r\) are the price of the nontradable good, the wage and the price of capital, all in terms of the tradable good.

While wages in both sectors will be equal in equilibrium as labor can be reallocated immediately between sectors, prices of capital can differ as both capitals are not the same good.

**Firms**

Each firm chooses capital and labor to maximize period-by-period profits:
\[ z_t^T F_t^T (k_t^T, n_t^T) - w_t^T n_t^T - r_t^T k_t^T \]  \hspace{1cm} (9)

\[ p_t z_t^N F_t^N (k_t^N, n_t^N) - w_t^N n_t^N - r_t^N k_t^N \]  \hspace{1cm} (10)

where

\[ F^i(k, n) = k^{(\theta^i)} n^{(1-\theta^i)} \]  \hspace{1cm} (11)

with \( i = \{T, N\} \).

The technology process is driven by:

\[ z_{t+1} = b + Az_t + \epsilon \]  \hspace{1cm} (12)

where \( z \) is a two variable vector, \( A \) is a matrix of 2 by 2, \( b \) is a vector of 2 by 1, the same as \( \epsilon \), the shocks to the technology, which are normal iid with mean zero and variance \( \Omega \).

4 Calibration and computation

We have 17 parameters to calibrate \((\delta^T, \delta^N, \beta, \nu, \gamma, \eta, \alpha, a, \theta^T, \theta^N, \sigma, \omega^s \text{ and } \rho^s) \) and 6 more to estimate with a VAR for the technology process.

Table 2 presents the parameters calibrated and estimated.

We fix \( \nu \) to the growth rate of population in the period 1960-2000 (1.38%) and \( \gamma \) to the growth rate of gdp per capita for the same period (0.9%).

The first order conditions imply the following equations in steady state (the subscript indicates partial derivative) (note: we assume that the price of both capitals are equal in steady state):

\[ \frac{(1 - \theta^T)/\theta^T}{(1 - \theta^N)/\theta^N} = \frac{k^N/n^N}{k^T/n^T}. \]  \hspace{1cm} (13)

\[ \frac{z^T F_2^T}{z^N F_2^N} = \frac{1 - a}{a} \left( \frac{c^N}{c^T} \right)^{\eta - 1} \]  \hspace{1cm} (14)

\[ \beta(z^T f^T_1 G_1^T + (1 - \delta^T)) = (1 + \nu)(1 + \gamma) \]  \hspace{1cm} (15)

\[ \beta(z^T f_1^T G_2^T + p(1 - \delta^T)) = p(1 + \nu)(1 + \gamma) \]  \hspace{1cm} (16)

\[ \beta(z^N f_1^N G_1^N + \delta^N) = (1 + \nu)(1 + \gamma) \]  \hspace{1cm} (17)
\[
\beta(pz^N f_1^N G_2^N + (1 - \delta^N)) = (1 + \nu)(1 + \gamma)
\]  
(18)

\[
\frac{1 - \alpha}{\alpha} = \frac{ac^{\eta - 1} z^N f_2^N (1 - h^N - h^T)}{ac^{\eta} + (1 - a)c^{\eta}}
\]  
(19)

Considering that the ratios capital-employment in both sectors have been relatively constant (in 1993 pesos, near 40,000 per employee in both sectors) and imposing the share of aggregate capital income to be 0.4, we use equation 11 to calculate \( \theta_T \) and \( \theta^N \). Both result to be almost equal to 0.4.

This numbers are reasonable. We can not calculate this parameters directly looking at the share of capital income in each sector because we do not have that data for Argentina, but we calculate them directly for the US and we found that the share in each sector is around 0.3, similar to the aggregate capital income share.

Gonzalez Rosada and Neumeyer (...) determined econometrically that \( \eta \) has a value of -1.5, which implies an elasticity of substitution between tradables and nontradables of 0.4. We used this value of \( \eta \) and a nontradable to tradable consumption ratio of 2.5 in equation 12 to obtain an estimate for \( a \) equal to 0.086.

We do not have much information about the elasticities of substitution in investment, determined by \( \rho_1 \) and \( \rho_2 \). We therefore fix them to be equal to the elasticity of substitution in consumption.

We fix \( \beta \) to be the same as in a one sector model, that is a value of 0.889.

We calibrate the \( \omega \)'s in the following way.

First we calculate the ratios of tradable component (machines and transport equipment) and nontradable component (nonresidential construction) to total capital, which are 0.05 and 0.04 respectively. Then we obtained scatter information for the 90's about: i) imports of capital goods by sector; ii) permits of construction by sector (in square meters). Using i) we determined that in steady state 50% of machinery goes to each sector (we assumed that national machinery will be distributed between sector in the same proportion). Using ii) we determined that 25% of construction goes to the tradable sector and 75% to the nontradable.

