Estimating Potential Output: Argentina 2003-2011, Medium Term Quarterly Calculations of the Production Function.

Mathew Bradbury, Queens College, CUNY
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Abstract:

A measure of the output gap and potential output is essential for macroeconomic policy surveillance and inflation forecasting. Argentina has been highlighted as a likely candidate for overheating in recent years. Many point to the pro-growth, labor and income distribution policies of the government in generating this overheating. A critical step in analyzing the effect of the current policy mix on the sustainability of growth in Argentina requires calculation of the output gap. This paper uses the production function method and the Hodrick-Prescott filter to calculate potential output and the output gap for Argentina. Data from international and country sources is compiled into a quarterly series used to make this calculation. Broad trends in labor, capital and total factor productivity are discussed. The results indicate that a large output gap is not manifest from Argentina's last decade of high growth.

Argentina's inflation figures have been widely discredited. This paper uses official estimates of inflation as a necessity in constructing real GDP and capital stock. Recent work has shown that although the level of official inflation statistics is too low, its variability is closly matches by more honest private estimates.(Cavalo, 2012) For this reason, real GDP will be overestimated, Trend GDP will be overestimated. But the gap should be relevant. So too should the gap and the inflation dynamic, which in this analysis is not strong. The correlation between the output gap and inflation was estimated to be .26, very weak. This suggests that the demand explanation for inflation is also weak.

Introduction:

Most macroeconomic policy decisions require distinguishing between cyclical and trend states of the economy. This is especially important in understanding policies that are meant to address the cyclical state of a macroeconomy. No less important is addressing the impact of structural or institutional change on the economy's long run ability to grow. The component of GDP which is cyclical must be distinguished from that which is structural, or long term. By convention, the level of output prevailing in the long run is referred to as *potential output*. The distinction between cyclical and potential output is difficult because potential output is unobservable and must be estimated. Choosing the appropriate cyclical and structural policy mix relies on knowledge of potential output. In these discussions a good estimation of the output gap is the difference between management and mismanagement of the economy, overheating or eliminating cyclical slack. Because potential output is not a static concept but one that changes in response to demographic, technological, structural and historical conditions, it warrants occasional scrutiny. The state of potential output is relevant in general but in periods such as the global financial crisis one may also question whether or not potential output has been effected, by hysteresis through degradation of labor or capital.

While Argentina has suffered from the global crises, the impact has been mitigated. Some attribute this to the macroeconomic policies of the country. Others highlight historical accident: being largely cut off from capital markets following default, they suffered less exposure and less contagion. Whatever the case may be, hysteresis from exposure to protracted recovery does not seem to be a pressing question regarding the state of Argentine production. On the other hand, the stance of macroeconomic policy has been unapologetic focused on labor policies, subsidies and capital restrictions the goal of which is to achieve more equitable results in terms of income distribution, poverty, economic growth. Naysayers point to overheating and inflation in decrying this and other policy stances that buck the status quo. The question becomes, whether or not these policies result in a fleeting and fragile success- dependent upon preserving price rigidities and vulnerable to the effect of inflation on real income and wealth. Or whether they represent a sustainable policy mix for the economy-generating lasting change.

In truth, answering these questions requires analysis that goes beyond the estimation of potential output. But before moving into the construction of a Philips Curve and overall policy discussion, it is a necessary place to start. This paper provides a calculation of potential output that is as up to date as current data allows. The calculation utilizes quarterly data, seasonally adjusted, whenever possible. In order to avoid the structural break that was the sovereign default the calculation focuses on the period after 2003. Because of this time span chosen, the reader may regard it as a *medium term* view of potential output. The calculation is reliable in the sense that its methodology is largely conventional. In addition to the calculation of potential output and the output gap trends in TFP, labor and capital accumulation are discussed.

