OUTPUT VOLATILITY IN DEVELOPING COUNTRIES

by

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Overview

Over the past few decades, many countries have experienced a marked decline in the volatility of output. However, there is still a significant difference between developed and developing countries in the level of output volatility. A proposed explanation for this phenomenon is the impact of economic policies on output volatility in developing countries. The empirical results reported in this study support this view. Trade openness and discretionary fiscal policy seem to increase volatility in developing countries, while the converse is true in developed countries. Furthermore, a flexible exchange rate regime is desirable to decrease volatility. However, many developing countries still use fixed rates for reasons such as a fear of floating, which contributes to volatility. The impact of monetary policy was found to be stabilising, but this could be the result of a favourable global economic environment. It should be noted, however, that uncontrollable factors such as financial systems and institutions play a vital role in all the above relationships.

Keywords: Output volatility, growth, government size, trade openness, fiscal policy, monetary policy, exchange rate

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Introduction

Over the last two decades, countries across the world have experienced a decline in the volatility of output. Different reasons have been advanced to explain this decline. One of these rests upon the phenomenon of structural change. Kent, Smith and Holloway (2005) provide evidence suggesting that reforms in product and labour markets have contributed to the decline in the volatility of output. The effect of these reforms is to enable resources to shift more easily towards more productive sectors during shocks. McConnell, Mosser and Perez-Quiros (1999) found a distinct difference between the output volatility experienced by the USA before and after 1984. They argue that the lower level of output volatility after 1984 was mainly caused by a change in the efficiency of inventory management. This conclusion was reached after the observation that inventory volatility declined significantly during this period, brought about by advancement in information technology and availability.

Another explanation proposed is that the decline in output volatility can be attributed to better policy. An example of this is the case of monetary policy. Before 1980, policy makers used monetary policy to try to affect economic growth and unemployment. In most instances this was destabilising. Thereafter, with the academic mind shift that monetary policy could not have a permanent effect on economic growth, monetary authorities focused on stabilising prices, which led to lower volatility than before. A number of economists hold that the recent decline in output volatility is the result of good luck. The absence of severe and frequent shocks caused output to be more stable than before.

However, Bejan (2006) and Hakura (2007) found that output volatility in developing countries remains larger than in developed countries. Furthermore, this gap seems to be increasing. In other words, output volatility decreased more in developed countries. One could argue that the absence of major shocks to the global economy led to a decline in output volatility in both developing and developed countries, but this cannot explain why the difference with regard to output volatility between these two groups of countries has increased.

In order to find an answer to why output volatility in developed countries decreased more than in developing countries, the investigation needs to shift to the effect of economic policy on growth volatility. Stated differently, has the choice and conduct of economic policies in developing countries contributed to output volatility more than in developed countries?

Bejan (2006) found that a higher level of trade openness leads to higher output volatility in developing countries, while the situation for developed countries is the exact opposite. Hakura (2007) provides evidence to suggest that discretionary fiscal policy contributes to the gap between output volatility in developed and developing countries. With regard to monetary policy, the results on this matter seem to be indecisive. Finally, there is also evidence to suggest that different exchange rate regimes have different effects on output volatility. The aim of this study is to examine each of these situations in turn. In other words, this study will look at the effects of trade openness, fiscal policy, monetary policy and exchange rate regimes on output volatility in developing countries.

Before one can attempt to investigate the likely sources of output volatility, a question central to this topic needs to be addressed. Why is the study of output volatility necessary? In most instances, the stability of an economic variable is desirable. This is because instability results in uncertainty and risk. Economic agents can make better decisions about their future activities when they operate in a stable environment. However, the volatility of certain economic variables also creates opportunities, especially for agents who are relatively risk averse. When determining whether the volatility of a particular economic variable is beneficial or detrimental, its effect on overall economic welfare should be established. When referring to a country as a whole, the per capita level of GDP is a sound approximation of economic welfare. Hence, what is the relationship between output volatility and GDP? This question is addressed in the chapter 1 of this study.

Chapter 1

The relationship between output and volatility

Up to the early 1980s, most economists believed growth and growth volatility to be mutually exclusive events. In other words, these events were studied independently as growth theory and business cycle theory respectively. Growth theory mainly focused on the trend of GDP and its determinants. However, business cycles were defined as deviations from this independent trend. The main reason for this is that the long-run growth rate of GDP, for most developed nations, can be approximated extremely accurately by means of a log-linear deterministic trend that occasionally yields surprisingly effective forecasts.

However, owing to the influential paper by Nelson and Plosser (1982), this view has come under scrutiny in the past two decades. In their paper, they find statistical evidence on the existence of a unit root in important economic time series. The significance of this is that regressions based on nonstationary variables may lead to spurious results. Furthermore, if the data-generating process of a specific variable is wrongly specified – in other words, if a stochastic trend is approximated by a deterministic trend in most instances it would lead to unreliable forecasts. Nelson and Plosser (1982) investigated 14 economic variables, including GNP, for the USA over the period 1860 to 1970. After applying certain statistical tests they found no evidence to reject the null hypothesis of a unit root at the 5% significance level.[1] The only exclusion was the unemployment rate which Nelson and Plosser (1982) concluded to be stationary around a constant trend.

[1] Nelson and Plosser (1982) used sample autocorrelation functions and the Augmented-Dickey-Fuller tests to test the unit root hypothesis. For an explanation of these tests see Gujarati (2003:807 – 818).

The case for nonstationary economic time series, however, is far from closed. The methods used by Nelson and Plosser (1982) have been criticised on the basis of the power and size of the unit root tests and the possibility of structural breaks in the time series.[2] Rudebusch (1993) argues that most unit root tests have low power – that is, they have a low probability of rejecting the null hypothesis, a unit root in this instance, when it is false. Diebold and Senhadji (1996) concur with this finding and extend the analysis by using a larger data set. When comparing their results to those of Nelson and Plosser (1982), they argue that their sample was too small, limiting the power of the test to reject the unit root null. Perron (1989) also criticised the unit root finding with his finding that the unit root hypothesis can be rejected in favour of a trend stationary series with a structural break occurring in 1929.

However, Murray and Nelson (1998) defend the case of a stochastic trend by showing that the choice of lag differences in the test statistics plays a vital role in the results. They also emphasise that large samples, like those of Diebold and Senhadji (1996), may violate the assumption that the underlying data-generating process is homogenous. They also claim that heterogeneity in the data may lead to a spurious rejection of the unit root hypothesis. More recent investigations into this problem have found inconclusive and differing results depending on the tests used and the way in which the tests were conducted.[3] It would seem that a definite answer to this problem is highly unlikely, owing to the inherent nature of statistical tests in which the manipulation of data and techniques could alter results marginally to favour different sides of the fence. Murray and Nelson (1998:17) suggest a possible way forward:

"In our view, a constructive direction for modeling aggregate output will be one that moves beyond the unit root issue and the use of dummy variables to represent shifts in level or growth rate. Determinism is not a hypothesis that is supported either in economic theory or in history."

Although some economists still believe the opposite, they are in the minority. The broadly accepted notion is currently one in which most major economic time series are seen as

[2] If a series contains a structural break, in other words, a change in the slope, it may lead to an acceptance of the unit root null if the break is not incorporated into the test by, say, using a dummy variable.
[3] See, for example, Murray and Zivot (1998), Abadir, Caggiona and Talmain (2005) and Hurlin (2004).

nonstationary. This paradigm shift led to the situation in which business cycles and growth are no longer regarded as two separate, independent fields of study, but rather a situation in which volatility and growth are related. The first section of this chapter will briefly explore possible theories of how volatility could have an impact on growth, both positively and negatively. The next section will review empirical findings from the literature, while the concluding section is an empirical investigation of this relationship for developing countries.

1.1 Plausible theories on the impact of volatility on growth

The emergence of real business cycle theory in the 1980s together with the findings of Nelson and Plosser (1982) suggested that growth and volatility may be related. The question of whether this relationship is negative or positive is subject to some controversy. Before investigating the empirical evidence, it is necessary to briefly consider the possible explanations of this relationship. Theories pointing to a positive relationship between growth and volatility will be discussed first, followed by a discussion of the theories predicting the opposite.

1.1.1 Theories advocating a positive relationship

Black (1987) suggested that a significant part of business cycle volatility is determined by the choices of rational actors. Investors can choose between investing in low-variance, low-return industries or in high-variance, high-return industries. Thus, the risk aversion of the people in a specific country largely determines the balance between volatile high growth and stable slow growth. In other words, if a country consists of people who are relatively risk averse, they would invest more in industries with slow stable growth, which would ultimately reflect in the economy as a whole. The converse also applies.

Aghion and Saint-Paul (1998) provide an alternative explanation of how growth and volatility may be positively linked by using the so-called “opportunity cost approach”. According to these authors, the opportunity costs of labour are lower during recessions. Since recessions are characterised by a slump in growth, there is less income and production lost during recessions when workers move between jobs. This is because of lower productivity during a recession. Thus, since the opportunity cost is lower and unemployment higher during recessions, labour will move towards more productive sectors. This would ultimately translate into higher growth in the future.

Hall (1991) presented a similar argument in which organisational capital plays the central role. Organisational capital depends on matching heterogeneous resources, such as matching workers to physical capital. If this “matching” is efficient, organisational capital is high. However, over time, workers experience a loss in productivity either because of aging or other factors. When unemployment is at its highest, recessions afford employers the opportunity to reorganise organisational capital by matching workers to physical capital in a manner that would lead to higher productivity than before. Hall (1991) describes this situation by referring to an office worker who becomes more disorganised and unproductive as the workload intensifies. When things slow down, the worker can reorganise and be more productive.

Caballero and Hammour (2000) put forward an interesting theory in which they build upon the idea of creative destruction developed by Schumpeter (1942). Schumpeter (1942) originally used the idea of creative destruction as a means to explain the evolution of capitalism into social democracy. Creative destruction basically means that certain ideas, which were created by a particular system, are later destroyed and replaced with more efficient ideas as the system evolves. This contributes to a continually changing and growing environment. Caballero and Hammour (2000) use this idea to explain why volatility may influence growth positively. Economic expansions are characterised by the emergence of new firms and businesses. These new firms, together with certain more established firms, may not operate efficiently. When the economy expands, these firms may still be able to stay profitable despite not operating proficiently. However, when the economy stagnates, these firms would struggle to endure and ultimately close down. Recessions thus represent times when the economy cleanses itself of these less productive and inefficient firms, which would then contribute to higher growth in the future.

1.1.2 Theories advocating a negative relationship

Learning-by-doing is a vital factor in the process of human capital accumulation. In most cases (i.e. most kinds of jobs), the theoretical knowledge acquired through formal schooling only provides the basis that a typical worker needs to perform his or her task efficiently. More important is on-job-training and experience, which workers can only obtain while working. Martin and Rogers (1997) acknowledge this fact by advocating fiscal policy as a stabilisation tool to augment growth. They state that the higher unemployment rate during recessions leads to a loss of human capital. The reasoning is straightforward. When economic circumstances are unfavourable, firms often cut back on personnel spending. This, in turn, deprives these workers of gaining valuable experience. The severity of a recession would either amplify or restrict this loss in human capital. In the future these effects will roll over to act against economic growth. Thus, higher volatility leads to lower growth. Interestingly, Van Ewijk (1997) incorporates both the opportunity cost approach and the learning-by-doing hypothesis in explaining the relationship between growth and volatility. According to him, the positive effect of the opportunity cost approach dominates when the economy is experiencing weak fluctuations, while the learning-by-doing approach dominates when the fluctuations are more severe.

Another source that could lead to a negative relationship between growth and volatility is the irreversibility of investment. Pindyck (1991) shows that, assuming investments are irreversible, increased fluctuations in economic activity can have a negative effect on growth[4]. This assumption of irreversible investment is credible since many investments, once made, are impossible to turn around because of fixed contracts or other statutory obligations. Firms may have the funds available for investments during favourable economic circumstances, but will be unable to sustain the investment during harsh economic conditions, and in the worst case scenario, close down. An example of this is higher interest payments on loans. The opposite applies to countries with higher than usual volatility, where firms may avoid investment altogether because of the uncertainty of the future. Both cases point to a situation in which volatility is harmful for growth.

[4] This explanation was also proposed by Bernanke (1983).

Stiglitz (1993) explains the negative correlation between growth and volatility through the effects of volatility on research and development. While admitting the positive influence of the Schumpeterian idea of creative destruction, he states that the costs of volatility, through its negative impact on research and development, significantly outweigh the benefits of creative destruction. Technological progress is the main factor determining long-run growth. Thus, if investments in new innovations are not sufficient, this will lead to lower growth in the future.

From the above it is already clear that there are differing results, depending on the assumptions of the model. Blackburn and Varvarigos (2006) justify this notion by deriving a dynamic general equilibrium model, which yields both a positive and a negative relationship through using different assumptions. In the model, long-run growth is determined by the accumulation of human capital, whereas volatility is determined by technological and preference shocks. Human capital accumulation depends on learning, which could be either deliberate (internal) or nondeliberate (external). Deliberate learning is characterised by an individual's own actions to increase his or her productivity, whereas nondeliberate learning occurs when an individual is forced externally to acquire new skills. Blackburn and Varvarigos (2006) go on to show how deliberate learning could lead to a negative relationship, while nondeliberate learning could lead to a positive relationship[5]. Finally, the relationship between growth and volatility was also found to be different, depending on which type of shock (technological or preference) was used.

All the above theories are economically plausible. However, it goes without saying that the relationship between growth and volatility cannot be both positive and negative at the same time. It could be that some or all of the above are part of the growth-volatility equation with preceding positive and negative signs. In other words, each theory contributes a small part to the final net answer. However, the only way to find the answer is to inspect the data. This is the aim of the next section in which the empirical results of different studies and models are examined.

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[5] For mathematical proof see Blackburn and Varvarigos (2006:5–15)

1.2 Empirical evidence from the literature

One of the most influential papers regarding empirical evidence on the relationship between growth and volatility is that of Ramey and Ramey (1995). Using a panel data set consisting of 92 countries over a period from 1962 to 1985[6], they detect a negative relationship between volatility and growth. The standard deviation and mean of per capita annual growth rates are used as estimates for volatility and growth respectively. In the base model, a regression of mean growth on the standard deviation of growth results in a statistically significant negative coefficient. Owing to the risk of autocorrelation and specification bias, Ramey and Ramey (1995) then add certain control variables to the base line regression to test whether the results are robust. The choice of these control variables was based on variables that have been found to be significant in the literature on growth regressions[7]. These variables incorporated estimates of investment, human capital, the initial level of GDP and the population growth rate. The inclusion of these control variables only leads to a stronger negative relationship between growth and volatility. Ramey and Ramey (1995) also test for possible country and time fixed effects. However, this does not alter the results.

Kroft and Lloyd-Ellis (2002) use the same framework as Ramey and Ramey (1995)[8], but they distinguish between short- and long-term volatility. Short-term volatility is defined as fluctuations that occur on a year-to-year basis and is mainly caused by uncertainty. Long-term volatility refers to business cycle fluctuations or movements from expansions to recessions, and vice versa. The way in which this is achieved is by first dividing the sample into periods of recessions and periods of expansions. The short-term volatility is then calculated in each of these phases. Long-term volatility is calculated as the variance resulting from changes from expansions to recessions, and vice versa. Afterwards, these two measures should equal the overall sample variance of GDP[9]. The regression then includes the standard deviation of both of the volatility measures (as the independent variables) and mean growth rates (as the

[6] The period was chosen on the basis of the availability of data for all the countries involved.
[7] Referring specifically to Levine and Renelt (1992).
[8] Kroft and Lloyd-Ellis (2002) use the same sample and data used by Ramey and Ramey (1995).
[9] For more details regarding the equations and methods, see Kroft and Lloyd-Ellis (2002:3-5)

dependent variable). The results yield a positive coefficient for short-term volatility and a negative coefficient for long-term volatility. However, the negative coefficient is larger than the positive coefficient in absolute terms. This suggests that the net effect of overall volatility on growth is negative. Furthermore, these results were robust to the inclusion of certain control variables.

Imbs (2002) criticises findings of a negative relationship between growth and volatility. He (2002:2) suggests that these findings are the result of an aggregation error:

"The negative link between aggregate growth and volatility masks a positive one at the purely disaggregated level."

In order to justify this statement, Imbs (2002) tests both the aggregated data case and a disaggregated case. The data set for the latter was obtained from UNIDO[10] and included variables such as sectoral value added, employment, factor content and the number of firms in manufacturing. The results point to a significant positive relationship between volatility and growth in the disaggregated case – in other words, where countries are subdivided into different sectors. According to Imbs (2002), the reason for the differing results, between the aggregated country and disaggregated sector level, is the heterogeneity between sectors of the economy. When the outputs of these sectors are combined to form aggregate GDP, it is unlikely to pick up these sectoral heterogeneity effects. The ignorance of these effects at the aggregate level then leads to a negative relationship. Imbs (2002) theoretically supports his finding, a positive relationship between growth and volatility, on the Schumpeterian view of creative destruction.

Turnovsky and Chatopadyay (1998) address the question of the relationship between growth and volatility purely for developing countries. More specifically, they focus on a sample of 61 countries classified by the World Bank as "least developed". When regressing mean output on the standard deviation of output, the resulting coefficient is both negative and significant. Surprisingly, when certain control variables are included, the coefficient becomes insignificant.

[10] United Nations Industrial Development Organization

This is in contrast to the findings of Ramey and Ramey (1995), which indicate that the inclusion of control variables only strengthened the negative coefficient. However, the control variables used by Turnovsky and Chatopadyay (1998) are not the same as those of Ramey and Ramey (1995) and include approximations of terms of trade volatility, government expenditure volatility and monetary growth volatility. The fact that the inclusion of these variables leads to a smaller negative (sometimes insignificant) coefficient of output volatility suggests that these factors may influence output volatility. In other words, when not included in the regression, their effect could be absorbed by the output volatility variable.

Although the above studies differ in respect of methods and results, they all investigate the relationship between growth and volatility over more or less the same sample period, roughly 1960 to 1990. It may be useful to consider the status of the relationship for prior periods. For example, Siegler (2001) investigates 12 countries over the period 1870 to 1929. Using the standard deviation of log differences of real GDP as an approximation for volatility, Siegler (2001) finds a negative relationship between growth and volatility. After including a wide range of possible control variables in five regression equations, the term explaining volatility is always significant and negative. Hence this result supports hypotheses like learning-by-doing or irreversibility of investment as explanations of how growth and volatility may be linked. One criticism of this result is the fact that a sample of 12 countries may not be representative of the population as a whole. However, when considering the more distant past, the availability of data is a major constraint.

Finally, Hnatkovska and Loayza (2003) pose four key questions concerning the growth and volatility relationship. First, is the link between growth and volatility positive or negative? Second, is the casual link from volatility to growth significant? Third, does volatility have a greater effect on growth in a certain subgroup of countries? Finally, does this effect diminish or expand over time?

Regarding the first question, Hnatkovska and Loayza (2003) use a sample of 79 countries (industrial and developing) over the period 1960 to 2000. They employ two measures of volatility, the standard deviation of per capita GDP growth and the standard deviation of the per capita GDP gap[11]. After testing the standard model, in which only growth and volatility are included in the regression, a negative coefficient is estimated for both measures of volatility. The situation remains mostly unchanged when control variables are included.

Regarding the second question, Hnatkovska and Loayza (2003) use an instrumental-variable procedure to test the casual relationship between growth and volatility[12]. They find that this effect operates from volatility to growth. In other words, the relationship between growth and volatility is not because of the fact that both are determined by other factors in the model.

To test the effect of volatility on growth for different country characteristics, Hnatkovska and Loayza (2003) include variables relating to economic development like output per capita, institutional and financial development. These tests show that the negative relationship between growth and volatility becomes stronger as one moves towards LDCs.

Finally, to assess whether this relationship has strengthened or diminished over the years, Hnatkovska and Loayza (2003) divide the sample into four successive periods of equal length. Regressions are run separately for each period to determine if these coefficients are significantly different from one another. The investigation concludes by pointing out that the coefficients are in fact statistically different from each other and that the negative effect has become significantly larger over the years, especially for developing countries.

1.3 Investigation into the relationship between growth and volatility

The different results in the literature, both empirical and theoretical, encourage further research into this topic. Even though the literature that reports a negative relationship between growth and volatility strongly outweighs the findings of a positive relationship, the literature is somewhat limited for developing countries. It is clear that most OECD countries have recently experienced stable growth. However, the same does not apply to most developing countries. Furthermore, findings such as those of Hnatkovska and Loayza (2003), which show empirically

[11] This approximation corresponds to RBC (real business cycle) thinking. The calculation of the output gap involves the estimation of a trend for each country's GDP series. The output gap is then defined as the difference between the actual and trend GDP.

