GROWTH AND VOLATILITY IN INTER- AND INTRA-NATIONAL DATA

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The undersigned, appointed by the dean of the Graduate School, have examined the dissertation entitled

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a candidate for the degree of doctor of philosophy, and hereby certify that, in their opinion, it is worthy of acceptance.

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1. Introduction

Countries exhibit well documented fluctuations in aggregate variables. Real business cycles models offered an explanation, seeking to account for these regularities in a perfectly competitive environment. The development of numerical methods allowed authors to quantitatively analyze short run variations in macroeconomic time series data. Early work in this field identified a number of stylized facts found in United States postwar data.

Kydland and Prescott (1982) and Long and Plosser (1983) suggested that fluctuations on macroeconomic variables arise when maximizing agents with standard preferences face productivity shocks. A stochastic dynamic general equilibrium model yielded statistics similar to those observed in U.S. data. Using parameter estimates borrowed from microeconomic evidence, relatively simple models replicated second moments of observed time series, a process known as "calibration". This approach also provided a rationalization of the sign of observed cross correlations between variables like output, investment and consumption.

Despite its success in many respects, this approach still could not explain other distinctive characteristics of modern economies. In particular, early models exhibited too small employment and investment variations when compared to data. On the other hand, consumption was more volatile in the theoretical economy than in data[1].

Further research proposed that these magnitudes could be corrected by incorporating the effect of the interaction between countries. In a world populated by two economies with identical technologies, one can expect capital to be allocated to the

[1] Kydland, Finn E. and Prescott, Edward C. "Time to Build and Aggregate Fluctuations." p. 1368

country that receives the positive productivity shock. This will result in higher domestic investment volatility. In addition, if countries can share risk by trading assets, we could expect consumption to be smoother in each economy[2].

Prior work was extended to study the nature of fluctuations in “open” economies environments. In this framework authors investigated the effects of productivity shocks, examining the behavior of variables like the trade balance and the terms of trade. Two – country models were able to replicate stylized facts using international data. However, some puzzles could not be solved. As an example, models exhibited consumption correlations across countries that were larger than those observed in data.

In an attempt to solve these controversies, international real business cycles models were further modified. New approaches included the “small” open economy case, non-tradable goods, and imperfect access to capital markets. The main purpose of the small open economy case is to build models that will replicate stylized facts of international macroeconomic data, like the countercyclical behavior of the trade balance. In “small open economies” models the economy is not able to affect world prices, which are considered exogenous variables. These perspectives were able to explain some of the empirical puzzles, although more research is needed to improve models’ correspondence with data.

Although the first real business models tried to mimic data from the United States, their methodology was quickly applied to study groups of developed countries. As shown in the work of Backus, Kehoe and Kydland (1992), this group of countries exhibited quite

[2] Backus, David K.; Kehoe, Patrick J. and Kydland, Finn E. “International Business Cycles.” *Journal of Political Economy*, August 1992, *100*(4), p. 746.

similar statistics. However, Developed Countries (DC) and Least Developed Countries (LDC) have different patterns with respect to macroeconomic variables fluctuations[3]. Assuming agents' preferences and technologies do not differ by much, this must be the result of countries' singular characteristics.

1.1 Inter-national Data

For concreteness, Table 1.1 presents some business cycles characteristics for an illustrative pair of countries. One is a developed economy and the other is a developing country.

Table 1.1: Business Cycles in Argentina and Canada

Variables	σ_x	$corr(x_t, x_{t-1})$	$corr(x_t, GDP_t)$
GDP			
Argentina	4.6	0.79	1
Canada	2.8	0.61	1
Consumption			
Argentina	5.4		0.96
Canada	2.5	0.7	0.59
Investment			
Argentina	13.3		0.94
Canada	9.8	0.31	0.64

Source: Selected from Table 1.2: Martin Uribe Notes on Open Economies. Taken from Mendoza (1991) and Kydland and Zarazaga (1997).

For example, summary statistics show that Argentina output variability is 64% larger than that of the Canadian economy. In terms of persistence of the cycle, there are no major differences. If we focus on consumption, Argentina exhibits a variability that is

[3] Uribe, Martin "Notes on Open Economies" Duke University.

more than twice that of Canada, and that is more correlated with output. Finally, investment also is more variable in Argentina than in Canada (around 36% more).

These regularities can be generalized to a sample of developed countries and LDCs listed in Appendix 3. Table 1.2 shows that the average variance of the output cyclical component for DCs is almost half than for the emerging economies. In terms of persistence of the cycle, there is not much difference.

Table 1.2: Business Cycles: Emerging versus Developed Economies

Variables	Emerging Countries	Developed Countries
σ_{GDP}	2.02	1.04
ρ_{GDP}	0.86	0.9

Source: Martin Uribe "Notes on Open Economies". Taken from Aguiar and Gopinath (2004).

According to the data, excessive output volatility is a distinctive feature of developing economies. This seems to suggest a negative correlation between output growth and output fluctuations. However, as pointed out by Ramey and Ramey (1995), the growth literature does explicitly address this topic[4]. Furthermore, standard real business cycles models do not link growth and volatility.

Ramey and Ramey (1995) provide evidence of the link between output growth and output variance for two samples of countries. The basic result of their work is that the correlation exists, it is negative and it is robust to the inclusion of other explanatory variables in growth regressions.

[4] Ramey, Garey and Ramey, Valerie A. "Cross-Country Evidence on the Link Between Volatility and Growth" *American Economic Review*, December 1995, *85*(5), pp. 1138-1151.

1.2 Intra-national Data

I compare the above shown results at the country level with data on gross state product growth and variability that exhibits a zero correlation between these two variables.

A measure of output fluctuation is obtained for all states belonging to the United States for the 1960 – 2000 period and then correlated with per capita real gross state products[5]. The result is quite puzzling: there is no evidence that richer states exhibit smaller output fluctuations, or that states with larger variability on their respective state product perform worse in terms of real gross state product. This evidence supports the hypothesis that there is no relationship between output fluctuation and output per capita at the state level.

I consider "rich" states those that are at the top quintile of the real per capita gross state product distribution, and "poor" states those that are the lowest. Assuming rich states to be analogous to developed countries and poor states to LDCs, we do not observe any striking difference between their average output volatility.

Table 1.3.A: Rich States versus Poor States (2000)

Variables	Rich States	Poor States
Average σ_{GSP}	3.952	3.269
Av. Per Cap. RGSP*	48,805	25,655

Source: Author calculations based on data from the US Bureau of Economic Analysis.
* = In 2000 chained dollars.

[5] See Appendix 1 for an explanation of the measure of output fluctuations, data source and transformation.

This table is reproduced, for the year 1963, to make sure that this result is not particular for the year 2000. States in the samples (top and low quintiles) are different.

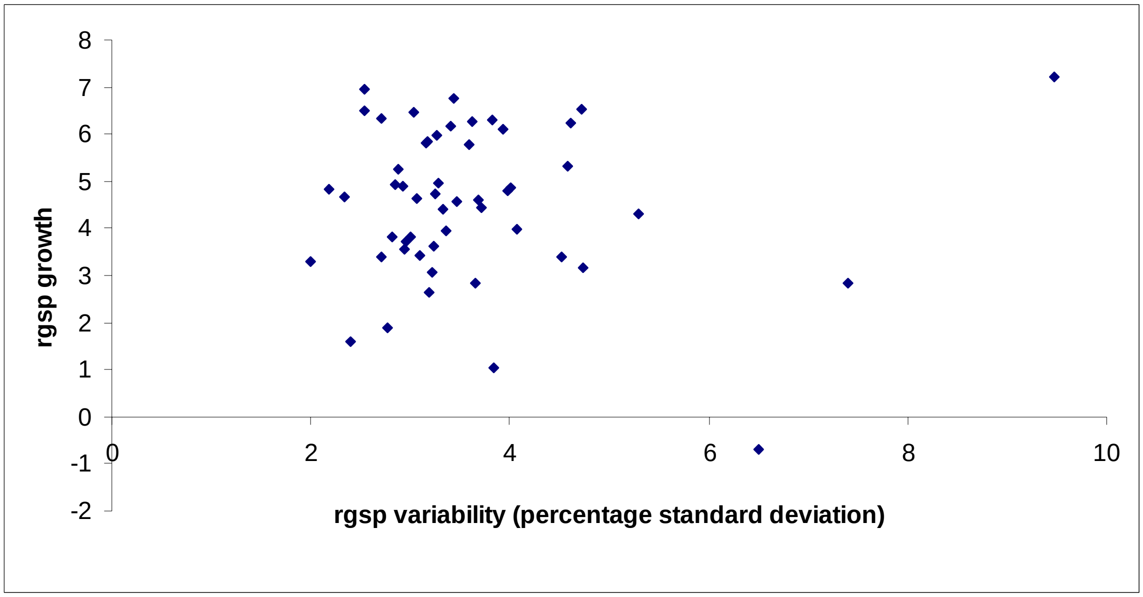
Table 1.3.B: Rich States versus Poor States (1963)

Variables	Rich States	Poor States
Average σ_{GSP}	4.474	3.532
Av. Per Cap. RGSP*	19, 282	10,490

Source: Author calculations based on data from the US Bureau of Economic Analysis.
* = In 2000 chained dollars.

As show by the above tables, there seems to be no correlation between real gross state product variability and per capita real gross state product. Actually, the richest states in the two selected years seem to fluctuate more than poorer states. To be more specific, growth rates of all 51 states are obtained for the period 1963 – 2000 and correlated with gross state product variability. The correlation coefficient obtained is – 0.0224. Graphically,

Graph 1.2 Rgsp variability versus Rgsp growth



1.3 Thesis

A question then arises: why the negative output variability – per capita output is present at the country level and not at the state level? Is there any reason as to why relatively richer states are allowed to exhibit a larger output variability and relatively poor countries are not? What can we learn from these correlations?

I propose that the lack of correlation between growth and volatility at the state level constitutes evidence of some type of volatility that does not affect growth. This type has been rationalized quite well by real business cycle models as shocks to productivity. On the other hand, the negative growth – volatility correlation at the country level suggests that there is other type of volatility, one that does affect growth. This paper suggests that political instability in emerging countries creates an asymmetric information problem which increases output volatility and reduces mean output in that group of countries.

This thesis is based on prior work by Aguiar and Gopinath (2007), Alesina et. al. (1992) and Aizenman and Marion (1993). Aguiar and Gopinath study the different business cycles characteristics of emerging and developed countries. They show that a relatively standard real business cycle model can replicate both groups of countries stylized facts. One of their conclusions is that the higher volatility exhibited by emerging countries is the result of shocks to the growth trend of the total productivity factor. In contrast, developed countries experience only transitory shocks to productivity. Aguiar and Gopinath do not provide any explanation about how this difference arises, but they suggest that they most probably are the result of some time of friction in emerging countries.