Calculation of Potential output

Being unobservable the measurement of potential output must be approached from a statistical/econometric manner or calculated from methodology rooted more closely to strictly economic methods. This paper, as is the standard, follows the latter approach. The production function approach avoids several problems associated with a statistical regression. First, capital and labor variations tend to be endogenous with total factor productivity. Second, capital and labor are fraught with measurement difficulties and definitional issues leading to inconsistent coefficients.(Gutierrez, 2005)

The calculation of potential output using the production function approach requires some concept of “normal” labor utilization and therefore can be used to discuss concepts of the NAIRU, the

Phillips Curve, and the competing claims model of inflation, thus fitting nicely with other research that hinges upon the results.

Using the production function approach to establish potential output is a method that arises from economic theory requiring a foundation of economic assumptions. The most notable of these assumptions regard the nature of the production function and returns to scale. Herein the standard Cobb-Douglass (CD) production function is used. This production function exhibits constant returns to scale (CRS) and constant unit elastic factor prices.[1]

(1) $$Y_t = A_t K_t^{(1-\alpha)} L_t^{\alpha}$$

The standard CD production function is familiar in equation (1) where, current values of TFP (A_t), capital stock (K_t), and labor (L_t) are denoted. Under CRS and perfect competition, the elasticities of capital $(1-\alpha)$, and labor (α) can be estimated from the wage share.[2] . The CD production function provides the theoretical foundation for calculating output at any given time. In order to calculate potential output we must find "normal" or trend values for our input variables including TFP. This requires smoothing the variable's path, eliminating cyclical components. The method chosen for this is the uni-variate Hodrick-Prescott (HP) filter and is the standard approach in the literature. The particular way in which the HP filter has been applied to labor and TFP are discussed below, together with a brief description of the variables constructed.

Capital:

The measure of capital stock used includes spending by private and public entities. The capital stock series is estimated from Gross Fixed Capital Formation (GFCF) series compiled by the World Bank in the World Development Indicators database. Theoretically, capital stock need not be smoothed, since it is likely that even though net investment may be very volatile, it is quite small relative to the level of capital stock. However, GFCF are available only as annual data. When conducting quarterly calculations these discrete jumps in capital stock figures generate distortions to the Solow residual, output gap and change in potential output. For this reason the annual capital stock series has been smoothed using an HP filter prior to the calculation of the Solow residual.[3] Consistent with standard procedure in growth accounting literature, this paper paper calculated capital stock index using the perpetual inventory method (PIM). In this method, capital stock is simply the accumulation of past investment flows adjusted for depreciation and is represented in equation (2). This method requires that we establish an initial year from which to apply our perpetual inventory method in accumulating capital stock. There are competing methods for setting capital stock in this initial year. This papers follows the work of Harberger (1978) which assumes a constant capital-ouput ratio in a given time. The growth of capital and output are equal in that period, thus capital in the initial year can be given by (3) where g is an average growth rate of output and δ is taken as rate of depreciation.(Nehru, 1993)

(2) $$K_t = I_t + (1-\delta) K_{t-1}$$

(3) $$\frac{(K_t - K_{t-1})}{K_{t-1}} = -\delta + i_t / K_{t-1} \quad \text{or} \quad K_t = \frac{I_t}{g+\delta}$$

1 While the production function method does not require making statistical assumptions on the properties of the time series inputs, it does require assumption on the functional form of the production function and its properties. These include constant returns to scale and factor price elasticity that sum to one.

2. Given assumptions of CRS and perfect competition, these elasticities can be estimated from the wage share. For this paper Argentina's labors wage share has been estimated $\alpha = .5561$.

3 Capital stock was also calculated using the PIM method applied to quarterly investment data. The results are extremely similar indicating that the smoothed GFCF would be a suitable input.

The initial year chosen was 1983 and the PIM was used to build the capital stock series from this date. The growth rate chosen for this calculation was average GDP growth from 1983 to 1987. The depreciation rate is assumed constant at 4%. Further refinements of this calculation may include separation of residential housing from other physical capital but are beyond the target scope of this paper.

