

THE EFFECTS OF BUSINESS CYCLES ON GROWTH

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This paper explores the links between business cycles and long-run growth. Although it is clear from a theoretical point of view that both of these phenomena are driven by the same macroeconomic variables, the interaction between economic fluctuations and growth has been largely ignored in the academic literature. The main reason for this lack of attention is the surprising stability of long-term growth rates and their apparent independence from business cycle conditions, at least among industrial economies. Business cycles in these countries can be characterized as alternating series of recessions followed by recoveries that bring gross domestic product (GDP) levels to trend; this suggests that one can study growth and business cycles independently. To illustrate this point, figure 1 displays real GDP per capita for the U.S. economy during the period 1870–1999. A simple log-linear trend represents a highly accurate description of the long-term patterns of per capita output in the United States.¹ This pattern is very similar for other industrial countries such as France, Germany, and Great Britain, although the slope of the trend shows stronger indications of breaks, especially after the Second World War.

The lack of a widely accepted, empirically valid growth model has resulted in the use of two distinctive approaches to studying the relation between growth and business cycles. From an empirical viewpoint, the (augmented) Solow model seems to fit the cross-country data quite well, as

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1. As Jones (1995a, 1995b) has pointed out, an extrapolation of a log-linear trend for the pre-1914 period produces extremely accurate point estimates of current GDP levels.

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Figure 1. U.S. Real per Capita GDP (in logs)

shown in Mankiw, Romer, and Weil (1992) and Barro and Sala-i-Martin (1992, 1995). However, early attempts to empirically validate endogenous growth models have not been very successful, as argued in Easterly and others (1993) and Jones (1995b). As a result, no clear framework has been established for analyzing the impact of business cycles on growth.

Despite such arguments, a growing literature establishes interesting theoretical links and empirical regularities relating growth and business cycles. Recent analysis of cross-country growth performances reveals less support for Solow-type growth models.² At the same time, since the work of Nelson and Plosser (1982), it is commonly accepted that business cycles are much more persistent than what is suggested in figure 1. Moreover, the GDP profile of countries other than the United States is at odds with steady-state models of economic growth, as suggested by Easterly and Levine (2001). Direct evidence has also been presented on the effects of business cycles on variables related to long-term growth. Productivity is affected by the business cycle and seems to react to events that are supposed to be only cyclical.³ Growth-related variables, such as investment or research and

2. Bernanke and Gürkaynak (2002); Easterly and Levine (this volume).

3. See, for example, Shea (1999).

development (R&D) expenditures, are procyclical. Finally, features of the business cycle, such as the volatility or persistence of economic fluctuations, are correlated with long-term growth rates.⁴ These empirical regularities are very difficult, or even impossible, to reconcile with models in which technological progress and long-term growth are exogenous.

This paper presents an overview of the theoretical arguments, together with a summary of the evidence of the effects of business cycles on growth in a large cross section of countries.⁵ The analysis is undertaken on two levels. The first part of the paper looks at the connections between certain characteristics of the business cycle and long-term growth rates and establishes a set of empirical regularities. These regularities are well captured by a simple endogenous growth model in which long-term growth dynamics are central to business cycles. Although this theoretical framework uncovers interesting connections between long-term growth and features of the business cycle such as persistence, it does not produce unambiguous predictions about whether the volatility of economic fluctuations has negative effects on long-term growth rates.

The second part of the paper directly studies the possibility that business cycles have a significant effect on long-term growth rates by looking at asymmetric business cycles as well as considering the general effects of uncertainty. Overall, the evidence presented suggests that business cycles and long-term growth rates are determined jointly by the same economic model. There is evidence that characteristics of the business cycle are not independent of the growth process, and the volatility associated with the business cycle is negatively related to long-term growth rates.

The paper is organized as follows; Section 1 studies the relation between the persistence of business cycles and long-term growth. Section 2 explores the links between volatility and growth, and Section 3 concludes.

1. TRENDS, PERSISTENCE, AND GROWTH

The stability of growth rates for the U.S. economy has been used as an argument for keeping the analysis of trends separate from the analysis of economic fluctuations. However, this apparent stability of U.S.

4. See Fatás (2000a, 2000b) for evidence on the effects of business cycles on R&D expenditures and the link between persistence and growth.

5. My sample of ninety-eight countries is identical to the one used by Bernanke and Gürkaynak (2002), and it excludes formerly planned economies. See the appendix for a detailed description of the data.

growth rates is at odds with the econometric analysis of its time series properties, which shows that the log-linear trend is far from being an accurate representation of its long-term properties. This stylized fact was brought up by Nelson and Plosser (1982), who question the traditional method of measuring business cycles as temporary deviations of output from a deterministic log-linear trend. Their paper triggered a debate on the persistence of output fluctuations and the existence of a unit root in GDP. Although some of this debate is still open, one fact is no longer questioned: output does not show a strong tendency to return to trend after being hit by a shock. Consequently, growth and business cycles cannot be separated analytically, which raises the need for models in which the stochastic properties of the trend are somehow related to the business cycle itself.

This evidence was initially used to promote the real business cycle theory, in which the persistence of business cycles is interpreted as a sign of the nature of the disturbances that causes business cycles (technological events). While this approach incorporates growth and fluctuations into a single model, however, there is still a sense in which growth is left out of the analysis, given that long-term growth rates are determined by the exogenous growth rate of technological progress in a Solow-type model.⁶

An alternative explanation to the high persistence of business cycle fluctuations comes from models that consider growth dynamics to be central to the properties of the business cycle. Within the framework of endogenous growth models, King, Plosser, and Rebelo (1988) and Stadler (1990) notice that many types of disturbances other than permanent shifts in the production function can produce persistent fluctuations. The intuition is simple: any temporary disturbance that has an effect on the amount of resources allocated to growth can produce permanent effects on the level of output. In other words, if investment in growth-enhancing projects is diminished during recessions and the recovery is not strong enough to catch up with lost time, then output will not return to its trend. Recessions can thus have costs that go well beyond the added volatility to the economy.