[12] For details of the specifics of the procedure, see Hnatkovska and Loayza (2003:7-8)

that volatility has a stronger negative impact on growth in developing countries and that this effect has grown stronger over time, support the need to investigate the link between growth and volatility solely for developing countries.

1.3.1 A model linking the business cycle to output

The model below shows theoretically how cyclical fluctuations influence output. It was proposed by Fatas (2001) and incorporates the learning-by-doing hypothesis. Although many different models draw similar conclusions, Fatas's model will be sufficient for the purpose of this chapter.

As a starting point, Fatas (2001) assumes the following production function, which is similar to that of most endogenous growth models:

$$Y_t = A_t L_t^{\delta} K_t \qquad (1)$$

where Y represents growth, A technological progress, L labour and K the accumulation of knowledge. Knowledge is determined by learning-by-doing and is characterised by the following:

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

Here, γ represents the extent of learning-by-doing in the economy. Dividing equation (1) by Y_{t-1} and replacing Y_{t-1} with $A_{t-1}L_{t-1}^{\delta}K_{t-1}$ on the right-hand side yields

$$\frac{Y_t}{Y_{t-1}} = \frac{A_t}{A_{t-1}}\left(\frac{L_t}{L_{t-1}}\right)^{\delta}\frac{K_t}{K_{t-1}} \qquad (3)$$

Substituting equation (2) into equation (3) and taking natural logs yields

$$logY_t - logY_{t-1} = logA_t - logA_{t-1} + \delta logL_t - \delta logL_{t-1} + \gamma logY_{t-1} - \gamma logK_{t-1}$$

Replacing K_{t-1} with $Y_{t-1}/A_{t-1}L_{t-1}^{\delta}$ and simplifying leads to the following:

$$logY_t - logY_{t-1} = logA_t - (1-\gamma)logA_{t-1} + \delta(logL_t - (1-\gamma)logL_{t-1})$$

Using lower case letters to denote logarithms yields:

$$\Delta y_t = a_t - (1-\gamma)a_{t-1} + \delta(l_t - (1-\gamma)l_{t-1}) \qquad (4)$$

Bearing in mind that the steady state is the case in which labour and technological progress remain unchanged, one can easily show that steadystate growth will be equal to[13]

$$\Delta y_t = \gamma\hat{a} + \delta\gamma\hat{l}$$

For simplicity, the assumption is made that labour is inelastic. Furthermore, a_t is assumed to follow an auto regressive process, more specifically an AR(1) process. This is done to add cyclical shocks to the model.

$$a_t = \hat{a}(1-\theta) + \theta a_{t-1} + \varepsilon_t \qquad \text{where } \varepsilon_t \sim N(0,\sigma^2)$$

Finally, using Wold's theorem[14], growth can be expressed exclusively as a function of ε_t as follows[15]:

$$\Delta y_t = (1-(1-\gamma)L)F(L)\varepsilon_t \qquad (5)$$

where

$$C(L) = 1 + \theta L + \theta^2 + L^2 + \theta^3 L^3 + \cdots$$

It is important to note that the accumulation of knowledge is the essential driving force behind output growth. This becomes clear if we set γ = 0 which produces a steady-state growth rate of 0. Also, the cyclical shock takes the form of a random walk process, even though at first glance

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[13] Steady state implies that At and Lt are constants. Thus, by setting lt and lt-1 equal to l and setting at and at-1 equal to a, it is simple to derive steadystate growth.

[14] Wold's theorem states that every covariance-stationary time series variable can be expressed as an MA(∞) process of its error term.

[15] This also becomes clear if one continuously replaces a_t in equation (4) with its AR(1) stochastic process.

it may appear to be a random walk with a constant drift[16]. In other words, technological progress will alternate around a horizontal trend. Finally, equation (5) shows that the effects of the shock on the growth rate are amplified by the effects on the accumulation of knowledge. This means that the growth rate will be lower than usual in the face of a recession. When the economy enters a recovery phase, growth will increase but output will not reach the trend it was on before the shock. This is because of the loss of output when the growth process was slower than usual.

The model shows that cyclical fluctuations, although transitory, exhibit long-term effects on output. A shortcoming of the model is that it does not show how volatility influences the growth process. After the shock, the growth rate returns to normal. This is the result of the symmetry between positive and negative shocks, or recessions and expansions, which have equal but opposite temporary effects on growth. Certain additional assumptions, however, can generate a longer-term negative relationship between growth and volatility. This would be the case when shocks are assumed to be asymmetric in the sense that negative shocks result in deeper recessions, while the effect of positive shocks remains unchanged.

The significance of the above model lies in the result that fluctuations have long-term effects on output and the fact that it suggests the possibility of a relationship between growth and volatility. This possibility will be examined empirically in the concluding sections of this chapter[17]. Finally, note that the model above will not be used as a framework for the empirical section that follows, but was merely described to point out the theoretical possibility of a link between growth and volatility.

1.3.2 Data and methodology

This and the subsequent section will investigate the empirical relationship between growth and volatility. These two sections are not a review of other empirical findings and all the results are original. The data set used was obtained from the Penn World tables and consists of 71

[16] This is because of the intercept which, in this case, does not have the effect of pushing the series in one direction.

[17] By way of the author's own work.

developing countries, as classified by the World Bank[18]. The choice of which countries to include was also influenced by the availability of data from 1960 to 2000. Firstly, the simple correlation between growth and volatility is examined by estimating a function of the following form:

$Growth_i = \beta_1 + \beta_2 Volatility_i + \varepsilon_i$

Growth was calculated as the average annualised growth rate of GDP[19], estimated by log differences between the initial and final value, over the entire 40-year period. Volatility was calculated as the standard deviation of the growth rates for the similar period.

Next, since averaging over such a long period could mean that some of the fluctuations in the data necessary to determine the relationship between growth and volatility might be lost, the above calculations are repeated for a period of 10 years. In other words, instead of having one entry per country, there are now four entries corresponding to the periods 1960 to 1969, 1970 to 1979, 1980 to 1989 and 1990 to 1999 for each country. This means that the pooled data consist of 284 entries for each variable instead of the original 71 per variable.

Furthermore, certain control variables are included to investigate the robustness of the results obtained from the simple correlation. Also, it is necessary to investigate whether volatility itself influences growth or whether its effects are merely channeled through other variables. The choice relating to which control variables to include was based upon variables found to be important in the literature. These variables include the population growth rate, the share of investment to GDP, the initial level of GDP and a human capital variable. The variable used to approximate the level of human capital in the economy is the percentage of secondary school attainment by the total population. This variable was obtained from the Barro and Lee (2000) data set. However, owing to the lack of sufficient data on all the countries used above, the sample had to be reduced to a total of 50 countries. Hence the function including the control variables is as follows:

[18] For a list of these countries see table A1 in the appendix.
[19] The variable used from the Penn World tables was RGDPCH: real GDP per capita(chain) at constant prices.

$Growth_i = \beta_1 + \beta_2 Volatility_i + \beta_2 X_i + \varepsilon_i$ were X is the set of control variables.

1.3.3 Results

As mentioned above, the first step was to investigate the simple correlation between growth and volatility. The results are shown in the table below.

Table 1.1 Volatility and growth: 40-year regression results

Dependent variable: GROWTH
Included observations: 71

Variable	Coefficient	Std error	t-Statistic	Prob
C	0.009123	0.001489	6.126395	0.0000
VOLATILITY	-0.150146	0.056349	-2.664557	0.0096
R-squared	0.093297	Durbin-Watson stat		2.087319

Source: Author's calculations

As can be seen from the table, the coefficient of volatility is negative and statistically significant. This is the first indication of a negative relationship between growth and volatility. The number of observations is then increased by calculating the corresponding variables over successive 10-year periods. The results are as follows:

Table 1.2 Volatility and growth: 10-year regression results

Dependent variable: GROWTH
Included observations: 284

Variable	Coefficient	Std error	t-Statistic	Prob
C	0.009436	0.001138	8.290219	0.0000
VOLATILITY	-0.147207	0.043696	-3.368917	0.0009
R-squared	0.038690	Durbin-Watson stat		1.715391

Source: Author's calculations

It is clear from the above that, although a fraction smaller, the coefficient on volatility is more significant when averaging does not occur over the entire sample period. However, these results, while promising, still do not confirm the negative influence of volatility on growth. This is because of the possibility that the volatility variable may be channeling the effects of other variables important to growth. Furthermore, the effects of the omitted variables are absorbed by the error term which leads to serial correlation. In order to find out if volatility itself has an impact on growth, it is necessary to include other variables proven to be significant in growth regressions. Also, it should be noted that the number of countries was reduced for the reasons mentioned above[20]. If the procedure followed in table 2 is replicated using the reduced sample, the following results are obtained:

Table 1.3 Volatility and growth: reduced sample regression results

Dependent variable: GROWTH
Included observations: 200

Variable	Coefficient	Std error	t-Statistic	Prob
C	0.011017	0.001417	7.775496	0.0000
VOLATILITY	-0.185013	0.064645	-2.861995	0.0047
R-squared	0.039725	Durbin-Watson stat		1.668909

Source: Author's calculations

It can be noted that the effect is still negative and significant, although slightly less significant than the coefficient in table 2. The varying results are normal since the effect of volatility on growth is not necessarily the same for all countries. Furthermore, this shows that the negative effect of volatility on growth is robust regarding sample size. However, serial correlation is still present due to the effects of the omitted variables on the error term[21]. Next, using the same sample as table 3, the control variables were all included simultaneously and yielded the following results:

[20] These countries are listed in table A2 in the appendix.
[21] Serial correlation is present in table 1.2 and table 1.3 due to the omitted variables case. However, there is no evidence of serial correlation when the control variables are included in table 1.4. These tests are shown in the appendix under table A3.

Table 1.4 Volatility and growth: control variables

Dependent variable: GROWTH
Included observations: 200

Variable	Coefficient	Std error	t-Statistic	Prob
C	0.034617	0.008410	4.116364	0.0001
VOLATILITY	-0.213673	0.060102	-3.555177	0.0005
INITIALGDP	-0.007735	0.002381	-3.248187	0.0014
INVESTSHARE	0.000446	7.06E-05	6.310730	0.0000
POPGROWTH	-0.188786	0.095994	-1.966630	0.0507
HUMANC	0.000108	7.86E-05	1.370129	0.1722
R-squared	0.238852	Durbin-Watson stat		1.808801

Source: Author's calculations

In table 4, the volatility variable is more negative and significant. Hence these results show that volatility influences growth directly and that this effect is not absorbed by other growth determinants. Also, the R-squared value increased significantly in table 4. This is because the additional variables increased the explanatory power of the model. In other words, the variation in growth is better explained by adding these additional variables. Thus, even though volatility has a significant and independent effect on growth, it only partly explains the variation in growth on its own. All the variables in the regression have the correct sign. It may be noted that the human capital variable is insignificant. This is because of autocorrelation between the latter and the population growth variable. If these variables are included separately, both are significant, without influencing the size and significance of the other variables[22]. Furthermore, the empirical analysis from above does not test for country or time fixed effects and assumes that allowing for these will not influence the results. Other researchers have tested this, and have all found that the results do not change significantly[23].

Finally, since it has been shown above that volatility influences growth directly, attention can now be focused on finding the factors that influence volatility. In other words, if it is possible to determine what factors influence volatility, it may be possible to counteract the negative

[22] These results can be seen under table A4 and A5 in the Appendix.
[23] Siegler (2001) is one of them.

impact of volatility on growth in developing countries. This is the aim of the following chapters. The first plausible determinant to be discussed is trade openness, which is the topic of chapter 2.

Chapter 2

Trade openness and growth volatility

The general view dominating the literature on the relationship between trade and growth is that trade liberalisation leads to higher economic growth. This was the main reason cited at the Doha round of trade negotiations on trade restrictions. Furthermore, many economists believe that trade liberalisation helps developing countries converge to growth levels obtained by industrial nations. The reasoning behind this is straightforward. If developing countries could import goods more easily and at a lower price from industrial nations, they could focus on the production of goods in which they have a comparative advantage. However, things are not so simple. Even though trade liberalisation has its benefits, it also makes such countries more susceptible to foreign shocks. In many cases, these shocks have mild implications for industrial nations while they may have far greater effects in certain developing countries because of their emerging market characteristics.

There is presently no consensus about the impact of trade openness on growth volatility. The most supported view states that greater openness to trade would lead to higher output volatility. This is because of the fact already mentioned above, namely that more open economies are more at risk of global shocks. Others have found that the opposite is true, namely that trade openness leads to more stable growth. The main reason cited for the latter is that countries can spread risk by diversifying their imports and exports, while specialising in goods where they have a comparative advantage.

The main aim of this chapter is to investigate the relationship between trade openness and growth volatility. However, since growth and volatility are also linked, it would be informative to briefly revise the literature on the impact of trade openness on growth. In other words, to fully understand the relationship between trade and volatility, especially the different impact that it has on developed and developing nations, one first has to investigate the impact of trade on growth and the different channels through which this link operates.

2.1 The relationship between trade and growth: not so simple

Does trade liberalisation lead to a higher growth rate? If it does, would this apply to developed and developing countries alike? This issue has been examined thoroughly in the literature. As mentioned above, the vast majority of economists concerned with this question believe that trade openness is in fact good for growth. For example, economists favouring endogenous growth modelling show empirically that openness is positively related to growth[24]. Various theoretical reasons have also been advanced to explain these empirical findings.

Since technological progress plays such a pivotal role in explaining growth in endogenous growth models, it has been argued that trade between nations leads to spillover effects. In other words, when countries are more open to trade, the technology in the more advanced nations will move more easily towards the less advanced nations. However, institutions like intellectual property rights along with other restrictions could dampen this effect. Also, if the less developed nation is not able to successfully incorporate certain newer technologies because of, say, poor infrastructure, these spillover effects might not have the desired effect of a higher growth rate.

Besides the idea that openness to trade could lead to higher growth because of technology, there are other cogent reasons that could explain the relationship. One such argument is based on the concept of specialisation. According to this concept, countries more open to trade can concentrate on the production of goods in which they have a comparative advantage, while importing other goods. This comparative advantage could be the result of the availability of certain natural resources or expertise in the production process built up over the years. Furthermore, specialisation in the production of a particular good could lead to economies of scale that would augment growth. It can also be noted that if each country were to concentrate on specific goods, the technology used in production would advance much more quickly than if

[24] See for example Romer (1990), Grossman and Helpman (1991) and Aghion and Howitt (1998).

both countries were to produce all goods. This is mainly because a budget for research and development could primarily be focused on specific goods instead of a range of different goods.

Even though the reasons mentioned above seem to be credible and straightforward, it is necessary to point out that a positive relationship between trade openness and growth depends on many other factors. Gilbert (2004), for example, investigated the relationship and found it to be positive. However, he also states that trade openness should go hand in hand with good governance. Furthermore, countries should aim to diversify their trade and not be solely dependent on exports. As Gilbert (2004:18) explains:

"In order to improve economic development a mix of trade policies and good governance are required."

In a study of 51 developing countries, Sarkar (2007) found that the relationship between growth and trade openness is positive. However, when the sample is split into groups according to the level of income and openness, only the group consisting of the 11 richest countries showed a positive relationship. This is evidence against the view that very poor countries benefit from trade liberalisation. Also, it is indicative of the fact that, when particular countries do not have good institutions and infrastructure, trade may have adverse effects on growth.

Rodriguez and Rodrik (1999) are also not convinced that trade openness leads to higher growth or, conversely, that trade restrictions affect growth negatively. They criticise the large amount of literature finding a positive association on the grounds of the wrong choices in variables along with misspecification (Rodriguez & Rodrik (1999:59)):

"For the most part, the strong results in this literature arise either from obvious mis-specification or from the use of measures of openness that are proxies for other policy or institutional variables that have an independent detrimental effect on growth."

Furthermore, Rodriguez and Rodrik (1999) make a vital point in stating that there is a difference between the effect of trade volumes and trade policies on growth. Even though trade policies affect the level of the volume of trade, the latter is also determined by factors such as transport costs and the world demand for certain goods. Thus, using variables relating to trade volumes could give inaccurate results. As for the choice of variables in general, Rodriguez and Rodrik (1999) state that most variables used in past studies were poor proxies for trade openness because of their correlation with other independent variables that influence growth. Also, many of these variables were dependent on growth - in other words, endogenous.

Frankel and Romer (1999) address the problem of endogeneity by adopting a somewhat different approach when analysing the relationship between growth and openness. They argue that since trade (exports minus imports) is not an exogenous variable, simple correlations between growth and trade may give inaccurate results. To solve this problem, Frankel and Romer (1999) use variables relating to a country's geographical characteristics to capture the part of trade that is not the result of a higher income[25]. The reason cited for using this approach is that trade and the geographical locations complement each other and that the geographical characteristics of any country are exogenously determined and not affected by income or growth. The results obtained from following this alternative approach are also suggestive of a positive impact of trade on growth. However, it should be noted that these results are still based on trade volumes rather than trade policy. Frankel and Romer (1999:395) underscore this in stating the following:

"The second limitation of the results is that they cannot be applied without qualification to the effects of trade policies."

Yanikkaya (2002) uses a wide variety of trade openness measures to further investigate this relationship. These measures are divided into two groups. The first group contains variables relating to trade volumes, such as the ratio of exports plus imports to GDP. The second group of variables concerns trade intensity. These variables are trade with OECD countries and trade with nonOECD countries. The results for the first group of variables indicate a positive relationship between growth and trade openness. Furthermore, when using trade intensity as a proxy for openness, the results indicate that the effect of trade on growth is similar for developed and developing countries. These findings therefore support the commonly held view

[25] For the methods and calculation of variables please see Frankel and Romer (1999:381–386)

that trade openness is good for growth. However, Yanikkaya (2002) also finds that tariffs and other trade barriers are in fact positively related to growth, especially for developing countries. This finding goes against conventional thought. It suggests that trade openness is good for growth through channels such as technology spillovers, but only if certain characteristics are met. If a certain country does not have these characteristics, then trade barriers might lead to higher growth rates than policies favouring openness. Yanikkaya (2002:84) explains this as follows:

"In other words, restrictions on trade can benefit a country depending on whether it is a developed or developing country, whether it is a big or small country, and whether a country has comparative advantage in those sectors that are receiving protection"

Thus, it would seem that trade openness could ultimately lead to higher growth if certain conditions are met. These conditions refer to country size, infrastructure, economic development and the goods to be traded. Furthermore, it is also essential that all the countries involved actually experience the benefits of trade. In other words, countries should find a midway during negotiations, which would result in both countries gaining equal advantage from the agreement.

2.2 Trade openness and volatility

"We have found that this relationship is a complex one."

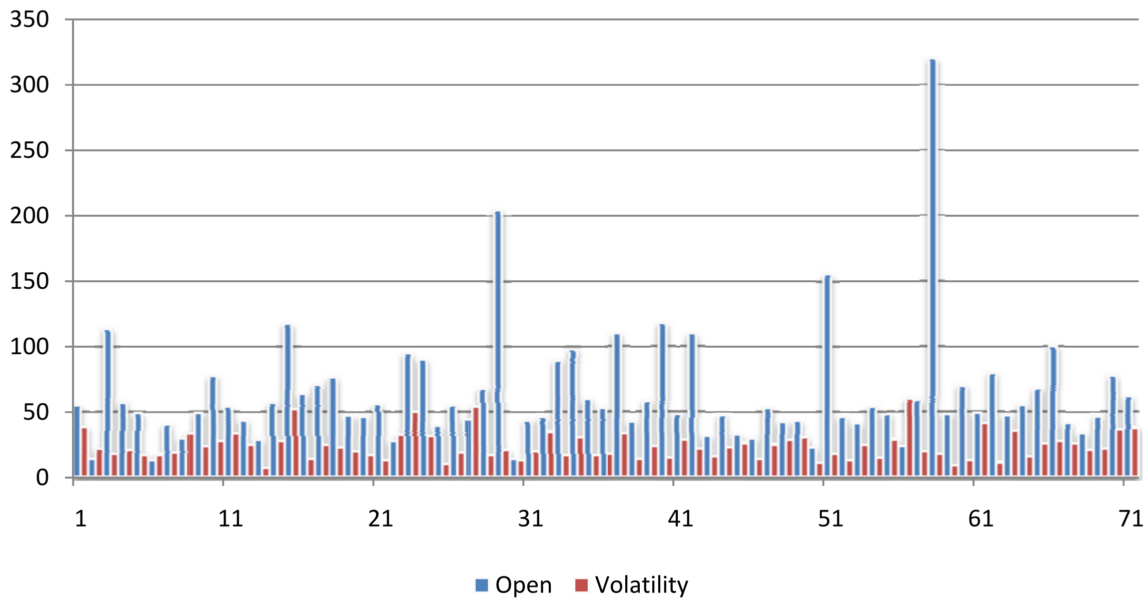
Bejan (2006:13)

Even though the relationship between trade openness and growth has been exhausted in the literature, the same cannot be said of the relationship between trade openness and growth volatility. Most economists, when confronted with this phenomenon, would argue that trade openness increases growth volatility. As mentioned above, the main reason for this is that countries more open to trade are also simultaneously more open to foreign shocks.