Alesina et. al. provide empirical evidence on the link between political instability and growth for a sample of 113 countries for the period 1950 – 1982. They measure political instability as the propensity of a government change using a probit model. Alesina et. al. find that there is a strong negative link between political instability and growth, and that their results are robust to a number of specifications.

Along the same lines, Aizenman and Marion obtain measures of policy uncertainty and they correlate them with growth: there is a negative link between policy uncertainty and growth for a sample of 46 developing countries for the period 1970 – 1985. Their measures of policy uncertainty are the variance of the residual of a policy variable in an autoregressive model of order one. Furthermore, Aizenman and Marion propose a model that can explain the data correlation. There are two shortcomings to this approach: it relies heavily on policy uncertainty persistence and assumes that policy uncertainty affects investment. However, Ramey and Ramey (1995) conclude that investment is not important in the link between growth and volatility.

Motivated by previous work and by the state evidence, I argue here that policy instability creates an asymmetric information problem between firms and governments in emerging countries. The asymmetry in information links volatility and mean output in emerging countries. To support that thesis, I provide state evidence for the volatility – growth correlation that shows that when economies are not subject to policy instability, there is no link between growth and volatility. My paper contributes to the literature by documenting the volatility – growth correlation at the state level and by proposing a theoretical explanation about the incidence of volatility on growth in emerging countries.

I investigate the effect that asymmetric information might have in explaining output fluctuations. Perfect competitive assumptions disregard the effect of the lack of information in economic decisions. Presently, this approach has the shortcoming that it does not always provide unambiguous results, which complicates the analysis. However, it is worth investigating if introducing the asymmetric information assumption can yield interesting conclusions about output fluctuations. To develop this idea further a detailed model is presented in chapter 4.

Naturally, states and countries also differ on the impact that their borders have in their economies. Although states have some level of autonomy, their borders are not as stringent as a national border. There seems to be evidence that border effects are important, at least for price determination. Engel and Rogers (1996)[6], provide evidence in favor of the hypothesis that international borders can account for a substantial percentage of price volatility by comparing data from the U.S. and Canada. Helliwell and McKitrick (1999) show that the domestic saving – investment correlation is nearly inexistent for Canadian provinces, suggesting that state borders are quite permeable.

In this thesis, state borders mean that states do not face political instability (or policy uncertainty), as they belong to a larger political organization (the United States). Along the same line, it would be interesting to study the business cycles characteristics of the European Union countries that have achieved, despite the existence of national borders, an incredible level of integration. That constitutes further research.

The paper proceeds as follows. Chapter 2 reviews the contributions of real business cycles theory to the study of macroeconomic fluctuations. Section 2.1 describes closed and open benchmark real business cycles models. Section 2.2 departs from perfectly competitive assumptions and lists contributions of asymmetric information to economic theory. Chapter 3 explains the empirical and theoretical specifications of relevant work about the growth and volatility correlation. It also summarizes empirical evidence of the economic effects of international borders. Chapter 4 describes a model in which the presence of private information explains larger output fluctuations. Finally, chapter 5 summarizes findings and proposes further research.

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[6] Engel, Charles and Rogers, John H. "How Wide is the Border?" *American Economic Review*, December 1996, *86*(5), pp. 1112 – 1125.

2. The Real Business Cycles Approach

Real business cycle models provide an account for fluctuations in macroeconomic time series data assuming a perfect competitive framework. In this chapter, I focus on the literature that concentrates on documenting empirical regularities in international data. A description of closed economies benchmark models follows. Later, the open economy framework is presented. Subsequent sections review further attempts to conciliate data and theoretical results. Finally, last subsection summarizes real business cycles models criticism.

2.1.1 Closed Economies

The idea that fluctuations in aggregate variables could arise in a competitive environment was initially developed in Kydland and Prescott (1982)[7]. These authors made this point clear by reproducing key stylized facts of US postwar data in a stochastic dynamic general equilibrium model.

Motivated by a criticism in the way of modeling investment technologies, Kydland and Prescott proposed a modification to the neoclassical growth model. They asserted that the two most common ways of modeling investment technologies were fundamentally wrong. In the standard neoclassical growth model the shadow price of capital and investment activity are not correlated. Assuming some type of capital good adjustment cost will eliminate the former problem but it is also incongruent with data. Rather, Kydland and Prescott formalize the idea that it takes time to undertake an investment project by introducing the idea of "time to build."

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[7]Kydland, Finn E. and Prescott, Edward C. "Time to Build and Aggregate Fluctuations."

The second key feature of their model is the introduction of a non – time separable utility function. This setup allows for a greater intertemporal substitutability of leisure, a necessary ingredient to derive fluctuations in employment. This approach is based on previous work by Grossman (1973) and Lucas (1977) and supported by empirical evidence. These modifications represent an attempt to incorporate into the model decision rules that generate time series that are closer to what we observe in data, an idea that will recur in this literature.

Kydland and Prescott propose a modified general equilibrium growth model with two exogenous stochastic components. These are a shock to technology and imperfect indicators of productivity.

Their model is able to replicate many of the features exhibited by post-war US data. These are: investment fluctuates more than output; consumption has a lower variability than output; both consumption and investment are positively correlated with real output; capital stock and real output are negatively correlated. For concreteness, Table IV from Kydland and Prescott (1982) is partially reproduced here.[8]

Table 2.1: Sample Standard Deviations and Correlations with Real Output U.S. Economy 1950:1-1979:2

	Standard Deviations (per cent)	Correlations with Real Output
Output	1.8	–
Total Consumption	1.3	.74
Investment Fixed	5.1	.71
Hours	2.0	.85
Productivity	1.0	.10

[8] Kydland, Finn E. and Prescott, Edward C. "Time to Build and Aggregate Fluctuations." p. 1365.

Model predictions are consistent with all of these facts, although the negative correlation between capital stock and real output is smaller in the model economy than in actual data.

Kydland and Prescott were not completely successful. They encountered some discrepancies between data and model's results: the most important being that the model predicts a higher variability in hours than in productivity[9].

The authors conclude that their assumptions about the investment technology (time to build) and the preference structure (non – time separable utility function) are critical for their model to be consistent with data. Further research in the field will incorporate these results, and most authors will use this structure while trying to explain other characteristics of business cycles.

Kydland and Prescott's work was amongst the first to formalize the method and the procedures of real business cycles models. The fact that their results are insensible to a wide range of parameter selection has at least two implications. First, their explanation about business cycles nature applies to different conditions. Second and directly suggested by the former, this model can be applied to different countries, an idea further developed by other authors.

Another important contribution to the real business cycle approach is the work by Long and Plosser (1983)[10]. The purpose of this work is to explain two basic characteristics of economic variables fluctuations: the amount of persistence of cycles and the co movement of measures of different economic activities. These authors build a dynamic stochastic general equilibrium model that relies on consumer preferences and

[9] This will be a recurrent problem in real business cycle theory.
[10] Long, John B. and Plosser, Charles I. "Real Business Cycles" *Journal of Political Economy*, February 1983

production technologies as explanations of these characteristics. The model also assumes a perfect competitive economy.

Specifically, consumer preferences in this context imply that consumers have a desire to smooth any increase in wealth both over time and over different commodities. The second part of this assumption sets the ground for the cycle expansion to other sectors of the economy and by thus adds to the persistence of the cycle. However, this assumption by itself is not able to induce fluctuations on variables like output, employment or consumption. To solve that problem, the second assumption implies a production technology that uses labor and previously produced inputs. In this economy, a commodity can have different uses, it could be either consumed, or used as an input in the production of other goods. In addition, there is a productivity shock that affects the production functions. One can foresee that when there is a shock to the production of good *i*, the production of other goods (that use good *i* as an input) will be affected as well.

Formally, the model assumes an infinitely lived representative agent that chooses a consumption – production path based on initial resources, preferences and available technology. There are "*N*" sectors in this economy, producing "*N*" different commodities. After the agent takes the consumption and leisure decision, a productivity shock affects the different production functions. The combination of inputs and labor then determine how much will be produced in the period, and that determines the commodity stock for next period.

In its general specification, the model assumes that the agent maximizes its expected utility:

$$U = \sum_{t=0}^{\infty} \beta^t u(C_t, Z_t) \quad 0 < \beta < 1$$

where β is a discount factor, C_t is an $N \times 1$ vector of good consumed at time *t* and Z_t is the quantity of leisure time chosen at time *t*. According to these preferences current leisure choice does not depend on recent leisure consumption.

Production possibilities for each good are described according to the following production functions:

$$Y_{t+1} = F(L_t, X_t; \lambda_{t+1})$$

where Y_{t+1} is an $N \times 1$ vector of commodities stock at time *t+1*, L_t is a vector of labor inputs at time *t*, X_t is a matrix of commodities inputs at time *t* and λ_{t+1} is a random vector that is realized at time *t+1*. Finally, the function F is an $N \times 1$ vector valued concave linear homogeneous function.

The agent is constrained by two conditions that must be satisfied at each point in time. Leisure and labor input choices are constrained by a given amount of total available time at time *t*:

$$Z_t + \sum_{i=1}^{N} L_{it} = H \qquad t = 0, 1, 2\ldots$$

At any point in time, time devoted to leisure plus the summation over labor used in all *N* sectors must equal total available time *H*. In a similar way, the consumption decision is restricted by stock available at any point in time:

$$C_{jt} + \sum_{i=1}^{N} X_{ijt} = Y_{jt} \qquad j = 1, 2, \ldots N; \quad t = 0, 1, 2\ldots$$

Consumption of good *j* at time *t*, plus the summation over all uses of good *j* in the production of other goods must equal the available stock of good *j* at time *t*. Assuming specific functional forms allow the authors to better analyze the business cycles implications of this model. First, the fraction of a commodity allocated to production is an increasing function of the productivity of that use. This includes time allocation, so that the amount of leisure consumed depends negatively on labor productivity. Second, quantities allocated to productive uses are also an increasing function of total stock of that commodity. With this assumption, a positive shock affects the production function of a given good. Hence, a larger amount of that good will be allocated into the production of other goods in the next period, thus propagating the cycle.