Labor:

As the economy experiences cyclical fluctuations, the unemployment level can be expected to respond. One difficulty, and advantage of the production function method, is that we must find some measure of "potential" labor hours. This will provide us with our labor input but will also provide a theoretical link to a non-inflation accelerating level of unemployment. To arrive at "potential" labor the ultimate measurement would be the number of "potential" labor hours worked. While this is the ideal approach, it suffers from the practical problem that hours worked are data not typically available for many countries, including Argentina. Consequently, we are forced to use number of people as the labor input rather than labor hours. Making this choice requires the implicit assumption that there is little variation in the average number of hours worked. If this is not the case, the variation will be captured by the estimation of TFP from the Solow residual.(Barbosa-Filho, 2004) In the absence of a weighted index of labor quality, the TFP residual will also capture effects from real world labor heterogeneity. Being that many important elements of the labor market and its evolution are, by this method, not isolated but instead captured together with other factors within TFP, it obscures our view of labor market utilization trends that may be of interest in their own right. Consequently, they must elsewhere be given special attention.

The calculation of labor (L), equation (4) is derived from multiplying the labor force by the employment rate. Our labor force is calculated from the working age population ages 15-65, (POPW) and the labor force participation rate (PART). The derivation of potential labor (LP), equation (5), utilizes the HP filter to isolate trend behavior. In this paper the HP filter is applied to both the labor force participation rate, now filtered (PARTHP) and the unemployment rate (UHP).[4] As an alternative, an estimate of the natural rate of unemployment might be used. A natural rate of 13% has been used in recent IMF research. (Ball, De Roux & Hofstetter, 2011)

$$(4) \quad L = (POPW * PART(1-U))$$

$$(5) \quad LP = (POPW * PARTHP * (1-UHP))$$

Total Factor Productivity

Given the opacity of our labor and capital contributions to output, TFP necessarily captures elements of heterogeneity and productivity differentials. From equation (1), TFP can be represented as the utilization $(U_L^{\alpha} U_K^{1-\alpha})$ and efficiency rates, $(E_L^{\alpha} E_K^{1-\alpha})$ of labor and capital, equation (6). In the absence of direct measure for these factors this papers calculates TFP from the Solow residual. Estimates of trend TFP are estimated via the application of an HP filter to the residual once it has been calculated, equation 6. Using (6) for calculating TFP leaves us open to two errors highlighted by equation (5). If capital is not utilized to full capacity, then changes in capacity utilization show up in the measure of TFP. And, as discussed, measuring labor as a head count rather than hours worked forces cyclical changes in the labor market to be bound up in TFP. These issues are more problematic in a

4 In addition the HP filter has been applied to the working population. This precaution is employed because working population data is only available on an annual basis. Smoothing allows us to avoid unnecessary volatility in fourth quarter calculations.

short run analysis; in the long run, they tend to balance out.

$$(6) \quad TFP = (E_L^{\alpha} E_K^{1-\alpha})(U_L^{\alpha} U_K^{1-\alpha})$$

$$(7) \quad TFP_t = \frac{Y_t}{L_t^{\alpha} K_t^{1-\alpha}}$$

Following from the above, potential output is calculated utilizing the HP smoothed series described above. Equation (8) expresses the formulation of the calculation used in this paper.

$$(8) \quad YP = TFPHP[(POP * PARTHP(1-UHP))^{\alpha} K^{1-\alpha}]$$

Results

Results from the calculation of the output gap are posted in Figure 1. The time span shown points to Argentina's recovery from two major shocks and tenacious maintenance of growth: First, the currency and debt crises of 2001, and second, the global financial crises in 2008. The plunge in 2008 was due to the global financial crises. It is remarkable how quickly Argentina was able to recover from this external shock while many of the western economies languish. The economy was not overheating in late 2007, and, by this measure, is not overheating now. From the calculations it can be seen that the output gap peaked in 2007 and again in late 2008. According to official data from WDI, consumer prices peaked in 2006 at 10% and the deflator peaked in 2008 at 19%.[5] However, current arguments regarding overheating seem overblown as the output gap hovered around 1% in late 2011. In fact, the average output gap was -0.17% over the period dating back to 2003. And yet, when one thinks of Argentina during this period one thinks not only of miraculous recovery, but also of historically high growth rates.

