Business cycle accounting for Argentina utilizing capital utilization*

Tiago V. de V. Cavalcanti* Pedro Elosegui**
George McCandless**
Emilio Blanco**
University of Cambridge*
Banco Central de la República Argentina**

August 31, 2007

Abstract

We use a variation on the business cycle accounting method of Chari, Kehoe and McGrattan [3] to study the business cycle in Argentina from 1972 to 2006. We use capital utilization as a household decision variable to be able to better extract the wedge that functions as a tax on capital. Applying the model to Argentina, we find that all four wedges are important in explaining the evolution of output over this period (although net exports is the least important). The major political subperiods can be characterized by the relative importance of each wedge. We compare the results of this technique to the standard narrative. JEL classifications: E22, E32, N16

1 Introduction

Using a prototype growth model, Chari, Kehoe and McGrattan (2007) propose an accounting procedure for guiding researchers in developing and analyzing quantitative models of economic fluctuations. This procedure uses real data together with the equilibrium conditions of a prototype growth model to measure four wedges that are explained by four variables of the model. These wedges are “distortions” and represent policies and institutions, which affect productivity and factors input. The authors show that a large class of economic models, including those with various added features (e.g., financial frictions, nominal rigidities, entrepreneur decisions, and monetary shocks) are equivalent to a prototype growth model with time-varying wedges. Institutions, public policies, fiscal, monetary, income and labor policies affect the three wedges and therefore the allocations of capital and labor, and productivity in the economy.

*The opinions expressed here are those of the authors and should not be taken to represent those of the Banco Central de la República Argentina.
In their standard model for business cycle accounting, Chari, Kehoe and McGrattan (2007) use four wedges that are explained by four variables of the model. The period \( t \) value for three of the wedges, government expenditures and net exports, total factor productivity, and labor, are found using the model and period \( t \) data. The fourth wedge, capital, is found using the intertemporal relations of the model and its aggregate effects on output are found as a residual of the effects of the other three wedges. For the US data used by CKM, the capital wedge is frequently found to be quite small. It is not clear if this is a characteristic of the US data they are using or a result of their calculation technique.

Making use of capital utilization data provides an alternative way of finding the capital wedge. Capital utilization information can be used directly in the production function (since it is utilized capital that creates production) and in the household budget constraint (since it is utilized capital that earns rents). In addition, it is quite natural to think of depreciation as being a function of capital utilization, since the more that capital is utilized in a period, the more likely it is to wear out and need replacement parts or maintainence. Given these characteristics of capital utilization, it becomes a household choice variable, households choose how much capital to send to the market each period, and adds an additional first order condition to the model. One can use this extra first order condition to extract, using period \( t \) data, a period \( t \) capital wedge.

Chari, Kehoe and McGrattan do provide an alternative specification in which they use variable capital utilization to adjust the capital stock. What they do not do, and what we do here, is make capital utilization a choice variable for the households, get the additional first order condition and use this extra equation to extract the capital tax and construct the capital wedge. Once the wedges are constructed it is possible to assess what fraction of output fluctuation can be attributed to each wedge separately and in combination.

In this paper, we apply a model with endogenous capital utilization to the Argentine economy\(^1\) from 1972 to the end of 2006. The accounting procedure allows us to analyze the Argentine economy during a time period subject to several structural breaks that can be associated to different economic regimes. The wedge decomposition helps to explain several features that characterize each of the different economic regimes. Emphasis is given to the evolution of labor and capital wedge as well as factor productivity, which in this model is adjusted by capital utilization.