In order to better analyze comovements across various sectors of the economy, Long and Plosser propose an empirical example in which the economy is composed of six sectors. Using U. S. data from the input – output table of 1967, they obtain a measure of how much of each sector's output is used as an input in the others sectors. The six sectors are agriculture, mining, construction, manufacturing, transportation and trade and services and miscellaneous. Impulse response functions are obtained from a moving average representation of next period aggregate output. The results include that the largest response to a shock takes place in the sector that produces the commodity whose production function received the shock. In general, other sectors exhibit a peak in their output as a response of a shock in a input sector after two periods. Finally, a shock to sectors that have many uses as inputs in the production of other commodities induce a larger output response in the whole economy than if the shock affects an industry that produces an intermediate good that is used less intensively.

One conclusion of this work is that simple economic principles can explain business cycles characteristics. In particular, persistence and comovement of economic variables are part of a desired consumption – production plan when both present and future consumption are normal goods for the agent. Capitalistic production is a key ingredient in obtaining these results. When labor is the only input in production, the model cannot exhibit business cycles features. As it is true with Kydland and Prescott's approach, Long and Plosser provide a working ground that can be modified in order to incorporate other explanations of business cycles.

2.1.2 Open Economies

Researches have devoted considerable effort to documenting empirical regularities in trade, output and consumption across countries. One area has extended benchmark real business cycles models by considering “open” economies. Backus, Kydland and Kehoe (1992) focus in explaining two of those, the countercyclical aspect of net exports and the dynamics between the balance of trade and the terms of trade[11]. This approach consists of a model that can account for observed data properties for 11 developed countries.

Data are obtained from OECD’s Quarterly National Accounts. Sample periods differ for the 11 countries, but they are all postwar statistics. Variables considered are real output, net exports and terms of trade. Backus, Kydland and Kehoe define terms of trade as the ratio of price of imports to price of exports, using implicit price deflators. This definition allows them to consider the terms of trade as the real exchange rate. Summary statistics of this data set permit authors to derive some common properties.

First, trade variables (trade balance and terms of trade) are more volatile in some countries than others. As an example, standard deviations for terms of trade go from 1.63 to 5.86. Second, trade variables are highly persistent. Third, as other authors also noted, net exports statistics are countercyclical for all countries. Fourth, current correlations between net exports and the terms of trade are negative most of the time. However, authors argue that in order to better understand the rather complicated process that dictates the relation between trade variables, we have to explore their cross-correlations functions. For all 11 countries cross-correlations functions exhibit a horizontal “S”

[11] Backus, Kehoe and Kydland “Dynamics of the Trade Balance and the Terms of Trade: The J-Curve?”

shaped curve, implying that net exports are negatively correlated with current and future movements in the terms of trade and positively correlated with past movements. Authors state that these results are robust with respect to different sample periods and to different choices of variable filters.

In an attempt to account for these patterns, Backus, Kydland and Kehoe propose a model that will try to replicate the properties observed in real data. If the model is successful, then we can identify these causes.

The model proposed is basically an open economies version of Kydland and Prescott (1982). This is a stochastic growth model, where fluctuations arise from shocks to productivity and government purchases of goods and services. The model considers two countries that produce two different goods.[12] Authors first "run" the model with certain parameters which define the "benchmark economy." The model calibration is directly taken from Kydland and Prescott (1982). With this choice of parameters, this model will replicate, to some extent, the most important characteristics exhibited by international data. Their findings are as follows: net exports and terms of trade are highly persistent, net exports are countercyclical, and net exports and terms of trade are negatively related.[13]

Then, to determine how different choices of parameters affect results, authors modify relevant parameter values and rerun the model. After performing this exercise, they conclude that the elasticity of substitution between foreign and domestic goods will not affect the shape of the cross-correlation function between net exports and terms of

[12] Backus, Kehoe and Kydland, op. cit. p. 89.
[13] Backus, Kehoe and Kydland, op. cit. p. 92-93.

trade (the horizontal “S”). However, it will affect at what time it becomes positive. They also find that adding shocks to government purchases will not affect significantly previous results.

Data from the model economy exhibits some differences when compared with actual data. The model predicts a horizontal “S” shaped curve that becomes positive somewhat faster than in real data. In addition, the model’s variables are not as persistent as in actual data. In order to account for this, authors propose a couple of approaches that could improve the strength of the model.

First, they suggest modifying the dynamics of investment and applying the idea of “time to build.” This improves the results of the model to some extent. Second, they apply the idea of “time to ship,” a friction in international trade that will prove to be as helpful as “time to build” in modifying the model performance. Both will shift the correlation function at least one quarter to the right, making the model a better approximation of real data.

In an attempt to clearly identify the cause of fluctuations in international data, authors run the model making two extreme assumptions. Their first approach is to assume that there is no capital, and the second is to assume that fluctuations arise solely from shocks to government purchases. They are able to demonstrate that under these assumptions the model will not replicate the characteristics exhibited by real data.

Finally, authors discuss two major shortcomings of the model economy. First, terms of trade is more variable in reality than what the model predicts. Second, according to the model, consumption correlation is larger than output correlation across countries, while the opposite is observed in international data.

Backus et al. conclude that the model can clearly state the role played by shocks to productivity and capital in the determination of the "S" curve. As noted by the authors, these ingredients are essential to obtain the pattern exhibited by real data. This result might have major policy implications since it suggests that government purchases of goods and services by themselves are not relevant to explain fluctuations of international trade time series.

This model is amongst the first to account for most of the fluctuations observed in international time series. It contributes to the real business cycle theory by setting a benchmark model for "open" economies.

This paper cannot explain what Backus, Kydland and Kehoe call "anomalies:" the larger variability of terms of trade in real data and the sizes of output and consumption correlations across countries. As noted by authors, the misleading results proposed by the model are robust to different choices of parameters, implying that there might me a problem with the model itself. Future revisions of this basic model will try to account for these anomalies and hopefully will yield a better understanding of the causes of fluctuations.

2.1.3 Small Open Economies

Continuing the previously discussed line of research, some authors proposed that a modification of the "open economy" benchmark model might better explain some of the anomalies stressed by Backus, Kehoe and Kydland. Mendoza (1991)[14] applies a real business cycle model to postwar Canadian data. His main focus is to be able to account for the positive saving – investment correlation even in the presence of perfectly mobile financial capital. As explained above, this correlation was somewhat puzzling since it implies some kind of imperfection in the financial international market. However, Obstfeld (1986) showed that with persistent enough productivity shocks, the aforementioned correlation arises in a dynamic – equilibrium model. Using an overlapping generations model, Finn (1990) stated that any type of investment – savings correlation may arise, depending on the nature of the technology shock[15]. According to these authors, a positive savings – investment correlation should not be interpreted as a lack of capital mobility. Mendoza's model is able to replicate many of the observed patterns in data including the countercyclical fluctuations in the balance of trade.

Distinctive characteristics of this model include the assumption of moderate capital adjustment costs and minimal variability and persistence in the technological shock. The first assumption will make physical capital less mobile than financial capital, something that seems plausible. Formally, this assumption enters Mendoza's model in the following way:

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[14] Mendoza, Enrique G. "Real Business Cycles in a Small Open Economy." *AER* 1991.
[15] Obstfeld, Maurice, "Capital Mobility in the World Economy: Theories and Measurement" *Carnegie-Rochester Conference Series on Public Policy*, Spring 1986, *24*, 55-103 and Finn, Mary G., "On Savings and Investment Dynamics in a Small Open Economy" *Journal of International Economics*, August 1990, *29*, 1-22; cited by Mendoza, op. cit. p. 798.

$$G(K_t, L_t, K_{t+1}) = \exp(e_t) K_t^{\alpha} L_t^{1-\alpha} - \left(\frac{\phi}{2}\right)(K_{t+1} - K_t)^2$$

where: $G(\cdot)$ is a production function

K, L are capital and labor inputs in production

$\phi > 0$ is the size of the adjustment cost.

$0 < \alpha < 1$ is the capital share, and e_t is the productivity shock.

The second one is an attempt to avoid criticisms of the business cycle approach that assert that most of the fluctuations expressed by the model are actually already embodied in the shocks. Finally, Mendoza introduces a different utility function that will treat the rate of time preference as endogenous. Agents are assumed to maximize their expected utility, which takes the following form:

$$E\left[\sum_{t=0}^{\infty}\left\{u(C_t - G(L_t)) \times \exp\left(-\sum_{\tau}^{\tau-1} v(C_\tau - G(L_\tau))\right)\right\}\right]$$

where the exponent term is an endogenous (depending on previous consumption levels) time preference parameter.

Some results include the fact that high positive saving – investment correlation can arise in a small open economy even if we assume perfect capital mobility. Also, the same productivity shocks that account for many of the stylized facts in postwar business cycles are able to explain the saving investment correlation.

Mendoza encounters the problem that his model overestimates the volatility of investment with respect to the closed economy case as noted above in Backus et al. (1992). This is actually the motivation of the capital adjustment cost assumption. Another limit of the analysis is the inability to replicate the observed behavior of productivity and consumption.

An important contribution of this paper is the extension to a small open economy case. This distinctive characteristic is formalized by the assumption that the world's real interest rate is taken as given by agents in the small open economy. Mendoza considers not only shocks to productivity but also to the terms of trade. These latter two contributions are suggested by the situation of many developing countries. Mendoza will explore the implications of these assumptions later.

2.1.4 Further Research

This section briefly describes further modifications to the benchmark real business cycles models. In these pages, the chief aim is to reduce discrepancies between actual data and model's predictions. Although they are successful at a specific level, there is not a comprehensive real business cycles model that accounts for empirical regularities of an open economy.

In a 1993 paper, Baxter and Crucini focus on the puzzling savings – investment correlation[16]. Although using a different approach, these authors are also able to replicate a positive S-I correlation using a two country stochastic growth model. The distinctive characteristics of their model include perfect capital mobility and taking into account the relative size of countries and their different ability to influence the world's interest rate.

As previous applications of real business cycle models, some facts cannot be explained. In this case, their model is unable to account for the behavior of labor, investment and output across countries and predicts, again, a near perfect consumption correlation across countries.

This work contributes to the real business cycle theory by distinguishing between smaller and bigger countries, while keeping the general equilibrium approach. This allows the authors to replicate the fact that the S-I correlation is lower in smaller countries.

Terms of trade shocks could also be a driving force behind international business cycles. In order to explore this possibility, Mendoza (1995)[17] proposes a model with terms of trade shocks that can account for international fluctuations. The author's

[16] Baxter, Marianne and Crucini, Mario J. "Explaining Saving--Investment Correlations."
[17] Mendoza, Enrique G. "The Terms of Trade, the Real Exchange Rate, and Economic Fluctuations."

motivation comes from the fact that fluctuations in the terms of trade can potentially play an important role in explaining business cycles, particularly for developing countries. As observed in actual data, past terms of trade shocks affected developed and developing countries unevenly. Industrialized countries suffer an increase in their energy prices, while developing countries faced increased energy prices along with a dependence on capital goods imports and on commodity exports.