Average growth rates for various periods are reported in Table 1. The average growth rate of GDP was 7.76% from 2003-2011. During the 90s it stood at 4.5% and dating back to 1980 the average growth rate was 2.86%. One might be tempted to interpret the historically high growth rates of the last decade as indicative of overheating. However, when contrasting these periods one must recognize that the 80s was a lost decade for most of Latin America. During the 90s the macroeconomic policy was myopically focused on inflation rather than economic growth. If the figures suggested by Argentina's current growth and strong estimates of potential output are accepted we see a picture of an Argentina that is awakening from long periods where policy repressed long run potential.

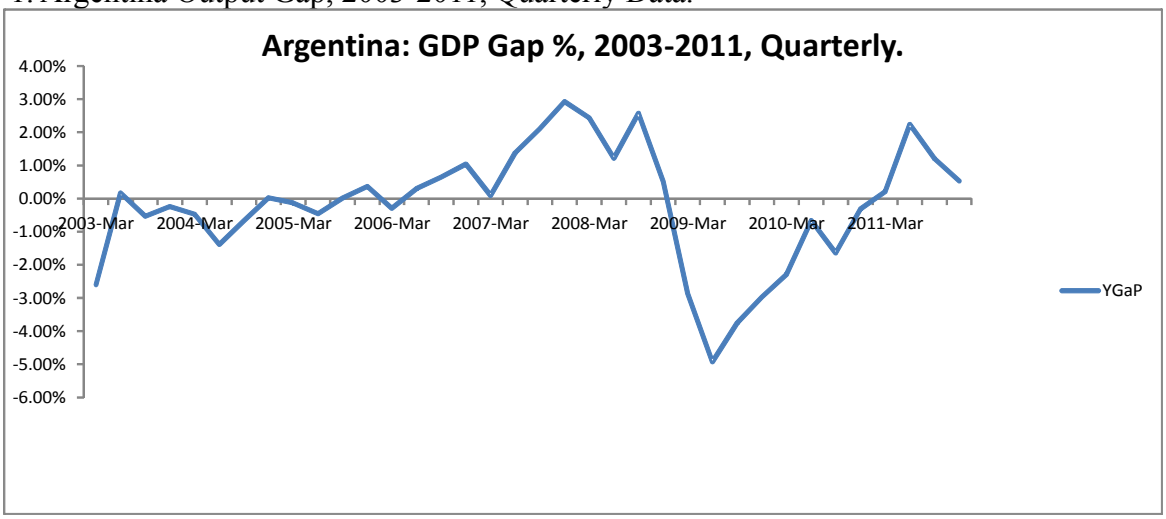
5 There has been widespread criticism of the official inflation data. Charges have been levied that true inflation runs at least double official estimates.

Table 1. Argentina: Period Growth Rates, Annual Averages.

	Average growth rate GDP
2003-2011	7.76%
1990-2011	4.50%
1980-2011	2.86%
1990-1999	4.52%
1980-1989	-0.73%

Source: WDI/GDF Database, World Bank

Figure 1. Argentina Output Gap, 2003-2011, Quarterly Data.



The standard growth accounting model indicates that there have been some remarkable changes in the production capacity for Argentina during the last 10 years. Average quarterly growth rate for GDP is 1.88% and the average quarterly growth rate of potential GDP derived from the model is 1.79%. This indicates that, other than through 2007 and 2008, unprecedented economic growth has been facilitated by unprecedented growth in factor supply and productivity. However, this view must be tempered by the limitations of the model: since TFP is calculated as a residual, and this residual is quite dominant, movements in GDP are largely mirrored by movements in TFP. As such, the Solow residual is often referred to as the measure of our ignorance rather than a measure of productivity.

A simple growth accounting exercise was conducted to view the contributions of each growth factor. The calculation used is standard and reported by equation 9. Lower case letters representing the percentage change in each variable and coefficients representing the relevant factor shares. The interpretation of the equation is that the percentage change in potential output is equal to the summation of change in each contributing factor. Labor and capital being adjusted according to their respective marginal products. Since we are here accounting for potential output, the HP filtered trend variables are used where appropriate.