The graph below shows the growth volatility and openness to trade of 71 developing countries. The volatility variable was calculated as the standard deviation of GDP over 40 years. It was multiplied by 1 000 in order to bring the two variables on a similar scale. The openness variable is the average of the trade share of GDP over 40 years. This graph shows no clear relationship between openness and growth volatility. In some circumstances, some countries more open to trade had higher volatility over the 40-year period, while others had lower volatility. Even the correlation between these two variables is extremely low at about 0.008. Although this graph is only a rough sketch of the situation, it clearly shows that the relationship between growth volatility and trade openness is by no means the same for all countries. In other words, countries with different characteristics will experience different effects on output volatility as a result of trade openness. These differences between countries make it extremely difficult to find a clear relationship between trade openness and volatility. These differences between countries, for example, financial depth, play a vital role in absorbing or exaggerating increased exposure to foreign shocks caused by greater openness to trade.

This section will first review the literature focusing on the relationship between trade openness and growth volatility. Thereafter, the different channels through which trade could influence volatility will be discussed. Finally, a comparison will be made between the contrasting effect of this relationship on developing and developed countries.

Figure 2.1 Trade openness and output volatility



Source: Heston, Summers and Aten (2002)

2.2.1 The relationship between growth volatility and trade

As mentioned above, most economists believe that trade openness will lead to more volatility because of foreign shocks. Easterly, Islam and Stiglitz (2002), for instance, found that trade openness does in fact lead to more economic volatility. The reasoning behind this was based on the previously mentioned theory of the effect of foreign shocks. Furthermore, Kose, Prasad and Terrones (2006) also found that countries more open to trade experience more volatility together with higher growth rates.

However, Cavallo (2007) argues that the effect of trade openness on volatility is in fact stabilising. Cavallo (2007) acknowledges the negative effect of trade openness on volatility through foreign shocks, but argues that trade may reduce financial related volatility. Furthermore, the net effect is then stabilising because of the ever-growing importance and magnitude of financial flows. The sample used by Cavallo (2007) incorporates 77 countries of which 21 are OECD countries. Also, Cavallo (2007) uses a similar technique to that of Frankel and Romer (1999) in order to prevent the endogeneity phenomenon. This technique involves the use of trade variables, which are independent of income, but determined instead by characteristics like geographical location, land remoteness and distance between trading partners. It has been shown that these constructed variables are highly correlated to trade flows. In addition, Cavallo (2007) uses trade/growth as a proxy for trade openness. Also, an interaction variable, trade/growth multiplied by the standard deviation of terms-of-trade shocks, is included to capture the fact that economies more open to trade are likely to experience more frequent and greater shocks originating from world markets. The result of a regression of output volatility on the above-mentioned variables points to a stabilising effect. The coefficient on the trade openness variable is negative, while the coefficient on the interaction variable is positive. However, the negative value outweighs the positive value in absolute terms, which suggests an overall stabilising effect. The positive coefficient on the interaction variable is caused by the fact that terms-of-trade risk increases growth volatility. Furthermore, Cavallo (2007) explains the overall negative effect as being the result of the stabilising effect of trade openness on growth through the financial channel. It is argued that openness to trade increases countries' creditworthiness, which, in turn, helps them to absorb shocks caused by sudden changes in capital flows (Cavallo 2007:25):

"In other words, more open economies might be less credit constrained and might therefore be able to smooth output fluctuations more easily."

In order to test this theory, the sample is divided into two groups corresponding to their exposure to capital flows. The results point to a stronger stabilising effect in the group of countries that are relatively more exposed to capital flows. Hence these results support the view that there is a strong stabilising effect of trade openness on growth, which operates through the financial channel.

In a study relating primarily to developed countries, Down (2007) found that trade openness contributed to a significant decline in growth volatility in developed nations. The main reason for this is the diversification of risks brought about by greater trade openness. Furthermore, Down (2007) states that country size also plays a vital role. In smaller countries, enhanced trade could lead to higher economic volatility. The argument put forward is that it is not so much trade openness causing growth volatility, but rather the ability of a specific country to reap the benefits (Down 2007:17):

"Trade exposure may not be associated with heightened levels of domestic economic volatility, but the size and depth of domestic markets may well be".

2.2.2 The different channels through which trade openness could influence growth volatility

Young Kim (2007) distinguishes between openness and external risk. The former is defined as the level of openness of a specific country with regard to the rest of the world. The latter is defined as the stability of the terms and circumstances under which trade occurs. The openness of a specific country can either increase or decrease domestic economic volatility, depending on the stability of the latter conditions (Young Kim 2007:185):

"Whether openness leads to greater volatility ultimately depends on whether international market integration concentrates or diversifies economic risk."

Young Kim (2007) argues that trade enlarges the domestic market, thus making it more stable and capable of withstanding foreign shocks. Furthermore, greater participation in world markets decreases the risk of losses caused by a fall in domestic demand. On the one hand, if the increased trade leads to "over" specialisation of a specific production process, it could be more volatile in the face of shocks. On the other, external risk should only have a negative impact on volatility. This is because of exchange rate fluctuations or changes in world supply and demand, which influence the price of exports and imports. Empirically, using a panel data set consisting of 175 countries over the period 1950 to 2002, Young Kim (2007) found that openness is not a significant variable in explaining economic volatility[26]. Instead, external risk has a statistically positive impact on economic volatility. These arguments and results suggest that it is not the level of openness of a specific country that induces volatility, but rather the amount of external risk it experiences.

Giovanni and Levchenko (2006) investigated the effect of trade openness on volatility by examining this phenomenon at the sectoral level. They found that higher trade in a specific industry causes higher volatility. It also leads to increased specialisation, which makes the specific industry more vulnerable to shocks. If the production process has been overly specialised, it will be more vulnerable to changes in input prices, changes in resources and changes in consumer choices and demand. An overly specialised industry can arise when only one specific "formula" is used in the production process. This "formula" refers to the use of certain resources, production techniques and a general way of doing things. Any changes in demand, resource prices or technological advancement will have negative influences on such industries mainly because they will find it harder to adapt and change their already deeply rooted production techniques.

[26] For specifics such as variable choice and regression techniques, see Young Kim (2007:191–202)

However, Giovanni and Levchenko (2006) also found that industries more open to trade are less correlated with the economy as a whole. In other words, these industries do not necessarily follow expansions and contractions experienced by the country as a whole. This is because of the influence of greater trade, which causes the output of these specific industries to follow the economic trends of their main trading partner. For instance, if there is a sudden rise in demand in the partner country, the domestic industry output will rise to meet the foreign demand even if the domestic country is experiencing an economic downturn. This situation decreases country-level volatility. Giovanni and Levchenko (2006) found the net effect on output volatility of the situations above to be negative. In other words, the overall effect is destabilising. Interestingly, they also found that this negative effect is on average five times larger in developing countries than in developed countries. This difference will be addressed in the next section.

It would therefore seem that greater trade openness increases volatility through the terms-of-trade channel and through external risks. Furthermore, overspecialisation because of high trade volumes could also make certain industries more susceptible to the risks associated with sudden changes or shocks. However, since trade enlarges certain markets, these markets should theoretically be less volatile. Also, in smaller countries, certain large industries mainly involved in trade are less correlated with the rest of the economy. This helps reduce volatility.

Also, when countries are more open to trade, the financial channel can stabilise growth. This is because of the increased creditworthiness of countries willing to trade with larger countries. Also, developed nations may be more willing to lend aid to trading partners (developing countries) in times of shocks. This may be the result of the necessity to import certain natural resources, which developing countries usually have more of.

2.2.3 The difference between developed and developing countries with regard to the effect of trade openness on volatility

According to Bejan (2006), there is in fact a difference in the effects of trade openness on volatility between developing and developed countries. He (2006) uses a sample consisting of 111 developing and developed countries over the period 1950 to 2000. When the whole sample is considered, the results point to a positive relationship between trade openness and growth volatility. This effect, however, has subsided in recent years. This positive relationship is not always statistically significant. The results become more interesting when the sample is split between developed and developing countries. For developing countries, more openness to trade leads to a more volatile economy. The situation for developed countries is the exact opposite. Bejan (2006) further states that terms-of-trade risk and the levels of specialisation are mainly responsible for the positive relationship between openness and volatility.

An opposite view to the above is that trade openness leads to a more stable economy for both developing and developed countries. It was suggested earlier in this chapter that the business cycles of smaller countries are correlated with their major trading partners. This idea is supported by the findings of Anderson, Kwark and Vahid (1999). In studying the business cycles of 37 countries, they found that these cycles were synchronised with those of their major trading partners. Anderson *et al.* (1999) found no relationship between trade openness and growth volatility. Regarding the synchronisation of business cycles between trading partners, Anderson *et al.* (1999) concentrated on the South Korean case. South Korea was chosen because it has implemented a highly successful export-oriented trade policy. Its major trading partners are Japan and the USA. In studying the correlation between the business cycles of these countries, Anderson *et al.* (1999) found that when trade volumes between South Korea and its major trading partners were high, their business cycles were more synchronised. This result implies that a smaller country can achieve more stable growth when it is more open to trade. This is because of the lower output volatility experienced in industrial countries over the last few decades.

However, even if synchronisation between the business cycles of trading partners is in fact significant, it does not necessarily imply that the smaller country will experience more stable growth. The smaller country may be unable to absorb certain shocks in contrast to the much larger developed country. This could be the result of factors such as financial depth and infrastructure. Anderson *et al.* (1999) suggest that the smaller country should diversify its trade with a few developed nations. If a smaller country could diversify its trade among a few larger countries, instead of maybe only one major partner, its growth path should be more stable. External shocks originating from one trading partner could, for example, be absorbed by a favourable economic situation in another trading partner.

2.3 Concluding remarks

It would seem that the relationship between growth volatility and trade openness is extremely complicated, especially when developing countries are considered. There seems to be some agreement that trade openness has partly contributed to the stable growth experienced in developed countries over the last two decades. However, the opinions are somewhat mixed when developing countries are considered. Openness to trade could cause increased volatility through the terms-of-trade channel and external shocks. However, if the specific developing country has a relatively advanced financial sector, this could reduce growth volatility. Furthermore, overspecialisation in the sectors heavily engaged in trade could also lead to higher volatility. Lastly, there is evidence to suggest that the business cycle of developing countries could be synchronised with those of their major trading partners. As mentioned above, exports should be diversified as much as possible. This would give smaller countries protection from more volatility in the cycles of a specific trading partner.

All in all, it would seem that the direction and strength of the effect of trade openness on growth volatility depend on whether the specific country exhibits enough developed country characteristics. However, for most developing countries and LDCs, especially in Africa, one must conclude that a high degree of trade openness would lead to higher volatility. The reason for this is that most of these countries are still too underdeveloped, especially their financial channels, to effectively handle shocks originating from the rest of the world.

In studying the relationship between trade and volatility, some of the papers mentioned above found that government size also plays a role in explaining volatility. This was mostly the case when government size was included as a control variable and subsequently yielded a significant coefficient. In addition to the results reported above, Bejan (2006) reported that there is a strong correlation between trade openness and the size of government. This is known as the compensation hypothesis. Basically this means that countries that are relatively more open to trade have larger governments in order to better absorb the greater exposure to foreign shocks originating from greater openness. Also, Bejan (2006) found that larger governments decreased volatility in developed countries, but increased it in developing countries.

This leads us to the topic of the next chapter, which investigates the role that government and fiscal policy play in explaining growth volatility.

Chapter 3

Fiscal policy and growth volatility

The previous chapter examined the link between trade openness and growth volatility. The aim of this chapter is to investigate fiscal policy as a possible determinant of growth volatility. The role of government in regulating the economy has been extensively studied since the rise of Keynesian theory after the Great Depression. During this period, the opinions of economists on the use of fiscal policy as a stabilisation tool changed periodically.

The role of government in output volatility is twofold. Firstly, discretionary fiscal policy can be used to intervene in the economy by deliberately increasing or decreasing government spending. According to the Keynesian approach, fiscal policy can be used as an effective stabilising tool, especially with regard to demand side effects. In other words, government spending should be deliberately decreased or increased, depending on whether the economy is expanding or contracting. However, the stance of new classical economists supports the opposite, for they feel that the use of fiscal policy in this regard could be destabilising.

Secondly, automatic stabilisers, by their nature, can also act to reduce volatility. Automatic stabilisers refer to the way in which the structure of government policies affects the economy automatically and are elements such as a progressive tax rate and transfer payments. A progressive tax rate rises more than proportionately as income rises. Thus, richer people face a higher tax rate than poorer people. If income were to increase in general, overall taxes would automatically increase and would ultimately lead to a smaller increase in disposable income. The same rationale applies in transfer payments. If there is an overall decrease in income, transfer payments to the poor increase.

However, the question of whether the above actually occurs in a real-world scenario is not that straightforward. The aim of this chapter is to investigate the role of government in reducing output volatility. The first section will focus on the theory of automatic stabilisers and its impact on volatility. The second section will examine discretionary fiscal policy and its effectiveness in moving the economy back to equilibrium after certain shocks. The third section will consider a review of empirical studies focusing on specific one-country cases. This is done because focusing on one country will enable the researcher to distinguish between the effect of discretionary fiscal policy and automatic stabilisers. Studies concerned with international cross-section data will then be reviewed. These studies generally do not distinguish between discretionary fiscal policy and automatic stabilisers and use government size as a proxy for the combined effect of the latter. The chapter concludes by specifically addressing the effect of government on volatility in developing countries and how this effect differs from the developed country case.

3.1 The theory of automatic stabilisers

As mentioned above, automatic stabilisers act to dampen the effect of shocks on aggregate output. The effectiveness of these automatic stabilisers has become increasingly important as other economic tools have become less useful. A prime example of this is the European Union in which monetary policy is rendered useless in its ability to counter shocks. Besides this, the notion that the mere design of government policy can act to decrease volatility is in itself appealing[27].

In order to better understand how automatic stabilisers act to reduce volatility it is necessary to investigate the theoretical link between the two variables. A review of a theoretical macro model proposed by Scharnagl and Tödter (2004) is provided below. The model is set out as follows:

$$y_t = \alpha(y_t - \tau_t) - \lambda(i_t - \pi_t - i^*) + g_t + \varepsilon_t \quad (1)$$

$$\pi_t = \eta q_t + \upsilon_t \quad (2)$$

[27] "Design" refers to the structure of tax regimes and transfer payments - for example, the choice between lump-sum taxes and a progressive tax system.

where y_t is output
τ_t is taxes
i_t is the interest rate
i_t^* is the equilibrium interest rate
π_t is the inflation rate (defined as the deviation from the inflation target)
g_t is government expenditures
ε_t is a demand shock that follows a white noise distribution
q_t is the price gap (difference between equilibrium price, p_t^* and current price, p_t)
υ_t is a price shock

Equations (1) and (2) describe the goods market. All the variables are stated as natural logarithms with the exception of i_t, i_t^*, π_t. The above equations simply state that demand depends on disposable income, the real interest rate, government expenditure and a demand shock.

$$q_t = \beta y_t - \gamma(i_t - i^*) + u_t \qquad (3)$$

$$i_t = i^* + \theta\pi_t \qquad (4)$$

where u_t is a price shock.

Equations (3) and (4) describe the money market. Equation (3) is determined by combining the following equations:

$$m_t - p_t = \beta y_t - \gamma i_t + u_t$$ long-run money demand function

$$p_t^* = m_t - \beta y_t^* + i^*$$ definition of the equilibrium price

The equilibrium price is thus observed when both output and the interest rate are in equilibrium. What should immediately be noted from the above is that monetary policy is committed to an inflation target. Hence the interest rate is indirectly determined by inflation. This is clear in equation (4), where the interest rate depends on the inflation rate (as defined above). In other words, the interest rate is set on the basis of the inflation rate.

$$\tau_t = \psi_0 + \psi y_t \qquad (5)$$

$$g_t = \kappa_0 + \kappa y_t \qquad (6)$$

$$d_t = g_t - \tau_t \qquad (7)$$

where ψ is the elasticity of taxes with regard to income
κ is the elasticity of government spending with regard to income

Equations (5) to (7) describe the government sector. Taxes and government spending react to changes in income according to their respective elasticities. Equation (7) simply describes the budget deficit. When all the above variables are simultaneously solved, it yields the following equation for output, y_t:

$$y_t = m(\kappa_0 - \alpha\psi_0 + \varepsilon_t)$$

$$m = \frac{1}{1 - \alpha + \rho(\theta - 1) + \alpha\psi - \kappa}$$

where $\rho = \frac{\lambda\eta\beta}{1 + \eta\gamma\theta}$

From the above equation it is clear that the effect of a demand shock, ε_t, on output, y_t, depends on the multiplier, m. In other words, a larger multiplier would mean that the effect of a demand shock would translate into a greater effect on output. In order to see how automatic stabilisers act to reduce this effect, it is necessary to focus on the variables ψ and κ. It is clear from the equation above that an increase in ψ would lead to a decrease in the multiplier. However, an increase in κ would lead to an increase in the multiplier. This suggests that taxes stabilise while government spending is destabilising. For the influence of government as a whole to stabilise, the following rule must apply:

$$\alpha\psi - \kappa < 0$$

According to Scharnagl and Tödter (2004), assuming plausible levels for the variables above, this inequality will hold. Automatic stabilisers therefore act to reduce volatility. However, although the model set out above shows how automatic stabilisers can influence volatility, it is unable to predict the effectiveness of these automatic stabilisers. The only way to determine this is to investigate the empirical relationship between volatility and automatic stabilisers. Scharnagl and Tödter (2004) use a Deutsche Bundesbank macroeconomic model to run a series of simulations in order to estimate the smoothing power of automatic stabilisers in Germany[28]. When introducing shocks through various channels, the results show that automatic stabilisers absorb on average 15 to 20% of the original shock. Results do not differ significantly when the same approach is applied to other OECD countries (Cohen & Follette 2000:60).

"The Automatic Fiscal Stabilizers: Quietly and Modestly Doing Their Thing."

Cohen and Follette (2000) identify three channels through which automatic stabilisers can affect volatility and growth. Firstly, in the insurance channel, savings are increased when a higher tax rate is anticipated. In other words, when people anticipate that the tax rate will rise in the future, they will save more in the present to be able to pay the higher taxes in the future. However, this channel is only effective if people anticipate the rise in taxes correctly and if government is relatively open about its future plans. This assumption is somewhat unrealistic because it is based on the Ricardian equivalence theorem[29]. Secondly, in the wealth channel, income taxes are lower during recession and higher during expansions. This is because of lower overall income during recessions and thus lower taxes. Thirdly, in the liquidity channel loans are more readily accessible because of lower taxes. In other words, if taxes are lower, income is higher and people will face less severe borrowing constraints. However, when using a macroeconomic model and introducing a negative demand shock, Cohen and Follette (2000) show that automatic stabilisers only decrease the multiplier by 10%.

Hence it would seem that the theory and channels through which automatic stabilisers affect volatility are clearly defined. However, in practice, automatic stabilisers only affect volatility moderately. This moderate effect is significant enough to conclude that automatic stabilisers do have a positive role to play in fighting volatility, maybe even more so in the future.

3.2 Discretionary fiscal policy

[28] For assumptions on and the structure of this model, see Scharnagl and Tödter (2004:10).
[3] The Ricardian equivalence theorem requires three assumptions to hold: perfect capital market, a fixed path of government spending and intergenerational concerns. These assumptions have been widely criticised.

Since the theory of discretionary fiscal policy and its impact on the economy have been thoroughly studied in the literature, it will only be briefly discussed here together with certain facts. The basic rationale behind discretionary fiscal policy is government's ability to change the budget in order to influence the economy. According to the classical economists, the economy will automatically return to the equilibrium level. However, Keynesian economists argued that prices and wages are not perfectly flexible. Thus, government intervention is warranted. In other words, during recessions, governments may increase government spending or decrease taxes in order to counteract the downswing in the economy. The same logic applies to expansionary cycles, when governments may decide to increase taxes and decrease spending to help bring the economy back to equilibrium. However, as stated above, the use of fiscal policy as a stabilisation tool and its effectiveness is questioned by New Classical economics on the assumption of rational expectations and market clearing. This assumption states that economic agents will form rational expectations of future events. Thus, if governments, say, pursue expansionary fiscal policy by reducing taxes, economic agents might not increase spending. If these agents expect taxes to rise again in the future, they may save now to be able to pay the taxes in the future. This view has been criticised by the New Keynesian view on various grounds. One of these criticisms is that agents may not always have enough information to make rational choices.