By studying 7 industrialized countries and 23 developing countries, Mendoza finds roughly the same stylized facts for international data discussed above. One important finding, however, is the fact that cycles tend to be longer in developing countries than in industrialized countries.

An important difference between Mendoza's model and the model proposed by Backus et al. (1992) is that the former author assumes that model terms of trade are exogenous. Mendoza also assumes trade only in one-period risk-free bonds, resulting in an incomplete international financial market. The origin of this assumption is that complete international financial markets will create a near perfect consumption correlation across countries, a well known feature of international real business cycles models. In order to resolve this, other authors introduced the notion of tradable and non tradable goods, which will be discussed later. Finally, Mendoza incorporates in his model the fact that roughly 2/3 of a country's imports are inputs and 1/3 are consumption goods by allowing agents to trade in both the capital good and the consumption good.[18]

Mendoza's three sector model economy, driven by terms of trade shocks and productivity shocks, is able to account for several additional stylized facts. Actually,

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[18] Mendoza, Enrique G. "The Terms of Trade, the Real Exchange Rate, and Economic Fluctuations." p. 103.

terms of trade shocks account for nearly 45 to 60 percent of the output and real exchange rate fluctuations in Mendoza's model. On the other hand, productivity shocks still remain an important explanatory variable. Macroeconomic variables have a different response to the shocks, depending on its origins. In this model economy, real exchange rates and interest rates differentials are procyclical if the shock arises from the terms of trade and are countercyclical if the disturbance arises from a productivity shock. The key is that Mendoza's analysis identifies the importance of terms of trade shocks in international business cycles.

Mendoza also draws attention to another unresolved problem of both international and closed economy real business cycles models; in the model economy the welfare costs of business cycles are small. Although Mendoza does not provide a definite answer to this puzzle, his developing model economy exhibits higher welfare costs than the benchmark industrial model economy. Applying a methodology introduced by Lucas (1987), Mendoza finds that the compensating variation needed to equate expected lifetime utility in the deterministic and non deterministic industrial model economy is around 0.011 percent. The same exercise for developing economies yields a figure in the order of 0.016 percent[19]. Pallage and Robe (2000) provide evidence consistent with this result[20]. Partially following Dolmas (1998)[21], Pallage and Robe find that welfare losses created by output fluctuations are higher in LDCs than in developed countries. Even

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[19] Mendoza, op. cit. p. 129.
[20] Pallage, Stephane and Robe, Michel, A., "Magnitude X on the Richter Scale: Welfare Costs of Business Cycles in Developing Countries" Center for Research on Economic Fluctuations and Employment, Working Paper 124, October 2000.
[21] Dolmas, Jim "Risk Preferences and the Welfare Cost of Business Cycles" *Review of Economic Dynamics*, Vol 1, 1998, pp. 646-676.

though measures of welfare costs are a matter of debate, it seems that welfare losses in developing countries are higher than in developed economies.

The almost perfect cross country consumption correlations predicted by open economies real business cycles models motivated some authors to modify these models in order to get more realistic results. The work by Stockman and Tesar (1995) is an example[22]. These authors contend the high degree of risk sharing assumed in previous work as the main feature of the model that accounts for why cross – country correlations are so high in the model economies. As previously noted by Backus et. al.: "…with complete markets, we expect the ability to share risk internationally to produce a large correlation between consumption fluctuations across countries. Indeed, in some theoretical economies, this correlation is one, regardless of the correlation between outputs."[23] Stockman and Tesar introduce nontradable goods in a real business cycle open economy model in an attempt to break down this correlation. Their approach derives from the fact that nearly half of a country's output consist of nontradable goods. Stockman and Tesar study is based in annual data for the seven largest industrialized countries.

Stockman and Tesar examine a two-country model (disaggregated into tradable and nontradable goods) that can account for international and domestic variables empirical regularities. The structure of the model allows the authors to understand why their model economy can mimic particular features of disaggregated data. By doing so they conclude that a model driven by technology shocks is not successful in replicating

[22] Stockman, Alan C. and Tesar, Linda L. "Tastes and Technology in a Two-Country Model of the Business Cycle: Explaining International Comovements."
[23] Backus, David K.; Kehoe, Patrick J. and Kydland, Finn E. "International Business Cycles." p. 746.

the cyclical behavior of data. In order to improve their results, the authors propose a "demand shock." Stockman and Tesar show that a combination of shocks to productivity and to "taste" does better than a shock only to productivity in explaining fluctuations. In particular, the fit is better with respect to disaggregated data. This suggests that further research might have to include "demand shocks" in addition to technology shocks to be able to account for business cycles fluctuations. Stockman and Tesar also conclude that introducing nontradable goods improves the ability of the model to replicate cross – countries consumption correlations.

In other work, Baxter and Crucini (1995) propose a way to overcome the high predicted consumption correlation across countries[24]. These authors explore the relationship between complete financial integration and the transmission of business cycles. Their idea is to clearly determine the role played by financial markets in explaining fluctuations. In particular why cross – countries consumption correlations are so low compared to what is generated by model economies.

Baxter and Crucini depart from the assumption of complete international capital markets. Their contribution is to assume that agents can only trade in noncontigent bonds, thus having incomplete access to international risk sharing. In a second step, the authors compare the results of their model with a model with complete markets.

By comparing their results to the complete market model, the authors find that the characteristics of productivity shocks are crucial to explain the results of their model. Under some conditions, both models results are essentially undistinguishable, meaning that restricting asset trade has no effects. However, if productivity shocks in each country

[24] Baxter, Marianne and Crucini, Mario J. "Business Cycles and the Asset Structure of Foreign Trade."

follow a random walk with spillovers and correlated innovations, the restricted asset trade model performs better than the complete market scenario. In particular, the former is able to replicate lower cross countries consumption correlations than the latter.

Baxter and Crucini point out the role played by financial asset restrictions in explaining international fluctuations. In particular, they draw attention to the nature of the shocks for international financial markets to have a relevant role. Not surprisingly, different productivity shocks can have different effects in the transmission of business cycles in a restricted financial market world economy.

Kehoe and Perri (2002) propose another solution for dealing with the high cross country correlation predicted by real business cycles models[25]. These authors' approach is to assume that international loans are imperfectly enforceable by introducing a different kind of friction in the international financial market. The Kehoe – Perri approach will yield different results from those of the complete market economy environment regardless of the choice of parameters. As such, their findings differ from the Baxter and Crucini approach. In their numerical simulations, Kehoe and Perri are also successful in lowering the cross country consumption correlation. However, they encounter other problems. For instance, their model economy produces the opposite sign in the correlation between net exports and output compared to the correlation in the actual data.

[25] Kehoe, Patrick J. and Fabrizio Perri. "International Business Cycles With Endogenous Incomplete Markets,"

2.1.5 Critique of the Real Business Cycles Approach

In my view, the most important criticisms of the real business cycle approach can be summarized as follows. First, there is little evidence in favor that productivity shocks are large enough at quarterly frequencies. The model economy needs productivity shocks that can be as large as 1 percent per quarter. Besides the well known oil shocks in the 70's, it is very difficult to find a productivity shock that can match the assumptions made by real business cycles models. Also, technological shocks are assumed to affect all sectors of the economy evenly, something that seems highly unlikely. There is some evidence that variations in the Solow residual might be a poor measure of technological shocks[26]. If that proposition is true, then technology shocks are not so large and the explanatory power of real business cycle theory is smaller.

Second, the absence of a formal econometric test to determine the fit of the model implies that the "goodness" of a model is to be tested by checking simple statistics. This argument asserts that since models are not usually tested against alternatives formulations of the problem, the result of the calibration process could just be one of many explanations[27]. Although there is a literature on evaluating the fit of dynamic structural economic models, there is yet no consensus as to which measure to use. Watson (1993) argued that the fit of a real business cycle model can be assessed by measuring how much stochastic error should be added to the model variables in order for the model to exactly

[26] Romer, David "Advanced Macroeconomics" Ch. 4, pp. 174 – 221.
[27] Stadler W. George "Real Business Cycles." pp. 1766 – 1772.

match actual data properties[28]. Watson suggests that the amount of stochastic error is a measure of how close the model is to actual data.

Third, there seems to be evidence supporting the hypothesis that intertemporal labor substitution is quite low. In a real business cycles model, this parameter serves as a propagation mechanism for the cycle. Along these lines, some studies suggest that changes in wages might not be the only factor determining labor supply. This implies that real business cycles models might not be considering important features of labor fluctuations.

Fourth, prototype real business cycles models ignore the effect of monetary disturbances on macroeconomic variables. Many authors believe that money has a real effect on economic variables, and by thus it should not be left out of any theory of fluctuations.

Despite the fact that all of these points received some attention, the most interesting question is still: to what extent technology shocks are responsible for aggregate fluctuations? In an attempt to resolve this controversy, S. Rao Aiyagari proposes a method for measuring the contributions of productivity shocks to real business cycles models[29]. According to Aiyagari, under the usual assumptions of competitive markets, no external economies of scale and no measurement errors, shocks can account for more than half –and perhaps even as much as 78%– of aggregate fluctuations. Relaxing these assumptions can lower the explanative power of technology shocks. Aiyagari states that the presence of imperfect competition, external economies of scale,

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[28] Watson, Mark W., "Measures of Fit for Calibrated Models", *Journal of Political Economy*, December 1993, *101*(6), pp. 1011-1041.

[29] Aiyagari, Rao S. "On the Contribution of Technology Shocks to Business Cycles."

overtime wage premiums or measurement errors can be consistent with a low contribution of technology shocks. By analyzing each one of these, Aiyagari shows that the higher the presence of these nonstandard assumptions the lower the point estimate of the contribution of technology shocks. Aiyagari concludes that the discussion about technology shocks contributions to fluctuations is really about measuring the importance of nonstandard assumptions. To settle this question, empirical studies need to provide evidence of the magnitude of these assumptions.

To conclude, although it is true that many questions still remain unanswered, it is also true that the real business cycle approach is a good starting point in order to better understand the dynamics of macroeconomic variables. In particular, extensions to the case of small open economies can help to answer some puzzles. Since the ability to affect the interest rate, the country size and the access to international financial markets seem to have an effect in the propagation of business cycles, this remains an interesting topic for future research.