The task of distinguishing these two explanations empirically is a difficult one. Two approaches have been followed. One is to compare the relative ability of both types of models to match features of the business cycle. This is the approach taken by Jones, Manuelli, and Siu (2000). Their conclusions are in some cases supportive of endogenous growth

6. See, for example, Kydland and Prescott (1982); King and others (1991).

models, but they encounter many difficulties discriminating between the two types of models. An alternative methodology is to look for empirical connections between the degree of persistence of business cycles and long-term growth rates. This is only interesting if there are significant differences in persistence across countries. Cogley (1990) studies the variability of the low-frequency component of output in a sample of nine countries; he shows that there are significant differences among them, with the United States having the most stable low-frequency component of the sample. If this degree of persistence is related to the long-term growth rates of these countries, then it would establish a direct connection between long-term growth rates and a feature of economic fluctuations intrinsically linked to the question of whether business cycles have long-term consequences beyond uncertainty and short-term volatility.

A reduced-form version of a model that displays endogenous growth can be used to illustrate the link between persistence and growth.⁷ Assume that the economy is characterized by a production function of the type

$$Y_t = A_t L_t^\alpha K_t, \quad (1)$$

where Y is output, L is labor, A is a technological parameter, and K is the economy's stock of knowledge; for simplicity, the stock of knowledge is assumed to affect all firms equally, and no firm is large enough to internalize the effects of its actions on this stock. Knowledge is accumulated by the process of learning by doing and takes the following functional form:

$$\frac{K_t}{K_{t-1}} = \left(\frac{Y_{t-1}}{K_{t-1}} \right)^\gamma, \quad (2)$$

where γ represents the degree of learning in the economy.⁸

7. See Fatás (2000b) for a complete optimizing model that leads to dynamics identical to those of this reduced form model.

8. This production function, together with the learning process, implies very strong scale effects. These scale effects are not necessary for any of the intuitions developed with this simple model, and a model without scale effects can display similar dynamics. I use such a simplistic production function and learning process to make the resolution of the model as simple as possible and to provide the clearest possible presentation of the intuition. See Fatás (2000b) for a detailed discussion of these arguments.

The growth rate of output at any point in time is equal to

$$\Delta y_t = a_t - (1 - \gamma)a_{t-1} + \alpha [I_t - (1 - \gamma)I_{t-1}], \quad (3)$$

where lowercase letters denote natural logarithms. I assume that a_t is a stationary process and that the labor supply function is such that labor is also stationary. Let a^* and I^* be the steady-state values of labor and productivity. In the absence of any cyclical disturbance, the economy will grow at a rate equal to

$$\Delta y_t = \gamma a^* + \alpha \gamma I^*. \quad (4)$$

I now introduce cyclical shocks by postulating a stochastic process for the technology parameter a_t . Assume that it follows an AR(1) process such that

$$a_t = \rho a_{t-1} + \mu_t. \quad (5)$$

Under the assumption that labor supply is inelastic, output growth can be expressed as a function of μ .

$$\Delta y_t = [1 - (1 - \gamma)L]C(L)\mu_t, \quad (6)$$

where L is the lag operator and $C(L)$ is the Wold representation of the AR(1) process for a_t , such that

$$C(L) = 1 + \rho L + \rho^2 L^2 + \rho^3 L^3 + \dots \quad (7)$$

From equation 6, it is clear that cyclical fluctuations have long-lasting effects on output despite their transitory nature, because of the effects on the accumulation of knowledge. One way to look at these long-lasting effects is to measure the change in the long-term forecasts of output when there is a shock to a_t . The solution is simply the sum of the coefficients from equation 6 for Δy_t , above.

$$\Delta y_t = D(L)\mu_t, \quad (8)$$

where $D(L) = d_0 + d_1 L + d_2 L^2 + d_3 L^3 + \dots$ is a lag polynomial. Then, the coefficients d_j measure the impact of a shock μ_t on the growth rate

of output in period $t + j$. Adding up these coefficients yields the long-run impact of a given shock on the level of output. In general, the equation,

$$P^J = \sum_{j=0}^{j=J} d_j, \quad (9)$$

represents the impact of a shock μ_t on the level of output at $t + J$. The infinite sum of all d_j coefficients measures the permanent impact of a given shock on the output level, let P be this sum, such that

$$P = \lim_{J \rightarrow \infty} P^J = D(1). \quad (10)$$

In the model, the sum of these coefficients is equal to

$$P = 1 + [\rho - (1 - \gamma)] + [\rho^2 - \rho(1 - \gamma)] + [\rho^3 - \rho^2(1 - \gamma)] + \dots, \quad (11)$$

which can be simplified to

$$P = \frac{\gamma}{1 - \rho}, \quad (12)$$

This expression is intuitive: the long-term effects of business cycles are an increasing function of the persistence of the shocks themselves and the parameter γ , which represents the speed at which knowledge accumulates through learning by doing. What is important for my argument is that long-term persistence becomes a measure of the long-term costs of recessions, and the origin of these costs are the effects that recessions have on the accumulation of knowledge (the driving force behind long-term growth). In this stylized model, output always returns to its log-linear trend in the absence of long-term growth ($\gamma = 0$).