\(^1\)Methods similar to those of the basic Chari, Kehoe and McGrattan method have been applied to both the modern Japanese economy and the prewar economy by Hayashi and Prescott [2] and [8] and to the French economy by Prescott [11]. Cole and Ohanan [4] have applied the basic model ot the U.S. and U.K. and Cavalcanti [2] to Portugal.
2 The model with capital utilization

We assume that capital depreciation, \( \mu_t \), is a function of capital utilization. Let depreciation be

\[ \delta_t = \bar{\delta} \exp \left( a \left( \mu_t - \bar{\mu} \right) \right) \]

where \( \bar{\delta} \) is the average depreciation rate, \( a \) measures how strongly depreciation responds to capital utilization, and \( \bar{\mu} \) is the average utilization. This formulation produces the average depreciation rate whenever utilization is average and increases the depreciation with increased utilization. The technical parameter \( a \) measures how depreciation responds to non-average levels of utilization. With this minor addition, we write the CKM model as

\[ U = E_t \sum_{i=0}^{\infty} \beta^i u(c_{t+i}, h_{t+i}) \]

subject to

\[ c_t + k_{t+1} - (1 - \bar{\delta} \exp \left( a \left( \mu_t - \bar{\mu} \right) \right)) k_t = (1 - \tau_t^h) w_t h_t + (1 - \tau_t^h) r_t \mu_t k_t + T_t \]

and a production function of the perfectly competitive firms of

\[ Y_t = A_t (\mu_t K_t)^\theta \left( \gamma_t H_t \right)^{1-\theta} \]

The first order conditions for the firms are

\[ w_t = (1 - \theta) \gamma_t A_t (\mu_t K_t)^\theta \left( \gamma_t H_t \right)^{-\theta} \]

and

\[ r_t = \theta A_t (\mu_t K_t)^{\theta-1} \left( \gamma_t H_t \right)^{1-\theta} \]

Note that the rental rate, \( r_t \), calculated here is that paid on utilized capital and not on total capital, and this is taken into account in the household budget constraint.

The first order conditions for the households (who, in period \( t \), choose \( c_t, h_t, k_{t+1}, \) and \( \mu_t \)) are

\[ \frac{u_h(c_t, h_t)}{u_c(c_t, h_t)} = - (1 - \tau_t^h) w_t \]

\[ (1 - \tau_t^h) r_t = a \bar{\delta} \exp \left( a \left( \mu_t - \bar{\mu} \right) \right) \]

\[ u_c(c_t, h_t) = \beta E_t u_c(c_{t+1}, h_{t+1}) \left( (1 - \bar{\delta} \exp \left( a \left( \mu_t - \bar{\mu} \right) \right)) - (1 - \tau_t^h) r_{t+1} \mu_{t+1} \right) \]

Three period \( t \) shocks, can be found in terms of period \( t \) observations on the data from the first two of these first order condition and the production function as

\[ \frac{u_h(C_t, H_t)}{u_c(C_t, H_t)} = - (1 - \tau_t^h) (1 - \theta) \gamma_t A_t (\mu_t K_t)^\theta \left( \gamma_t H_t \right)^{-\theta}, \]

\[ a \bar{\delta} \exp \left( a \left( \mu_t - \bar{\mu} \right) \right) = (1 - \tau_t^h) \theta A_t (\mu_t K_t)^{\theta-1} \left( \gamma_t H_t \right)^{1-\theta}, \]
and

$$A_t = \frac{Y_t}{(\mu_t K_t)\theta (\gamma^t H_t)^{1-\sigma}}.$$ 

In addition, the resource constraint that must hold is

$$C_t + K_{t+1} + G_t = Y_t + (1 - \bar{\delta} \exp (a (\mu_t - \bar{\mu})) ) K_t.$$ 

Notice that with the extra choice variable of capital utilization, it is possible to extract all four of the time $t$ shocks using just time $t$ data on $C_t$, $H_t$, $K_t$, $G_t$, and $\mu_t$. $G_t$ come directly from the data on government expenditures and net exports. $A_t$ is calculated given output, the production function and the data on the capital stock, capital utilization and labor (along with labor productivity growth). $\tau^h_t$ and $\tau^k_t$ are then calculated from the two remaining first order conditions.