2.2 Contract Theory[30]

The origins of what is known today as "contract theory" can be traced back as far as 60 years ago. The notion of "state contingent" commodities introduced by Arrow and Debreu and the theory of choice under uncertainty are amongst its first building blocks. In addition, the concepts of "incentive compatibility" and "private information" set the ground for the theory of incentives and economics of information. Some of the recent contributions to this versatile group of theories include dynamic contracting, which added tools like contract renegotiation and incomplete contracts. As stated above, some authors incorporated concepts from contract theory into real business cycles models.

Contract theory departs from perfect competitive analysis. Most importantly, some agents have private information, creating a framework in which agents have to consider extra constraints. As a result, equilibria are not always Pareto optimal. This does not mean, however, that asymmetric information always yields allocations in which agents' welfare is reduced. Usually, it is rather complicated to obtain unambiguous results about welfare.

There are well known conclusions about the effect of information asymmetries in markets such as the credit or labor markets. Under standard conditions, equilibrium interest rates and wages are such that markets do not clear. This is an alternative explanation for credit rationing and unemployment, rather than price stickiness.

For concreteness, consider the credit market. Assume there are "safe" and "risky" borrowers. They need the same amount of money to undertake their projects, that yield the same expected return. Safe (risky) borrowers have a higher (lower) probability of

[30] This section is taken mainly from Bolton, Patrick and Dewatripont, Mathias "Contract Theory" Massachusetts Institute of Technology, 2005.

repayment, but a lower (higher) return. There is a bank that has less than the total amount of funds required to fund both projects. With perfect information, the financial intermediary optimally funds either project and uses all its funds, by setting a repayment contingent on the borrowers' type. When investment returns depend on lender's private information, financial intermediaries might decide to offer a contract that actually leaves some projects without funds. Because the bank cannot distinguish safe from risky borrowers, raising the interest rate means losing the "safe" borrowers. If the bank thinks there are too many "risky" borrowers in the market, it will decide to fund the safe projects and leave some risky projects unfunded.

The previous example helps us understand the potential effects of information asymmetries in the supply of funds. Assume financial intermediaries in LDCs face more difficulties when trying to assess borrower's types. Then, an increase in "risky" projects (a negative shock) will reduce the supply of funds by more in LDCs than in DCs, resulting in a bigger output drop than in DCs. This is just one of the many channels by which information problems might explain LDCs higher output volatility.

The previous example relies on the type of contract the bank can offer to borrowers. It is not a general result. However, further refinements of this idea might allow one to model the effect of private information in a general equilibrium framework and obtain similar conclusions.

3. Evidence on the Correlation Between Growth and Volatility

This chapter complements the literature review on business cycles by incorporating possible links between growth and volatility. To this end, I discuss the evidence on the growth volatility correlation at the country level and suggest a candidate linking factor based on prior empirical work. Finally, I lists some contributions about the different effects of state and national borders.

3.1 Empirical Evidence

I begin by describing Aguiar and Gopinath (2007) approach to the study of business cycles in developed and emerging countries. I then summarize prior work on the link between policy variability and growth.

It is common to observe multiple policy regime modifications in emerging countries. Sometimes they arise because of institutional reasons, as the lack of independence of central banks, while sometimes they are just the result of years of bad economic performance and a desperate quest for growth. Aguiar and Gopinath (2007) suggest that these frequent changes have an effect on output volatility. These authors provide evidence that shocks to the growth trend are the main source of fluctuations in emerging countries, as opposed to developed countries, in which fluctuations can be explained mostly by transitory shocks.

Aguiar and Gopinath exercise consists in decomposing empirical estimates of the Solow residual into transitory and permanent shocks. This approach suggests that shocks to the growth trend are more important for emerging countries than for developed economies.

In this approach, the production function is assumed to take the following form:

$$Y_t = e^{zt} K_t^{1-\alpha} \left(\Gamma_t L_t \right)^{\alpha}$$

where Γ_t and z_t represent productivity processes and the other variables have the standard interpretation of a growth model. In particular, z_t is assumed to be an AR(1) process:

$$z_t = \rho_z z_{t-1} + \varepsilon_t^z$$

where $|\rho_z| < 1$ and $\varepsilon_t^z \sim$ iid $N(0, \sigma_z)$. The productivity process embodied in Γ_t is represented by the following law:

$$\Gamma_t = e^{gt} \Gamma_{t-1} = \prod_{s=0}^{t} e^{gt}$$

where $g_t = (1 - \rho_g)\mu_g + \rho_g g_{t-1} + \varepsilon_t^g$. As usual, $|\rho_g| < 1$ and $\varepsilon_t^g \sim$ iid $N(0, \sigma_g)$. According to these assumptions, z_t is the shock to the productivity level and g_t is the shock to the growth of productivity (where μ_g is productivity's long run mean growth rate)

Aguiar and Gopinath show that the log of the Solow residual:

$$sr_t = z_t + \alpha \ln \Gamma_t$$

can be decomposed into the sum of a random walk component and a transitory component:

$$sr_t = \tau_t + s_t$$

where

$$\tau_t = \alpha \mu_g + \tau_{t-1} + \left(\frac{\alpha}{1 - \rho_g} \right) \varepsilon_t^g$$

is a random walk with drift and

$$s_t = z_t - \left(\frac{\alpha \rho_g}{1 - \rho_g} \right) \left(g_t - \mu_g \right)$$

is a stationary series. Aguiar and Gopinath obtain estimates of the following ratio:

$$\frac{\sigma^2_{\Delta\tau}}{\sigma^2_{\Delta sr}} = \frac{\alpha^2 \sigma^2_g}{\left(1 - \rho_g\right)^2 \sigma^2_{\Delta sr}}$$

to measure the importance of the permanent shock versus the transitory shock.

Data are annual observations of the Solow residual from Mexico (emerging country) and Canada (developed country) from 1981 to 2002. Preliminary results indicate that the ratio of the variance of the trend shock to the total variance is 1.72 for Mexico and 0.82 for Canada. However, due to the short length of the sample and other econometric considerations, this result is not robust and is poorly estimated. Choosing alternative parameters actually reverses the result, indicating that shocks to the growth rate of productivity are more important in the developed country (Canada).

In light of the problems encountered before, Aguiar and Gopinath propose a different approach to the estimation of the same ratio. These authors calibrate a standard real business cycle model to represent two identical economies that differ only in their productivity parameters. The main idea is to extract information about the productivity parameters from data on consumption and net exports fluctuations and from the correlation between income and net exports.

This idea arises from combining consumption data with the permanent income hypothesis. If agents are informed about the nature of the shock, changes in consumption relative to output and net exports reveal the underlying characteristics of the shock: transitory or permanent. Agents that see their income increase as a result of a permanent shock to output will increase their consumption by more and therefore we should observe an increase in the trade deficit (sharp decrease in net exports). However, if the shock is transitory, agents increase their savings and the current account improves, at the same time that consumption increases by less than output.

Using the same data from Mexico and Canada, Aguiar and Gopinath obtain estimates of the productivity parameters that yield the following values for the ratio of the variance of the random walk component to the total variance of the Solow residual:

Table 3.1.1: Aguiar and Gopinath estimates

	$\sigma^2_{\Delta\tau}/\sigma^2_{\Delta sr}$
Mexico	0.96
Canada	0.37

These estimates prove to be robust to different choices of model parameters. Using data on the variance of net exports instead of consumption yields essentially the same results. More importantly, this estimation procedure also accounts for other business cycles characteristics of emerging and developed economies.

To conclude, Aguiar and Gopinath exercise suggest that the process followed by the Solow residuals of an emerging economy and a developed country are quite different. When the Solow residual is decomposed in a permanent and transitory component, the ratio of the variance of the permanent component to the variance of the transitory is larger in the emerging economy. This implies that shocks to the growth rate of the Solow residual are more important in an emerging country than in a developed economy, which exhibits a relatively stable trend, mostly affected by transitory shocks.

Finally, it is important to note that Aguiar and Gopinath suggest that although their framework is that of a standard real business cycle model, frictions arising from market imperfections might be the underlying cause of the different characteristics of the Solow residual processes. In their own words:

> Our analysis highlights a key difference in the stochastic process for Solow residuals in emerging and developed economies. Given a process for the residuals, a standard equilibrium model matches the business cycles facts well. However, this does not imply that frictions are unimportant. More likely, the properties of the Solow residual are a manifestation of a deeper friction. Our analysis suggests that models with market imperfections that endogenously generate volatile and persistent shocks to total factor productivity may be an important avenue for future research.

My work suggests that asymmetric information can be one of the market imperfections that create shocks to total factor productivity and therefore explain the different business cycles characteristics of emerging and developed economies.

Ramey and Ramey (1995) document a negative correlation between output volatility and output growth at the country level. This empirical evidence does not correspond to the generally accepted premise that output growth and output volatility are unrelated. Ramey and Ramey argue that in light of their work this approach needs to be reconsidered. According to these authors, there are many reasons as to how output volatility might be related to growth.

Various authors proposed channels by which increased output volatility might have a negative effect on output growth. According to Aizenman and Marion (1993), increased policy uncertainty might lead to lower output.

Along the same lines, in Ramey and Ramey (1991) an ex ante commitment to technology by firms induces lower output, since firms end up producing less output ex post. In this framework, the accumulation process is hindered and therefore there is a negative relation between output growth and output volatility.

On the other hand, Black (198) and Mirman (1971) argue that output variance and output growth should be positively related. The former proposes that if countries have a choice between technologies, countries that have higher mean growth are the ones that chose the high variance – high return technology. The latter assumes a precautionary motive for savings. If this is true, then countries with high output volatility should save more, have a higher investment rate, and therefore exhibit higher growth rates.

I do not think that these two explanations are true. I do not see a particular striking difference between the variance of production technologies between developed and emerging countries. In particular, a firm in an emerging country has not a choice with respect to the production technology, since capital inflows are restricted by other type of problems, like policy uncertainty. With respect to the precautionary savings motive, if agents save more in light of higher output volatility, this is because they recognize the negative link between output variance and output growth. If this link operates in that economy, it is not necessarily true that higher savings will lead to higher output.

Ramey and Ramey collect data on output growth and volatility for two samples of countries. The first one consists of 92 countries with data from 1960 to 1985, while the second involves 24 OECD countries with data from 1950 to 1988.

Ramey and Ramey conduct a regression analysis based on the following equation:

$$\overline{\Delta y_i} = \alpha + \beta\sigma_i \qquad (1)$$

where $\overline{\Delta y_i}$ is mean growth for country *i*, and σ_i is the standard deviation of growth for country *i*. The following table summarizes their results for both samples:

Table 3.1.2: Model 1 ($\overline{\Delta y_i} = \alpha + \beta\sigma_i$)

	α	β
92 countries sample	0.030	– 0.154
24 OECD countries	0.026	0.147

The parameter of interest is β, which is statistically significant for the 92 countries sample, but not statistically different from zero on the OECD countries. There is evidence of a negative correlation between mean growth and output volatility for the first sample.