(9) $$y_t^{pot} = a_t^{hp} + \alpha l_t^{hp} + (1-\alpha) k_t^{hp}$$

In terms of standard growth accounting the contributions of TFP, labor and capital stock accumulation are reported in table 2. The lions share of the change in potential output shows up in the contribution of TFP.

Table 2. Accounting for growth in potential and real output. Argentina, 2003-2011 Quarterly, period averages growth rate.

Potential Output	TFP, HP	Labor, HP	Capital Stock, HP
1.75%	0.91%	0.35%	0.50%
Actual Output	TFP	Labor	Capital Stock, HP
1.88%	0.95%	0.37%	0.50%

From 2003-2011, potential output grew at a quarterly average growth rate of 1.75%. Actual GDP over the same period grew at a quarterly average of 1.88%. When annualized these figures are consistent with Argentina's annual growth rate. Growth accounting at a quarterly scale yields similar results when accounting for actual output.

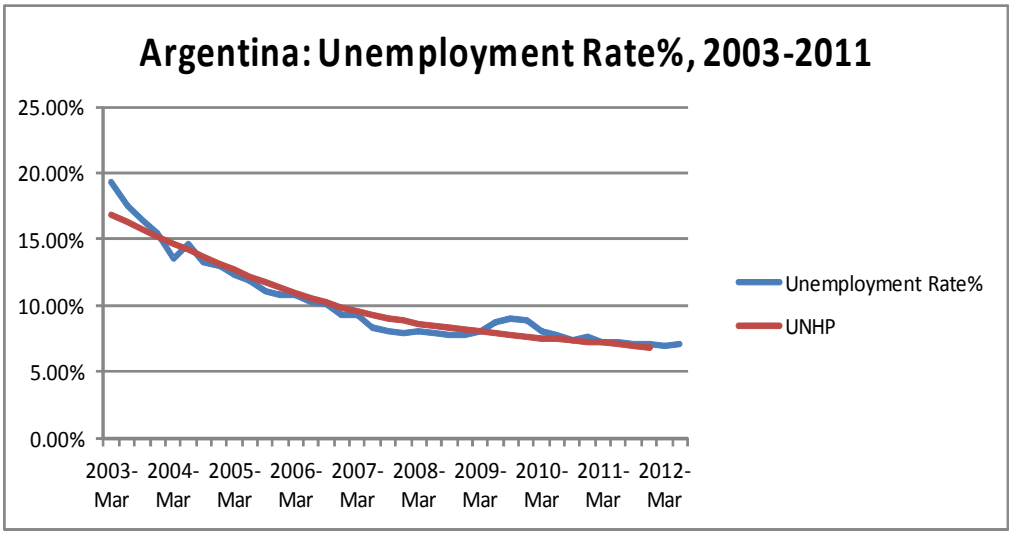
Table 3. Argentina. Unemployment, Labor Force Participation Rate. Annual Averages, Percent.

Period Averages	Unemployment %	Labor Force Part. Rate%	Inflation, GDP Deflator%	GDP growth rate%
1980-1989	N/A	N/A	566.74	-0.73
1990-1999	11.98	64.46	222.22	4.52
2003-2011	9.91	68.44	13.1	7.76
1993-2003	15.2	64.65	3.77	1.43
1980-2011	9.63	N/A	N/A	N/A

Source: WDI, World Bank.