The above model produces a simple, intuitive explanation suggesting that business cycles have permanent effects on output through the dynamics of the growth process. During recessions, the growth process slows down. Recoveries bring the growth rate back to normal, but the level remains below the log-linear trend followed before the recession. Countries with larger growth rates have more to lose

during recessions than countries with lower rates, and they therefore display larger permanent effects of business cycles. As a result, fast-growing countries display more volatile trends.⁹

The relationship described above can be used to discriminate among different theories on growth and business cycles. For example, in a model in which growth stems from exogenous technological progress (assume that A grows exogenously at some rate), this measure of persistence (P) would simply be a function of the parameter ρ . The typical formulation of a real business cycle has $\gamma = 0$ and $\rho = 1$, together with exogenous technological progress for the technological parameter A . Under these circumstances, persistence would be independent of growth and $P = 1$.

Is there any empirical evidence that persistence and growth rates are correlated? The answer is yes. Using a sample of about a hundred countries from the Summers-Heston dataset, I calculate the degree of persistence of annual fluctuations to determine whether this degree of persistence is correlated to the countries' long-term growth rates. Persistence is calculated using two different methods. First, I estimate an AR(1) process for GDP growth and approximate P by inverting the lag polynomial associated with the AR(1) process. Second, I use Cochrane's variance ratio, which has often been used to estimate the persistence of time series.¹⁰ This measure is equal to

$$V^J = \left(\frac{1}{J} \right) \frac{\text{var}(y_t - y_{t-J})}{\text{var}(y_t - y_{t-1})} = 1 + 2 \sum_{j=1}^{J-1} \left(\frac{1-j}{J} \right) \rho_j, \quad (13)$$

where ρ_j is the j^{th} autocorrelation of the growth rate of output. Taking the limit of this expression as J tends to infinity, I obtain a measure of long-run persistence,

$$V = \lim_{J \rightarrow \infty} V^J. \quad (14)$$

9. A set of papers postulate that recessions can have the opposite effect (that is, be beneficial for growth). Caballero and Hammour (1994), Galí and Hammour (1991), and Hall (1991) all present models in which recessions lead to permanent improvements in productivity because research activities offer a higher return than production activities during such periods or because recessions lead to the destruction of the least productive firms.

10. See Cochrane (1988) for a description of this series.

Table 1. Persistence and Growth^a

Explanatory variable	P		V ⁵	
	All	OECD	All	OECD
Sample				
β	0.066 (0.029)	0.383 (0.137)	0.090 (0.043)	0.611 (0.102)
Summary statistics				
R ²	0.09	0.53	0.07	0.62

a. Persistence $\beta = \alpha + \beta \text{ Avg.Growth}_i + \eta_i$. Sample: 1950–1998. Robust standard errors in parentheses.

Both V and P take the value 0 for a trend-stationary series and the value 1 for a random walk. For any other series,

$$V = |P|^2 \frac{\text{var}(\mu)}{\text{var}(\Delta y)}. \tag{15}$$

For the model above, this expression is equal to

$$V = \frac{\gamma^2 (1 - \rho^2)}{(1 - \rho)^2 [\gamma^2 + 2(1 - \rho)(1 - \gamma)]}.$$

This expression is always increasing in γ as long as $\gamma < 2$, a condition that is required for output growth to be a stationary series. In other words, fast-growing countries display a larger degree of persistence as measured by either of the two indicators (P or V).

Table 1 presents the results of regressing the degree of persistence of annual fluctuations on the long-term growth rate of output for both the full sample (ninety-eight countries) and the restricted sample of member countries of the Organization for Economic Cooperation and Development (OECD).¹¹ This procedure is carried out for the two proposed measures of persistence and using per capita GDP as measures of economic activity. In the case of the variance ratio, I choose a window of five years (that is, including correlations of GDP growth with its first four lags).

In all cases, the coefficient is positive and significant. In the case of the OECD economies, the fit of the regression and the size of the coeffi-

11. See the appendix for a detailed description of the countries included.

cient are larger than in the overall sample.¹² These differences can partially be attributed to the different nature of the business cycle across countries. OECD economies generally exhibit well-defined business cycles, so the measure of persistence is appropriate for them. Some of the other countries, however, experience less regular, less uniform booms and recessions; a symmetric measure of persistence like the one used in table 1 can be much noisier in these cases than among the OECD countries. This reasoning explains the larger standard errors in the full sample. The fact that the coefficient is low has no straightforward explanation. A formal test could not reject the hypothesis that they are equal, and the two coefficients become closer in size if one corrects for outliers. However, whether these effects are of greater economic importance for OECD countries remains an open question.¹³

The results of table 1 show strong support for the idea that growth and business cycles are not independent phenomena. Persistence, which serves as a measure of the long-term effects of business cycles, is positively correlated to growth. Explaining the estimates of table 1 one requires a theory in which growth and fluctuations are jointly determined.

One has to be careful in interpreting the results of table 1 in terms of the effects of volatility on growth. The results suggest that growth dynamics play a role in shaping business cycles, but the argument could be entirely symmetric. The discussion on recessions (negative shocks) also applies to booms (positive shocks). Thus while fast-growing countries feel the effects of recessions more than slow-growing countries, they also benefit more from positive shocks. In that sense, the correlation between persistence and growth, although encouraging, does not provide a direct link between the volatility of fluctuations and average growth. Given enough symmetry, more fluctuations lead to more volatile trends, but the average growth rate remains constant. The next section explores theories and empirical evidence that go beyond this first relationship between growth and business cycles. By introducing asymmetries and by taking into consideration the direct role that volatility and uncertainty can play in determining growth rates, the analysis establishes a link between volatility and average growth rates.

12. These results are also confirmed when using quarterly data; see Fatás (2000b).

13. If the regressions from Table 1 are estimated by a robust minimum absolute deviation technique to check for the possibility that outliers, the estimates for the full sample and the OECD sample are closer. It is also interesting to point out that with this estimation technique, the significance of the coefficient increases for both samples confirming that outliers are not driving our main result.