Ramey and Ramey second approach considers the effect of variables that the growth literature has identified as having effects on growth. These variables are introduced in the vector *X* of the following equation:

$$\Delta y_{it} = \lambda\sigma_i + \theta X_{it} + \varepsilon_{it} \qquad (2)$$

$$\varepsilon_{it} \sim N\left(0, \sigma_i^2\right) \qquad i = 1,...., I \quad t = 1,...., T$$

where y_{it} is the growth rate for country *i* at time *t*, σ_i is the standard deviation of the residuals ε_{it}, and θ is a vector of coefficients associated to the control variables included in the vector X_{it}. In this specification, the relevant parameter is λ. The following table reports the main results of this regression[31]:

Table 3.1.3: Model 2 ($\Delta y_{it} = \lambda\sigma_i + \theta X_{it} + \varepsilon_{it}$)

	92 country sample	24 OECD countries
Constant	0.0727	0.158
Volatility	**– 0.211**	**– 0.385**
Average investment share of GDP	0.127	0.069
Average population growth rate	– 0.058	0.212
Initial human capital	0.00078	0.00014
Initial per capita GDP	– 0.0088	– 0.0172

In this case, controlling for the variables that we think affect growth reverses the correlation for the OECD sample, that is negative now. Both coefficients are significant at standard levels.

This second model suggests that investment share is not an important variable in explaining the relation between output growth and output volatility. Even though that the model controls for investment as a share of GDP, both coefficients on volatility are negative. Furthermore, dropping investment as an explanatory variable has no unambiguous effect on the relation between volatility and growth: the relevant coefficient drops in the 92 sample, while it increases in the OECD sample (both in absolute value). Note that both explanations that argued a positive correlation between output growth and volatility assumed that investment decisions were crucial to derive that relation.

[31] Taken from Ramey and Ramey, op. cit., p. 1140 and 1142.

As some theoretical explanations of the negative relation between output volatility and output growth rely on the existence of some level of uncertainty, Ramey and Ramey construct an econometric specification that investigates this relationship. Basically, they estimate the relation between volatility and growth in a growth forecasting equation. This is done by assuming the same specification as model one, but with explanatory variables that contain only past and present information. They also include lagged values of log GDP and a time trend.

The estimation yields statistically significant values of the parameter β : – 0.178 for the 92 country sample and – 0.949 for the OECD sample. Although these coefficients differ by much in their absolute value, there represent evidence in favor of a negative relation between output volatility and growth.

Ramey and Ramey conduct a last experiment to test the robustness of their results. To this end a new model is estimated. This model links government spending (a variable that is linked to output volatility across time and countries) to output volatility and growth in the following manner:

$$\Delta y_{it} = \lambda \sigma_i + \theta X_{it} + \varepsilon_{it} \qquad (3)$$

$$\varepsilon_{it} \sim N\left(0, \sigma_{it}^2\right) \qquad \sigma_{it} = \alpha_0 + \alpha_1 \hat{\mu}_{it}^2$$

where the only new variable $\hat{\mu}_{it}^2$ is the square of the estimated residual for country *i* in period *t* from the forecasting government spending equation. In this case the parameters of interest are λ and α_1. Ramey and Ramey report various result from this the estimation of this model after using different variables in the *X* vector (including countries fixed effects and time effects)[32].

The main conclusion is that in all specifications λ is negative for both samples, although not always statistically significant for the 92 country group. As expected, the parameter α_1 is always positive, implying a strong positive relation between government spending and output volatility.

Finally, Ramey and Ramey conclude that our usual view about growth and volatility needs to be revised. These authors provide evidence in favor of a negative correlation between output growth and output variance at the country level. They also note that investment does not seem to be an important channel by which volatility might affect growth.

Ramey and Ramey note that government spending is positively related to innovation volatility. Since the latter variable negatively affects output growth, this suggests that government spending, by inducing uncertainty in the economy might be harming growth. This is very close to the thesis of this paper: government induced asymmetric information problems increase output volatility and decrease mean output at the country level. At the state level, however, the asymmetric information problem is more or less contained and output volatility and mean output are unrelated.

Aizenman and Marion (1993)[33] study the relation between measures of policy uncertainty and growth. Their paper provides a theoretical explanation of the impact of policy uncertainty in investment and growth. Aizenman and Marion also show empirical

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[32] See Ramey and Ramey, op. cit. p. 1147.
[33] Aizenman, Joshua and Marion, Nancy "Policy Uncertainty, Persistence and Growth" *Review of International Economics*, 1993, 1(*2*), pp. 145 – 163.

evidence of the negative effect of policy uncertainty in growth for a sample of 46 developing countries during the 1970 – 1985 period.

Aizenman and Marion are motivated by the idea that excessive fluctuation on macroeconomic policies might adversely affect growth. Frequent changes in monetary or fiscal policy increase uncertainty in the economy and reduce growth. This relation seems to be more evident in the case of developing countries. Firstly, these authors provide evidence of this link.

Aizenman and Marion construct measures of policy uncertainty that are defined to be the standard deviation of the residuals of the following autoregressive process:

$$(Policy)_t = \beta_0 + \beta_1 (Policy)_{t-1} + \varepsilon_t$$

The data set consists of annual data of 46 developing countries for the 1970 – 1985 period. There are potentially many variables that could increase uncertainty in the economy. Notably, those related to monetary and fiscal policy are particularly important, since in a way they indicate the level of commitment of the government to a set of policies. Aizenman and Marion chose to study the effect of the following variables:

Table 3.1.4: Aizenman and Marion variables

Variable name	**Description**
Gov	ratio of government consumption expenditure to GDP
ggov	growth in the ratio of government consumption expenditure to GDP
ipub	ratio of public investment to GDP
Def	ratio of government budget deficit to GDP
Rev	ratio of government revenues to GDP
Do	growth in domestic credit
Mo	growth in money
In	inflation rate

Aizenman and Marion fit the autoregressive process for each of their policies variables and obtain a standard deviation for each of them. Then, they estimate the impact of these measures of policy uncertainty on output growth for the same period. The following table shows their results:

Table 3.1.5: Correlation between policy uncertainty and growth[34]

Policy variable	N	Correlation	Significance (t-statistic)
Gov	46	– 0.387	– 2.78
Ggov	46	– 0.338	– 2.38
Ipub	34	– 0.312	– 1.85
Def	43	– 0.431	– 3.05
Rev	42	– 0.418	– 2.91
Do	38	– 0.327	– 2.08
Mo	44	– 0.224	– 1.49
In	44	– 0.215	– 1.42

The results of the econometric exercise seem conclusive. There is evidence that supports the hypothesis that policy uncertainty and growth are negatively related. Of course, the problem of causality still remains to be solved.

Aizanman and Marion suggest a rationalization of the previously discussed relation by setting a general equilibrium model in which the combination of policy uncertainty and persistence create an equilibrium with low (or zero) investment and consequently low growth.

Aizenman and Marion theoretical approach has the shortcoming that relies heavily on the persistence of the policies undertaken by the government. Without persistence, their model does not predict the negative correlation between policy uncertainty and growth observed in data. Another caveat is the reliance on investment as a transmission mechanism in the relation between uncertainty and growth. Ramey and

[34] This table reproduces Table 2 from Aizenman and Marion, op. cit. p. 147.

Ramey (1995) disregard investment as an important explanatory variable in the relation between volatility and growth, based on their empirical tests.

Finally, Aizenman and Marion provide evidence of the negative interaction between policy uncertainty and growth for a sample of developing countries. This result confirms the idea that frequent regime changes (in monetary or fiscal policy) create uncertainty and disrupt growth. This approach suggests that policy uncertainty impacts growth, but as seen in Ramey and Ramey (1995), the channel seems not to be investment. Therefore, my thesis is that policy uncertainty does affect growth, but through a different channel: asymmetric information problems.

Alesina et. al (1992) investigate the link between political stability and economic growth. On a first approach, one can think of several ways in which the lack of political stability might affect growth: increased uncertainty in the economy, agents' reluctance to invest, increased probability of expropriations, etc. On the other hand, the political science literature has identified channels by which low growth or a bad performing economy might precipitate political changes, sometimes violent ones.

Alesina et. al. provide empirical evidence that political instability negatively affects growth, while they do not find evidence of the reverse causality. Another interesting finding relates to the persistence of political instability: contemporaneous government collapses increase the probability of further collapses. This finding confirms the common idea that countries with poor institutions or with fragile governments usually exhibit political turmoil for extended periods of time.

There are previous studies that investigate the link between political instability and economic growth. One their shortcoming was that their choice of the dependent variable of political instability was too restrictive (i.e. only coups d'etat). Alesina et. al. propose two variables to measure political unrest. The first one is the commonly used that records any regular or irregular transfer of executive power. The second one codes major government changes, which includes all irregular transfers of power and a subset of regular transfers of power that imply a change in the party or coalition of parties.

Alesina et . al. use the following probit model to obtain a measure of political instability:

$$c^* = \beta X_1 + \eta$$

where c^* is a latent variable that is positive when there is a government change.
X_1 is a vector of variables (political and economic) that determine the occurrence of a government change.
η is a normally distributed error with zero mean.

Therefore, political instability is measured as the average estimated probability c^* over the sample for each country. Data consists of annual data for 113 countries for the periods 1950 – 1982 and 1960 – 82. The two periods reflect data unavailability in about half the countries in the sample.

Alesina et. al include their measure of political instability as another explanatory variable in an otherwise standard growth regression:

$$Y = \lambda X_2 + \theta(INS) + \varepsilon$$

where Y is average economic growth in each country.
X_2 is a vector of economic variables that affect economic growth.
INS is the measure of political instability.
ε is an error term with zero mean.

The authors find that the coefficient on their measure of political instability is significant at the 1 percent level and equal to – 0. 112. The value of the same parameter drops (in absolute value) to – 0.090 but remains significant when a variable that captures the occurrences of coups d'etat is included in the regression. Finally, both measures of political instability yield significant estimates when included in the growth regression.