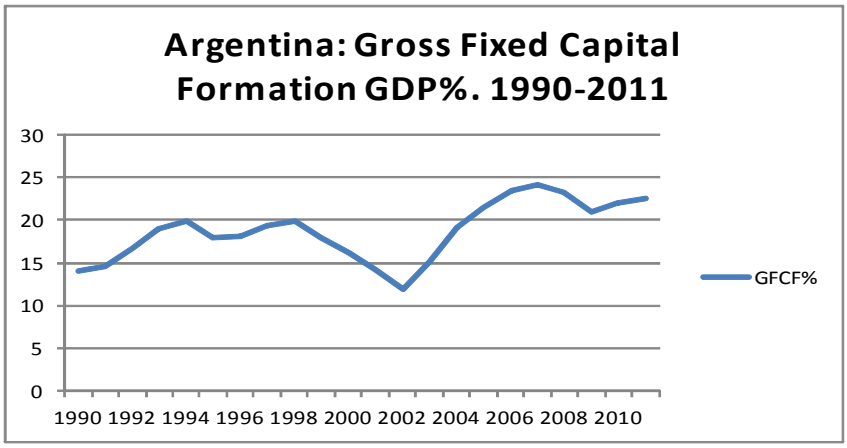
Table 3 reports on important labor utilization averages by period. Argentina's average unemployment rate over the most recent period, 2004-2011 is not uncharacteristic of its economy when viewed over three decades. Average unemployment was higher in the 1990s by 2% during the convertibility regime. Before one begins to consider this normal range of unemployment as one that is consistent with stable prices it must be remembered that inflation ran in the triple digits through the 80s up until 1993. The 80s was a lost decade of hyper stagflation. A view of the prevailing unemployment rates alone is not sufficient to indicate overheating especially if other factors in the economy warrant this level of labor utilization without wage-price spirals. The 80s, 90s and current period in Argentina all operate under very different structural, fiscal and monetary regimes. Perhaps the more important change viewed in recent data for Argentina is not the unemployment rate itself but this together with the 6.17% increase in the average labor force participation rate. Together, these factors have a compound effect on reducing the supply side constraint on the labor market. The effect is that if productivity is rising or if there is slack then potentially, unemployment could decline without placing upward pressure on wages. Actual and HP trended unemployment rate from 2003 are reported in Figure 2.

Figure 2. Actual and HP Trend Unemployment rates, Quarterly, 2003-2011



The capital stock series was calculated back to 1980 using Gross Fixed Capital Formation, GFCF. Figure 3, shows GFCF as a percentage of GDP since 1990. One can clearly see the reduction in GFCF in the late 90s as Argentina struggled to stay current on rising debt service costs running up to default. After default Argentina has been able to push capital formation up to 23% of GDP, and sustain these rates through the global financial crises.

Figure 3: Argentina Gross Fixed Capital Formation as a Percentage of GDP, 1990-2011.



Source: WDI, world bank. Annual data.

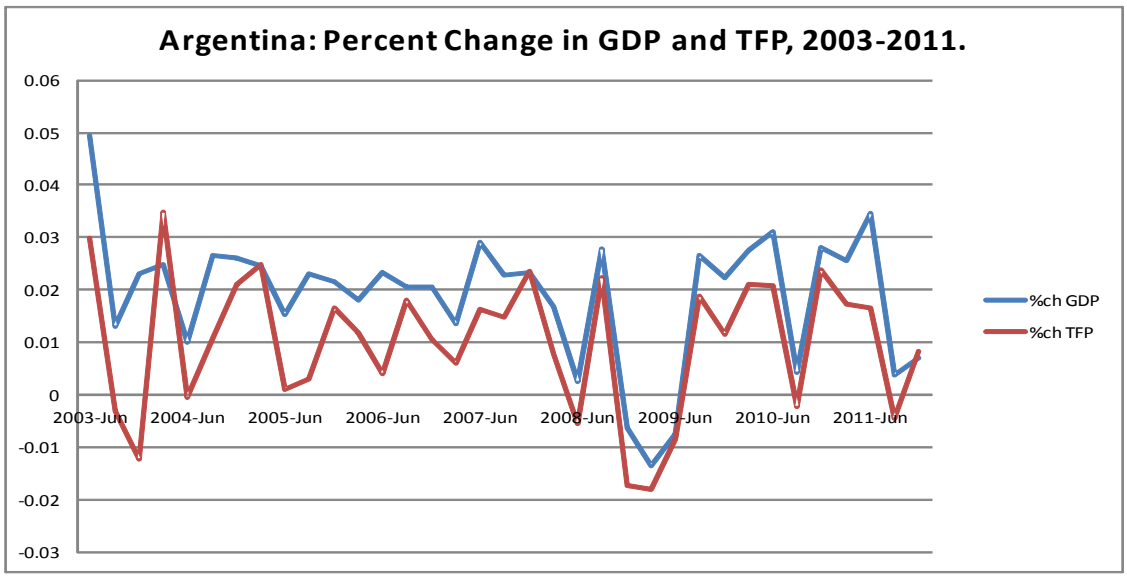
Positive trends in both labor and capital factor inputs bode well for sustained growth in Argentina, but as is typical of growth accounting exercises, TFP plays the largest role.