Auerbach (2005) lists certain facts about fiscal policy. Firstly, there seems to be evidence showing that governments still use discretionary fiscal policy to attain short-run outcomes. Furthermore, policy lags do not seem to play a significant role in preventing discretionary fiscal policy to achieve short-run results. The only restraining factor, in the use of discretionary fiscal policy, seems to originate from budgetary pressure. In other words, if governments face a large budget deficit or surplus, government policy may be rendered useless. This may be the result of adverse effects, which would arise if the budget were forced even more out of proportion by using it as a tool to influence the economy. What remains is to investigate empirically the effect of discretionary fiscal policy on volatility. This is the aim of the subsequent two sections.

3.3 Empirical findings from a one-country investigation

As mentioned above, fiscal policy has recently become more important in the European Union. This is because monetary policy is under the control of the ECB and individual countries must find alternate means to intervene in the economy. Policy makers in Europe are turning more towards discretionary fiscal policy to attain certain fundamental targets[30]. These targets may include the output gap and the public debt-to-GDP ratio. In other words, if these variables were to increase past a certain threshold, active fiscal policy would be used to intervene. It should be noted that this intervention represents an active change in fiscal policy despite the effect of automatic stabilisers. Malley, Philippopoulos and Woitek (2007) investigate this phenomenon by using a dynamic stochastic general equilibrium model. This model is applied to data from Germany, France and the UK separately. The model incorporates real wage rigidity, which is included on the basis of its relevance to European countries[31].

In this model, fiscal policy can be either active or passive. In active fiscal policy, government uses discretionary fiscal policy to intervene in the economy. This can be achieved through the use of policy instruments such as public consumption, investments, government transfers or taxes. In passive fiscal policy, there is no direct interference from government in the economy and the only way in which fiscal policy influences the economy is through automatic stabilisers. Thus, an active fiscal stance represents both the use of discretionary fiscal policy and automatic stabilisers, whereas a passive stance only represents the use of automatic stabilisers. Both these cases are then separately subjected to productivity shocks and the consequent effects on output are then measured. It is important to note that the difference in the effect on output between the two cases represents the effect of the use of discretionary fiscal policy.

Furthermore, it is assumed in this model that government reacts to either a substantial increase in the output gap or an increase in the public debt-to-GDP ratio. In other words, in this model, government chooses to focus on stabilising output or public debt. The results obtained by Malley *et al.* (2007) show that active government policy can in fact reduce the volatility in output. Furthermore, discretionary fiscal policy seems to be more efficient in reducing volatility

[30] Assuming these countries stay within the 3% budget deficit rule.
[31] It is well known that wage rigidities are a source of market failure in European countries.

when public consumption is used as the policy instrument, instead of investment. Malley *et al.* (2007) also found that higher real wage rigidity is correlated with a greater stabilising effect as a result of government intervention. Even though these results seem promising with regard to the use of fiscal policy as a stabilising tool, Malley *et al.* (2007) are not as optimistic. They argue that the welfare gains in the use of government policy for stabilisation purposes, are minor and negligible. This is because when government focuses on a specific target, say, decreasing output volatility, volatility in public debt will increase - hence a trade-off.

Even though this study sheds some light on the subject of the impact of government policy on output, it is still not definitive. The reason for this is the small number of countries under consideration. Furthermore, the countries used above have similar economic characteristics. If one required a more detailed answer, one would have to consider investigations of large sample studies which include developed and developing countries. This is the aim of the following section.

3.4 Empirical findings from cross-country investigations

As mentioned above, although investigating specific country cases allows one to distinguish between the effects of automatic stabilisers and discretionary fiscal policy, it undermines the validity of the findings. This is because country characteristics differ substantially, especially when government policy is concerned. In other words, the economic environment is different for each country. Thus, there may be singular instances where fiscal policy may be able to decrease output volatility, and vice versa, but these might be misleading for the whole sample.

This is evident from the findings of Bejan (2006). She uses government size as an approximation for the effect of automatic stabilisers. The rationale for this choice is that larger governments should have more effective automatic stabilisers[32]. She found that there is a strong correlation between trade openness and the size of government. This is known as the compensation hypothesis. Basically this means that countries that are relatively more open to trade have larger governments in order to better absorb the greater exposure to foreign shocks originating

[32] Throughout this section, larger governments serve as an approximation for the effect of automatic stabilisers.

from greater openness. She also found that larger governments decreased volatility in developed countries while this effect was insignificantly positive in developing countries.

The above findings are supported by the work of Viren and Koskela (2003). Using a sample of 91 countries, consisting of both developed and developing countries, the above authors found that larger governments are associated with greater output stability. However, when the whole sample is considered, this positive association no longer holds. In other words, if a sample consisting of both OECD and developing countries is used, the positive association disappears. Furthermore, the results are not statistically sound. The coefficient on the government size variable enters the regression equation either slightly significant or slightly insignificant. They argue that the relationship between growth volatility and government size may not be linear. The reason for this is that, for most countries, government size increased exponentially rather than linearly in the past few decades. For this reason, average values generated by a linear equation may not be representative of the true situation. Thus, further empirical work is needed to fully explore this notion.

Fatas and Mihov (2001) studied the relationship between growth volatility and government size in a sample consisting of 20 OECD countries. A wide variety of controls were used together with different measures of both output volatility and government size. The results show strong evidence that larger governments are associated with less output volatility. This finding was robust with regard to the use of different measures and the inclusion of different controls. Fatas and Mihov (2001) strengthened this finding by replicating the situation for US states. Once again the results point to a negative relationship between government size and output volatility. In other words, this finding provides evidence to suggest automatic stabilisers decrease output volatility in developed countries.

One of the main criticisms of the view that larger governments tend to lower output volatility is the fact that these results could not be replicated when different models were used. This is especially true when simple RBC models were used. However, Andres, Domenech and Fatas (2004) investigated the performance of this relationship in respect of an altered RBC model. The RBC model they used included certain rigidities. They showed that the negative relationship between output volatility and government size holds for the use of different economic models, but this situation depends on the degree of nominal and real rigidities included in the model. This result seems logical, since including sufficient rigidities means that certain economic variables are not as responsive to shocks as would usually be the case. It also raises suspicion about the question of whether real-world countries exhibit sufficient nominal and real rigidities to enable government size to influence output volatility negatively. This seems to be the case in some European countries, as pointed out above. However, whether this conclusion can be generalised to all countries is not yet certain.

Viren (2005) criticised the findings of Fatas and Mihov (2001) on the basis of the small samples they used. According to Viren (2005:12), these small samples are not a true representation of the world as a whole.

"It looks that there is no strong relationship between these variables and the previous findings may just reflect some peculiar features of the small samples which have thus far been used in empirical analyses."

Using a large World Bank dataset, Viren (2005) found no evidence to suggest that larger governments act to reduce output volatility. Also, both OECD and developing countries were included in the investigation. This may suggest that including two different subsamples with different characteristics could obscure the results. In other words, if the relationship is negative in developed countries and positive in developing countries, testing these groups together might lead to spurious results.

Hence it would seem that the majority of evidence on purely OECD countries suggests that larger governments act to reduce output volatility. In other words, automatic stabilisers act to reduce volatility in developed countries. However, evidence on developing countries seems to yield either insignificant or slightly significant positive results.

3.5 The difference between developed and developing countries

As noted above, there seems to be a clear difference between the impact of government policy in developed and developing countries. Hakura (2007) notes that developed and developing countries have experienced more stability over the last three decades. However, there is still a large gap between the volatility experienced in developed and developing countries. Hakura (2007) investigated a large sample of countries in order to establish what factors could help explain this gap. One of the main findings is that discretionary fiscal policy played a prominent role in increasing volatility in developing countries. This was especially true in Sub-Saharan and Latin American countries.

The question still remains as to why government spending leads to higher volatility in developing countries, while it reduces volatility in developed countries. According to Hakura (2007), the reason for this is that most developing countries experience more government spending volatility. Thus, the greater economic volatility is mainly a result of unstable government spending in developing countries. This is because developing countries face more stringent budget restrictions, which could lead to unforeseen changes in taxes and government spending. Furthermore, developing countries are more susceptible to the negative effects of global shocks, which could induce governments to intervene. In other words, since global shocks have a greater economic impact on developing countries, governments in these countries may intervene more than in developed countries. Also, since other policy instruments and economic tools are not as sophisticated in developing countries, this could lead policy advisors to turn to government spending as an option to intervene in the economy.

3.6 Concluding remarks

As noted above, there are still mixed opinions about the use of fiscal policy to stabilise the economy. Theoretically, government can intervene in the economy in two ways. Automatic stabilisers refer to the way in which the structure of government policies affects the economy automatically. Automatic stabilisers are elements such as a progressive tax rate and transfer payments. However, discretionary fiscal policy can be used to stabilise the economy by deliberately increasing or decreasing government spending and taxes.

Empirical findings suggest that automatic stabilisers do act to reduce output volatility in developed countries. However, this effect appears to be insignificant or slightly destabilising for developing countries. The evidence on discretionary fiscal policy suggests that the effect is different for developed and developing countries. In developing countries, the use of discretionary fiscal policy has contributed to output volatility, but the reasons for these findings are unclear. They could be the result of the inherent instability of government spending in certain developing countries.

The next chapter will investigate the role of monetary policy in reducing output volatility. Since the evidence suggests that fiscal policy increases output volatility in developing countries, it would be helpful to investigate the case of monetary policy. Furthermore, since inflation targeting has become a popular target for monetary policy over recent years and has been adopted by various countries, it is necessary to study the implications of an inflation-targeting regime in respect of output volatility. Finally, it would be insightful to see how inflation targeting fared compared to other monetary policy regimes in output volatility.

Chapter 4

Monetary policy and growth volatility

The previous chapter focused on the impact of fiscal policy on growth volatility. The aim of this chapter is to examine the role of monetary policy in output volatility. Recently, price stabilisation has been high on the list of objectives of monetary authorities. This being said, monetary policy could also be used to attain other goals. Countries with a fixed exchange rate use monetary policy to maintain the fixed rate. Furthermore, monetary policy has often been used to fight unemployment during recessions. Monetary policy could also follow a regime which focuses on multiple targets simultaneously or having a basket of targets on which it concentrates. Thus, monetary policy could be divided into three main regimes: inflation targeting, exchange rate targeting or mixed policy. However, regardless of the choice of a specific regime or target, any active monetary policy may have an impact on the growth rate in the short run.

The aim of this chapter is to investigate the possible effect of monetary policy on output volatility. In order to do this, one must investigate the performance of specific monetary policy regimes and their effect on output volatility. This problem will be addressed by focusing on inflation targeting and then comparing this regime with the other monetary policy regimes.

4.1 Inflation targeting at a glance

Inflation targeting is a relatively new approach to monetary policy. New Zealand was the first country to implement inflation targeting in 1990. Since then a large number of countries have adopted this approach. In most cases, these countries have experienced improvements in their macroeconomic indicators. Most countries, however, remain cautious in adopting this regime.

Inflation targeting, as a framework for monetary policy, requires a set target for inflation[33]. In other words, the main goal of monetary policy in this instance would be to reach and maintain the set inflation target. The central bank communicates this target to the public. Thus, inflation targeting is characterised by a high degree of transparency. Furthermore, if it is seen to be actively pursuing the set goals, the central bank will gain a high degree of credibility. Another advantage of this regime is that the central bank can be held accountable for missed targets.

The question arises whether countries that have adopted inflation targeting as a monetary policy regime have fared better than countries that have not adopted this regime. Dotsey (2006) compares the data for five countries that followed inflation targeting against those of six countries that did not adopt it. The data for the inflation-targeting countries are divided into two for the sake of comparison. In the first group, data were collected for each country over a period of 10 years prior to the adoption of inflation targeting. The second group consisted of data collected after active inflation targeting, up to 2004. The results are outlined in the tables below.

Table 4.1 Comparison between inflation targeters

	Pre-inflation targeting				**Post-inflation targeting**			
Country	***Inflation***	***Growth***	***S.D. inflation***	***S.D. growth***	***Inflation***	***Growth***	***S.D. inflation***	***S.D. growth***
NZ	11.4	1.8	2.9	2.7	2.1	3	1.8	2.4
Canada	5.7	2.8	2.9	2.9	2	2.7	1.3	2.1
U.K.	5.5	2.5	3	1.9	2.5	2.9	0.8	0.7
Australia	6	3.2	2.9	2.7	2.6	3.8	1.6	1.1
Sweden	6.7	1.9	2.9	2.3	1.5	2.5	1.1	1.6
Avg	7.1	2.4	2.9	2.5	2.1	3	1.3	1.6

Source: Dotsey (2006:13)

[33] This target could be either a point target or a target range.

As can be seen from the table above, inflation declined significantly for all five countries. The greatest decline in inflation was experienced in New Zealand. Growth rates increased for all countries, with the exception of Canada, whose growth rate fell only marginally. The volatility of inflation, measured by the standard deviation of inflation rates, decreased for all countries. Finally, output volatility decreased for all countries. The greatest decline in output volatility was experienced by the UK. Next, the case will be considered for the set of countries that did not adopt inflation targeting:

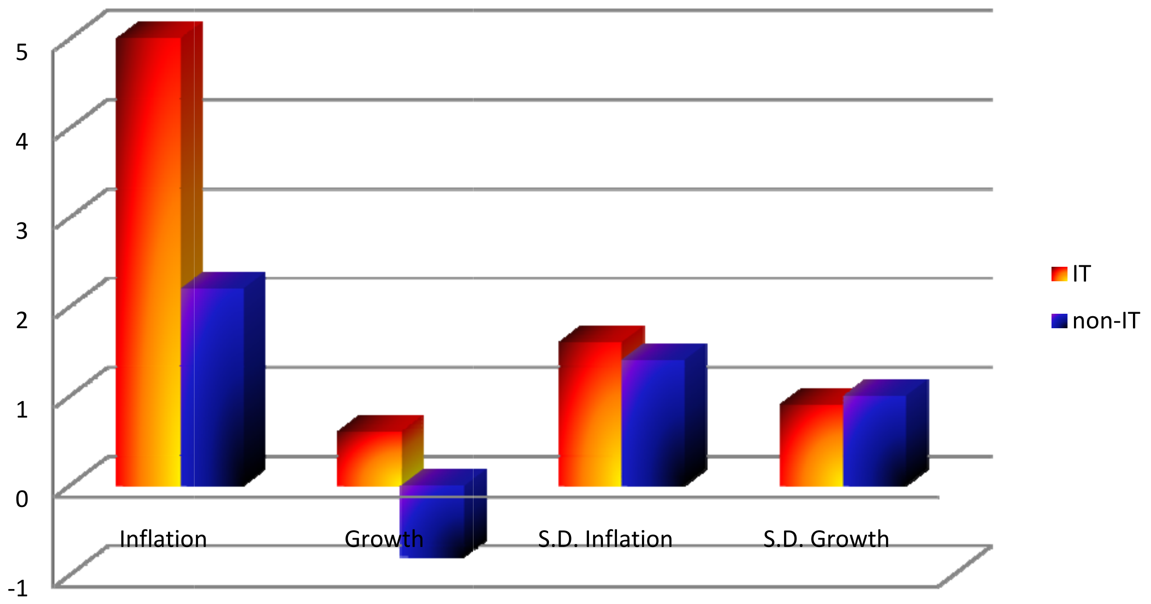
Table 4.2 Comparison between noninflation targeters

	Year: 1982–1992				**Year: 1992-2004**			
Country	***Inflation***	***Growth***	***S.D. inflation***	***S.D. growth***	***Inflation***	***Growth***	***S.D. inflation***	***S.D. growth***
U.S.A	4	3	1.3	2.6	2.5	3.3	0.6	1.2
Japan	1.9	3.7	1.1	1.8	0.1	1.1	1	1.6
Germany	2.6	2.7	1.7	5.3	1.8	1.1	1.4	1.4
France	5.1	2.2	3.3	1.1	1.6	1.9	0.6	1.3
Netherlands	2.6	2.5	2.3	2.2	2.4	2.4	0.8	1.6
Italy	8.3	2.2	4.6	1.3	3	1.5	1.3	1.4
Avg	4.1	2.7	2.4	2.4	1.9	1.9	1	1.4

Source: Dotsey (2006:13)

The table above shows that inflation decreased for all six countries in this sample. Italy experienced the greatest decline in inflation. However, growth decreased for all the countries with the exception of the USA, where growth increased slightly. The volatility of inflation decreased for all the countries in the sample. Furthermore, output volatility decreased in four of the countries included. Thus, what remains is the comparison between the two samples. Below is a graph showing the average values obtained from the tables above[34].

Figure 4.1 Differences in inflation and growth between two intervals



Source: Author's calculations

The values from the above were obtained by subtracting the average value in the latter period from the average value in the first period[35]. This was done for all the variables except growth. The growth variable from the above was obtained by subtracting the average value of the first period from the average value of the latter period. By using the average values of each sample, one can conclude that the greatest decline in inflation was experienced by the inflation-targeting countries. This is not surprising since this was exactly the objective. Growth rates increased on average for the inflation-targeting countries but decreased for the noninflation targeting countries. The volatility of inflation and the volatility of growth decreased over the sample period for both sets of countries.

[34] The values used are those from the tables of Dotsey (2006).
[35] Hence these figures represent percentage point changes.

Overall, it would seem that inflation targeting was successful in reducing inflation, especially in countries that had a high inflation rate to begin with. According to Cecchetti and Ehrmann (2002:248):

"To a very real extent, inflation targeting has achieved its primary objective: the lowering of inflation."

It would also seem that inflation targeting had a positive effect on growth. Growth increased in the inflation-targeting countries but, on average, decreased in the other countries. Regarding the volatility of these variables, there does not seem to be a significant difference between the two sets of countries. However, this does not mean that inflation targeting has no effect on output volatility. A larger sample of countries would be needed to determine this effect.

4.2 Inflation targeting and output volatility: theory

From the data presented above, it is clear that the countries included in the sample experienced a decline in both output and inflation variability. This would normally lead to a conclusion implying that the relationship between output volatility and inflation volatility is positive. In other words, a central bank's commitment to reducing inflation volatility would also lead to decreased output volatility. However, drawing this conclusion from the simple analysis from above would be inaccurate.

The reason for this is that the relationship between output and inflation varies, depending on the type of shock that hits the economy. Aggregate demand shocks move inflation and output in the same direction, while aggregate supply shocks move output and inflation in opposite directions. Thus, depending on the type of shock, central bankers face different trade-offs. What remains is to explain how the relationship between the volatility of output and inflation reacts to different shocks. The following theory proposed by Cecchetti and Ehrmann (2002) will be outlined below in order to shed some light on this problem.

The model is based upon the assumption that any central banker's policy objectives can be analytically represented by the following quadratic loss function[36]:

$$L = E[\alpha(\pi - \pi^*)^2 + (1 - \alpha)(y - y^*)^2] \qquad (1)$$

where E is the expected value
π is the inflation rate
y is the log of output
π^* and y^* represents the desired levels of these variables
α is the weight associated with the deviation from the desired levels

Hence the main objective of the central bank in the above situation would be to minimise the loss function. The way in which this is done is to minimise the deviations of output and inflation from their desired levels.

There are certain drawbacks to using the specified model. It should be noted that both terms included in the equation are quadratic. In other words, no matter what the direction of the deviations is, the terms will always be positive. According to the above equation therefore, a large increase in either of the variables will compel monetary policy to be equally aggressive as with a similar decrease in either of the variables. In other words, the above equation states that monetary policy is equally averse with regard to increases and decreases in the variables. One could even go further and state that, in this case, monetary policy is only concerned with the degree of the deviation and not with the direction thereof. This situation, however, is not representative of the real world, where monetary policy would certainly be more aggressive towards a large decrease in output than to a large increase in output.

A second shortcoming of the equation is that it includes only output and inflation. Exchange rates are not included in the equation. Cecchetti and Ehrmann (2002) argue that the exchange rate would only be an indirect target of monetary policy and that in many respects it is linked to inflation and output. Hence for this reason and for the sake of simplicity, exchange rates will be excluded from the model.

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[36] See Cecchetti and Ehrmann (2002:252-255) for the techniques used to solve the model.

The next step in formulating this model is to specify how the central bank would intervene when there are certain changes in output and inflation. Here one needs to make an assumption about the relationship between interest rates and inflation and output. This is necessary to capture the effect that a change in the interest rate, brought about by the central bank, has on inflation and output.

$$y_t = -\gamma(r_t - d_t) + s_t \qquad (2)$$

$$\pi_t = -(r_t - d_t) - \omega s_t \qquad (3)$$

where r_t represents the interest rate
d_t and s_t are demand and supply shocks respectively
γ is the inverse slope of the aggregate supply curve
ω is the slope of the aggregate demand curve

The above equations are simple representations of the link between output, inflation and the interest rate. It is clear that an increase in the interest rate will lead to a decrease in both output and inflation, and vice versa. Hence the interest rate as a policy instrument only allows for a move of output and inflation in the same direction. In other words, it is impossible to manipulate the interest rate in order to move output and inflation in opposite directions. Furthermore, demand shocks move both output and inflation in the same directions. However, supply shocks create a dilemma in that they move output and inflation in opposite directions. Thus, using the interest rate could be extremely effective for controlling demand shocks, since it can simultaneously move output and inflation back towards their original positions. The situation is quite different for supply shocks, where monetary authorities are forced to choose between output and inflation.