As Alesina et. al. state, there are endogeneity problems with using a single equation model to measure the effects of political instability on growth. Their approach consists in estimating the following structural model with two equations:

$$c^* = \alpha_c X_c + \beta_c X + \gamma_c y + u_1$$

$$y = \alpha_y X_y + \beta_y X + \gamma_y c^* + u_2$$

where y = annual rate of growth
X = exogenous variables that determine both government change and growth
X_c = exogenous variables that determine government change only (instruments for instability)
X_y = exogenous variables that determine economic growth only (instruments for growth)

In this specification the relevant parameters are γ_y and γ_c , which measure the contemporaneous effects of political instability on growth and of growth on political instability respectively.

Alesina et. al find that this approach is better, since they are able to reject the hypothesis that shocks to the dependent variables are uncorrelated. Furthermore, their instruments exhibit the right properties (no correlation with the other dependent variable). The following table summarizes the findings of this second specification (t – statistics are in parenthesis):

Table 3.1.6: Results from the structural model

	1950 – 1982 Sample	1950 – 1982 Sample
γ_y	– 0.014 (– 2.85)	– 0.014 (– 1.60)
γ_c	1.720 (0.21)	– 0.126 (– 0.016)

These results suggest that political instability does negatively affect growth. Also, there seems to be evidence that current political instability does not affect the growth rate. Alesina et. al. state that their results are robust to changes in the model specification expressed above. These include the addition of other variables related to growth or political instability and other means of identifying the model.

To conclude, Alesina et. al provide empirical evidence of the link between political instability and growth. As opposed to Aizenman and Marion (1993), these authors do not suggest a model consisted with observed date. It is the purpose of my research to offer a theoretical explanation for this phenomenon, making emphasis on the distinctive characteristics of the economics of developing countries and states.

3.2 Border Effects

Assuming evidence in favor of the hypothesis that LDCs face worse information problems than DCs exists, this will only explain the negative output variability – per capita output correlation at the country level. This proposal also strives to explain why this correlation is zero when considering U.S. states as different economies.

There is evidence that supports a "border effect". Engel and Rogers (1996) find that national borders are important in explaining price dispersion using U.S. and Canadian data. According to these authors, both distance and the national border are significant determinants of price variability. Engel and Rogers study consumer price data disaggregated into 14 good categories. The exercise consists in explaining price dispersion across 9 Canadian cities and 14 U.S. cities. Engel and Rogers measure of price dispersion is the percentage standard deviation of a previously constructed relative price series. Considering a time period from September 1978 to December 1994, these authors show that price dispersion is much higher for cross – border city pairs than for city pairs inside the same country. Engel and Rogers try to measure the importance of the border effect relative to distance, as determinants of price variability. Their most conservative estimate of the "magnitude" of the border could be as large as 1,800 miles. In other words, if distance were the only explanatory variable, the Canadian – U.S. border will have to be that "wide" in order to explain the observed price dispersion.

In addition, they find that the border effect is relatively more important that the distance factor. Engel and Rogers try to find plausible explanations of the latter fact. In their own words[35],

> We explore some of the possible reasons why the border is so important, such as nominal price stickiness, integration of labor markets and trade barriers. Nominal price stickiness appears to account for a large portion of the border effect, but most of the effect is left unexplained.

Engel and Rogers work suggests that national borders have a significant effect on price dispersion. Aside from asymmetric information problems, LDCs and states differ in the fact that there are no national borders that separate states.

Analyzing the savings – investment correlation, Helliwell and McKitrick (1999) find that national borders and state borders have different implications for the allocation of capital[36]. Helliwell and McKitrick find that the S – I correlation is much higher across countries than across provinces. Using data from OECD countries and Canadian provinces, these authors provide further evidence for the hypothesis that national and state borders play quite significant different economic roles.

State borders are more "permeable" that national borders. This allows for more factor mobility between states than across countries. In the presence of a negative productivity shock in one state (or region), firms and workers have the option to move to another state at relatively lower costs than moving to another country. This precept

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[35] Engel, Charles and Rogers, John H. "How wide is the border?" *American Economic Review*, December 1996, *86*(5), p. 1113.
[36] Helliwell, John, F., and McKitrick, Ross "Comparing Capital Mobility across Provincial and National Borders" *The Canadian Journal of Economics*, 32(5), November 1999, pp. 1164 – 1173

suggests that we should observe relatively more capital and labor mobility in states with higher real state gross product variability.

The above mentioned are amongst many possible reasons as to why the output variability – per capita output correlation is zero at the state level. Further research should asses the relative importance of the border effect and other explanations.

I propose to incorporate the effects of asymmetric information into a dynamic general equilibrium model featuring a developed economy and a developing country. I will then compare correlations produced by the model economies and actual data. I will pay particular attention to the output variability – output level correlation. If the model economies can replicate that characteristic of data, then I will incorporate “border effects” so that the model can also explain why the aforementioned correlation is zero for states and negative across countries.

4. Model

This section introduces a partial equilibrium model that emphasizes the role of asymmetric information problems in explaining output fluctuations. In this context, the presence of information asymmetries will induce production decisions that result in larger output variance. To show that, I compare first best (full information) outcomes with second best (private information) outcomes. This chapter ends with model's conclusions and a note on its scope. A description of the environment and the equilibrium concept follows.

4.1 Environment

The economy lasts for one period. There is one firm and a government. The firm considers producing a consumption good in a competitive market. If the entry is consummated, the firm takes the price as given and only decides how much to produce. If the firm does not enter the market it will earn nothing. I assume that the firm decides to enter the market if it is indifferent. The firm has access to a production technology that can produce the consumption good from capital and that exhibits zero marginal costs. I assume that the firm is endowed with sufficient capital to produce any positive amount of the consumption good.

The firm interacts with the government in the following way. The government provides the necessary conditions (roads, enforcement of contracts) for the execution of transactions in this market. I will refer to these conditions as "market infrastructure". The government pays for this infrastructure by taxing firms according to the following expenditure function:

$$\theta_i g(q) \qquad \text{for } i = H, L \text{ and } \theta_H > \theta_L > 0$$

Where q is the amount of the consumption good produced by any firm and $g(q)$ is a twice differentiable function that satisfies $g'(q) > 0$, $g''(q) > 0$. According to this function, an increase in output production determines an increase in government expenditures; and for any given level of production, an extra unit produced requires more government expenditure than the former.

The parameter θ_i captures the idea that the government can be of two types: "high" and "low". The "high" type government (less efficient) requires higher levels of expenditure for the same amount of goods produced by firms, while the more efficient government requires less expenditure for the same level of production. Formally, the government has to satisfy the following budget constraint:

$$T(q) - \theta_i g(q) \geq 0 \qquad \text{for } i = H, L \text{ and } \theta_H > \theta_L > 0$$

where q is the amount of the consumption good produced by the firm, and $T(q)$ is a monetary transfer from the firm to the government. The function $T(q)$ could be interpreted as a tax scheme. However, $T(q)$ could also represent the monetary costs in which firms incur if the market infrastructure is not appropriate (e.g. transaction costs associated with imperfect enforcement of contracts).

The firm seeks to maximize profits subject to the constraint imposed by the monetary transfer to be paid to the government. At the beginning of the period, the firm does not know the government's type, although I will analyze a situation in which that parameter is known to the firm to obtain a benchmark result. The parameter θ_i is government's private information, sot that the firm only knows that the government is of type "high" with probability β and of type "low" with probability $(1-\beta)$. The firm will decide how much to produce in a way that has to be consistent (incentive compatible) with the government expenditures requirements. Typically, the firm seeks to design a contract that prevents the “high” type government to mimic the behavior of the “low” type government. I will only analyze situations in which the firm decides to enter the market, and then compare its different production plans.

At the end of the period, the government reveals its type and chooses an allocation (a production plan) that is consistent (incentive compatible) with it. The firm executes the monetary transfer and the government pays for the necessary amount of infrastructure to support that production plan.

4.2 Equilibrium

In this model, an equilibrium consists of a contract that specifies a production plan q^* and a monetary transfer from the firm to the government $T(q^*)$. The government will not accept the contract if it cannot satisfy its budget constraint, in which case the firm cannot operate in the market. If the contract is accepted, the firm enters the market and the government provides the market infrastructure.

4.3 First and Second Best

In this section I analyze a benchmark situation in which there is no private information. Because the government’s type is known to all parties, the firm can propose a production plan associated with a monetary transfer that is contingent on it. The firm maximization problem is[37]:

$$\max_{q} \quad pq - T(q)$$

[37] Here *p* is the price of the consumption good.

subject to $$T(q) - \theta_i\, g(q) \geq 0 \quad \forall\ i = H, L$$

Replacing the constraint and taking the first order condition yields:

$$\theta_i\, g'(q) = p \quad \forall\ i = H, L$$

Put together both first order conditions to get:

$$\theta_H\, g'(q_H^*) = p = \theta_L\, g'(q_L^*)$$

According to previous assumptions about the expenditure function, this condition determines: $$q_L^* > q_H^*$$

According to this production plan, the firm will produce more output if the government is of type “low”. A more efficient government results in higher output. If the government accepts this contract, its budget will be balanced:

$$T(q_i^*) - \theta_i\, g(q_i^*) = 0 \quad , i = H, L$$

Now I turn to a numerical example to calculate expected output for this outcome. Assume that $g(q) = q^2$ so that:

$$\theta_i\, g'(q) = p \rightarrow \theta_H .2q_H^* = p = \theta_L .2q_L^* \rightarrow q_L^* = \frac{p}{\theta_L} > q_H^* = \frac{p}{\theta_H}$$

Expected output is:

$$\bar{q}^* = \beta q_H^* + (1-\beta) q_L^* = \beta \frac{p}{\theta_H} + (1-\beta) \frac{p}{\theta_L} \rightarrow E(q^*) = \frac{[\beta\theta_L + (1-\beta)\theta_H]p}{\theta_H \theta_L}$$

Now I analyze the effects of private information in the design of the contract. Here the firm does not know the government’s type when taking its production decision. Therefore, the contract cannot be contingent on the government’s type anymore.

Following Bolton and Dewatripont[38], the set of possible contracts can be restricted to $[q_L, T(q_L)]$ and $[q_H, T(q_H)]$. The firm now has to design a contract that is incentive compatible for the government. This means that the firm wants to make sure that the government has the incentive to behave as "low" type when it is "low" type and vice versa. This translates into another constraint in the firm maximization problem that now looks like this:

$$\max \quad \beta[pq_H - T(q_H)] + (1-\beta)[pq_L - T(q_L)]$$

subject to

$$T(q_H) \geq \theta_H g(q_H) \qquad \text{(IRH)}$$

$$T(q_L) \geq \theta_L g(q_L) \qquad \text{(IRL)}$$

$$T(q_H) - \theta_H g(q_H) \geq T(q_L) - \theta_H g(q_L) \qquad \text{(ICH)}$$

$$T(q_L) - \theta_L g(q_L) \geq T(q_H) - \theta_L g(q_H) \qquad \text{(ICL)}$$

To solve this problem, eliminate the IRL constraint, since it is automatically satisfied by ICL and IRH. Next, eliminate the constraint that is satisfied at the first best optimum: the ICH in this case[39]. Later check that this constraint is indeed satisfied at the second best outcome. Check that the two remaining constraints will bind at the optimum and use them to eliminate T_L and T_H from the maximand.