2. BUSINESS CYCLES, UNCERTAINTY, AND GROWTH

Do business cycles affect long-term performance? Is volatility bad for growth? The evidence presented thus far cannot answer these questions. In models of the type above, an increase in uncertainty—that is, an increase in the volatility of the disturbance μ —has no effect on long-term growth rates. Average growth is not affected by business cycles.

There are two ways of modifying the analysis so that volatility and uncertainty become relevant for long-term growth. The first is very mechanical and consists of thinking about fluctuations as being asymmetric. What if more fluctuations meant deeper recessions relative to unchanged expansions? Rodrik (1991), for example, considers the case of policy reform and the uncertainty introduced by the possibility that reform is reversed. In his model, additional uncertainty not only increases risk, but also lowers the average return to investment, because it is assumed that no reform leads to larger distortions.¹⁴ Another example is the analysis of political uncertainty. Political uncertainty is usually measured by variables such as the number of revolutions and military coups or the number of political assassinations. An increase in both of these variables does not simply represent more volatility around a constant mean, but rather indicates more volatility and a lower mean. Introducing this type of asymmetric fluctuation into an endogenous growth model can lead to a straightforward connection between fluctuations and growth. For example, introducing asymmetric fluctuations in the disturbance μ in the model from the previous section establishes a direct relationship between average technology and its volatility and, therefore, the average growth rate of output. More volatile economies would display a lower mean for the technology parameter, A , than would less volatile economies, and they would grow at a lower rate as a result. Another possible source of asymmetry is the accumulation process. What if the negative effects of recessions on learning by doing are stronger than the positive effects of booms? This is the spirit of the model developed by Martin and Rogers (1997). In this case, there is also a negative relationship between volatility and growth.

The second way to link business cycles and growth is to introduce risk aversion or irreversibilities to investment. In this case, even if disturbances and business cycles are held symmetric, uncertainty can

14. Hausmann and Gavin (1996) make a similar argument to explain the poor growth performance of Latin American countries.

also directly affect growth.¹⁵ For example, Feeney (1999) argues that risk sharing (through trade) and the associated decrease in uncertainty and volatility can have positive effects on growth. An endogenous growth model can also introduce general equilibrium effects of uncertainty on growth through consumer's behavior and the labor supply, as in Jones, Manuelli, and Stachetti (1999) or de Hek and Roy (2001).

In the sample of countries considered here, what are the main sources of uncertainty and volatility that make business cycles so different across countries? One possibility involves differences in economic policies. Talvi and Végh (2000) and Fatás and Mihov (2002) present evidence of differences in fiscal policy behavior across countries and examine how these differences are associated with different political institutions or economic structures. A second candidate is terms-of-trade shocks and the economy's degree of openness, as argued by Rodrik (1998). A third possibility is that the development of financial markets is strongly correlated with the shape of business cycles. Well-functioning financial markets can provide the tools for smoothing business cycles. In the absence of these tools, countries are more likely to suffer excessive volatility (see, for example, Caballero, 2000).

Several papers analyze the relationship between volatility and growth from an empirical standpoint. The first group of papers looks directly at the relationship between volatility and growth without focusing on a specific channel through which the effects take place. This group includes Ramey and Ramey (1995), Kormendi and Meguire (1985), and Martin and Rogers (2000). A second strand of the literature explores specific sources of uncertainty and how this uncertainty has affected long-term growth. For example, Alesina and others (1996) study the effects of political instability on growth, while Judson and Orphanides (1999) analyze the effects of the volatility of inflation on growth. Most of these papers present evidence in favor of the hypothesis that volatility, uncertainty, or political instability hurts growth. I now review some of this evidence, presenting additional tests of the robustness of the relationship between volatility and growth and also investigating some of the specific channels through which the relationship takes place.

I start by measuring the volatility of the business cycle by the standard deviation of per capita GDP growth rates. Table 2 displays the results of a regression of average growth rates (1950–1998) on business cycle volatility for all the countries in the sample. The coefficient is

15. Bernanke (1983); Bertola and Caballero (1994).

Table 2. Business Cycle Volatility and Growth^a

<i>Explanatory variable</i>	(1)	(2)
Volatility	-0.241 (0.075)	-0.179 (0.090)
Per capita GDP in 1960 (log)		0.365 (0.182)
<i>Summary statistics</i>		
R^2	0.13	0.15

a. $Growth_t = \alpha + \beta Volatility_t + \delta X_t + \eta_t$. Sample: 1950–1998. Robust standard errors in parentheses.

positive and significant. Conditioning the correlation to the logarithm of 1960 per capita GDP does not alter the size of the coefficient, although its significance falls.¹⁶ In terms of the size of the coefficient, a one standard deviation increase in volatility (about 2.3 percent) leads to a decrease in the growth rate of per capita GDP of about 0.4 percent, a relatively large effect.

2.1 Volatility versus Uncertainty

Table 2 measures business cycle volatility as the standard deviation of per capita GDP growth rates. This measure includes variations in GDP that can be forecast by economic agents. If what really matters for growth is uncertainty, then the residuals of a forecasting equation for output growth might provide a key indicator. For each of the countries in the sample, I regress output growth on its own lagged value, as well as on a linear and a quadratic trend. Introducing these trends serves to remove low-frequency movements in output that log-linear detrending cannot address.¹⁷ The results are practically identical, both in terms of the size of the coefficient and the fit of the regression (see table 3). Because of the similarity of the results, the rest of the paper uses the standard deviation of per capita output growth rates to measure volatility.

16. Although the data starts for some countries in 1950, we always choose 1960 as the 'initial' year in order to keep consistency across countries. Using 1950 for those countries for which data is available does not change any of the results presented in the paper.

17. These low frequency movements could bias some of our results because they could be measured as volatility of output growth when they are simply changes in average growth rates over time.

