CYCLES, AGGREGATE DEMAND, AND GROWTH

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Abstract: This paper discusses the possible relations between cycles, aggregate demand shocks and growth and proposes a simple time series method for analyzing this statistical relation that endogenizes the impact of cycles on the definition of trend output. We apply this method to analyze the cases of the US, Germany and the UK and find that cycles do seem to have a strong impact on trend output but this impact is different for the three economies in question.

Keywords: Growth, business cycles, asymmetric time series.

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1. Introduction

Growth theory has focused on the causes of increases in the levels of per capita income from a perspective that assumes that, generally, the business cycle has no role to play. This assumption eliminates any influence of cyclical behavior stemming from aggregate demand and nominal shocks on the long run performance of nations. That is, growth theory is a theory of *potential output growth*. This contrasts with the more policy oriented and popular view that good macroeconomic management is a pre-condition for healthy and sustainable growth in the long-run. The question then arises as to whether demand shocks and other determinants of the business cycle do have a role to play in determining the level of potential output.

The relation between cycles and growth is not a new issue in macroeconomics, but revived interest on it arose as a consequence of the development of the endogenous growth models of Romer (1986 and 1990), Lucas (1988) and Aghion and Howitt (1992). Back in the 1960s and 1970s this relation was also tackled within Keynesian frameworks by authors such as Kaldor (1966 and 1970) and Thirlwall (1979). The Real Business Cycle (RBC) literature, on the other hand has continued to assume that business cycles do not affect potential output, hence eliminating non-linearities arising in the decomposition of shocks.[1] Recently, with the development of new datasets and econometric techniques, authors such as Malley and Muscatelli (1999) and Pedersen (2003) have attempted to unveil statistical relations between cycles and productivity.

The issue has obvious implications for macroeconomic policy because, if potential output depends on the state of the cycle, *output gaps* will also do. Anti-inflationary policies based on output gap indicators within Phillips Curve or Taylor Rule frameworks would need to look into these issues. This is of special relevance within the Euro area given the way macroeconomic policies are designed and constrained with a strong monetary policy-dominance. A close look into these issues would require an analysis of the role that labor market and goods market rigidities play in the direction and strength of the relation between cycles and growth. Our aim in this short paper is to show the possible relations between cycles, aggregate demand shocks and growth and devise a simple method for analyzing this statistical relation that endogenizes the impact of cycles on the definition of trend output. We apply this method to analyze the cases of the US, Germany and the UK. We found that cycles do seem to have a strong impact on trend output but this impact is different for the three economies in question. As such, this is just a first step to integrate these issues and should be seen more as prospective analysis than final answers that should come from further and more detailed research.

The paper is organized as follows. Next sections presents the different mechanisms put forward in the literature linking cycles and growth. Section 3 describes the

[1] See Clarida et al (2003) and Galí (1999)

econometric methodology used in this study. Section 4 comments the results, and the final section concludes.

2. Growth and cycles: the mechanisms

There are several mechanisms that can link business cycles and growth (see Saint-Paul, 1997 and Aghion and Howitt, 1998 for surveys of this topic). Broadly, we can classify them into two groups. The first emphasizes the positive impact of upturns in the cycle on productivity. The second emphasizes the positive impact of recessions on productivity.

The idea that cyclical booms can affect long-run growth has roots on the *learning-by-doing* (LBD) idea of Arrow (1962) that has been partially re-taken by endogenous growth models. Expansions due to demand or supply shocks would increase the size of the market inducing division of labor and investment in capital which will generate a learning curve enhancing productivity and long-run growth. Modern models such as Stadler (1990) have focused on the impact of expansions on R&D activity. If firms face financial constraints, boom periods will allow firms to finance R&D through retained profits. This pro-cyclicality of R&D emphasized also by Stiglitz (1993) would induce an impact of demand shocks on long-run productivity. There is no need, however, to resort to explicit R&D for generating this mechanism as we know that R&D is usually carried out by large firms or small firms that are highly dependent on large ones. If financing constraints *`a la* Fazzari et al (1988) are predominant, expansionary periods would induce higher investment in capital. As capital embodies technical progress or is complementary with human capital, firms' productivity would increase without explicit R&D. There is, however, another related link. As booms expand the size of the market, the scope for division of labor and *roundabaoutness* increases productivity in the way that was already pointed out by Young (1928).