Next, assuming that the economy is linear, the optimal policy response is also a simple linear function, described as follows:

$$r_t = \mathrm{a}d_t + \mathrm{b}s_t \qquad (4)$$

Now, solving the model through straightforward substitutions yields $a = 1$. This means that demand shocks can be offset by a one-for-one change in the interest rate. The situation for supply shocks is more complicated.

$$b = [-a\omega + (1-a)\gamma]/[a + (1-a)\gamma^2] \qquad (5)$$

The interest rate's response towards a supply shock therefore depends on the slopes of the aggregate demand and aggregate supply curves as well as the size of the deviation from the desired levels of output and inflation. However, the aim of this exercise is to determine the effect of a policy response on the volatility of output and inflation. In order to derive these equations, one needs to substitute the values obtained for a and b from above into equation (4). Next, the new equation (4) has to be substituted for the values of r_t in equations (2) and (3). What remains is to calculate the variances of both output and inflation from equations (2) and (3). This results in the following:

$$\sigma_y^2 = (1 - \gamma b)^2 \sigma_s^2 \qquad (6)$$

$$\sigma_\pi^2 = (\omega + b)^2 \sigma_s^2 \qquad (7)$$

where σ_s^2 is the variance of the supply shock.

The above equations, subjected to certain manipulations, can be rewritten as follows:

$$\frac{\sigma_y^2}{\sigma_\pi^2} = \left[\frac{\alpha}{\gamma(1-\alpha)}\right]^2 \qquad (8)$$

This equation is insightful since it shows the trade-off between output and inflation variability. If $\alpha = 0$, the ratio above is equal to 0. As α approaches 1, the ratio above approaches ∞[37]. In other words, if the central bank is highly averse towards inflation volatility, output volatility will be higher in the face of supply shocks. This is because supply shocks demand a choice from the central bank regarding inflation and output. If the central bank cares more about the inflation target, output will be more volatile.

[37] Remember that α represents the central bank's aversion towards inflation variability.

Furthermore, the ratio from equation (8) only depends on the slope of the supply curve, not the demand curve[38]. This is because demand shocks are offset one by one by a change in the interest rate and this affects both output and inflation equally. Thus, if a certain country faces a relatively steep supply curve, the trade-off between inflation and output volatility will be smaller. If a country faces a flat supply curve, the trade-off between output and inflation volatility will be higher[39].

Hence the relationship between output volatility and inflation volatility is a complex situation depending on many variables. In many instances, it is impossible to infer the nature of this relationship by studying diagrams such as those mentioned above. The reason for this is that demand shocks and supply shocks have different effects on the relationship between output and inflation volatility. Demand shocks have no impact on this relationship, since it moves output and inflation in similar directions. However, supply shocks force one to choose between fighting inflation volatility or output volatility, and this creates a trade-off. The size of this trade-off depends on the aversion towards inflation variability and on the slope of the supply curve, as explained above.

4.3 Inflation and output volatility: empirical evidence from the literature

The empirical evidence on the relationship between growth volatility and inflation targeting is still rather slim compared with other economic factors. One of the reasons for this is that inflation targeting is still a relatively new monetary policy regime and the time frame for statistical analysis is still rather short.

Another difficulty involved in empirically establishing a relationship between output volatility and inflation targeting originates from the fact that this relationship depends on the environment to which an economy is exposed. Cecchetti and Ehrmann (2002) argue that an increased aversion towards inflation variability will lead to an increase in output volatility in the face of aggregate supply shocks. In investigating 23 countries, not all strictly inflation targeters,

[38] The slope of the aggregate supply curve is given by $1/\gamma$.

[39] See Cecchetti and Ehrmann (2002:225) for a diagram of the relationship between the slope of the supply curve and the trade-off between inflation and output volatility.

they found that the aversion towards inflation variability increased significantly throughout the sample. In other words, even countries that do not explicitly target inflation exhibited a higher aversion towards inflation volatility. This higher aversion towards inflation volatility was still lower than the corresponding measure for strict inflation-targeting countries, but only slightly lower. Furthermore, Cecchetti and Ehrmann (2002) mention that this might have contributed to increased output volatility.

Landerretche, Corbo and Schmidt-Hebbel's (2001) result was similar. They found that the aversion towards inflation variability was not that different between inflation-targeting and noninflation-targeting countries. They also showed that output volatility declined considerably for both sets of countries. However, these results are not encouraging in the sense of finding a connection between inflation targeting and output volatility.

Ball and Sheridan (2003), investigating a sample of 7 OECD countries, found no evidence that inflation targeting is a superior monetary policy regime and that declines in variables such as output volatility cannot be ascribed to inflation targeting. In comparing inflation targeting with other monetary policy regimes, they found little differences in the performances. A likely explanation cited by the authors was that noninflation-targeting countries exhibited the same characteristics as inflation-targeting countries. Thus, many countries also focus on the inflation rate as their main objective without stating it explicitly. A case in point is the USA, which many economists have labelled an undercover inflation-targeting country.

Leduc and Sill (2006) investigate the influence of monetary policy on output volatility in the USA for the period after 1984. The authors found that monetary policy only played a minor role in reducing output volatility, quantifying this effect to be 17%. According to Leduc and Sill, the major reason for the decline in both inflation and output volatility was that global shocks decreased significantly in size in the preceding few decades.

Studies that attribute the recent decline in output volatility to inflation targeting are scarce. In other words, there is little evidence that inflation targeting is solely responsible for a significant decline in output volatility. One such finding is that of Yu (2006), in which the focus is on Japan.

Yu found that, for the period 1975 to 1992, the low volatility experienced by Japan was the result of effective "undercover" inflation targeting. Even though Japan did not explicitly target inflation during that period, its monetary policy exhibited characteristics resembling inflation targeting.

However, as noted above, most empirical studies show that inflation targeting is not as effective as one would hope in lowering output volatility.

4.4 Concluding remarks

At first glance, it would seem that inflation targeting was extremely successful in decreasing both inflation and output variability. This would be the conclusion after examining the data as was done in section 4.1 above. However, the first clue that suggests otherwise is that noninflation-targeting countries experienced similar declines in both inflation and output variability. In other words, it was not only inflation targeting, but monetary policy as such that was successful in this regard. One might argue that most countries do indeed target inflation in some manner, even if not explicitly. This argument would be in favour of stating that inflation targeting is effective in reducing output volatility and inflation volatility.

However, certain economists believe that the recent decline in global output volatility cannot be attributed solely to inflation targeting. This is because the interest rate is only effective in lowering inflation and output volatility if shocks are predominantly from the demand side. Supply shocks force the monetary authorities to make a choice. Hence, if an economy is hit by a supply shock, its monetary authorities will have to choose between curbing inflation volatility or output volatility. Thus, a country that has a relatively high aversion towards inflation variability would suffer more in terms of output volatility.

It is for this reason that many economists do not believe that inflation targeting, or monetary policy in general, was significantly responsible for the downturn in output volatility, but instead that it was because of the absence of significant supply shocks. Furthermore, inflation targeting has only been around for a short time period and has yet to be severely tested. Only the future will tell whether this promising monetary policy regime will in fact hold up.

Chapter 5

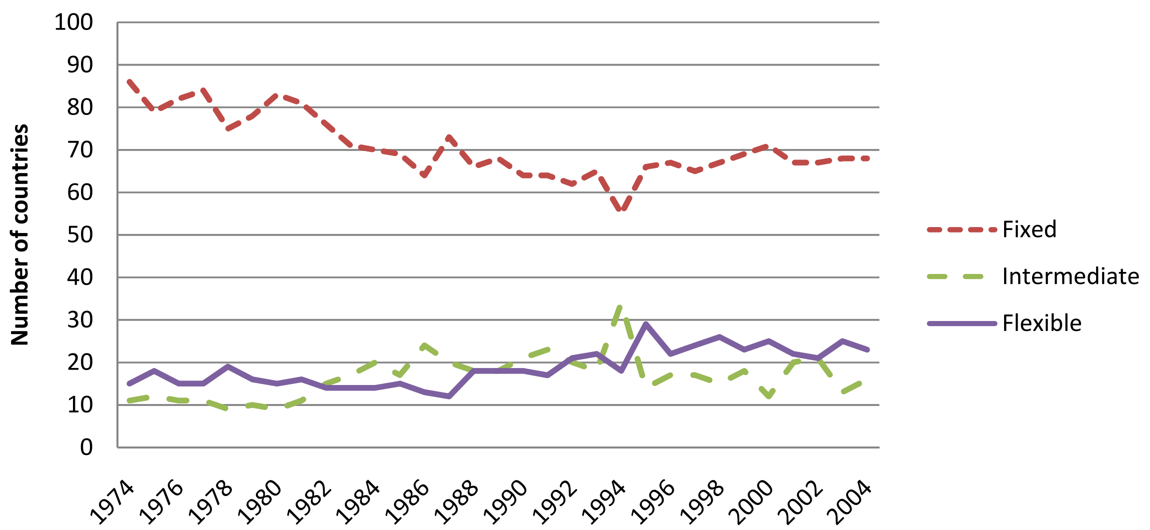
Exchange rates and growth volatility

The aim of this chapter is not to discuss which exchange rate regime would be most efficient in a particular country case, but to ascertain which exchange rate regime, flexible or fixed, contributes more to output volatility. The findings reported by Mussa (1986) gave rise to two fundamental features commonly accepted when investigating the exchange rate. Firstly, a fixed exchange rate regime exhibits a less volatile real exchange rate compared to a flexible regime. Secondly, real aggregates remain virtually unchanged no matter what exchange rate regime is used. In other words, the choice of either a flexible or fixed exchange rate regime will have no affect on the real economy. A number of studies have confirmed these results, despite the fact that such results were reported mainly for industrial countries. The question thus arises: What is the situation for developing countries?

The debate on the most efficient exchange rate regime has always been an integral part of economic literature. The choice between a flexible and a fixed exchange rate regime is not always that simple. This choice becomes even more complicated if one considers the wide variety of different exchange rate regimes that are possible, not to mention the difficulty involved in classifying these regimes in certain instances. However, the current consensus seems to lean towards a more flexible exchange rate above a fixed exchange rate regime, which is evident in the increase of the number of countries adopting the former. One reason for this is the recent financial crises experienced by countries such as Brazil, Argentina and certain Asian countries during 1997 and 1998. These countries all used some sort of fixed exchange rate. Furthermore, this consensus is strengthened by the fact that leading industrial countries are currently using floating exchange rates without any major problems being experienced. The case for developing countries is even more complex than the industrial country counterpart, and there is even less agreement on the subject matter.

The graph below shows the number of countries according to the exchange rate regime used at the time. The data are the updated set constructed by Levy-Yeyati and Sturzenegger (2001). This is a *de facto* set, which is different from the IMF *de jure* data set. The latter classification is based on the exchange rate regime which the countries state they are using. However, many countries act and intervene in such a way that it is sometimes unclear what regime they are using. Hence the *de facto* classification takes into account how countries intervene in the exchange rate. Exchange rate regimes are divided into three groups: fixed, intermediate and floating. What is more, certain countries were removed from the original data set owing to missing values or if the start and end entries did not correspond with the sample period. The graph shows that fixed exchange rate regimes have declined with a downward trend, while the number of countries with floating exchange rate regimes increased with an upward-sloping trend. What the graph does not show is the hollowing-out hypothesis that intermediate regimes are phasing out. However, when applying a *de jure* classification, this hypothesis becomes clearer.

Figure 5.1 Changes in *de facto* exchange rate regimes



Source: Levy-Yeyati and Sturzenegger (2001)

This chapter therefore endeavours to determine which exchange rate regime causes higher volatility in developing countries. The next section will address possible theories on the links between the exchange rate and output volatility in developing countries.

5.1 The link between output volatility and exchange rates

According to Yougbaré (2006), the exchange rate can influence output volatility in three ways. Firstly, there is the ability of the exchange rate to adjust in response to shocks. Secondly, the exchange rate could influence volatility through its impact on economic policy. Finally, the impact of exchange rates on the financial system influences output volatility. These three channels are briefly discussed below.

5.1.1 The efficiency of the different exchange rates in the face of shocks

Traditionally, the efficiency of different exchange rate regimes was determined by examining the performance of these different regimes in the face of economic shocks. Ever since the work of Poole (1970), there has been some consensus that different shocks are absorbed differently by flexible and fixed exchange rates. If domestic nominal shocks are prevalent, especially in relation to monetary shocks, the agreement between some economists is that a fixed exchange rate would lead to lower output volatility.

However, if one assumes a negative foreign real shock, it has been shown that a flexible exchange rate acts to absorb the shock. According to Hoffmann (2005:19):

"… floating exchange rate regimes are able to utilize the exchange rate as a ´shock absorber'…".

Hoffmann (2005) argues that flexible exchange rates are better than fixed exchange rates in absorbing foreign shocks. Assume a negative foreign shock which makes foreign goods relatively cheaper. This would lead to a decrease in exports for the domestic country and dampen economic activity. Under a flexible exchange rate regime, the decrease in exports would lead to a depreciation of the exchange rate. The depreciation would make domestic goods more attractive abroad and thus dampen the contractionary effects of the shock. Under a fixed exchange rate, this relative price imbalance between domestic and foreign goods has to be corrected entirely through changes in quantities. In other words, the demand for exports will fall to the level where the ratio between foreign and domestic prices returns to its original state. With the presence of nominal rigidities such as sticky prices, the process of returning to equilibrium would take longer under the fixed exchange rate regime and would have a greater effect on output volatility. The real exchange rate depreciates in both cases. However, under a flexible exchange rate regime the nominal exchange rate adjusts, which decreases the amount by which prices and quantities need to change. In fixed exchange rates, the nominal exchange rate is constant, which means that the real exchange rate can only adjust through changes in prices.

Flexible exchange rate regimes are therefore preferable in cases characterised by real shocks, while fixed exchange rate regimes are preferable in situations characterised by domestic monetary shocks.

5.1.2 The impact of the exchange rate on volatility through changes in economic policy

More recently, the debate has shifted towards the trade-off between credibility and flexibility. One of the advantages of having a flexible exchange rate is the autonomy of monetary policy. Under a fixed exchange rate regime, monetary policy is partially or entirely devoted to defending the fixed exchange rate. Assume, for example, a specific country with a fixed exchange rate. Assume further that the monetary authorities in this country increase the money supply by means of open-market operations. This increase in the money supply will cause domestic interest rates to decrease. The lower domestic interest rate compared with the foreign interest rate will force investors to demand more foreign currency in exchange for domestic currency to invest abroad. Under a flexible exchange rate, this would cause a depreciation of the domestic exchange rate. However, under a fixed exchange rate, this is not possible. The monetary authorities would have to intervene by selling foreign currency reserves in exchange for domestic currency. This reduces the supply of domestic currency, thus offsetting the original increase in the supply of money. This simple example shows how monetary policy could be ineffective in the case of a fixed exchange rate regime.

The above situation can be generalised by the idea of the impossible trinity stemming from the Mundell-Fleming exchange rate models. The theory states that it is impossible to simultaneously have a fixed exchange rate, high capital mobility and an independent monetary policy. If capital mobility is high, the monetary authorities must keep the domestic interest rate the same as the interest rate of the country to which the currency is pegged, otherwise the difference between the interest rates will cause large capital flows, which would make the fixed exchange rate unsustainable. In other words, monetary policy cannot operate independently if capital is highly mobile and if the exchange rate is fixed.

A different argument states that fixed exchange rates might lead to more stable growth. The rationale behind this is the increased credibility obtained through using a fixed exchange rate. As stated above, when a country has a fixed exchange rate, monetary policy is concerned with maintaining parity. Domestic monetary policy should mostly follow the monetary policy movements of the country to which the exchange rate is pegged. This creates a highly credible economic environment that encourages investment and stable growth, assuming the economic environment is stable in the foreign country to which the exchange rate is pegged. However, this also means that the domestic country should adhere to changes in foreign monetary policy even though it might not be in the best interest of the domestic country. If the foreign country adopts an aggressive monetary policy, the domestic currency might not be able to follow and, in most instances, this would lead to devaluation and a loss in credibility. This in turn would lead to higher volatility.

5.*1.3 The role of the financial environment*

This section deals with the manner in which the changing financial environment could influence the relationship between exchange rates and output volatility. It is a well-known fact that the financial integration between countries has accelerated in recent years. This has many benefits and creates many opportunities.

However, this increased financial integration could also have an impact on the relationship between growth volatility and exchange rates. Greater financial integration basically translates into higher volumes of capital flows, assuming of course a certain level of capital mobility. With higher volumes of capital flows, countries are more open to foreign risks.

One theory relating to these risks is called the “original sin”. This idea was first introduced by Eichengreen and Hausmann (1999). These authors define the original sin as a situation that arises when a country does not use domestic currency to borrow from abroad. In other words, the domestic country’s foreign debt is denominated in foreign currency. Eichengreen and Hausmann (1999) used Bank of International Settlement data to show that the majority of borrowing worldwide occurred in five major currencies, all of which were developed countries. If there were large fluctuations in the exchange rate, this might have affected the ability of the specific country to service its foreign debt, a situation that would have led to slower growth and higher volatility. Thus, in this situation, it would have been preferable to have a fixed exchange rate. There are ways in which a country can manage its external exposure in this regard, which is simply to efficiently diversify its foreign lending or persuade foreign lenders to use the domestic currency to denominate the debt. If this is the case, the effect of the original sin phenomenon might be negligible, which would not rule out flexible exchange rates for small countries with large amounts of foreign debt.

Another risk associated with greater financial integration and capital mobility is speculative currency attacks. Speculative currency attacks arise when foreign and domestic investors sell assets denominated in domestic currency in large amounts. Fixed exchange rates are more vulnerable to currency attacks owing to the larger amount of foreign reserves required to maintain the fixed rate. The recent financial crises experienced in Asia and certain other countries such as Argentina have reopened the debate on the effects of speculative attacks. Past models designed to explain the end of the Bretton Woods system showed that speculative attacks had no significant economic costs except when the authorities raised the interest rate to protect the fixed exchange rate. However, recent models concerned with the effects of speculative attacks argue that there are certain economic costs even if the authorities do not raise the interest rate. In other words, recent models predict that any speculative attack will have substantial economic costs, regardless of any actions from authorities. The recent Asian crisis is an apt example of the risks associated with speculative attacks.

During the early 1990s, certain Asian countries were praised for their remarkable economic performance. However, this would not last. The reason for this is that the remarkable growth experienced by these countries was not the result of technological progress. Even before the crises, Krugman (1994) reported that Asia's high growth rates were because of capital investment, which could not be sustained. During this period, these countries had relatively high interest rates. This, coupled with financial integration, made foreign investors favour these countries. Also, the USA had extremely low interest rates and investors were looking elsewhere for higher returns. As a result, the economy was fuelled by debt. Domestic credit was also more freely available. According to Yougbaré (2006:10):

"Indeed, financial intermediation contributes to leverage domestic credit feeding and amplifying economic distortions."

By the mid-1990s, these countries had large current account deficits and were forced to increase borrowing from other nations to maintain pegged exchange rates. When the USA raised interest rates, investors withdrew capital from these countries. This resulted in many firms becoming bankrupt. As the situation deteriorated, more investors sold their assets, resulting in large amounts of capital outflows. The governments raised interest rates to high levels in order to prevent the currencies from collapsing, but without success. In the end they were forced to switch to a floating exchange rate.

5.2 Empirical results from the literature

The theories discussed above are not conclusive. The reason for this is straightforward. Some of these theories favour a fixed exchange rate regime, while others prefer a flexible regime. It should be noted that these predictions are subject to certain assumptions about the economic environment in which a specific country operates – hence the need to turn to the empirical evidence.

Tamayo (2006) investigates the relationship between volatility and exchange rate regimes for the period 1978 to 2000. The data were obtained from 53 developing countries. The author uses the *de facto* classification of the exchange rate regimes as derived by Levy-Yeyati and Sturzenegger (2001). The exchange rate regime enters the regression equation as a dummy variable along with other control variables. Furthermore, Tamayo (2006) focuses on the effect of capital flows, and whether or not this effect differs according to the exchange rate regime[40]. The results point to a positive coefficient on the fixed exchange rate system. Thus having a fixed exchange rate leads to higher volatility in this study. Furthermore, the effect of capital outflows on growth depends on the exchange rate regime. In the case of a fixed regime, the negative effect of capital outflows on growth is delayed but leads to a greater loss in growth in the future. The effect of capital inflows on growth, by contrast, is not influenced by the choice of an exchange rate regime. Lastly, Tamayo (2006) suggests that further research on this topic should take into consideration that the exchange rate regime variable might be endogenous.