Table 3. Uncertainty and Growth^a

<i>Explanatory variable</i>	(1)	(2)
Uncertainty	-0.247 (0.077)	-0.187 (0.093)
Per capita GDP in 1960 (log)		0.36 (0.181)
<i>Summary statistics</i>		
R^2	0.13	0.15

a. $Growth_t = \alpha + \beta \text{Uncertainty}_t + \epsilon X_t + \eta_t$. Sample: 1950–1998. Robust standard errors in parentheses.

2.2 Volatility versus Bad Policies

The biggest concern with the negative correlation between growth and business cycles found in tables 2 and 3 is the possibility that a third variable (or group of variables) is correlated with both of them and is ultimately responsible for this correlation. The first candidate is so-called bad economic policy. Governments with policies that are unfriendly to growth can introduce additional sources of volatility in the economy. It might also be the case that bad economic policies are generally more volatile policies, leading to more pronounced business cycles. If so, more volatile policies might be correlated with lower growth, while the true cause of lower growth is the low average quality of the policies.¹⁸

Empirically assessing whether volatility is acting as a proxy for bad policies in the regressions of tables 1 and 2 requires identifying variables that can serve as direct measures of policies that hurt growth and are correlated with the volatility of the business cycle. For example, the degree of openness is known to be correlated with long-term growth, and it is also related to the general degree of uncertainty faced by an economy.¹⁹ Government size, which is a relevant variable in many growth models, is also related to the volatility of business cycles. Finally, inflation or inflation variability are key variables in business cycles and have been shown to have an effect on growth.

Table 4 presents the results of introducing these four variables into the analysis. Once again, the size of the coefficient is practically

18. As discussed before, in the analysis of policy reform in developing countries in Rodrik (1991), a higher probability of failure of reform is associated both to worse economic policy (higher distortions) and more uncertainty.

19. See Rodrik (1998).

Table 4. Business Cycle Volatility versus Bad Policies^a

<i>Explanatory variable</i>	(1)
Volatility	-0.187 (0.083)
Per capita GDP in 1960 (log)	0.394 (0.190)
Trade openness	0.019 (0.007)
Inflation	0.004 (0.003)
Inflation Volatility	-0.002 (0.001)
Government size	-0.014 (0.017)
<i>Summary statistics</i>	
R^2	0.29

a. $Growth_i = \alpha + \beta \text{Volatility}_i + \delta X_i + \eta_i$. Sample: 1950–1998. Robust standard errors in parentheses.

unchanged from the previous table. Although this is only a partial list of variables capturing policy effects, I conclude that in the regressions, business cycle volatility is not capturing differences in economic policies, at least not in those related to inflation, openness, or government size.

2.3 Specific Sources of Business Cycle Volatility

The previous tables measured volatility by the standard deviation of output growth. What are the main variables that determine this volatility? Do all of them have the same effect? Answering these questions can be useful for two reasons. First, it can help discriminate among different theories by providing a more precise measure of the cause of the volatility that affects long-term growth rates. Second, it can be used in the main regression to avoid biases associated with endogeneity or omitted variables. The idea is to introduce variables that are clearly related to economic policy and the business cycle but that, in principle, should not be directly related to long-term growth rates. I look at variables that are normally considered to be neutral in the long run, starting with a set of variables that are associated with monetary policy. These include average inflation, the volatility of detrended money balances, and a measure of the exchange rate arrangement of

Table 5. Business Cycle Volatility and Economic Policy^a

<i>Explanatory variable</i>	(1)
Exchange rate flexibility	-0.901 (0.401)
Volatility in monetary policy	0.132 (0.053)
Volatility in fiscal policy	0.172 (0.223)
Inflation	0.002 (0.001)
<i>Summary statistics</i>	
R^2	0.21

a. $\text{Volatility}_i = \alpha + \delta X_i + \eta_i$. Sample: 1950–1998. Robust standard errors in parentheses.

each country.²⁰ I also include a measure of the volatility of fiscal policy: the residual of a forecasting regression of the budget deficit that includes output growth as well as a linear and a quadratic trend. My empirical strategy is first to see whether these variables are correlated with the measure of business cycle volatility and then to use this correlation to refine the estimates of the effects of volatility on growth.

A regression of output volatility on these four variables produces coefficients of the sign that would be expected (see table 5). Countries with fixed exchange rates, a higher inflation rate, more uncertain monetary policy, and more volatile fiscal policy have a more pronounced business cycle.

The information contained in table 5 can be used to reproduce the estimates of tables 2, 3, and 4, using these four variables as instruments of the volatility of the business cycle. Results are presented in table 6. The effect of volatility on growth is still significant, and the coefficient is larger in magnitude compared with the results of the ordinary least squares (OLS) regressions.

I do not claim that these variables are, under all theories, exogenous to economic growth or unrelated to all possible omitted variables that directly influence economic growth.²¹ Rather, the results of table 6 confirm the negative relationship between growth and business cycles

20. Including the volatility of inflation rates does not add much to the analysis as it is highly correlated with the average inflation rate.

21. For example, and as argued before, inflation rates or the volatility of monetary and fiscal policy can be related to overall 'bad economic policy' that leads to lower economic growth.

Table 6. Growth and Business Cycle Volatility, with Economic Policy Variables^a

<i>Explanatory variable</i>	(1)	(2)
Volatility	-0.483 (0.163)	-0.453 (0.189)
Per capita GDP in 1960 (log)		-0.073 (0.243)

a. $Growth_t = \alpha + \beta Volatility_t + \delta X_t + \eta_t$. Sample: 1950–1998. Robust standard errors in parentheses

when the volatility of economic fluctuations is measured using a set of variables that originate in monetary and fiscal policies generally believed to be neutral to economic growth beyond their impact on economic fluctuations.