These mechanisms are capable of opening up avenues through which aggregate demand shocks, either real or nominal, can influence long-run growth. Empirical studies of RBCs have only been able to attribute to technology shocks less than 30% of output variations at medium-run horizons (see Christiano et al, 2003 and Galí, 1999). One is tempted to infer that a larger role in fluctuations is played by aggregate demand and hence, demand factors may have a role to play in determining potential output. This counters the modeling approach of the vast majority of growth theory. The role of demand on growth through its impact on productivity is a theme that has been largely the focus of cumulative causation models of growth. These models, based on Kaldor (1970) and Dixon and Thirlwall (1978) emphasize the role that external demand has on expanding output and initiating cumulative processes of productivity expansion. Recently León-Ledesma (2002) has presented a model along these lines that incorporates the role of R&D, LBD and technology diffusion. The model is able to generate a rich set of dynamic paths for relative productivities and is compatible with both diverging and converging productivity levels across countries. Models like this provide a link between demand and growth through induced productivity that resembles those mentioned earlier.

On the other hand, recent models of endogenous growth through 'creative destruction' have pointed out the possible positive impact of recessions on long-run growth. In essence, the approach takes an evolutionary selection view in which recessions clean industries from its inefficient units, increasing average productivity (Caballero and Hammour, 1994). Also, the reorganization of activities within firms usually takes place during recessions, as the opportunity cost of restructuring is lower given that the cost of lost production and asset values is lower (Hall, 1991). These mechanisms would then imply that long-run trend growth would be positively affected by recessions.

Empirical evidence is still scarce[2] and mainly inconclusive. In addition, most of the evidence focuses on the US experience with EU countries left aside. The evidence using disaggregated data points out to an important role of the opportunity cost mechanism. However, disaggregated data may have the disadvantage that it does not account for aggregate effects on productivity stemming from externalities and aggregate division of labor. Also, time series dimensions for this kind of data are usually small and hence they tend to work with particular periods of expansion or recession rather than providing a more general view of the impact of cycles. Finally, there is little evidence that tries to identify the importance of different possible links between cycles and growth.

3. Empirical methodology

As an initial attempt to analyze these relations, we propose the use of non-linear univariate time series models that allow equilibrium levels of the variables to vary depending on a threshold variable. The idea is the following. We can estimate an autoregressive model for output in which the equilibrium or trend level of output depends on the previous state of the cycle. The obvious candidate is the family of so-called

[2] See, for instance, Baily et al (2001), Malley et al (forthcoming), Malley and Muscatelli (1999) and Pedersen (2003). León-Ledesma and Thirlwall (2002) also show that the natural rate of growth does depend on actual output growth, which is evidence linking cycles and potential output.

Threshold Autoregressive models (TAR) due to Tong (1983). We allow output to have a different trend component and persistence pattern depending on whether the cycle is above or below a certain threshold and, hence, see how that equilibrium is affected by the cycle. This is related to the existing evidence on the asymmetric behavior of output as first pointed out by Nefcti (1984).

Specifically, if output behaves asymmetrically, we can use the following TAR (Threshold Autoregression) representation (Caner and Hansen, 2001):

$$\Delta y_t = \theta_1^{'} y_{t-1} 1_{\{z_{t-1} < \lambda\}} + \theta_2^{'} y_{t-1} 1_{\{z_{t-1} \geq \lambda\}} + \sum_{j=1}^{p} \gamma_j \Delta rid_{t-j} + \zeta_t \,, \tag{1}$$

where $y_{t-1} = (1\ t\ x_{t-1})$, x_t is output and $1_{\{.\}}$ is the indicator function that takes the value of 1 if z_{t-1} is higher or lower than a threshold λ, and 0 otherwise. The variable z_t is any stationary variable that would determine the change of regime or, in our case, the cycle. For our purposes, we can set z_t in several different ways. There is no obvious candidate to measure cycles, but here we will work with two simple definitions that may be subject to further refinement:

- Set the cycle indicator as $z_t = x_t - x_{t-m}$, that is, the increase in output over a period of m quarters.
- Set the cycle indicator as the difference between actual output and a smoothed estimate of output such as the Hodrick-Prescott (HP) filter, that is, the output gap: $z_t = (x - hpx)_{t-m}$.[3]

[3] We also carried out the rest of estimates using a Band-pass Filter (BP), but the results were very similar to those using the HP filter and are not reported here.