In the actual implementation, we take $K_0$ as given and calculate the sequence of gross investments, $K_{t+1} - (1 - \bar{\delta} \exp (a (\mu_t - \bar{\mu})) ) K_t$. Note that the capital stock path will depend on the parameter $a$ of the depreciation function. The sub-utility function used for implementation is

$$u(C_t, H_t) = \log C_t + \psi \log (H - H_t)$$

so

$$u_h(C_t, H_t) = -\frac{\psi C_t}{H - H_t},$$

$$u_c(C_t, H_t) = -\frac{\psi C_t}{H - H_t}.$$ 

To find the impact of each of the wedges independently, we use a system solver to find the values of $C_t$, $H_t$, $\mu_t$, and $Y_t$ as the zeros for the system

$$0 = -\frac{\psi C_t}{H - H_t} + \left(1 - \tau^h_t\right) (1 - \theta) \gamma^t A_t (\mu_t K_t)\theta (\gamma^t H_t)^{-\theta}$$

$$0 = a\bar{\delta} \exp (a (\mu_t - \bar{\mu})) - (1 - \tau^h_t) \theta A_t (\mu_t K_t)^{\theta-1} (\gamma^t H_t)^{1-\theta}$$

$$0 = A_t - \frac{Y_t}{(\mu_t K_t)\theta (\gamma^t H_t)^{1-\theta}}$$

$$C_t + K_{t+1} + G_t = Y_t + (1 - \bar{\delta} \exp (a (\mu_t - \bar{\mu})) ) K_t.$$ 

In each pass, three of the wedges are set to their average value, the initial capital stock and the sequence of investment from the data are used to calculate the paths of the four variables as they respond to this wedge.

$$\frac{\psi C_t}{(H - H_t) (1 - \tau^h_t) (1 - \theta)} H_t = Y_t$$

$$\frac{a\bar{\delta} \exp (a (\mu_t - \bar{\mu})) \mu_t K_t}{(1 - \tau^h_t) \theta} = Y_t$$

$$C_t + K_{t+1} + G_t - (1 - \bar{\delta} \exp (a (\mu_t - \bar{\mu})) ) K_t = Y_t$$

$$A_t (\mu_t K_t)^\theta (\gamma^t H_t)^{1-\theta} = Y_t$$
3 The data and the wedges

The data are quarterly and run from 1972.1 to 2006.4, a relative long period of time for studies of Argentina. The period has been characterized as one of economic and political turbulence.[1] From 1972 until the debt crisis of 1982, the period has been characterized as an alternation of so called "stop and go" policies and the "plata dulce" period that ends up in the debt crisis. The 80s can be characterized as inflation and hyperinflation period with various failed attempts to introduce stabilization programmes. The problem with inflation was only dominated in 1991, after the introduction of the "Convertibility Plan", a currency board system that characterized the decade until it collapses at the end of 2001. Finally, after that important social, economic and financial crisis, the economy has been recovering with singular impetus since 2003. Clearly, the economic outlook can be split between decades with particular characteristics, the 70s, the 80s, the 90s and the after 2001 crisis period. The wedges would be help to analyze each of these periods and their impact on capital, labor and productivity.

We use series on the real, per capita value of output, consumption (in this case, the combined private and public consumption), net exports, investment, and an index for capital utilization\(^2\). The pre-1993 data do not come with private and public consumption separated, so we assume that government consumption enters the utility function along with private consumption. Since government consumption is not available, the variable \(G_t\) in the above equations now only contains net exports. The series for the capital stock is constructed using

\[
K_{t+1} = Y_t + (1 - \delta \exp(\alpha (\mu - \bar{p}))) K_t - C_t - G_t,
\]

using a value of 21490 for the 1980.1 value of the per capita capital stock, calculating backwards to 1972.1 as well as forward to 2006.4. In the calculations we used \(\theta = .57, \delta = .06174/4, \gamma = 1, \bar{p} = 0.6878, \psi = .75, \) and \(\alpha = 1\). The depreciation series that comes from the function is shown in Figure 1. The time series for capital that come from the above calculations is shown in Figure 2. For the years that overlap, our time path for the capital stock is generally similar to the one in Kydland and Zarazaga [9].

Using this data, one finds \(A_t\) using equation 3, \(h_t\) using equation 1, and \(g_t\) from equation 2. The net export wedge, \(G_t\), comes directly from the data. The results of this calculation are shown in Figure 3.