2.4 Cross-Country Variation

The effects of volatility on growth should differ among countries. The development of financial markets, the degree of openness, and the level of development can condition the negative effects of uncertainty on investment and growth. This section explores this issue by incorporating interaction terms between the volatility of output and per capita GDP, together with a measure of financial development (the average ratio of M3 to GDP). Table 7 shows the results of introducing these two interaction terms in the main regression.

In both cases, the interaction terms are significant, suggesting that the effects are larger for poor countries and countries with relatively less developed financial markets. This is true regardless of whether in the regression we condition for initial per capita GDP. Moreover, both the fit of the regression and the significance of the coefficient on volatility improve considerably. Of the two interaction terms introduced, the one with per capita GDP achieves a higher significance when both variables are introduced in the regression (see columns 3 and 6). From an economic viewpoint, both interaction variables are large in size. For example, large differences are found on analyzing the individual regressions (such as columns 1 and 2) and measuring the effect of volatility on output for the countries with the highest and lowest levels of development or financial deepening. Using the estimates of column 5, the (net) coefficient on volatility for the country with the average level of financial development is about -0.25 , which is practically identical to the

Table 7. Growth and Business Cycle Volatility: Cross-country Variation^a

<i>Explanatory variable</i>	(1)	(2)	(3)	(4)	(5)	(6)
Volatility	-1.583 (0.278)	-0.418 (0.072)	-1.329 (0.298)	-3.311 (0.436)	-0.411 (0.099)	-3.100 (0.514)
Volatility* per capita GDP	0.190 (0.040)		0.146 (0.047)	0.399 (0.055)		0.363 (0.066)
Volatility* financial development		0.005 (0.002)	0.002 (0.001)		0.005 (0.002)	0.002 (0.001)
Per capita GDP in 1960 (log)				-1.511 (0.280)	0.009 (0.179)	-1.488 (0.321)
<i>Summary statistics</i>						
R^2	0.37	0.21	0.32	0.53	0.20	0.50

a. $\text{Growth}_i = \alpha + \beta \text{Volatility}_i + \delta X_i + \eta_i$. Sample: 1950–1998. Robust standard errors in parentheses.

coefficient estimated in table 2 (with no interaction terms). The same calculation for the country with the lowest level of financial development produces a larger coefficient (in absolute value) of about -0.361 . The coefficient turns positive for the country with the highest level of development, at about 0.10. In other words, for high levels of development (measured by per capita GDP or financial deepening), the relationship between growth and business cycles turns positive instead of negative.

I can only speculate about the reason for this effect. One possibility is that business cycles differ in nature significantly depending on the level of development. Another possibility is that fluctuations and uncertainty only result in lower growth when financial markets are not fully developed and cannot provide risk-sharing mechanisms to protect agents against uncertainty. Theories that predict a positive correlation between growth and volatility probably fit rich countries better than poor countries. These theories suggest that countries choose from a set of technologies characterized by different combinations of risk and returns (growth). Countries that opt for riskier technologies will display both more pronounced business cycles and faster growth. This process, however, requires very well developed financial markets that can channel funds to those risky projects.

2.5 Effects of Business Cycles on Investment

In looking for a mechanism that explains the observed correlation between growth rates and business cycle volatility, the obvious candidate is investment. Uncertainty can adversely affect investment, and

Table 8. Investment and Business Cycle Volatility^a

<i>Explanatory variable</i>	(1)	(2)	(3)
Volatility	-1.106 (0.363)	-0.244 (0.361)	-8.42 (3.226)
Per capita GDP in 1960 (log)		5.227 (0.861)	0.33 (1.778)
Volatility* per capita GDP			1.043 (0.418)
<i>Summary statistics</i>			
R^2	0.11	0.33	0.43

a. $\text{Investment}_i = \alpha + \beta \text{Volatility}_i + \delta X_i + \eta_i$. Sample: 1950–1998. Robust standard errors in parentheses.

investment is one of the most robust variables for explaining long-term growth rates. Ramey and Ramey (1995) find that the link between investment and business cycle volatility is less robust than that between growth and business cycles. Aizenman and Marion (1999), however, find that the link between investment and volatility is stronger if one includes only private investment. Table 8 replicates these regressions for the dataset; it indicates that business cycle volatility is negatively correlated with average investment rates (see column 1, which reports the results of a regression run with only volatility on the right-hand side). A 1 percent increase in volatility reduces the average investment rate by about 0.5 percentage points. A quick, back-of-the-envelope calculation suggests that this drop in investment can justify lower growth rates of about 0.07 percent. This is about one-third of the effect estimated when average growth rates are regressed on volatility. According to these numbers, therefore, at most one-third of the effect of volatility on output growth can be attributed to its effect on lower investment.

Not only is the estimate of the effects of volatility on investment small, but it is not robust to the introduction of the initial level of GDP, as shown in column 2. This result can be overturned by allowing for the effect of volatility on growth rates to depend on the level of per capita GDP. In this case, the coefficient remains significant (see column 3). This last result suggests that taking into account the possibility that the relationship between volatility and growth is a function of the level of development greatly improves the fit of these regressions. Simple calculations using the range of values of the interaction term suggest that the coefficient of volatility on growth is about -3 for the poorest countries in the sample and about 1 for the richest countries.

Table 9. Growth and Business Cycle Volatility: Robustness Tests^a

<i>Explanatory variable</i>	(1)	(2)	(3)	(4)
Volatility	-0.145 (0.103)	-0.142 (0.059)	-0.110 (0.096)	-0.081 (0.071)
Per capita GDP	0.016 (0.227)	-0.437 (0.207)	-0.102 (0.213)	-0.753 (0.271)
Secondary education in 1960	0.069 (0.036)			0.028 (0.019)
Investment		0.153 (0.024)		0.143 (0.025)
Population Growth			-0.679 (0.229)	-0.413 (0.204)
<i>Summary statistics</i>				
R^2	0.15	0.53	0.21	0.54

a. $\text{Growth}_t = \alpha + \beta \text{Volatility}_t + \delta X_t + \eta_t$. Sample: 1950–1998. Robust standard errors in parentheses.