We assume that output may have a different behaviour depending on whether i) past *changes* in output have been higher or lower than a certain threshold λ; ii) the output gap is higher or lower than a certain threshold λ; iii) the output gap is higher or lower than zero. We call these models Δy, $HP_{gap}1$ and $HP_{gap}2$ respectively. The first model is a momentum-TAR model or M-TAR as in Enders and Granger (1998). The lag length *m* for the changes in output and the output gap will be data determined as will be the search for the optimal threshold λ. Finally, the parameter vectors θ_1 and θ_2 can be partitioned as

$$\theta_1 = \begin{pmatrix} \mu_1 \\ \tau_1 \\ \rho_1 \end{pmatrix}, \qquad \theta_2 = \begin{pmatrix} \mu_2 \\ \tau_2 \\ \rho_2 \end{pmatrix}$$

The choice of the threshold λ could be simply made on an a priori basis, such as setting $\lambda = 0$ as in the third model. However, this would be a biased estimate of the threshold, if asymmetric adjustment exists, and a subjective measure. In order to search for the optimal threshold in models 1 and 2, we follow Chan (1993) and find λ as the value of z_t that minimises the residual sum of squares of the OLS estimation of (1).[4]

Our aim is to test for different behaviour of output depending on the state of the cycle, i.e. asymmetry. In order to test for the existence of asymmetry in the adjustment under both regimes we test the null hypothesis $H_o : \theta_1 = \theta_2$ on the OLS estimation of (1), making use of the Wald statistic (W) proposed in Caner and Hansen (2001). Finally, we also chose *m* to minimise the residual sum of squares. Given that the Wald test of asymmetry is a monotonic function of the residual variance, we choose *m* as the value which maximizes the Wald test of asymmetry. Output, however, may have a unit root or near unit root. This is confirmed when we apply three different unit roots tests to our data

[4] In practice, we eliminated the highest and lowest 10% values of z_t.

for the US, UK and Germany for the period ranging from 1960Q1 to 2001Q2. Table 1 reports the results of applying the ADF, KPSS and Elliott (1999)-DFGLS test. Just two out of the eighteen tests reject the null of a unit root in the ADF and DFGLS tests or accepts the null of stationarity in the KPSS test. This poses non-trivial problems when testing for asymmetry. We hence follow Caner and Hansen (2001) and test simultaneously for asymmetry and unit roots. Stationarity would imply rejecting H_o: $\rho_1 = \rho_2 = 0$, and we also make use of two Wald statistics (R1 and R2).

Table 1. Unit root tests on output

		ADF		KPSS		Elliott $DFGLS_u$	
	Lag	Constant	Trend	Constant	Trend	Constant	Trend
Germany	4	-1.262	-2.536	3.325	0.342	-0.603	**-3.431**
UK	3	-0.390	-2.201	3.349	0.250	-0.255	-2.732
US	2	-1.235	-3.333	3.365	0.329	-0.953	**-3.323**

Bold indicates the rejection of the null of a unit root for the ADF and DFGLS tests and the acceptance of the null of stationarity for the KPSS test at the 5% level.

The procedure we follow to test simultaneously for asymmetry and unit roots implies first estimating a baseline model for the linear ADF regression to determine the lag augmentation of the DF regression using general-to-specific techniques as used for finding the augmentation lag in the tests reported in Table 1. We then select the threshold by minimising the residual sum of squares of (1) as mentioned earlier and fit the TAR model by OLS for every value of *m*. We choose the *m* that minimises the residual sum of squares for all values of *m*.

Given that the asymptotic null distribution of the asymmetry test (W) is non-standard, Caner and Hansen (2001) recommend the use of bootstrap methods to obtain p-values. In a Monte Carlo experiment they show that the power and size of the test does not crucially depend on whether we impose a unit-root. Hence, we obtained p-values by carrying out

1,000 iterations of the unconstrained asymmetry test, i.e. not imposing the existence of a unit root. Finally, the unit root hypothesis involves testing for H_o: $\rho_1 = \rho_2 = 0$. There are two possible alternatives: H_1: $\rho_1 < 0$ *and* $\rho_2 < 0$ and

$$H_2 : \begin{cases} \rho_1 < 0 \quad and \quad \rho_2 = 0 \\ or \\ \rho_1 = 0 \quad and \quad \rho_2 < 0 \end{cases}$$

The first alternative corresponds to the stationary case, whilst the second implies stationarity in only one of the regimes, which implies overall non-stationarity but a different behaviour from the classic unit-root. Caner and Hansen (2001) develop asymptotic theory for the distribution of this unit-root test. However, for finite samples they recommend the use of bootstrapping. As the distribution of the test statistic will depend on whether or not a threshold effect exists, p-values obtained through the bootstrap are not unique. We hence obtained the bootstrapped p-values from 1,000 iterations under the hypothesis that the threshold is not identified (R1) and under the hypothesis that it is identified (R2). These two tests have substantially more power than the ADF test as threshold effects become more important. In order to discriminate between the two alternatives in H_2, Caner and Hansen (2001) recommend looking at the t-ratios of ρ_1 and ρ_2.