Combining IRH and ICL yields:

$$\theta_H g(q_H) = T_H$$

$$T_L - \theta_L g(q_L) = \theta_H g(q_H) - \theta_L g(q_H) \rightarrow T_H = \theta_L g(q_L) + g(q_H)(\theta_H - \theta_L)$$

Now the unconstrained maximization problem looks like this

[38] Bolton and Dewatripont "Contract Theory" Ch. 2.

[39] See Appendix 2 for an explanation

$$\max_{q_L, q_H} \quad \beta\left[pq_H - \theta_H g(q_H)\right] + (1-\beta)\left[pq_L - \theta_L g(q_L) - g(q_H)(\theta_H - \theta_L)\right]$$

Take the first order conditions with respect to q_H and q_L:

$$q_L: \quad (1-\beta)\left[p - \theta_L g'(q_L)\right] = 0 \rightarrow \theta_L g'(q_L) = p$$

$$q_H: \quad \beta\left[p - \theta_H g'(q_H)\right] - (1-\beta)\left[g'(q_H)(\theta_H - \theta_L)\right] = 0 \rightarrow$$

$$(1-\beta)\left[g'(q_H)(\theta_H - \theta_L)\right] + \beta\left[\theta_H g'(q_H)\right] = \beta p$$

$$\rightarrow \theta_H g'(q_H)\left[(1-\beta)\frac{(\theta_H - \theta_L)}{\theta_H} + \beta\right] = \beta p$$

$$\rightarrow \theta_H g'(q_H)\left[\frac{1-\beta}{\beta}\frac{(\theta_H - \theta_L)}{\theta_H} + 1\right] = p$$

$$\theta_H g'(q_H) = \frac{p}{1 + \frac{1-\beta}{\beta}\frac{(\theta_H - \theta_L)}{\theta_H}} < p$$

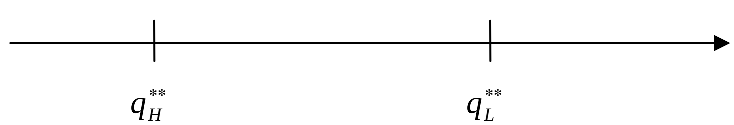
This contract implies a production plan with a larger output variance than the first best outcome. If we denote first best outcomes by * and second best outcomes by **, we can state:

$$q_H^* > q_H^{**} \text{ , while } q_L^{**} = q_L^*$$

Graphically:

Perfect information (first best) outcome

Private information (second best) outcome



From the graphic representation it is clear that output variance is larger on the second best.

The last step of this derivation is to check that the ICH constraint is indeed satisfied at this outcome. Departing from the fact that the ICL binds,

$$T\left(q_L^{**}\right) - \theta_L\, g\left(q_L^{**}\right) = T\left(q_H^{**}\right) - \theta_L\, g\left(q_H^{**}\right) \rightarrow \text{using } q_L^{**} > q_H^{**} \text{ and } \theta_H > \theta_L$$

$$T\left(q_L^{**}\right) - \theta_H\, g\left(q_L^{**}\right) \leq T\left(q_H^{**}\right) - \theta_H\, g\left(q_H^{**}\right) \qquad \text{(ICH)}$$

4.4 Results

Private information yields an increase in output variance. The fact that the firm does not know the government' type affects its production decision. To make sure that the low type government does not mimic the behavior of the high type, the firm will be forced to propose a production plan that involves smaller output in the case of private information. This result is in line with the fact that there is a negative correlation between per capita output levels and output fluctuation at the country level. This model is motivated by the documented higher policy variability of developing countries with respect to developed countries.

This example attempts to formally illustrate the plausible effects of asymmetric information on output decisions. In this model, the government's type becomes private information to the firm, because of the policy uncertainty. Although the government's type is unknown at every period, this model only considers one period. Further developments of this idea include the introduction of a dynamic general equilibrium model with which asymmetric information problems.

5. Conclusion

This work combines data on output growth and volatility at the country and state level. Data shows a negative correlation between output growth and volatility across countries. Despite the evidence, the growth literature does not explicitly links volatility and growth. In particular, in standard real business cycles models the output growth rate and output volatility are unrelated. The main purpose of this paper is to identify a factor that relates mean output and output volatility at the country level. I construct a measure of output volatility for the 50 states that constitute the United States and study the correlation with mean output and output growth. The lack of correlation between output growth and variance in the latter data set is one of the motivations for this work. To be consistent with data, the factor linking growth and volatility should not be present across states.

Alesina et. al. (1992) and Aizenman and Marion (1993) provide evidence of a negative correlation between policy uncertainty and growth for different samples of countries. According to these authors, developed countries are able to design less uncertain policies than developing countries. Motivated by the previous result, I suggest that the driving factor of output volatility at the country level is policy uncertainty. If that is true, the correlation between output growth and volatility should be negative across countries (as empirical studies show that developing countries exhibit more policy uncertainty), but should be zero at the state level, since the driving factor is not present.

To formalize that idea, I propose a model in which agent's decisions result in a negative correlation between mean output and output volatility. This model neither relies in the persistence of policy uncertainty nor identifies private investment as a relevant link between growth and volatility. In particular, it assumes that firms producing in developing countries face a government whose type they do not know. Firms solve the resulting asymmetric information problem by designing a production plan that (negatively) links output variance and output levels. It is important to note that the model presented here considers only one period. The nature of the driving factor (policy variability) determines that the type of the government will not be known the next period. The literature on repeated bilateral contracting distinguishes two cases to analyze the implications of dynamic adverse selection problems. In the first one, the type of the informed individual is fixed over time. This does not apply to the situation described in this paper. On the second case, the informed party's type is drawn every period. This is closer to a government changing its type frequently and thus creating the link between growth and volatility. The fact that the government reveals its type at the end of the period says nothing about its type next period. Therefore, because of the changing nature of the government's type (documented by the literature) in developing countries, firms face the same problem at every period.

This paper contributes to the literature by proposing a direct link between growth and volatility across countries. This idea has at least one important implication for economic policy, in particular for developing and emerging countries. If their output volatility is the result of sudden changes in their policies, then it will affect their ability to grow. In this case, it makes sense to reduce significantly the variation of economic policies. This could be undertaken with institutional reforms, such as providing central banks with more independence from the government. From a theoretical point of view, this idea is (in part) against the common precept that there are very few gains from trying to avoid business cycles fluctuations. Lucas famous approach states that the welfare gain from facing a non stochastic consumption path is quite small for a risk averse individual. The policy recommendation derived from this idea is that it is basically useless to direct monetary and fiscal policy to reduce output fluctuations. This paper complements Lucas' approach by stating that if volatility and growth have a common source (policy instability) then it makes sense to direct efforts at solving that problem. In short, I argue that output fluctuation is not bad in itself, only when it is the result of factors as excessive policy variability.

Future research must be directed to study the behavior of state/province economies that constitute emerging countries. How are these economies affected by the policy variability induced by the central government? Do we observe the same pattern as in states belonging to the United States? Another promising avenue for research is to consider the business cycles characteristics of member countries of the European Union. In light of the level of integration already achieved, one might consider them small open economies interacting in a similar way as of states. If so, is the growth – volatility correlation inexistent or negative?

Finally, the ultimate goal of this line of research is to construct a dynamic general equilibrium model that incorporates the asymmetric information problem described in this paper. The objective is to rationalize agent's decisions that link growth and volatility, in the spirit of the model discussed by Aguiar and Gopinath.

Appendix

1. Data methodology

Data are annual estimates of gross state product (GSP), logged and detrended using the Hodrik – Prescott filter with a lambda parameter equal to 100. Data source is the Bureau of Economic Analysis (BEA). Series for GSP for the period 1963 – 1989 were transformed into 2000 chained dollars using the U.S. Gross Domestic Product implicit deflator, according to the following formula:

$$def_t = \frac{usrgdp_t}{usgdp_t}$$

where $usgdp_t$ is US gross domestic product in billions of current dollars

$usrgdp_t$ is US gross domestic product in billions of 2000 chained dollars

def_t is the US implicit deflator for year *t*.

GSP series for the period 1963 – 1989 are transformed according to this formula:

$$rgsp_{t,i} = gsp_{t,i} \times def_t$$

where $rgsp_{t,i}$ is state *i* gross state product in billions of current dollars

$gsp_{t,i}$ is state *i* gross state product in billions of 2000 chained dollars

def_t is the US implicit deflator for year *t*.

Data for Real Gross Domestic Product for the period 1990 – 2004 is taken directly from the BEA. Fluctuations are measured as the percentage standard deviation of the cyclical component of the filtered series.

2. Proof

At the first best outcome, the “low” type government has an incentive to mimic the behavior of the “high” type government and therefore earn a positive surplus. To see this, define government surplus as:

$$T\left(q_i^*\right) - \theta_i g\left(q_i^*\right) = 0 \quad , i = H, L$$

Then, if the “low” type acts as the “high” type, it will receive the other allocation and its surplus will be:

$$T\left(q_H^*\right) - \theta_L g\left(q_H^*\right) \rightarrow \theta_H g\left(q_H^*\right) - \theta_L g\left(q_H^*\right) = \left(\theta_H - \theta_L\right) g\left(q_H^*\right) > 0$$

Therefore, the first best outcome is not incentive compatible for the “low” type government. However, it is incentive compatible for the “high” type government that does not want to mimic the behavior of the other type. Applying the same reasoning as before:

$$T\left(q_L^*\right) - \theta_H g\left(q_L^*\right) \rightarrow \theta_L g\left(q_L^*\right) - \theta_H g\left(q_L^*\right) = \left(\theta_L - \theta_H\right) g\left(q_L^*\right) < 0$$

To conclude, I drop the incentive compatibility constraint (ICH) that is satisfied at the first best outcome and solve the second best problem only with the ICL.

3. Emerging and developed countries

Emerging countries:

Argentina, Brazil, Ecuador, Israel, Korea, Malaysia, Mexico, Peru, Philippines, Slovak Republic, South Africa, Thailand, Turkey

Developed countries:

Australia, Austria, Belgium, Canada, Denmark, Finland, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland

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VITA

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