It thus seems that although business cycle volatility has negative effects on investment, investment cannot be the only channel through which uncertainty and volatility affect growth. Even in the best scenario, this channel can only account for about one-third of the total effect. This interpretation seems to corroborate the results of Easterly and Levine (2001), who argue that factor accumulation cannot explain most of the cross-country variation on growth rates.

2.6 Robustness of the Correlation to Other Growth-Related Variables

All the previous tables indicate that volatility matters for growth. More volatile economies tend to display lower long-term growth rates. In this section, I run a series of regressions to see whether this relationship between volatility and growth is robust to the introduction of a series of variables that have been shown to be relevant for growth. Most of the variables introduced are supposed to be independent of the volatility of business cycles, and there is no prior indication of the direction in which they might affect the results. This exercise follows the methodology of Levine and Renelt (1992) in testing the robustness of different sets of variables explaining cross-country differences in growth rates.

The set of variables added to the main regression is that identified by Levine and Renelt (1992). I include a measure of initial human capital (secondary education), the average investment rate, and the

Table 10. Volatility and Growth: Interaction between Business Cycles and Level of Development ^a

<i>Explanatory variable</i>	(1)	(2)	(3)
Volatility	-2.772 (0.282)	-1.7 (0.645)	-0.27 (0.091)
Per capita GDP in 1960 (log)	-2.229 (0.235)	-1.856 (0.422)	-0.953 (0.220)
Secondary education in 1960	0.037 (0.015)	0.04 (0.018)	0.026 (0.017)
Investment	0.083 (0.013)	0.143 (0.021)	0.12 (0.024)
Population Growth	-0.624 (0.153)	-0.562 (0.205)	-0.465 (0.465)
Volatility *	0.34		
Per capita GDP	(0.036)		
Volatility *		0.212	
Per capita GDP in 1960		(0.082)	
Volatility *M3/GDP			0.004 (0.001)
<i>Summary statistics</i>			
<i>R</i> ²	0.77	0.58	0.57

a. $\text{Growth}_i = \alpha + \beta \text{Volatility}_i + \delta X_i + \eta_i$, Sample: 1950–1998. Robust standard errors in parentheses.

growth rate of the population. Table 9 presents the results of including one variable at a time, as well as all variables together. All regressions also include the 1960 level of per capita GDP. The four columns reveal that the relationship between volatility and growth becomes weaker as these controls are added. The coefficient is still always negative, but its size goes down by almost half and its significance falls below standard levels.²²

These results cast doubt on the robustness of the relationship between volatility and growth, but they offer no hint on the economic mechanism that lies behind the estimates. It is unclear why a variable such as average population growth would be related to business cycle volatility in a way that breaks down the relationship between volatility and growth.

To examine these robustness tests more carefully, I again allow an interaction term between volatility and the level of development. Table 10 summarizes the results of a regression identical to that in table 9, but with a new variable that captures the interaction between

22. Similar results are obtained if one uses uncertainty, measured by the residual of a forecasting regression for output growth, instead of volatility.

business cycles and the level of development. Three variables represent possible sources of interaction with volatility: average (log) per capita GDP (column 1), initial (log) per capita GDP (column 2), and the average ratio of M3 to GDP (column 3).

All three columns produce consistent and interesting results. First, all the variables are significant and have the correct sign. Second, and most important, the introduction of an interaction term drastically increases the significance of the estimate of volatility on growth. This estimate appears much more robust than in table 9. The interaction term is positive in all cases, which confirms my previous estimates and suggests that the negative effects of business cycles on growth are much larger for poor countries. My main result is thus robust to the introduction of growth-related variables as long as I allow for differences across poor and rich countries in the effects of volatility on growth.

Table 10 can also be used to provide a reading on the significance of these interaction terms in relation to the ability of poor economies to converge to the levels of development of rich countries. The table suggests that the speed of convergence is a function of the volatility of business cycles. For countries with very volatile business cycles, lower per capita GDP does not ensure convergence toward richer economies. Taken in conjunction with theories postulating that poor economies are more likely to be subject to political and economic uncertainty, this finding points to the possibility that countries will fall into growth traps. Uncertain environments in poor countries prevent growth from taking off, and this lack of growth creates the conditions for uncertainty and economic volatility.

2.7 The Importance of Asymmetries in the Business Cycle

The analysis thus far indicates that economic fluctuations are negatively related to growth, but the question remains whether other features of the business cycle can influence the relationship between the two variables. The obvious candidate is the asymmetry of business cycles. In fact, the paper has frequently referred to the possibility that asymmetric business cycles are responsible for the observed link between volatility and growth. A proper characterization of business cycle asymmetries in a sample of ninety-eight countries is beyond the scope of this paper, but I want to see whether simple statistics that capture the asymmetric nature of shocks can modify or explain the main results.

Table 11. Growth and Business Cycles Asymmetries^a

<i>Explanatory variable</i>	(1)	(2)
Business cycles asymmetry ^b	0.334 (0.242)	0.188 (0.198)
Volatility		-0.229 (0.071)
<i>Summary statistics</i>		
R^2	0.02	0.13

a. $Growth_t = \alpha + \beta Skewness_t + Volatility_t + \eta_t$, Sample: 1950–1998. Robust standard errors in parentheses

b. Measured as the skewness of per capita GDP growth rates.