Using the laws of motion for capital in steady state and dividing by capital we obtain

\[
(1 + \gamma)(1 + \nu) = (1 - \delta^T) + \frac{G^T}{k}
\]  
(20)
\[(1 + \gamma)(1 + \nu) = (1 - \delta^N) + \frac{G^N}{k}\]  

(21)

Finally using the above information on shares of investment, the average value of aggregate capital and equations 13 to 19 we solve simultaneously for the four \(\omega\)'s, \(\delta^T\) and \(\delta^N\).

We calibrate \(\alpha\) using equation 17 and previous estimates of parameters. \(\sigma\) is fixed to 2.

Table 2 also presents the estimated parameters of the stochastic process. The "spillover" coefficients, the coefficients that determines the effect of productivity in one sector on the productivity in the other sector the following period, are very small and statistically insignificant, so I decided to set them to zero.

The computation procedure is the following:

i) given the parameters calibrated and the estimated parameters of the technology stochastic process, we compute decision rules for the centralized problem using linear quadratic method as presented in, for example, Hansen and Prescott (1995);

ii) we simulate paths for aggregate and sectoral capital, investment, labor, product and consumption. This is done by assuming that the economy was in steady state in 1986 (that is fixing capital and productivity levels in 1986 to their steady state value) and inputing the observed changes in productivity in the decision rules.

iii) we calculate the simulated real exchange rate using shadow price, that is, the ratio between marginal utility of nontradable consumption to marginal utility of tradable consumption:

\[p = \frac{U_2}{U_1} = \frac{(1 - a)}{a} \left(\frac{c^N}{c^T}\right)^{\eta - 1};\]  

(22)

5 Findings

Endogenous RER

The findings are mostly negative. Table 3 presents the results. There I specify the volatility of both data and model time series and the correlation
between the data and the model. (This allows me to avoid presenting countless graphs. Notice though that we may lose some information as leads and lags.)

Overall we observe that we can replicate better the series for nontradables than for tradables.

Figure 7 shows that the simulated aggregate capital still increases in the second half of the nineties, while the data is roughly constant. In this respect, with a less parsimonious we do not do any better than KZ(2001).

But the approach allows us to see where this overestimation does come from. We observe that it is the overestimation of tradable capital that counts (see figure 8).

Observe that the correlation between data and model simulation for investment are quite high. In fact, the qualitative changes in investment are replicated quite well. But the magnitudes are too big comparing to the data (figure 9). Two more observations: underinvestment persists through all the decade and it is more pronounced in tradable goods (that is machinery and transportation capital) than in nontradable.

The RER puzzle

Figure 10 presents the simulated behaviour of the real exchange rate. We observe that it moves in opposite direction to the data. The behaviour of the RER in our model is determined mainly by the relative change in the sectoral productivities (as in much of the open macroeconomics literature; see Obstfeld and Rogoff....).

We can gain some intuition of this relationship through an impulse response exercise: a 5% increase in the level of nontradable productivity (table 4). The four types of investment will increase as well as both capitals (next period). Labor in tradables will slightly increase while labor in nontradables will slightly decrease (as relatively more tradable capital has to be produce to increase the capital in the nontradable sector). Over all, the production of nontradables will increase more than the production of tradables. To clear markets, the price of nontradables in terms of tradables will have to diminish.

Now we have not one but two puzzles! How can we solve the RER puzzle? Is there any alternative preferences to palliate the difference between simulated RER and data? We turn now to answer this question.

The appreciation of the RER came along with an increase in income. In general, tradable and nontradable consumption seem to change differently with income: when income increases the share of nontradable consumption
in total consumption increases; that is, $c^N$ is a superior good. This fact, other things equal, will increase the price of nontradables with an increase in income, which have led to the argument that the appreciation of the RER was due to the increase in income, despite the increase in the relative productivity of nontradables.

To test this hypothesis we postulate a new momentary utility function with non-homothetic preferences

$$U(c^T, c^N, l) = [(ac^{T\eta} + (1 - a)c^{N\eta + \lambda})^{\alpha/\eta l^{1 - \alpha}}l^{1 - \sigma}/1 - \sigma$$  \hspace{1cm} (23)

We calibrate $\lambda$ in the following way. Income increased roughly from $6000$ in 1990 to $8000$ in 1997. The change in the share of nontradables in total consumption increases roughly from 60\% to 78\%. Given $\eta = -1.5$, this change implies $\lambda$ equal to 1.4. Observe that the value for this parameter is very similar to the one estimated econometrically by Gonzalez Rosada and Neumeyer (200..). We need to adjust $a$ accordingly to 0.45.