Yougbaré (2006) also studies the relationship between growth volatility and exchange rate regimes, for the period 1973 to 2000. The regression equation is given by

$$Growth\,Volatility = \beta_0 + \beta_1 ExReg + \beta_2 X + \varepsilon$$

This equation is straightforward. Growth volatility depends on the exchange rate regime and a set of control variables denoted as X[41]. However, the difficulty lies in the classification of the exchange rate regime variable. In this case it is a dummy variable with a value of 1 if the exchange rate is pegged, and 0 if it is not. Yougbaré (2006) classifies a country as having a pegged rate if this was the case for more than 50% of the sample period. In other words, if a country had a pegged exchange rate regime for more than 14 years, it was classified as having a pegged rate. The rest is classified as nonpegged. Intermediate regimes therefore fall into the latter category. Furthermore, Yougbaré (2006) suggests that the exchange rate regime variable might be endogenous. The reason for this is that output volatility might have an influence on the choice of an exchange rate regime. In other words, countries might opt for a certain

[40] For a detailed description of the techniques used to investigate the effect of capital flows, see Tamayo (2006).
[41] See Yougbaré (2006:15) for the calculation of the volatility variable.

exchange rate regime specifically in order to reduce volatility. To address this problem, Yougbaré (2006) uses the method of instrumental variable general method of moments (GMM). The results indicate that pegged exchange rates increases growth volatility. Also, the level of financial development has a significant influence on this relationship. Countries with fixed exchange rates and a low level of financial development will experience higher volatility.

Another study using the Instrumental variable GMM estimators to overcome the endogeneity problem is that of Bastourre and Carrera (2004). Furthermore, they investigate both the *de jure* and *de facto* classifications of the exchange rate regime. In other words, they investigate the exchange rate that countries claim to be using, as well as the exchange rate that results once the actions of the country in this regard are taken into account. The results of these two classifications are similar in the sign of the coefficients, but differ in size. For fixed exchange rates, the effect on output volatility was larger for the *de jure* classification. For intermediate regimes, the effect was larger for the *de facto* classification. There was no significant difference with regard to the effect of flexible regimes.

Bleany and Fielding (1999) studied the trade-off between inflation and output volatility. The study involves a sample of 80 developing countries over the period 1965 to 1989. The authors studied the effect of the high levels of inflation experienced by these countries on output volatility. The theoretical argument states that there is a trade-off between inflation and output volatility in the choice of an exchange rate regime. Having a fixed exchange rate leads to lower inflation in developing countries, while simultaneously increasing output volatility. The reason for this is that a fixed exchange rate allows the country to import the anti-inflation credibility from the country to which the currency is pegged. However, a country with a fixed exchange rate is more vulnerable to external shocks. The results of the empirical exercise support the theory. Developing countries with a flexible exchange rate regime experienced higher inflation together with lower output volatility. Developing countries with a fixed exchange rate experienced lower inflation together with higher output volatility. Hence Bleany and Fielding (1999) suggest that developing countries face a choice between price stability and output stability.

Hoffmann (2005) tries to establish whether the effect of changes in the global real interest rate and global output on domestic output differs in respect of the choice of exchange rate regime. In other words, the study aims to establish which exchange rate regime fares comparatively better in the face of global shocks. The theory of this has been set out above. It predicts that flexible exchange rates are better able to reduce volatility if the source of the shock is external. The empirical results suggest that flexible exchange rate regimes are more effective in absorbing external shocks[42]. This is because, in the case of a negative shock, the real exchange rate depreciates and this smooths the adjustment to the new equilibrium. For fixed exchange rates, this adjustment takes place through the trade balance. Thus under a fixed exchange rate regime, the adjustment to the new equilibrium would be more volatile.

From the above, it would therefore seem that a flexible exchange rate regime is better able to reduce output volatility in developing countries. However, this does not necessarily mean that all developing countries should adopt a freely floating exchange rate regime to achieve a more stable economic environment. Every country has a different economic situation regarding its financial development, trade volumes and openness, and so on. This in turn influences the effectiveness of a specific exchange rate regime in attaining its primary goal. Also, the choice of exchange rate regime should not be the top priority. Calvo and Mishkin (2003:28) emphasise this in the following statement:

"Indeed, we believe that the choice of exchange rate regime is likely to be of second order importance to the development of good fiscal, financial, and monetary institutions in producing macroeconomic success in emerging market countries."

Hence the choice of a specific exchange rate regime should be carefully considered by each country, taking into account its own macroeconomic characteristics. However, the evidence shows that for countries wishing to reduce output volatility, a flexible exchange rate would be more suitable.

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[42] Hoffmann (2005) uses a panel VAR approach in modelling this relationship. See Hoffmann (2005:12–13) for an explanation of methodology.

5.3 Concluding remarks

Ever since the collapse of the Bretton Woods system, the number of countries opting for a flexible exchange rate has increased. However, the choice of the best exchange rate regime is still unclear. Regarding the ability to reduce output volatility, the theory seems to be inconclusive. If the main source of shocks is external real shocks, the theory predicts that a flexible exchange rate is more effective in reducing volatility. However, a fixed exchange rate is preferable if domestic nominal monetary shocks prevail. Other theories focus on phenomena such as speculative currency attacks, which are more likely under a fixed exchange rate. Moreover, a fixed exchange rate constrains monetary policy in the face of shocks. Most empirical studies suggest that a flexible exchange rate lowers volatility in developing countries. However, this might come at the cost of higher inflation.

Since all the major determinants of output volatility have now been discussed, the next chapter will focus on the empirical relationship between these variables and output volatility.

Chapter 6

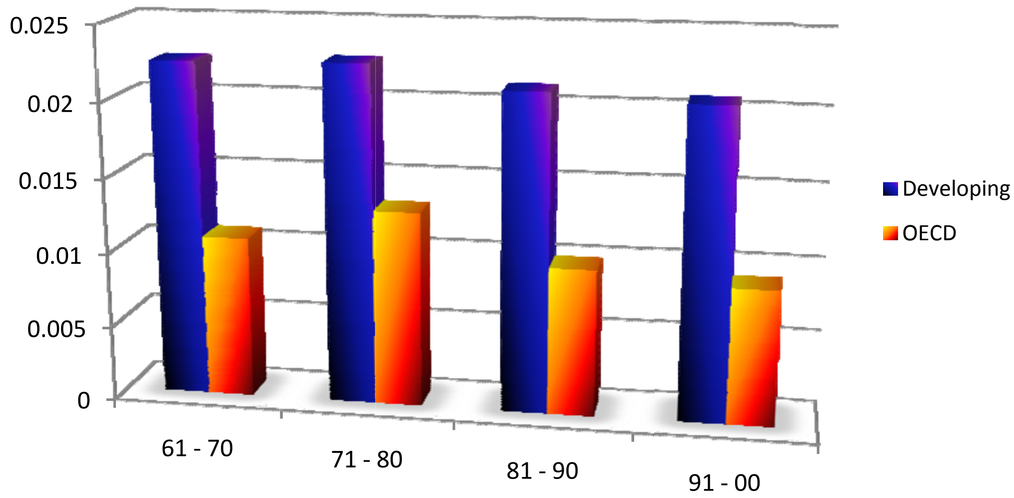
Determinants of output volatility: empirical analysis

The empirical evidence on the determinants of output volatility is diverse in the sense that a large number of possible determinants have been proposed and investigated. Most of these investigations focus mainly on one specific determinant of output volatility. In other words, there are few investigations that simultaneously address a set of possible determinants of output volatility. The aim of this chapter is to see whether the determinants examined in the previous chapters have a significant empirical relationship with output volatility.

It was noted in chapter 1 that there is a divergence in the volatility of output in developed and developing countries. Figure 6.1 below compares the level of volatility experienced by developed and developing countries from a historical perspective. Output volatility is measured as the standard deviation of GDP growth rates. The sample is divided into four subsets, each spanning one decade. Furthermore, the sample comprises 71 developing countries and 22 OECD countries. The average output volatility is then calculated for all the countries in each specific decade. Hence there are four data entries for both the developing and OECD set.

Figure 6.1 shows that output volatility is much lower in the OECD countries. However, during the decade 1971 to 1980, output volatility increased most in the OECD country sample. Thereafter it decreased for both sets of countries. Figure 6.1 does not show the rate of the decrease in output volatility experienced by the two sets of countries. To this end, one needs to study figure 6.2, which shows the same data but in the form of a line graph.

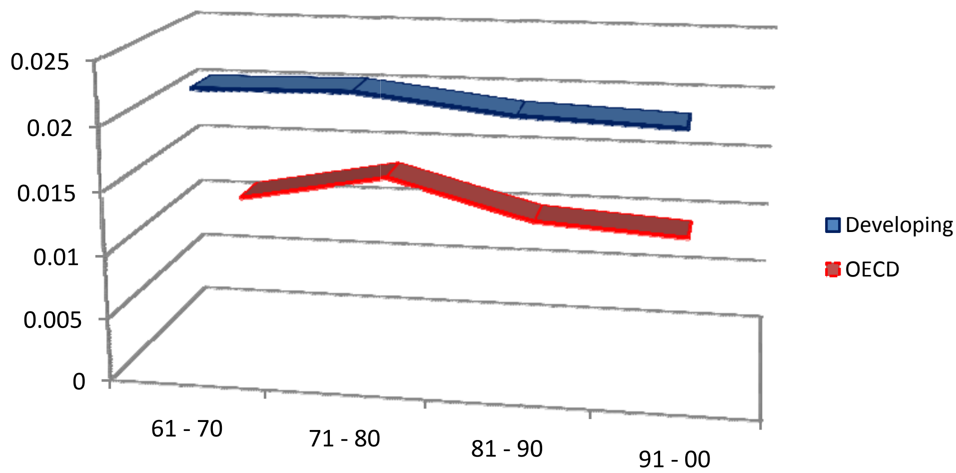
Figure 6.1 Output volatility from 1960 to 2000: levels



Source: Heston et al. (2002)

Figure 6.2 below shows that the rate of the decrease in output volatility from the 1970s was significantly greater for the OECD country set. In other words, output volatility decreased faster in OECD countries. The corresponding trend for developing countries is much flatter.

Figure 6.2 Output volatility from 1960 to 2000: trend



Source: Heston et al. (2002)

Thus, owing to the fact that developing countries have significantly higher levels of growth volatility, the empirical exercise in this chapter will be concerned with developing countries only. Section 6.1 will briefly review the findings from the previous chapters in order to compare the results from the empirical investigation with the results found in the literature. Section 6.2 will focus on the empirical investigation and covers the data issues, methodology and results.

6.1 A brief review of the findings in previous chapters

Chapter 1 argues that the volatility of output has a significant impact on the trend growth rate of the economy. The results of the empirical investigation in chapter 1 showed that this relationship is negative. In other words, higher output volatility leads to slower trend growth. The ideal would therefore be to minimise output volatility in order to decrease the negative effect on growth. From the graphs above it is clear that this area requires attention in developing countries. To minimise output volatility, the factors contributing to higher output volatility must be determined.

This was the aim of the subsequent chapters. These chapters outlined the theories and previous findings in the literature regarding the main determinants of output volatility. Each chapter attempted to find an answer regarding the relationship between the specific determinant and output volatility on the basis of the findings reported in the literature. Below is a brief review of these findings.

6.1.1 Trade openness and output volatility

The literature dealing with the relationship between output volatility and trade openness is inconclusive. Easterly *et al.* (2002) found that greater trade openness leads to higher volatility. The authors argue that the reason for this result is the fact that more open countries are more susceptible to foreign shocks. However, Cavallo (2007) found that greater trade openness leads to more stability, and acknowledges the negative impact of foreign shocks, but asserts that greater trade reduces financially related volatility. Furthermore, Young Kim (2007) finds no significant relationship between output volatility and trade openness. Hence the relationship between these two variables could be positive or negative. The direction of this relationship depends on specific factors. Openness has a negative effect on volatility through the terms-of-trade channel. Also, highly specialised trade might lead to increased volatility. However, larger trade sectors might be uncorrelated with the main growth path of the economy, thus dampening the effects of shocks. Finally, financial channels could act to stabilise growth, but to effectively stabilise the economy, the financial sector has to be highly developed. In developing countries, this is often not the case. There is thus no conclusive answer.

The empirical results rely heavily on the choice of countries included in the sample. In other words, one would not be surprised to find a positive relationship between growth and output volatility if only middle-income developing countries were to be included in the sample, because these countries should have relatively advanced financial markets.

6.1.2 Fiscal policy and output volatility

The role of fiscal policy in output volatility is twofold. By definition, automatic stabilisers act to reduce volatility. Scharnagl and Tödter (2004) estimate that automatic stabilisers absorb around 15% of a negative shock. Further evidence in this regard suggests that automatic stabilisers reduce volatility in developed countries, while the results for developing countries yield insignificant or slightly destabilising effects.

The effect of discretionary fiscal policy on output volatility differs between developed and developing countries. Hakura (2007) found that discretionary fiscal policy increased volatility in developing countries. She argues that this is because of a high level of government spending volatility. This is especially true for extremely poor countries such as those in sub-Saharan Africa.

6.1.3 Monetary policy and output volatility

Has monetary policy contributed to the decline in output volatility in developed countries? The literature on this topic suggests that monetary policy is mainly effective in respect of demand shocks. By contrast, supply shocks force monetary authorities to choose between inflation and output volatility. Leduc and Sill (2006) investigated the situation in the USA and found that monetary policy contributed to around 17% of the decline in output volatility in the years after

1984. Furthermore, inflation targeting does not seem to be any better than other monetary policy regimes in reducing volatility.

In general, because of the reliance of monetary policy on the economic environment, it is extremely difficult to judge the efficacy of such policy. Some economists believe that monetary policy has helped to lower both inflation and output volatility, but this may only be because of the absence of large shocks in recent years. Regarding developing countries, sufficient evidence on this topic has yet to come to light.

6.1.4 Exchange rates and output volatility

Chapter 5 pointed out that flexible exchange rate regimes have become more popular in recent years. Theory suggests that a fixed exchange rate regime helps to lower output volatility when domestic monetary shocks prevail. However, flexible exchange rate regimes work better in this respect when foreign real shocks prevail. Most of the empirical evidence suggests that flexible exchange rates are associated with lower output volatility, although some studies find no difference between fixed and flexible rates.

6.2 Empirical investigation

This section deals with the empirical analysis of the determinants of output volatility. Section 6.2.1 describes the data and construction of various variables, while section 6.2.2 focuses on the results.

6.2.1 Data and methodology

The empirical investigation below combines data from different sources because no single data set contains all the relevant data. Most of the data were obtained from the Penn World tables mark 6.1. The data on human capital were obtained from the Barro-Lee (2000) data set. Furthermore, the Levy-Yeyati and Sturzenegger (2001) *de facto* exchange rate classification was used to construct the exchange rate variable. Finally, discount rates were obtained from the IMF's IFS data set.

Combining all these data sets reduced the number of countries to a sample that would have been too small to draw any conclusions. This was especially true when trying to combine the IMF data set on discount rates with the Levy-Yeyati and Sturzenegger data set on exchange rates. This is because the countries included in the former did not match those from the other data sets or they had insufficient data entries. Two samples were therefore used. The first sample consists of 38 developing countries[43]. This sample is used when investigating the effect of openness, fiscal policy and exchange rates on output volatility. The second sample consists of 27 developing countries and is mainly concerned with investigating the effect of monetary policy on growth volatility[44].

Both samples contain data from 1975 to 2000. Investigating the effect of exchange rates on growth volatility prevents the time period from going further back than 1975. The time periods are divided into five periods spanning five years each. Hence for a particular country there were data for 1976 to 1980, 1981 to 1985, 1986 to 1990, 1991 to 1995 and 1996 to 2000. This was necessary for computing the volatility variables. For each country there are thus five entries. For the larger sample this generates 190 entries per variable and 135 entries for the smaller sample.

Finally, there is no reason to suspect that the data sets used are unreliable because they are well known and have been widely used. All the variables were tested and found to be stationary[45]. Stationarity implies that the mean and variance of a specific variable are constant over time and that the covariance depends only on the lag between the two time periods and not on the actual time periods at which it is measured. Stationarity is important because using nonstationary variables makes standard hypotheses testing invalid and could lead to spurious regression results. A discussion of the variables used in the empirical investigation follows.

[43] A list of these countries is included in the appendix under table A6.
[44] A list of these countries is included in the appendix under table A7.
[45] All variables were tested for stationarity using the Augmented Dickey-Fuller test. These test outputs are provided in the appendix under table A8.

GrowthVol – growth volatility

Growth volatility is the dependent variable in all regressions. It was calculated as the standard deviation of the annual growth rates over the five-year periods. The annual growth rates were calculated as the log differences of per capita GDP. The variable used was real GDP per capita (Laspeyres). This method of approximating growth volatility has been used in a number of studies such as that of Ramey and Ramey (1995).

Open – trade openness

This variable was constructed to investigate the effect of trade openness on growth volatility. It was calculated as the average openness over each five-year period. The openness variable was obtained from the Penn World tables, defined as exports plus imports as a share of GDP. This is a popular approximation of the trade openness of a particular country. It has been used in a number of empirical studies such as those of Cavallo (2007) and Frankel and Romer (1999).

The rationale for using the above as an approximation for trade openness is simple. Countries with larger shares of imports plus exports to GDP will, on average, have less trade restrictions and will therefore be more open to trade. Furthermore, the expectation is that this variable will have a positive sign. In other words, greater trade openness should lead to higher output volatility. This is because greater trade openness makes developing countries more susceptible to foreign shocks. Also, in many instances, these countries have poorly developed financial systems and other economic characteristics, which would only intensify the effects of the shock.

AutoGov – automatic stabilisers

The aim of this variable is to investigate the role of automatic stabilisers in respect of output volatility. To this end, most researchers use the “size of government” as an approximation of the combined effect of automatic stabilisers. The reason for this approximation is that empirical studies, such as that of Van Den Noord (2000), show that government size is highly correlated to conventional measures of automatic stabilisers like marginal tax rates and the progressivity of taxes. The variable used is the government share of GDP from the Penn World tables. The average is then calculated over each five-year period.

The expected sign of this variable is positive. Throughout the literature, this variable was found to be insignificant or slightly positive for developing countries. Automatic stabilisers can be destabilising if they are built into a distortionary tax system. According to Andres and Domenech (2003:7):

"Textbook macroeconomics tells us that, under a continuous balanced budget, automatic stabilizers built in distortionary taxes fail to operate since the public sector surplus becomes procyclical, thus aggravating economic fluctuations."

DisGov – discretionary fiscal policy

The aim of this variable was to investigate whether discretionary fiscal policy played a role in increasing volatility in developing countries. The variable was constructed as the standard deviation, over a period of five years, of the government share of GDP from the Penn World tables. This variable serves as an approximation for the activeness of discretionary fiscal policy.

The expected sign of this variable is positive. The rationale for this is that developing countries experience more government spending volatility which would lead to higher output volatility. This is because of developing countries face more stringent budget restrictions. These restrictions may lead to unforeseen changes in taxes and government spending. Furthermore, developing countries are more susceptible to the negative effects of global shocks, which could induce governments to intervene.

Exreg – exchange rate regimes

A dummy variable was included to see whether a fixed or a flexible exchange rate regime contributes more towards output volatility. The data used for the construction of this variable were obtained from the Levy-Yeyati and Sturzenegger (2001) *de facto* exchange rate regime data set. This data set contains a three-way classification of exchange rate regimes for each country. All purely fixed regimes were assigned a value of 1 and all the remaining regimes were assigned the value 0. The regime that a particular country had for most of each five-year period was then used as the final entry. In other words, if a country had a fixed regime for three years, followed by two years of a relatively flexible regime, the final entry would indicate a fixed regime. Yougbaré (2006) used this method.

The expectation is that this variable will have a positive coefficient. The literature on this topic suggests that a flexible exchange rate is better suited to lower output volatility. The rationale behind this is that flexible exchange rates are better at absorbing foreign shocks. Also, when using a fixed exchange rate, monetary policy has to defend the exchange rate parity. Under flexible exchange rate regimes, monetary policy could focus more on other economic factors such as price stability.

Monact – monetary activeness

This variable was used to capture the effect of monetary policy on output volatility. However, defining a variable for this purpose is troublesome. There has yet to emerge a clearly superior classification of the above for use in cross-country investigations. Some researchers use the interest rate, but this is mainly the case in vector auto regression (VAR) analysis (e.g. Cecchetti & Ehrmann 2002). The variable used in this empirical exercise is the volatility of the discount rate[46] as measured by the standard deviation of the discount rates over each five-year period.