Taking each of these wedges separately and using the mean value for the remaining three, one can calculate the importance each of the wedges has had in producing cycles in the Argentine economy. The contribution to Argentine output of each of the four wedges over the last 35 years are shown in Figure 4.

From the graph, one can see that total factor productivity factor, \(A_t\), captures the long term cycle that is comprised of the decline of the 1980’s, the

\(^2\)The index on capital utilization comes from FIEL. The other data comes from INDEC except that output is defined from the national income accounting identity, \(Y = C + I + G + \text{net}X\).
Figure 1: Depreciation

Figure 2: Calculated capital stock
growth of the 1990’s and some of the crash and recovery of the 2000’s. In addition, it captures most of the seasonal movements in the data, which can be characterized as a large annual fall in the first quarter (mostly caused by vacations). It is interesting to note that there is a peak in the total factor productivity factor in 2002, since the decline in labor and capital utilization meant that the factors still being used were highly productive. The part of the business cycle explained by net exports is quite small, although it does capture a slow decline until around 1993 and a gradual rise thereafter. In addition, net exports adds a small seasonal component that mostly reinforces the one found in total factor productivity.

The bottom two graphs in Figure 4 show the effects of \( \tau^k \) and \( \tau^h \). The capital wedge captures a number of important events in Argentine economic history. Capital clearly suffered from the hyperinflations of 1989 and 1991 as well as the inflation leading up to the Austral Plan in 1985 and the debt crisis of 1981-2. Interestingly, capital did not seem to suffer from the Tequila crisis during 1995, where the main changes seem to be reflected in the labor wedge. It also very clear suffered from the 2002 crisis and recovered to a level similar to that before the crisis. The output growth in the last few years does not see to come from capital. The labor wedge shows that labor had a long slow decline during the 1980’s, although much less sensitive to business cycles than capital, suffered in the hyperinflations at the beginning of the 1990’s, recovered a bit after that and was heavily hit by the Tequila crisis of 1995. This is consistent with the big jump in unemployment observed in the mid-1990’s. The 2001 – 2
Figure 4: Effects of the four wedges on output
The effects of each of the wedges on \( C \), \( \mu \), and \( H \) are shown in Figure 5. As one might expect, given the importance of output in determining consumption, the effect of each wedge on explaining consumption is very similar to its effect on explaining output. The effect of net exports, the unlabeled line in each graph, is small in all cases, although it is a bit more important, and seasonal, in explaining labor movements. In explaining capital utilization, it is not surprising that the capital wedge captures some important movements, especially the drop in 2002. Technology, \( A \), captures long trends in the capital utilization as well as some seasonals. The labor tax wedge does not explain much of utilization, although it does reenforce the decline in the 2002 crisis.

As one might expect, most of the movement in employment is explained by the labor tax wedge. The net export wedge provides a bit of a seasonal and a bit of long term movement, however, this is small. The impact of the technology (\( A \)) wedge and the capital wedge on labor are very similar, so much so that they cannot be very well separated in the graphs.

4 More detailed historical analysis of the growth accounting exercise for Argentina

The impacts of the wedges on output is shown in Figure 4. The effects of total factor productivity captures much of the long term movement in output: the long decline of the 1980's, the growth for most of the 1990's and the decline that began in the late 1990's. One of the more interesting short run components of \( A \) is the rise in total factor productivity beginning in 2004 and continuing until the end of the sample. The effects of the net exports wedge on output follows a similar overall path but with much smaller impact on output. The capital tax wedge moves output quite differently, causing it to rise for much of the first third of the sample, then a decline and ending up pretty flat for the second half of the time period. The effects of the labor tax on output over the long run is pretty flat.

Major crises have occurred with certain regularity in the period under consideration. A serious inflation in 1975-6 was followed by a military coup (a potential regime change\(^3\)). A period of an overvalued peso (known as the Tablita) was followed by a foreign exchange crisis. The return to democracy witnessed high and rising inflation that in 1985 was met with the Austral plan. The transition from the 1980s to the 1990s suffered two hyperinflations. A banking crisis in 1995 resulted in the closing or consolidation of much of the banking system. The recession that began in late 1998 became a full blown banking and exchange crisis in 2002. Each of these crisis events can be noted.