Theoretically, TFP should capture productivity changes and the data would suggest strong consistent productivity gains for Argentina over the period. The limitations inherent in our factor measurement of labor and capital also are captured by TFP. These elements relate to the utilization and efficiency of labor and capital. Labor utilization is captured by our unemployment rate. However, heterogeneity of labor (a ditch digger vs. an engineer) will not be captured by our head count measure of labor. Similarly, our measure of labor does not account for hours actually worked. Nor does it account for the degree of underemployment in the economy or other misutilization of labor skills. With

respect to capital TFP will capture heterogeneity in the quality of technology. An office chair and a computer have very different marginal products. In addition, our measure of capital stock by itself does not account for less than full utilization. And at its core the model assumes perfect competition. This assumption allows us to use labor share of income as our measure of factor marginal products.
If the underlying economy is monopolistically competitive wages can not be expected to equal marginal product and thus the wage share will not capture this coefficient on labor. The differences must then be absorbed in TFP. Empirically TFP has performed notoriously badly at capturing the digital revolution and is suspect when it comes to being viewed as a reliable indicator of technology.

In this context of understanding TFP it requires note that there are two interpretations of this Cobb-Douglas based model. The first is that potential output is determined by supply side forces alone. In this case, Argentina's great improvements in TFP, labor utilization and capital accumulation have facilitated a small output gap even while the economy grows at high rates. Another interpretation is that TFP is endogenous to the model. In this, more Keynesian reading, causality runs from real income to TFP. This later perception of TFP fits better with the manner in which it is calculated, as the residual unexplained by labor and capital factors as measured.

Figure 4: Argentina, Change in GDP and TFP, Percent, 2003-2011.



Conclusion

Potential output and therefore output gaps are unobservable measures and must be either statistically estimated or calculated from theoretical models. Yet, a measure of potential output is essential to macroeconomic surveillance, and as a measure for policy impact. The concept of the output gap is of particular importance when considering the topic of inflation and its macroeconomic genesis. Positive output gaps signal that aggregate demand pressure may be overheating the economy and that rising factor costs may soon generate a correction.

There has been much discussion and criticism levied against the sustainability of the recent period of growth in the Argentine economy. Critics have asserted that rogue macroeconomic management policies have led to low unemployment, misaligned currency and high inflation, indicating that the economy is overheating.**(**IMF, 2011**)** Others assert that the pro-growth policies of Argentina's government have resulted in remarkable improvements in employment, income distribution and poverty reduction. Proponents also assert that maintaining these gains need not be unsustainable.

(Weisbrot, Montecino & Kozameh, 2011) All of these positions hold that inflation in Argentina is worrisome. They differ with respect to how severe a threat the rate of inflation poses to the economy and whether or not it is prudent to sacrifice growth in order to achieve lower inflation.

The calculation of the output gap can only take us so far in an analysis of policy and inflation. The next step would be to view of the Phillips Curve, and scrutinize monetary policy. But, a measure of the output gap allows us to get some idea whether or not aggregate demand pressures may be generating inflation that is consistent with macroeconomic overheating too much short run income chasing to few short run goods. Theoretically, sustained positive output gaps should lead to wage-price spirals as the economy corrects to long run factor utilization and output levels.

The theoretical underpinning of this process can be seen in the standard Phillips Curve or a Phillips curve derived from monopolistic competition and bargaining process for determination of the real wage.

It is indisputable that Argentina is experiencing inflation. Whether it is 10% or 25% matters. Knowledge of the long run anchor of potential output helps us determine what is driving that inflation.