Finally, given our interest in the impact of cycles on trend growth, we also carried out an F-test for equality of the trend parameters H_o: $\tau_1 = \tau_2$. This test, however, should be taken with more caution as we relied on standard F distributions to test for significance.

4. Results

Table 2 reports the results of the asymmetry and unit root tests together with their bootstrapped p-values. The table also reports the lag of the threshold variable *m* and the optimal threshold for models Δy and $HP_{gap}1$. Notice that, as R1 assumes no identified threshold under the null, its value is the same for the three models. The model was estimated for three major economies, the US, the UK and Germany using quarterly data for the 41 years ranging from 1960:1 to 2001:2. The period is long enough so as to capture several episodes of booms and recessions and hence increasing the precision of our estimates of the asymmetry effects.

The first thing to notice in the results is the strong asymmetry present in the data judging by the values of the W test. Only in two cases we can accept the null of linearity, although only at the 10% level and not at the 5%. This asymmetry seems to be stronger for Germany, followed by the US and the UK in that order. The F-test on the trend parameter produces mixed results. Only in the cases of the US and Germany trend asymmetry seems to be contributing to the overall asymmetry of the model. In the case of the UK the trend component of output does not seem to change with changes in the business cycle.

The unit root tests are somewhat surprising. Once we account for the possible presence of asymmetries, it appears that output is stationary around a trend. This contradicts much of the evidence on real output non-stationarity that considers a linear representation under the alternative.[5] For the case of the US and Germany, where

[5] In his seminal paper on structural breaks and unit roots, though, Perron (1989) finds that output is stationary around a breaking trend.

asymmetry is stronger, the rejection of the null under the identified threshold test R2 is stronger as expected.

Tables 3, 4 and 5 present the results of the estimated parameters when we assume asymmetry for each country and model considered. There are general patterns in the three models and, although models $HP_{gap}1$ and 2 are the closest two, the choice of the cycle indicator does not affect strongly the pattern of cyclical behavior of real output. To ease interpretation of the results, it is worth reminding that parameters with the subscript 1 correspond to expansionary phases of the cycle. In all three countries the velocity of adjustment to the trend component (ρ) is higher in recessions than in booms. This is a consequence of the fact that usually expansions last longer than contractions. In many cases the series appear to be non-stationary during expansions and stationary in recessions. The exception is Germany in the Δy model. However, the large intercept found for that model casts doubts about the results for that particular model.[6]

When analyzing the parameters of the trend variable we find interesting results. First, for the UK there is practically no difference between expansions and recessions as we would expect from the previous tests. This indicates that the impact of cycles on growth in the UK is either very limited or not possible to capture using this technique. For the US there are substantial differences, especially in models Δy and $HP_{gap}2$. In this case the trend output after a recession seems to have a higher slope. This shows support for a stronger impact of the opportunity cost kind of effect as opposed to LBD effects. Finally, for Germany, the opposite results appear. In this case the trend output growth is higher after an expansion than after a recession.

[6] In fact, in this model only 11% of the observations belonged to the expansionary periods. This is a consequence of the high threshold value (λ). We could have trimmed the search for λ further, but preferred to keep this result for comparison purposes.

Our results, hence, are not able to determine uniquely the direction of the link between cycles and growth. Nevertheless, an important fact is that LBD effects appear to outweigh cleansing or opportunity cost effects in the economy where labor markets are acknowledged to be more rigid. The other way around happens with the US, the economy with the most flexible labor markets. Our simple approach is not able to test directly this proposition, but points out to a strong role of labor market institutions on the relation between cycles and growth.

Table 2. Tests of threshold effects tests for output

Country	*US*			*GER*			*UK*		
	Δy	$HP_{gap}1$	$HP_{gap}2$	Δy	$HP_{gap}1$	$HP_{gap}2$	Δy	$HP_{gap}1$	$HP_{gap}2$
λ	0.019	0.041	0	0.075	0.031	0	0.012	0.033	0
m	4	3	4	5	2	3	3	2	1
W *(p-value)*	**19.656 (0.004)**	**11.069 (0.030)**	7.920 (0.070)	**32.307 (0.000)**	**13.874 (0.028)**	**12.247 (0.016)**	**9.278 (0.038)**	**11.180 (0.042)**	9.430 (0.076)
F-test trend *(p-value)*	**3.991 (0.047)**	0.026 (0.871)	**5.036 (0.026)**	**21.994 (0.000)**	0.773 (0.381)	**4.021 (0.041)**	0.035 (0.852)	1.668 (0.198)	0.644 (0.424)
R1 *(p-value)*	**11.672 (0.001)**	**11.672 (0.001)**	**11.672 (0.001)**	**6.934 (0.016)**	**6.934 (0.016)**	**6.934 (0.016)**	**9.301 (0.004)**	**9.301 (0.004)**	**9.301 (0.004)**
R2 *(p-value)*	**23.357 (0.002)**	**16.151 (0.007)**	**15.221 (0.018)**	**32.477 (0.001)**	**11.451 (0.008)**	**11.126 (0.022)**	**9.311 (0.016)**	**8.741 (0.005)**	5.299 (0.094)
Lag	2	2	2	4	4	4	3	3	3