\(^3\)Zablotsky [12] looks at military coups in Argentina as regime changes with democratic periods raising taxes on land and military regimes lowering them,
Figure 5: Effect of each wedge separately on $C$, $\mu$, and $H$
in Figure 4, with greater or lesser short term impact on output. What is of interest is how these crisis differed and what our wedges can tell us about how they were different.

The return of Peron to power in 1973 is marked by a sharp decline in the labor tax and a relatively small decline in total factor productivity as seen in Figure 3. The labor tax returns to its original level with the military coup of 1976 and stays high for most of the time the military is in government (it falls at the end of the period as the military is leaving government). There is a steady fall in the capital tax over the military period that is accompanied by a secular decline in total factor productivity. The overvalued peso of the Tablita permitted capital accumulation and is observed in the positive effect of net exports on output in the period just prior to 1980. This capital accumulation is also indicated in the increase in output from the capital tax but does not show up in total factor productivity.

The low level of the tax on labor continues throughout all of the Alfonsin presidency. During the first part of this period, total factor productivity continues to fall and then stays low for the second half of the 1980’s (the so called "lost decade"). The tax on capital rises for most of this period, although with substantial variation. The effects of net exports on output are relatively constant over the Alfonsin period. The hyperinflation of 1989 generates rises in net exports (as imports fall) and increases in the capital tax, but has little effects on the labor tax or on total factor productivity.

The hyperinflation in 1991, at the beginning of the Menem period, was somewhat different from that of 1989. The effects of both the capital and labor wedge on output are negative and the tax on capital was particularly high. It is also one of the peaks of the net export wedge. The beginning of the convertibility period\(^4\) is marked by a fall in the tax on labor (and a increase in output from the labor wedge) and a secular rise in total factor productivity. The Tequila crisis of 1995 hit labor hard but had almost no effect on the other wedges. This is consistent with the large increases in unemployment that accompanied and followed that crisis.

The general trend of the recession of 1999 to 2002 and the recuperation after is captured in the net export wedge. The crisis of 2002 hits both the labor and capital wedges hard, with sharp increases in the wedges and sharp declines in the part of the business cycle explained by these wedges. These two effects are so sharp that total factor productivity actually rises during this crisis. The recovery during the Kirchner period comes from a large reduction in the tax on labor and an increase in total factor productivity. The tax on capital increases to a level similar to the Peron period at the beginning of the sample (the mid-1970’s) and net exports decline modestly. In Figure 4, the effect of both the labor wedge and factor productivity are the highest over the sample and the effect of the capital wedge is a small decline after the initial recuperation from the 2002 crisis. These results are consistent with the perception that the Kirchner government looks to benefit workers at the expense of owners of

\(^4\)See Baer, Elosegui and Gallo [1] for a detailed explanation of the convertibility plan.
5 Conclusions

The growth accounting technology provides another window through which we can decompose the economic history of a country. The narrative of economic history frequently points out that particular policies were favorable to one or another factor or that much of the evolution of the period was based on Solow residuals or total factor productivity. The growth accounting technique allows us to decompose the business cycle and growth of Argentina into a net export component, a total factor productivity component, and components that function as taxes on labor and on capital.

This paper makes two contributions to the literature. First, we provide a method for extracting the wedge that functions as a capital tax by adding to the model capital utilization as a household decision variable and then applying the data on capital utilization to the wedge extraction process. With this method, the wedge for the tax on capital makes a substantial contribution in explaining the business cycle of Argentina (while the earlier method resulted in very little explanatory power for the capital wedge for the United States). This result may come from the method or may come from the greater importance that the capital wedge has in Argentina. This is for further study. The second contribution is applying this method to Argentina and comparing the results of the growth accounting technique to the narrative history.

References


A particularly fine work on total factor productivity in Latin America is by Elias [6].