Accepting the basic concepts of the Phillips curve indicates that inflation may be demand led when an output gap is persistent. But during factor price correction the output gap may be falling while prices continue to rise.

The calculation of potential output conducted here reveals positive trends in the economy's ability to harness and use its capital and labor resources. Argentina has been able to bring more people into the labor force while keeping unemployment rates consistent with historical levels. Argentina's ability to increase the labor force participation rate will reduce inflationary pressure from economic growth through relaxing the supply constraint on the labor market. While real wages have been rising, there is some evidence from the model that this may be justified by pronounced gains in TFP. Current rates of capital accumulation, with gross fixed capital formation around 23% of GDP should bode well for capital deepening through this decade. And elevated TFP figures may indicate that utilization of capital is high. Each of these developments support growth and the perspective that these improvements have influenced not just current output but the economy's potential output. However, the inflation question still looms. The concern is not whether potential output is consistent with 5% inflation or 15% inflation. The concern is whether or not these estimates of potential output are consistent with non-accelerating inflation. The underlying model asserts that that is exactly how potential output should be interpreted. If we do so, we see that it was late 2007 when worries regarding overheating may have been appropriate. The global financial crises certainly restrained overheating pressures by 2008. And most recently, late 2011, the output gap was only around 1% and falling. If current inflation is still rising, while the growth rate slows slightly, we might interpret that the correction is already underway. Yet, the impressive growth in potential output indicates that this correction may take place without a dramatic slowdown of the Argentine economy.

Authorities may do well to trust in their own policies. This would require removing rigidity in some macroeconomic nominal prices -particularly the exchange rate.

Reference:

Francesca D'Auria, Cecile Denis, Karel Havik, Kieran Mc Morrow, christophe Planas, Rafal Raciborski, Werner Roger and Alessandro Rossi. “Production function methodology for calculating potential growth rates and output gaps.” European Commission. Directorate General for Economic and Financial Affairs. ISBN 978-92-79-14906-1

Ball, Laurence. De Roux, Nicolas and Hofstetter, Marc. “Unemployment in Latin America and the Caribbean”. WP/11/252. IMF

Barbosa-Filho, Nelson. “Estimating Potential Output: A survey of the Alternative Methods and Their applications to Brazil.” ECLAC, LC/BRS/R.152. September, 2004

Cavalo, A (20120) Online and Official Price Indexes: Measuring Argentina's Inflation. M.I.T.

Harberger, A. (1978). “Perspectives on Capital and Technology in Less Developed Countries”m in M.J. Artis and A.R. Nobay (eds.) *Contemporary Economic Analysis* (London; Croom Helm)

IMF, (2011). *Regional Economic Outlook: Western Hemisphere Watching Out for Overheating.* World Economic an Financial Surveys. IMF, april, 2011.

Meinen, Gerhard. Verbiest, Piet, Wolf Peter-Paul. 1998. “Perpetual Inventory Method: Service Lives, discard Patterns and Depreciation Methods.

Harberger, Arnold (1998), “A view of the Growth Process”. The American Economic Review 1-32 (March).

Nehru, Vikram and Dhareshwar, Ashok. “A New Database on Physical Capital Stock: Sources, Methodology and Results. *Revista de Analisis Economico,* Vol. 8. No(1) pp 37-59. Junio, 1993.

Hofman, Andre' (2000), “Standardized Capital Stock Estimates in Latin America: a 1950-94 update”, *Cambridge, Journal of Economics,* No. 24.

De Masi, Paula. (1997) “Estimates of Potential Output: Theory and Practice”. IMF, WP/97/177.

Hodrick, R.J. And E.C. Prescott (1980), “Postwar US Business Cycles: An Empirical Investigation,” Carnegie-Mellon University, Department of Economics, Discussion Paper No. 451.

IMF (1996b) World Economic Outlook October

Weisbrot, Mark. Ray, Rebecca, Montecino, Juan and Kozameh, sara. (2011) “The Argentine Success Story and its Implications.” CEPR

Gutierrez, Mario (2005),Economic growth in Latin America: the role of investment and other growth sources