The rationale behind this choice is that the discount rate is one of the main tools that monetary authorities use when intervening in the economy. Furthermore, the volatility of the discount rates is an approximation of how actively the monetary authorities changed the discount rates. It also indicates how aggressive monetary authorities were at the time in addressing the problem at hand. It is also necessary to be aware that there is a difference between the *volatility* of variables such as growth and the *volatility* of discount rates. Growth volatility is the outcome of a system of economic processes, while the discount rate is set by monetary authorities. A high volatility therefore shows that a country changed its discount rate

[46] The discount rate is similar to the repo rate in South Africa.

substantially and was extremely aggressive in achieving its goal. The data on discount rates were obtained from the International Monetary Fund's IFS data set.

As noted above, the empirical evidence from the literature is inconclusive about the effect of monetary policy on output volatility. However, the expectation is that the effect of monetary policy should be stabilising. In other words, the coefficient will have a negative sign. The reason for this is that significant supply shocks were absent during the sample period. Furthermore, monetary policy is effective in relation to demand-side shocks. It was shown in chapter 4 that, in the face of demand shocks, monetary policy could simultaneously achieve price and output stability. Hence even if output stability was not the main goal of the monetary authorities, it might have been an added benefit in fighting inflation.

The following four variables were included as control variables:

PCGDP – per capita GDP

The variable was simply calculated as the logarithm of the initial level of per capita GDP for each five-year period. The variable was included to control for country size and development. As noted above, developed countries exhibit much lower levels of output volatility. This would suggest that, in some instances, volatility could fall as a country develops towards the industrial country level.

Even though the sample only includes developing countries, certain countries are much larger and more developed than others – hence the need to control for this effect. The data were obtained from the Penn World tables.

Inv – investment

Ramey and Ramey (1995) have shown that higher levels of investment are associated with lower output volatility. For this reason investment was included as another control variable. The data were obtained from the Penn World tables. The variable was constructed as the average of the logarithm of the investment share of GDP over each five-year period.

Infvol – inflation volatility

Higher inflation volatility may lead to higher output volatility. The volatility of inflation affects consumption and thus the volatility of output. This variable was used in a number of studies (e.g. see Easterly *et al.* 2000 and Bejan 2006). The data on the price level of consumption were obtained from the Penn World tables. Inflation was calculated as the log differences of the consumer price index. Inflation volatility is thus the standard deviation of inflation over each five-year period.

HumanC – human capital

Human capital is often included as a variable in growth regressions. However, the level of human capital may also influence growth volatility. In a country with high levels of human capital, workers may adapt better to changing situations brought about by shocks. Hence countries with higher levels of human capital may experience lower output volatility. The total years of schooling attained by the population of age 25 or older were used to approximate human capital. These data were obtained from the Barro-Lee (2000) data set.

The effects of each determinant of growth volatility discussed in the previous chapters are first tested individually. This is done to capture the effect of each determinant alone and observe how much of the variation in the dependent variable is explained by the variation in each determinant individually. Determinants found to be insignificant during this first phase of the investigation will be dropped when all the variables are included simultaneously, otherwise the inclusion of these variables might lead to autocorrelation. The basic equation used is as follows:

$$Y_t = \beta_0 + \beta_1 InDep + \theta X_t + \mu_t$$

where Y_t is the dependent variable or output volatility
$InDep$ is the independent variable
X_t is a set of control variables

Next, all independent variables are tested simultaneously to see whether they remain significant determinants of growth volatility and to observe how much of the variation in growth volatility is described by the variation in all the determinants together.

6.2.2 Results

The table below shows the results relating to the effect of trade openness on output volatility.

Table 6.1 Trade openness and output volatility: regression results

Dependent variable: GrowthVol
Method: least squares

	1	2	3	4	5
Constant	0.011011 (6.238)***	0.008987 (4.844)***	0.00342 (0.796)	0.010857 (1.155)	0.010987 (1.167)
Open	0.0001 (3.427)***	0.000105 (3.665)***	0.0000984 (3.400)***	0.0000863 (2.697)***	0.0000845 (2.623)*
Infvol		0.029938 (3.003)***	0.03211 (3.194)***	0.032166 (3.197)***	0.031768 (3.145)***
Inv			0.005328 (1.435)	0.00719 (1.687)*	0.007079 (1.656)*
PCGDP				-0.002512 (-0.890)	-0.002194 (-0.763)
HumanC					-0.000249 (-0.597)
R^2	0.058801	0.102114	0.111951	0.115738	0.117448
N	190	190	190	190	190
Aikake info	-6.145859	-6.182444	-6.182934	-6.176681	-6.16809
Durbin-Watson stat	1.448493	1.526757	1.565093	1.564619	1.555167
P(F-stat)	0.000749	0.000042	0.000061	0.000134	0.000313

The numbers in brackets represent the t-statistics of each coefficient.
Significance at 1%, 5% and 10% is shown by ***, ** and * respectively

Source: Author's calculations

When only trade openness is included in the regression, it yields a positive and statistical significant coefficient. However, the effect is small. A one percentage point increase in the five-year average of the level of trade openness would lead to an increase in the standard deviation of growth over five years of 0.0001. Furthermore, trade openness explains about 6% of the variation in growth volatility. When all the control variables are included, the openness variable remains significantly positive, but the level of significance diminishes. Also, the coefficient of openness decreased to 0.0000845. Trade openness together with the control variables explains about 12% of the variation in growth volatility. Thus, although the evidence above shows that greater trade openness increases growth volatility, the effect is small. Policy makers might be willing to sacrifice this small increase in volatility for the larger gains in growth effected by greater trade openness.

Table 6.2 represents the results for fiscal policy:

Table 6.2 Fiscal policy and output volatility: regression results

Dependent variable: GrowthVol
Method: least squares

	1	2	3	4	5	6
Constant	0.011907 (10.776)***	0.009871 (5.140)***	0.009229 (4.735)***	0.000367 (0.087)	0.00864 (0.990)	0.008431 (0.959)
DisGov	0.003181 (5.656)***	0.002822 (4.506)***	0.002619 (4.125)***	0.002837 (4.474)***	0.002778 (4.368)***	0.002795 (4.358)***
AutoGov		0.000117 (1.294)	0.000115 (1.278)	0.00008 (0.886)	0.00005 (0.608)	0.00006 (0.643)
Infvol			0.016551 (1.679)*	0.019811 (2.014)**	0.020583 (2.088)**	0.020607 (2.085)**
Inv				0.008391 (2.350)**	0.010266 (2.588)**	0.010295 (2.587)**
PCGDP					-0.00278 (-1.083)	-0.00289 (-1.106)
HumanC						0.000103 (0.249)
R^2	0.145435	0.153024	0.165672	0.189846	0.194982	0.195253
N	190	190	190	190	190	190
Aikake info	-6.242421	-6.24081	-6.24533	-6.26421	-6.26004	-6.24985
Durbin-Watson stat	1.402226	1.42414	1.441732	1.492707	1.492872	1.496915
P(F-stat)	0	0	0	0	0	0

The numbers in brackets represent the t-statistics of each coefficient.
Significance at 1%, 5% and 10% is shown by ***, ** and * respectively

Source: Author's calculations

The DisGov variable from the above is significantly positive. A one-unit increase in the standard deviation of the government share of GDP over five years increases the standard deviation over five years of growth by 0.003181. This variable alone explains about 15% of the variation of growth volatility. The DisGov variable remains significant even after all the control variables have been included, while the effect of this on growth volatility diminishes only slightly. All the variables together explain about 20% of the variation in growth volatility. Hence increases in the volatility of discretionary fiscal policy lead to increases in the volatility of growth. Furthermore, the AutoGov variable enters the regression insignificantly positively in all cases. It would therefore seem as if automatic stabilisers did not play an active role in reducing growth volatility in the sample period.

Table 6.3 depicts the results for the effect of exchange rate regimes.

Table 6.3 Exchange rate regime and output volatility: regression results

Dependent variable: GrowthVol
Method: least squares

	1	2	3	4	5
Constant	0.012913 (11.287)***	0.011805 (9.596)***	0.00127 (0.295)	0.008865 (0.990)	0.008776 (0.974)
Exreg	0.006738 (4.230)***	0.006278 (3.954)***	0.006775 (4.295)***	0.006259 (3.759)***	0.006310 (3.650)***
Infvol		0.022881 (2.293)**	0.026489 (2.665)***	0.027028 (2.716)***	0.027065 (2.710)***
Inv			0.009258 (2.550)**	0.010759 (2.725)***	0.010793 (2.718)***
PCGDP				-0.002564 (-0.968)	-0.002612 (-0.971)
HumanC					0.00004 (0.112)
R^2	0.086887	0.111866	0.141869	0.14619	0.146249
N	190	190	190	190	190
Aikake info	-6.176154	-6.193364	-6.217204	-6.211726	-6.201268
Durbin-Watson stat	1.536589	1.563494	1.665079	1.654787	1.656825
P(F-stat)	0.000037	0.000015	0.000003	0.000007	0.00002

The numbers in brackets represent the t-statistics of each coefficient.

Significance at 1%, 5% and 10% is shown by ***, ** and * respectively

Source: Author's calculations

The exchange rate variable from the table above is a dummy variable. It takes the value of 1 if the exchange rate regime is fixed. The positive coefficient therefore suggests that a fixed exchange rate regime is associated with higher growth volatility. The results show that having a fixed exchange rate increases the standard deviation of growth over five years by 0.006738. This effect remains relatively stable even after the control variables have been included. The exchange rate variable alone explains about 9% of the variation in growth volatility. This is somewhat low. Countries with fixed exchange rate regimes might feel reluctant to switch to a flexible exchange rate regime solely on the basis of the small percentage of volatility, which is explained by the exchange rate.

Table 6.4 below shows the results of the investigation of the effect of monetary policy on growth volatility. The data used to obtain the regression output below are from the smaller sample of countries. As stated above, the two samples of countries could not be combined because the data for the data sets did not correspond. Combining the data sets would have resulted in a sample that would have been too small to draw any inferences and would have run the risk of a degrees of freedom problem.

Table 6.4 Monetary policy and output volatility: regression results

Dependent variable: GrowthVol
Method: least squares

	1	2	3
Constant	0.024594 (9.664)***	0.042463 (6.181)***	0.039661 (2.615)***
Monact	-0.002202 (-1.934)*	-0.002291 (-2.061)**	-0.002339 (-2.053)**
Inv		-0.018062 (-2.790)**	-0.018616 (-2.650)***
PCGDP			0.001019 (0.207)
R^2	0.027343	0.081496	0.081798
N	135	135	135
Aikake info	-4.96162	-5.004091	-4.989605
Durbin-Watson stat	1.554159	1.679401	1.679903
P(F-stat)	0.055285	0.003659	0.010587

The numbers in brackets represent the t-statistics of each coefficient.
Significance at 1%, 5% and 10% is shown by ***, ** and * respectively

Source: Author's calculations

The results indicate that the periods during which monetary policy was more active and aggressive are associated with lower output volatility. In other words, countries that used monetary policy more often and more aggressively experienced a decline in growth volatility. A one percentage point increase in the five-year volatility of the discount rate would lead to a decrease in growth volatility over five years of 0.002202. This effect remains relatively stable after the control variables were included.

However, monetary policy alone only explains about 3% of the variation in growth volatility. Furthermore, whether the decline in output volatility was the main objective of the monetary authorities is not known. However, as stated in chapter 4, inflation and output volatility can simultaneously be addressed by monetary policy if significant supply shocks are absent. Supply shocks, contrary to demand shocks, force a decision by the monetary authorities to address either output volatility or inflation volatility. Hence the above results could also be explained by an increased aversion towards inflation. Also, the sample used above may not be large enough to be representative of all developing countries.

Finally, all the regressions above were tested for heteroscedasticity and autocorrelation. The Newey-West standard errors approximation method was used in all cases to assess whether the presence of heteroscedasticity or autocorrelation, if present, altered the results significantly. The results show that heteroscedasticity or autocorrelation did not change the results significantly and the subsequent conclusions remain the same. These tests are shown in the appendix under table A9.

The next step in this investigation is to simultaneously include all the independent variables in the regression. The AutoGov variable relating to the effect of automatic stabilisers was not included in the investigation below because it was insignificant throughout the exercise in table 6.2. The next table (6.5) also excludes the effect of monetary policy because combining the other independent variables with the variable relating to monetary policy would lead to a tiny sample. This minute sample would make any inferences invalid. The aim of including the rest of the independent variables is to observe whether these variables remain robust with regard to the size and sign of the coefficients.

Table 6.5 Determinants of output volatility

Dependent variable: GrowthVol
Method: least squares

	1	2	3	4	5
Constant	0.007729 (4.483)***	0.006853 (3.833)***	-0.002867 (-0.692)	-0.00447 (-0.486)	-0.005535 (-0.597)
Open	0.00005 (1.792)*	0.00006 (2.014)**	0.00004 (1.407)	0.00004 (1.388)	0.00004 (1.396)
DisGov	0.002650 (4.705)***	0.002440 (4.257)***	0.002577 (4.545)***	0.002589 (4.528)***	0.002683 (4.623)***
Exreg	0.004184 (2.605)***	0.003856 (2.397)**	0.004591 (2.853)***	0.004649 (2.833)***	0.00502 (2.976)***
Infvol		0.0168 (1.735)*	0.019309 (2.014)**	0.019211 (1.996)**	0.019208 (1.995)**
Inv			0.009121 (2.592)**	0.008765 (2.207)**	0.009031 (2.268)**
PCGDP				0.000524 (0.195)	0.000206 (0.076)
HumanC					0.000387 (0.955)
R^2	0.20538	0.218104	0.245645	0.245802	0.249563
N	190	190	190	190	190
Aikake info	-6.294096	-6.299712	-6.325045	-6.314727	-6.309199
Durbin-Watson stat	1.469962	1.481829	1.564761	1.565941	1.587598
P(F-stat)	0	0	0	0	0

The numbers in brackets represent the t-statistics of each coefficient.

Significance at 1%, 5% and 10% is shown by ***, ** and * respectively

Source: Author's calculations

The results above show that all three independent variables retain their signs. The DisGov variable is significant in all cases and the size of the coefficient remained relatively stable compared to the results in table 6.2. The ExReg variable is also significant throughout, while the size of the coefficient diminished slightly from the results reported in table 6.3. The openness variable is significant until the inclusion of the variable relating to investment. This could be because of an underlying relationship between the two variables. Some developing countries run large trade deficits to attract capital investment from abroad. When the investment variable was removed from the table above, the openness variable remained significant throughout. However, the size of the coefficient of the openness variable diminished even further from the level reported in table 6.1. It is interesting to note that the variable measuring inflation volatility is significant in most cases and has a much larger coefficient than the other independent variables. This suggests that higher inflation volatility causes higher output volatility. The larger coefficient shows that an increase in inflation volatility would have a greater impact on output volatility than any of the other independent variables. This finding supports the use of inflation targeting as a monetary policy regime. This might also explain why the results from table 6.4 show that active monetary policy reduced output volatility. If more active monetary policy was successful in keeping inflation relatively stable, this would have decreased output volatility.

Furthermore, all the variables together explain about 25% of the variation in growth volatility. This number seems low but might have been underestimated. All the above independent variables are in some way averaged over five years. This is necessary because of the way in which the dependent variable was calculated. In some instances, this averaging discards some of the variation in the independent variables. In other words, the averaging removes some of the explanatory power of the independent variables.

What remains is to ensure the validity of the findings by testing for statistical properties such as autocorrelation, heteroscedasticity and multicollinearity. Autocorrelation refers to the situation in which the error terms are correlated. With regard to autocorrelation, the use of the Durbin-Watson test will suffice. From the Durbin-Watson statistical tables, for 190 observations and seven independent variables, d_L = 1.697 and d_U = 1.841, at the 5% significance level. The Durbin-Watson test-statistic from the table above is 1.587, which is less than the lower limit of 1.697. It would therefore seem as if positive autocorrelation is present. Heteroscedasticity refers to the situation in which the error variances are nonconstant. The test used to examine this phenomenon is White's general heteroscedasticity test. The results from the test are included in the appendix under table A10. From this table, the White test-statistic is 26.844. White's test statistic is asymptotically distributed as a chi-square distribution with degrees of freedom equal to the number of independent variables, excluding the constant, in the test regression. Here the degrees of freedom are equal to 13. From the chi-square tables, the 5% chi-square critical value is equal to 22.362. Thus, since the test statistic of 26.844 is larger than the critical value of 22.362, the null hypotheses of no heteroscedasticity can be rejected. In other words, heteroscedasticity is present. The remedial measure used for the presence of both autocorrelation and heteroscedasticity is the Newey-West standard errors or heteroscedasticity and autocorrelation standard errors, which correct the table above for the effects of autocorrelation and heteroscedasticity. This output is presented in the appendix under table A11. The results are similar to those in the above table, with all the independent variables retaining their signs and significance. Also, there are no noteworthy changes in the sizes of the coefficients. Hence even though heteroscedasticity and autocorrelation were present, they did not alter the results significantly. Multicollinearity refers to the situation in which the independent variables are correlated. The simple pair-wise correlations between these variables should usually be high if multicollinearity is present. This table is presented in the appendix under table A12. The table shows that the correlations between the independent variables are relatively low, which is an indication that multicollinearity is absent.

6.3 Concluding remarks

The aim of this chapter was to estimate the relationship between growth volatility and the possible determinants of this, as discussed in the previous chapters. The results suggest that greater trade openness leads to higher volatility. The reason for this could be the fact that greater trade openness makes developing countries more susceptible to foreign shocks. However, even though greater trade openness leads to higher growth volatility, the effect of this on volatility is minor. Policy makers might be willing to sacrifice such a small loss in terms of greater growth volatility for the gains in growth generated by greater trade. Regarding fiscal policy, it would seem that automatic stabilisers did not play a significant role in reducing growth volatility. However, the results indicate that discretionary fiscal policy did significantly contribute to growth volatility. This is because of the higher volatility of government spending in developing countries. Developing countries face more stringent budget restrictions which could lead to unforeseen changes in taxes and government spending. Furthermore, developing countries are more susceptible to the negative effects of global shocks, which could induce governments to intervene. Furthermore, a fixed exchange rate regime is associated with higher output volatility compared to a more flexible regime. This concurs with most previous studies. Measuring monetary policy for use in cross-country studies of output volatility poses a challenge. This chapter uses changes in the discount rate to approximate the level of activeness and aggression exhibited by the monetary authorities. The results suggest that countries that used monetary policy more often and more aggressively enjoy a reduction in output volatility, even though this may not have been the main objective of the policy. In the absence of major supply shocks, monetary policy could address inflation and output volatility simultaneously. Hence reducing output volatility might have been a secondary benefit in addition to lowering inflation.

Chapter 7

Conclusion

Over the past few decades, many countries have experienced a decline in the volatility of output. Different explanations have been put forward for this phenomenon. These can be divided into three categories, namely structural change, sound policy and luck. However, there seems to be a significant difference between developed and developing countries with regard to the level of output volatility and the rate of decline. In other words, even though output volatility decreased on average in developed and developing countries, the reduction was more significant in the former. Although structural change and luck could potentially explain the overall global reduction in output volatility, economic policy is the most likely candidate to explain the increasing difference between the volatility experienced in developed and developing countries.

7.1 A negative relationship between growth and volatility

Before any attempt can be made to investigate the likely causes of output volatility, the question of whether output volatility has any effect on the economy has to be addressed. The paper by Ramey and Ramey (1995) was influential in this regard. They provided empirical evidence suggesting that volatility affects growth negatively. Even though certain studies advocate the opposite, that is, a positive relationship between growth and volatility, the results of an inverse relationship between the two variables are generally accepted[47]. The empirical exercise in the chapter 1 of this study supports the finding of a negative relationship between growth and output volatility in developing countries. Thus, lower output volatility translates into higher growth rates.

[47] See, for example, Imbs (2002).

7.2 The determinants of output volatility

With regard to the likely causes of output volatility in developing countries, this study investigated the role of trade openness, fiscal policy, monetary policy and exchange rate regimes. Different theories have surfaced, aiming to explain how trade openness could affect volatility. The general view suggests that trade openness increases a country's susceptibility to foreign shocks. On the one hand, Young Kim (2007) argues that trade enlarges the domestic market, thus making it more stable and capable of withstanding foreign shocks. Furthermore, greater participation in world markets decreases the risk of losses due to a fall in domestic demand. On the other hand, Giovanni and Levchenko (2006) warn that higher trade in specific industries could lead to overspecialisation, which could potentially increase volatility. This being said, the empirical evidence presented by Giovanni and Levchenko (2006) suggests that these sectors are less correlated with the rest of the economy, thus acting to reduce volatility. Bejan (2006) compares the effect of trade openness on volatility between developed and developing countries. The results indicate that trade openness had a stabilising effect in developed countries, while the opposite is true for developing countries.