Now we used the data on consumption to get the price, using equation 12 modified:

$$p = \frac{1 - a (\eta + \lambda)}{a} \frac{c^{N\eta + \lambda - 1}}{c^{T\eta - 1}}$$ \hspace{1cm} (24)

The result, shown in Figure 11, is that the RER should still have depreciated, though less than with homotheticity. (We solved for the model with the new momentary utility and we found that neither anomaly is corrected, though the changes are as predicted: the overestimation of capital and the exchange rate depreciation are slightly less.)

This exercise clarifies the puzzle: even if we replicate faithfully the consumption profiles we will missed badly the price.

A radically different way to go is to include frictions in the exchange rate market. Thus we turn now to the discussion and implementation of alternative ways of doing this.

Fix price

The real exchange rate story of low investment in the 90’s argues that the price of nontradables was too high with respect to an equilibrium price. Two questions arise somewhat related: i) why there was not adjustment? ii) how do we model this feature in the framework that we set above?

The answer to the first question is difficult. One answer would be that the price is sticky. But not even the most fiercest keynesian, I guess, would argue that it is so sticky that it does not adjust for 10 years when the relative price is the double of what it should be without stickiness.
A second answer, more plausible, is that during the whole period the government was intervening to maintain a high real exchange rate. This raises two questions: why to do it? and how to do it?

I will not answer these questions in detail, because I do not have such an answer. But I will suggest some hints. The reason might be related to fear of deflation, difficulty to lower public wages and political influence of the newly privatized public services. The instrument might have been the following.

During almost the whole period the government was taking loans abroad to close the fiscal deficit. During almost the whole period there was deficit in the current account. These are the so-called twin deficits. So one could say that the government was maintaining a high exchange rate (appreciated) by using the loans to buy the excess supply of nontradables, while the net flow of tradables was closing the excess demand of tradables. In this sense the collapse of the real exchange rate is just the follow up of the dryness of the capital market. In 2001, with no more external loans, the government had to change the nominal exchange rate or let the economy deflate. They chose the first. (Observe that the level of real exchange rate after the huge nominal devaluation in 2002 is very similar to the one predicted by the model for, say, 2001).

In this paper I do not provide the evidence to support this hypothesis but the following exercises might indicate which type of evidence we need as well as the quantitative magnitude of it. They might also suggest that the hypothesis is implausible if results are less in accordance with the data than the benchmark model.

Turning to the second question, the first alternative is to fix the price to the observed RER. The steady state for this model is the same as the endogenous price model. Computationally the only difference is that we estimate a process for the price and include it as a third exogenous variable in the decentralized version of the benchmark model. The coefficient of the first order autoregressive process is 0.79.

We obtained completely unrealistic results. The capital in the tradable sector goes to zero immediately and the capital in the nontradable sector grows disproportionately. Meanwhile the effects of the technology shocks are multiplied by one thousand. The direction of the effects of the fix price seems to be in the needed direction to explain better the data, that is: a higher price affects positively the investment in nontradables and negatively the investment in tradables and the consumption in nontradables. But unless we believe that all consumption in nontradables was consumed by the government and all consumption in tradables was imported, then this is a quantita-
tively unreasonable model. (note: This non-equilibrium real business cycle model goes in the tradition of Danthine and Donaldson (1995). There they argue: "We have illustrated the non-Walrasian approach to business cycle models through representations of the labor markets involving contracts and shirking considerations. Finally, non-Walrasian models are not limited to labor market frictions. In principle, non-market-clearing theories of product markets could also be incorporated").

The way to go seems then to postulate a fix price model (to maintain the qualitative results) but with some more restrictions on the accumulation of capital (to reduce the magnitude of the effects). This could be done, for example, by imposing time-to-build capital or adjustment costs. I do not experiment with those models but the following alternatives are seen as short cuts to their results.

An alternative option is modeling the friction as a tax/subsidy scheme. The government fix a tax equal to the misalignment amount on the nontradable. Thus, with appreciation of the RER, the producers of nontradables are granted a subsidy and the consumers of nontradables suffer a tax, and they cancel each other. The solution to this problem is trivial: quantities do not change as the price paid by the consumers is reduced by the tax amount. (Observe that this option still needs an interpretation).

The following two models are intermediate options between both extremes, the fix price, where the effects are huge, and the tax/subsidy scheme, where the effects are null. Mainly they still allow the price to adjust, but they provoke changes in the quantities.

In this models we use as a measure of misalignment \( \tau \), defined by:

\[
\tau = \frac{p^o}{p^s} - 1
\]

where \( p^o \) is the observed price and \( p^s \) is the simulated price. We assume that in 1990, a year where the currency float freely and there were almost no capital controls in the Central Bank, the observed exchange rate was the equilibrium exchange rate. That is, we put \( \tau_{1990} = 0 \). Figure 12 presents the time-varying misalignment. (note: Was there overvaluation in 1990s? There was overvaluation indeed, between 70% and 170%. Overvaluation was very high in the years following the launch of convertibility plan in 1991 and from 1995 on declines steadily.)