I calculated the skewness of per capita GDP growth rates for each country in the sample and then used this measure of asymmetry as an explanatory variable in the basic growth regression. Table 11 shows the results of regressing average growth rates on skewness and on skewness and volatility. The coefficient on skewness has the right sign, indicating that average growth is lower when business cycles are skewed toward large negative shocks.²³ The coefficient is not significant, however, and both the coefficient and the significance drop even further when the measure of volatility is introduced into the regression. I therefore conclude that business cycles that are skewed to the left (that is, when countries suffer large, infrequent negative shocks) are more harmful to growth than symmetric fluctuations. However, the effect is weak and the coefficient is not significant, especially after introducing the volatility of business cycles into the regression.

Although the results of table 11 seem to question the economic importance of asymmetries in the link between business cycle and growth, it is important to take into account the difficulties of consistently characterizing asymmetries for the sample of countries under study. The type of asymmetries captured in the theoretical framework of Rodrik (1991), for example, is poorly captured by an indicator such as the skewness of the distribution.²⁴

23. See Hausmann and Gavin (1996) for similar arguments in the case of Latin America.

24. One possible solution to this measurement problem is to look at a specific source of economic fluctuations (such as oil shocks) and characterize asymmetries by looking at the response to both positive and negative shocks to that variable. Even so, there is a question on whether those shocks have the same impact in economies at different stages of development.

3. CONCLUSIONS

This paper studies the link between business cycles and long-term growth rates. Business cycles and growth are generally analyzed separately under the assumption that business cycles can be characterized by transitory dynamics that have no effect on long-term trends. The stability of growth rates over the last hundred years in the United States and other industrial economies, combined with the good fit that Solow-type growth models produce in cross-country studies, has been used as a strong empirical argument for keeping economic fluctuations out of growth models and restricting the study of business cycles to deviations around the steady state.

The empirical evidence presented here has uncovered interesting interactions between cycles and growth that are significant both economically and statistically. My argument is based on two related pieces of evidence. First, business cycles cannot be considered temporary deviations from a trend. This observation, which is largely studied in the literature that looks at the trend-cycle decomposition, is instrumental for understanding the effects of volatility on growth. Under the interpretation presented in this paper, the documented persistence of business cycles is a measure of the effects of business cycles on growth. The fact that there is a strong positive correlation between persistence of short-term fluctuations and long-term growth rates contradicts business cycle models based on small deviations from a steady-state solution in a Solow-type growth model. This paper shows that a simple endogenous growth model in which business cycles affect growth can easily replicate this correlation.

Second, in models featuring asymmetric business cycles, an increase in volatility can lead to a decrease in long-term growth rates. Even without asymmetries, uncertainty related to business cycle volatility can lead to lower growth. The data support this proposition. Countries with more volatile fluctuations display lower long-term growth rates. A series of robustness tests designed to correct for possible omitted variables bias or problems of endogeneity reveals that the relationship is robust. Additional evidence points to a nonlinear relationship between growth and business cycles, which is well captured by an interaction term between volatility and the level of development. The effect of business cycles on growth is much larger for poor countries. This finding holds true if the level of development is measured by the degree of financial deepening. A plausible interpretation of this effect is that the development of financial markets reduces the costs associated

with volatility and uncertainty because it opens possibilities for risk sharing among individuals.

Although the results clearly support models that integrate business cycles and long-term growth, the process of extracting policy recommendations from them is inherently difficult. The lack of an accepted theoretical framework limits the ability to produce structural tests of well-specified theories. So far, endogenous growth models have had only limited success explaining cross-country growth patterns. The results of this paper encourage further theoretical development of endogenous growth models with business cycles. They also suggest that making explicit the effects of economic fluctuations on growth could improve the models' ability to explain features of the business cycle.

APPENDIX

List of Countries

Algeria	Ecuador	Malawi	Singapore
Angola	Egypt	Malaysia	Somalia
Argentina	El Salvador	Mali	South Africa
Australia	Ethiopia	Mauritania	Spain
Austria	Finland	Mauritius	Sri Lanka
Bangladesh	France	Mexico	Sudan
Belgium	Germany	Morocco	Sweden
Benin	Ghana	Mozambique	Switzerland
Bolivia	Greece	Nepal	Syria
Botswana	Guatemala	Netherlands	Tanzania
Brazil	Haiti	New Zealand	Thailand
Burkina Faso	Honduras	Nicaragua	Togo
Burma	Hong Kong	Niger	Trinidad and Tobago
Burundi	India	Nigeria	Tunisia
Cameroon	Indonesia	Norway	Turkey
Canada	Ireland	Pakistan	Uganda
Central African Rep.	Israel	Panama	United Kingdom
Colombia	Italy	Papua New Guinea	United States
Congo	Jamaica	Paraguay	Uruguay
Costa Rica	Japan	Peru	Venezuela
Cote d'Ivoire	Jordan	Philippines	Zaire
Chad	Kenya	Portugal	Zambia
Chile	Korea, Republic of	Rwanda	Zimbabwe
Denmark	Liberia	Senegal	
Dominican Republic	Madagascar	Sierra Leone	

Source of variables:

GDP, population, and investment rates are from the Summers-Heston Penn World Tables, version 6.0 (available at www.princeton.edu/~gurkaynk/growthdata.html).

Inflation, money supply (M3), openness, government size, and budget deficit are from the World Bank, *World Development Indicators, 2001*.

Exchange rate arrangements are from the International Monetary Fund, "Annual Report on Exchange Arrangements and Exchange Restrictions," several years. Original coefficients (from 1 to 10) have been transformed to a scale of 1 to 3, where 1 represents fixed, 2 intermediate, and 3 flexible exchange rates. Fixed exchange rates correspond to the original values of 1 to 5, intermediate to the values of 6 to 8, and flexible to the values 9 and 10.

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