The effect of fiscal policy on output volatility is twofold. Firstly, automatic stabilisers refer to the way in which the structure of government policies automatically affects the economy. However, the effect of automatic stabilisers on volatility is negligible. Cohen and Follette (2000) estimate that automatic stabilisers only absorb about 10% of a negative shock to the model. Fatas and Mihov (2001) investigate a sample consisting of 20 OECD countries. The results indicate that larger governments, which were used as an approximation for automatic stabilisers, decreased volatility. Viren and Koskela (2003) found a similar relationship when considering only developed countries. However, when both developed and developing countries are included in the analysis, the negative relationship between government size and volatility disappears. This result may be an indication that the above relationship is different for developed and developing countries. Secondly, discretionary fiscal policy could also affect growth volatility. Hakura (2007) finds that discretionary fiscal policy contributed to volatility in developing countries, but reduced volatility in developed countries.

Has monetary policy made any significant contribution to the decline in output volatility in developed countries? Ever since the realisation among economists that monetary policy cannot influence growth in the long run, the monetary authorities have turned towards short-run goals, the most prominent of these being price stability or inflation targeting. Examining the data shows that inflation targeting countries have been successful in reducing inflation. Output volatility has also decreased. However, economists are sceptical about whether inflation targeting as a monetary policy regime played a significant role in reducing output volatility. One reason for this is that monetary policy is mainly effective in the face of demand shocks, where inflation and output can be addressed simultaneously. However, supply shocks force monetary authorities to choose between inflation and volatility. Furthermore, since major supply shocks have been absent over the past few decades, many economists believe that inflation targeting and monetary policy in general have not been sufficiently tested. Most of the empirical evidence on this matter suggests that monetary policy only played a minor role in reducing volatility[48]. There is a shortage of literature on developing countries. Furthermore, finding an appropriate approximation variable for monetary policy could be troublesome[49].

Which exchange rate regime is better for lowering volatility – fixed or flexible? The theories on this matter are diverse. When considering the ability of different exchange rate regimes to absorb shocks, theory predicts that a fixed regime would be more suitable in the face of domestic nominal shocks, while a flexible regime would be better suited to foreign real shocks. Moreover, having a flexible exchange rate allows monetary policy to operate more freely, which could be useful in addressing short-run fluctuations. However, a fixed exchange rate enhances credibility and creates a more stable economic environment. For smaller countries, a flexible exchange rate could lead to the phenomenon known as "original sin", while a fixed exchange rate is more vulnerable to speculative currency attacks. The empirical evidence on this topic regarding developing countries is one-sided. Most empirical studies conclude that a flexible exchange rate is better suited to lower output volatility.

[48] See, for example, Leduc and Sill (2006).

[49] Throughout the literature on this topic, many different approximations for monetary policy were suggested. These include different money supply classifications such as inflation variability and interest rates.

7.3 Empirical results

The empirical exercise in chapter 6 of this study found evidence to suggest that trade openness has a significant positive effect on growth volatility in developing countries. Thus, greater trade openness leads to higher volatility. However, this effect is small. Policy makers might be willing to sacrifice such a small loss with regard to output volatility for the much larger gains in growth associated with greater trade openness.

With regards to fiscal policy, the results contribute to the literature finding a positive relationship between growth volatility and discretionary fiscal policy. In other words, discretionary fiscal policy was destabilising in developing countries. The result was also robust in respect of the inclusion of certain controls. Furthermore, the results indicate that automatic stabilisers did not play any role in reducing growth volatility in developing countries.

The results concerning monetary policy suggest that periods during which monetary policy was more active and aggressive are associated with lower output volatility. In other words, developing countries that used monetary policy more often and more aggressively experienced a decline in growth volatility. Whether this decline in output volatility was the main objective of the monetary authorities is not known.

Finally, the results in Chapter 6 present strong evidence in support of findings which suggest that fixed exchange rate regimes increases growth volatility. On the other hand, flexible exchange rate regimes were associated with lower growth volatility.

7.4 Concluding comments

The empirical investigation in this study indicates that, in most instances, all the above determinants do play a significant role in determining output volatility in developing countries. Furthermore, it also highlights the likely reason as to why there is a difference between volatility in developed and developing countries. While some of the determinants discussed above act to reduce volatility in developed countries, these same determinants increase volatility in developing countries. For instance, trade openness and government size are negatively correlated with volatility in developed countries, while the opposite is true for developing countries. Also, developing countries are more likely to have more fixed exchange rate regimes, which would also lead to more volatility.

Whether anything could be done on the part of developing countries to correct this is unlikely. As the results above show, greater trade openness increases volatility, but only slightly. This should be weighed against the gains in growth brought about by greater openness. Developing countries would in most instances favour the gains in growth. Also, government spending in developing countries is more unstable than in developed countries. This may be due to budget constraints or political agendas. Furthermore, developing countries use fixed exchange rates more so than developed countries. Flexible exchange rate regimes require relatively advanced financial markets, which certain developing countries do not have. A somewhat surprising result is that monetary policy reduced volatility in developing countries. However, as explained above, this may be a sample phenomenon in the sense that the shocks during the sample period was predominantly from the demand side.

The factors that set developing and developed countries apart are largely responsible for the difference between the volatility experienced in these two groups of countries. These factors, such as an advanced financial system, good institutions and stable governments, are in most cases the underlying cause as to why certain policies reduce volatility in developed countries while increasing volatility in developing countries. Thus, the concerns about output volatility should be of second-order importance to the development of advanced financial systems, effective institutions and more stable governments.

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Appendix

Table A1. List of countries included in the empirical analysis in chapter 1

Algeria	Guatemala	Nigeria
Argentina	Guinea	Pakistan
Barbados	Guinea-Bissau	Panama
Benin	Honduras	Paraguay
Bolivia	Hong Kong	Peru
Brazil	India	Philippines
Burkina Faso	Indonesia	Romania
Burundi	Iran	Rwanda
Cameroon	Jamaica	Senegal
Cape Verde	Jordan	Singapore
Chad	Kenya	South Africa
Chile	Korea, Republic of	Sri Lanka
Colombia	Lesotho	Syria
Comoros	Madagascar	Taiwan
Congo, Republic of	Malawi	Tanzania
Costa Rica	Malaysia	Thailand
Côte d`Ivoire	Mali	Togo
Dominican Republic	Mauritius	Trinidad &Tobago
Ecuador	Mexico	Uganda
Egypt	Morocco	Uruguay
El Salvador	Mozambique	Venezuela
Ethiopia	Nepal	Zambia
Gabon	Nicaragua	Zimbabwe
Gambia, The	Niger	

Table A2. List of countries excluded from the analysis in chapter 1

Benin
Burkina Faso
Burundi
Cape Verde
Chad
Comoros
Congo, Republic of
Côte d`Ivoire
Egypt
Ethiopia
Gabon
Gambia, The
Honduras
Hong Kong
Jordan
Madagascar
Morocco
Nigeria
Romania
Rwanda
Tanzania

Table A3. Breusch-Godfrey LM tests for Serial Correlation

Test for table 1.2 and table 1.3 respectively:

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	3.122753	Prob. F(2,280)	0.045573
Obs*R-squared	6.196512	Prob. Chi-Square(2)	0.045128

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	2.675193	Prob. F(2,196)	0.071409
Obs*R-squared	5.314502	Prob. Chi-Square(2)	0.070141

In both cases above, the null-hypothesis of no serial correlation can be rejected at the 10% significance level.

Test for table 1.4:

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.765613	Prob. F(2,192)	0.466463
Obs*R-squared	1.582407	Prob. Chi-Square(2)	0.453299

In this case, the null-hypothesis of no serial correlation can’t be rejected at the 10% significance level.

Table A4. The growth regression excluding the human capital variable

Dependent variable: GROWTH
Included observations: 200

Variable	Coefficient	Std error	t-Statistic	Prob
C	0.031666	0.008147	3.886636	0.0001
VOLATILITY	-0.224434	0.059720	-3.758069	0.0002
INVESTSHARE	0.000459	7.00E-05	6.560370	0.0000
INITIALGDP	-0.006080	0.002057	-2.955898	0.0035
POPGROWTH	-0.243572	0.087466	-2.784767	0.0059
R-squared	0.231487	Durbin-Watson stat		1.796405

Table A5. The growth regression excluding the population growth variable

Dependent variable: GROWTH
Included observations: 200

Variable	Coefficient	Std error	t-Statistic	Prob
C	0.027799	0.007718	3.601896	0.0004
VOLATILITY	-0.214835	0.060539	-3.548677	0.0005
INVESTSHARE	0.000429	7.06E-05	6.077777	0.0000
INITIALGDP	-0.007209	0.002384	-3.024328	0.0028
HUMANC	0.000172	7.19E-05	2.390687	0.0178
R-squared	0.223678	Durbin-Watson stat		1.790915

Table A6. List of countries included in the larger sample from chapter 6

Argentina	Malawi
Benin	Mali
Bolivia	Mexico
Brazil	Nicaragua
Cameroon	Niger
Chile	Pakistan
Colombia	Paraguay
Costa Rica	Peru
Dominican Republic	Philippines
Ecuador	Senegal
Egypt	South Africa
El Salvador	Sri Lanka
Guatemala	Syria
India	Thailand
Indonesia	Togo
Iran	Trinidad &Tobago
Kenya	Uruguay
Korea, Republic of	Venezuela
Lesotho	Zambia

Table A7. List of countries included in the smaller sample from chapter 6

Benin	Korea, Republic of
Burkina Faso	Mali
Burundi	Niger
Cameroon	Nigeria
Chad	Pakistan
Colombia	Philippines
Congo, Republic of	Rwanda
Costa Rica	Senegal
Côte d`Ivoire	South Africa
Egypt	Sri Lanka
Gabon	Thailand
Gambia, The	Togo
India	Trinidad &Tobago
Jordan	

Table A8. Dickey-Fuller stationarity tests for all variables

For all the test outputs below, if the test-statistic exceeds the critical values, the null hypothesis of non-stationarity can be rejected.

Growth volatility: larger sample

Null hypothesis: GROWTHVOL has a unit root
Exogenous: constant
Lag length: 0 (automatic based on SIC, MAXLAG=14)

		t-Statistic	Prob*
Augmented Dickey-Fuller test statistic		-10.18039	0.0000
Test critical values:	1% level	-3.465014	
	5% level	-2.876677	
	10% level	-2.574917	

Growth volatility: smaller sample

Null hypothesis: GROWTHVOL has a unit root
Exogenous: constant
Lag Length: 0 (automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob*
Augmented Dickey-Fuller test statistic		-9.126608	0.0000
Test critical values:	1% level	-3.479656	
	5% level	-2.883073	
	10% level	-2.578331	

Openness: larger sample

Null hypothesis: OPEN has a unit root
Exogenous: constant
Lag length: 0 (automatic based on SIC, MAXLAG=14)

		t-Statistic	Prob*
Augmented Dickey-Fuller test statistic		-5.272698	0.0000
Test critical values:	1% level	-3.465014	
	5% level	-2.876677	
	10% level	-2.574917	

Exreg: larger sample

Null hypothesis: EXREG has a unit root
Exogenous: constant
Lag length: 0 (automatic based on SIC, MAXLAG=14)

		t-Statistic	Prob*
Augmented Dickey-Fuller test statistic		-8.323655	0.0000
Test critical values:	1% level	-3.465014	
	5% level	-2.876677	
	10% level	-2.574917	

AutoGov: larger sample

Null hypothesis: AUTOGOV has a unit root
Exogenous: constant
Lag length: 1 (automatic based on SIC, MAXLAG=14)

		t-Statistic	Prob*
Augmented Dickey-Fuller test statistic		-6.160002	0.0000
Test critical values:	1% level	-3.465202	
	5% level	-2.876759	
	10% level	-2.574962	

DisGov: larger sample

Null hypothesis: DISGOV has a unit root
Exogenous: constant
Lag length: 0 (automatic based on SIC, MAXLAG=14)

		t-Statistic	Prob*
Augmented Dickey-Fuller test statistic		-8.647630	0.0000
Test critical values:	1% level	-3.465014	
	5% level	-2.876677	
	10% level	-2.574917	

MonAct: smaller sample

Null hypothesis: MONACT has a unit root
Exogenous: constant
Lag length: 0 (automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob*
Augmented Dickey-Fuller test statistic		-9.061322	0.0000
Test critical values:	1% level	-3.479656	
	5% level	-2.883073	
	10% level	-2.578331	

HumanC: larger sample

Null hypothesis: HUMANC has a unit root
Exogenous: constant
Lag length: 0 (automatic based on SIC, MAXLAG=14)

		t-Statistic	Prob*
Augmented Dickey-Fuller test statistic		-5.891071	0.0000
Test critical values:	1% level	-3.465014	
	5% level	-2.876677	
	10% level	-2.574917	

Infvol: larger sample

Null hypothesis: INFVOL has a unit root
Exogenous: constant
Lag length: 0 (automatic based on SIC, MAXLAG=14)

		t-Statistic	Prob*
Augmented Dickey-Fuller test statistic		-12.96587	0.0000
Test critical values:	1% level	-3.465014	
	5% level	-2.876677	
	10% level	-2.574917	

Inv: larger sample

Null hypothesis: INV has a unit root
Exogenous: constant
Lag length: 0 (automatic based on SIC, MAXLAG=14)

		t-Statistic	Prob*
Augmented Dickey-Fuller test statistic		-5.780007	0.0000
Test critical values:	1% level	-3.465014	
	5% level	-2.876677	
	10% level	-2.574917	

Inv: smaller sample

Null hypothesis: INV has a unit root
Exogenous: constant
Lag length: 0 (automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob*
Augmented Dickey-Fuller test statistic		-4.094683	0.0014
Test critical values:	1% level	-3.479656	
	5% level	-2.883073	
	10% level	-2.578331	

Pcgdp: larger sample

Null hypothesis: PCGDP has a unit root
Exogenous: constant
Lag length: 0 (automatic based on SIC, MAXLAG=14)

		t-Statistic	Prob*
Augmented Dickey-Fuller test statistic		-4.848191	0.0001
Test critical values:	1% level	-3.465014	
	5% level	-2.876677	
	10% level	-2.574917	

Pcgdp: smaller sample

Null hypothesis: PCGDP has a unit root
Exogenous: constant
Lag length: 0 (automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob*
Augmented Dickey-Fuller test statistic		-3.948920	0.0023
Test critical values:	1% level	-3.479656	
	5% level	-2.883073	
	10% level	-2.578331	

Table A9. Tests for Heteroscedasticity and Autocorrelation

Newey-West standard errors for the results in table 6.1

Dependent Variable: GROWTHVOL
Included observations: 190
Newey-West HAC Standard Errors & Covariance (lag truncation=4)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.010987	0.010409	1.055499	0.2926
OPEN	8.45E-05	3.89E-05	2.171296	0.0312
INFVOL	0.031768	0.011461	2.771774	0.0061
INV	0.007079	0.005183	1.365801	0.1737
PCGDP	-0.002194	0.002958	-0.741936	0.4591
HUMANC	-0.000249	0.000458	-0.543963	0.5871
R-squared	0.117448	Mean dependent var		0.016388

Newey-West standard errors for the results in table 6.2

Dependent Variable: GROWTHVOL
Included observations: 190
Newey-West HAC Standard Errors & Covariance (lag truncation=4)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.008431	0.010180	0.828195	0.4086
DISGOV	0.002795	0.000951	2.938540	0.0037
AUTOGOV	6.11E-05	9.28E-05	0.657984	0.5114
INFVOL	0.020607	0.012847	1.604112	0.1104
INV	0.010295	0.004945	2.081947	0.0387
PCGDP	-0.002887	0.002681	-1.076539	0.2831
HUMANC	0.000103	0.000463	0.221901	0.8246
R-squared	0.195253	Mean dependent var		0.016388

Newey-West standard errors for the results in table 6.3

Dependent Variable: GROWTHVOL
Method: Least Squares
Newey-West HAC Standard Errors & Covariance (lag truncation=4)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.008776	0.008939	0.981833	0.3275
EXREG	0.006310	0.001590	3.967484	0.0001
INFVOL	0.027065	0.011620	2.329154	0.0209
INV	0.010793	0.004940	2.184956	0.0302
PCGDP	-0.002612	0.002760	-0.946179	0.3453
HUMANC	4.75E-05	0.000418	0.113561	0.9097
R-squared	0.146249	Mean dependent var		0.016388

Newey-West standard errors for the results in table 6.4

Dependent Variable: GROWTHVOL
Newey-West HAC Standard Errors & Covariance (lag truncation=4)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.039661	0.019071	2.079693	0.0395
MONACT	-0.002339	0.000831	-2.815621	0.0056
INV	-0.018616	0.009234	-2.015880	0.0459
PCGDP	0.001019	0.005998	0.169912	0.8653
R-squared	0.081798	Mean dependent var		0.020985

In all cases above, the results are not significantly different from the results reported in the tables in Chapter 6.

Table A10. White's general heteroscedasticity test

White heteroscedasticity test

F-statistic	2.227521	Probability	0.010189
Obs*R-squared	26.84444	Probability	0.013066

Test equation:
Dependent variable: RESID^2
Method: least squares
Date: 09/07/08 Time: 22:17
Sample: 1 190
Included observations: 190

Variable	Coefficient	Std error	t-Statistic	Prob
C	0.001468	0.001610	0.911802	0.3631
OPEN	-2.30E-06	1.55E-06	-1.489973	0.1380
OPEN^2	2.04E-08	9.91E-09	2.056302	0.0412
DISGOV	1.40E-05	2.62E-05	0.535185	0.5932
DISGOV^2	2.27E-06	4.02E-06	0.564944	0.5728
EXREG	9.22E-06	3.27E-05	0.282485	0.7779
INFVOL	0.000600	0.000397	1.513637	0.1319
INFVOL^2	-0.000700	0.000622	-1.125391	0.2620
INV	-0.000571	0.000532	-1.073715	0.2844
INV^2	0.000274	0.000233	1.175008	0.2416
PCGDP	-0.000603	0.000898	-0.670714	0.5033
PCGDP^2	7.93E-05	0.000130	0.611519	0.5416
HUMANC	1.15E-05	2.59E-05	0.445122	0.6568
HUMANC^2	-8.44E-07	2.83E-06	-0.298604	0.7656

R-squared	0.141287	Mean dependent var	9.79E-05
Adjusted R-squared	0.077859	S.D. dependent var	0.000188
S.E. of regression	0.000180	Akaike info criterion	-14.33157
Sum squared resid	5.73E-06	Schwarz criterion	-14.09231
Log likelihood	1375.499	F-statistic	2.227521
Durbin-Watson stat	2.046956	Prob(F-statistic)	0.010189

Table A11. Newey-West standard errors

Dependent variable: GROWTHVOL
Method: least squares
Date: 09/07/08 Time: 23:03
Sample: 1 190
Included observations: 190
Newey-West HAC standard errors & covariance (lag truncation=4)

Variable	Coefficient	Std error	t-Statistic	Prob
C	-0.005535	0.008708	-0.635660	0.5258
OPEN	4.33E-05	3.37E-05	1.284747	0.2005
DISGOV	0.002683	0.000824	3.257327	0.0013
EXREG	0.005020	0.001373	3.655970	0.0003
INFVOL	0.019208	0.012462	1.541315	0.1250
INV	0.009031	0.004557	1.981689	0.0490
PCGDP	0.000206	0.002506	0.082134	0.9346
HUMANC	0.000387	0.000406	0.952826	0.3419

R-squared	0.249563	Mean dependent var	0.016388
Adjusted R-squared	0.220700	S.D. dependent var	0.011454
S.E. of regression	0.010111	Akaike info criterion	-6.309199
Sum squared resid	0.018606	Schwarz criterion	-6.172482
Log likelihood	607.3739	F-statistic	8.646464
Durbin-Watson stat	1.587598	Prob(F-statistic)	0.000000

Table A12. Pair-wise correlation matrix of independent variables

	PCGDP	OPEN	INV	INFVOL	HUMANC	EXREG	DISGOV
PCGDP	1.000000	-0.314800	0.410534	-0.047477	0.235327	-0.343118	-0.225455
OPEN	-0.314800	1.000000	0.165637	-0.056957	-0.177314	0.326737	0.182259
INV	0.410534	0.165637	1.000000	-0.157617	0.034063	-0.140743	-0.113848
INFVOL	-0.047477	-0.056957	-0.157617	1.000000	-0.061422	0.126154	0.217824
HUMANC	0.235327	-0.177314	0.034063	-0.061422	1.000000	-0.322071	-0.248478
EXREG	-0.343118	0.326737	-0.140743	0.126154	-0.322071	1.000000	0.223361
DISGOV	-0.225455	0.182259	-0.113848	0.217824	-0.248478	0.223361	1.000000