We then estimate a first order autoregressive process for this misalignment. The coefficient is equal to 0.86, which indicates high persistence.

i) A tax on the price of the nontradable for the consumers and an offsetting lumpsum subsidy on consumers. This is a short cut for a fix price
rationing equilibrium. The results are again too strong, though not as much as the fix price model. Capital in tradables goes to zero, while capital in nontradables slightly diminishes. This makes aggregate capital to diminish by 40% in the 90s!

ii) A "mark-up" model. In this model the market price does not take into account the tax directly, but in their private decisions both, producers take into account the subsidy on price, and consumers take into account the tax on price. That is, the market price is determined by the quantities, but these quantities are determined by the market price and the tax. This model is quite ad-hoc and the foundations of it are weak. We are interested in it because the qualitative effects are very similar to the fix price model but the quantitative effects are of reasonable magnitude. In particular, we will have excess supply and demand. We present the results in table 5. We still can not replicate the aggregate capital series, but observe that we replicate much better the sectoral capitals (figure 13). The rest of the results are quite similar to the benchmark model. Figure 14 shows the excess supply for nontradables. If the instrument suggested above is correct, this is the amount that should be financed by the government.

6 Concluding comments

A neoclassical model with sectoral productivity shocks can explain neither the movements in real exchange rate nor the process of aggregate capital accumulation for Argentina in the 90s. In particular, it overestimates the accumulation of capital in the tradable sector.

A model with a fix price does worst. In particular, it predicts the disappearance of the tradable sector in two years.

Two models might do better: an actual open economy two sector model or a two sector fix price with adjustment costs model.

There are some related questions that deserve study.

i) How to interpret the sectoral productivity shocks? Why measured shocks are so big comparing to other countries? Why there have been a secular decline in TFP in the tradable sector?

ii) What is the relationshipship between real exchange rate and relative TFP? Why the correlation is negative while for most countries is positive (see, for example, Kakkar (2001))? Is it possible that the causality is the reverse one, that the movements in real exchange rate caused relative productivity changes?
7 References


Figure 1: capital one sector

pesos 1993

- model
- data
Figure 2a: gdp Argentina

pesos 1993

tradable
nontradable
Figure 3a: capital Argentina

[Graph showing trends in tradable and nontradable assets over years]
Figure 4a: employment Argentina

- **tradable**
- **nontradable**
Figure 2b: gdp us

[Graph showing the growth of tradable and nontradable GDP from 1976 to 2001. The nontradable GDP is represented by a solid line, and the tradable GDP is represented by a dashed line. The y-axis represents thousands of US$ in 1996.]
Figure 4b: employment us

- Thousands
- Tradable
- Nontradable
Figure 8: capital tradable
Figure 13b: capital nontradable

The graph shows the trend of capital nontradable over the years from 1986 to 2001. The x-axis represents the years, while the y-axis represents the pesos. Two lines are plotted: one for the model (model1) and another for the data. The model line is a smooth curve, while the data line fluctuates more.
Figure 13a: capital tradable

pesos 1993


model1
data
markup
income effect
Figure 13b: capital nontradable

The graph shows the trend of capital nontradable from 1986 to 2001. The y-axis represents pesos 1993, ranging from 0 to 1.2. The x-axis represents the years from 1986 to 2001. The graph includes data points for model1, data, markup, and income effect.
Figure 14: nontradable consumption
### Table 1: Argentina - Growth accounting

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<td>Capital intensity</td>
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|             | Y/N                | Capital intensity | Employment intensity | TFP     |
| 1976-1981   | -5.81%             | 6.29%             | -0.72%              | -10.67% |
| 1981-1986   | -0.49%             | 0.76%             | -0.57%              | -0.43%  |
| 1986-1991   | -3.08%             | 1.22%             | -0.26%              | -3.37%  |
| 1991-1996   | -1.01%             | -2.31%            | -0.05%              | 1.57%   |
| 1996-2001   | -2.73%             | -0.58%            | -3.25%              | 1.40%   |

<p>|             | Y/N                | Capital intensity | Employment intensity | TFP     |
| 1976-1981   | 4.06%              | -1.07%            | 1.59%                | 3.80%   |
| 1981-1986   | -0.39%             | -0.83%            | 0.99%                | -0.05%  |
| 1986-1991   | 0.73%              | -0.55%            | 1.35%                | 0.49%   |
| 1991-1996   | 5.46%              | -1.41%            | -1.19%               | 8.40%   |
| 1996-2001   | 0.41%              | 1.32%             | 3.03%                | -3.75%  |</p>
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