Bold indicates rejection of the null of no asymmetry or unit root at the 5% level. P-values are obtained through the bootstrapping technique of Caner and Hansen (2001), except for the F-test on the trend.

Table 3. Estimates of the threshold model: US

Country	*US*		
	Δy	$HP_{gap}1$	$HP_{gap}2$
μ_1	**0.221** **(2.923)**	**0.232** **(1.817)**	0.177 (1.572)
μ_2	**0.557** **(3.995)**	**0.288** **(3.691)**	**0.320** **(3.673)**
ρ_1	**-0.061** **(-2.812)**	**-0.066** **(-1.796)**	-0.049 (-1.520)
ρ_2	**-0.157** **(-3.931)**	**-0.080** **(-3.595)**	**-0.089** **(-3.593)**
τ_1	**4.555e-04** **(2.700)**	**5.403e-04** **(1.721)**	3.608e-04 (1.378)
τ_2	**0.001** **(3.671)**	**5.987e-04** **(3.419)**	**6.771e-04** **(3.480)**

Bold indicates rejection of the null of no significance at the 5% level.

Table 4. Estimates of the threshold model: UK

Country	*UK*		
	Δy	$HP_{gap}1$	$HP_{gap}2$
μ_1	**0.291** **(2.399)**	-0.364 (-0.612)	-0.154 (-0.224)
μ_2	**0.328** **(1.964)**	**0.236** **(2.303)**	**0.239** **(2.343)**
ρ_1	**-0.077** **(-2.397)**	0.099 (0.628)	0.043 (0.234)
ρ_2	**-0.083** **(-1.888)**	**-0.061** **(-2.253)**	**-0.062** **(-2.290)**
τ_1	**4.562e-04** **(2.503)**	-6.761e-04 (-0.536)	-6.761e-04 (-0.536)
τ_2	4.979e-04 (1.562)	**3.397e-04** **(2.210)**	3.397e-04 (1.210)

Bold indicates rejection of the null of no significance at the 5% level.

Table 5. Estimates of the threshold model: Germany

Country	*Germany*		
	Δy	$HP_{gap}1$	$HP_{gap}2$
μ_1	**2.040** **(5.135)**	0.304 (1.373)	0.032 (0.214)
μ_2	**0.209** **(2.613)**	**0.214** **(2.544)**	**0.327** **(3.440)**
ρ_1	**-0.569** **(-5.119)**	-0.084 (-1.360)	-0.009 (-0.209)
ρ_2	**-0.056** **(-2.503)**	**-0.057** **(-2.437)**	**-0.088** **(-3.329)**
τ_1	**0.004** **(5.185)**	**7.838e-04** **(1.740)**	**0.002** **(3.221)**
τ_2	**3.533e-04** **(2.244)**	**3.649e-04** **(2.176)**	**5.609e-04** **(2.995)**

Bold indicates rejection of the null of no significance at the 5% level.

5. Conclusions

Usual growth theory models *potential output growth* leaving no role for aggregate demand and other cyclical shocks on long-run growth. This contrasts with the more policy oriented and popular view that good macroeconomic management is a pre-condition for healthy and sustainable growth in the long-run. We have attempted to contribute to the question of whether demand shocks and other determinants of the business cycle do have a role to play in determining the level of potential output.

We have done so by fitting a Threshold Autoregressive model on output for the US, Germany and the UK. In this model, the trend or equilibrium level of real output is allowed to change depending on the state of the business cycle. Using different definitions of cycle we arrived at similar conclusions. Our findings show a strong asymmetry of real output. Real output also seems to be stationarity during recessions. The impact of the business cycle on the trend component of output differs for each economy. For the UK we did not find a different behavior depending on the cycle. For the US we found that trend output increases after recessions. The other way around happens to Germany, where trend output growth appears to be higher after an expansion. These results point out to labor markets as important determinants of the relation between cycles and growth, which is a topic open for further research. Research on this direction can have important implications for the design of stabilization policies to promote growth.

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