THE VOLATILITY OF THE OUTPUT GAP IN THE G7

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Ray Barrell[1] and Sylvia Gottschalk[2]

National Institute of Economic and Social Research (NIESR), 2 Dean Trench Street, Smith Square, London SW1H 3PE, United Kingdom.

Abstract: The decline in output volatility in the US has been variously ascribed to changes in the policy regime reflected in inflation volatility, improved stockholding and increased international integration. We investigate output volatility in the G7 in a panel context treating these as competing explanations. We show that an encompassing panel has a significant role for both net financial wealth and trade openness. There is also a role for inflation volatility, even though previous studies have ignored the fact that it may be endogenous and its role therefore spurious. However, its importance clearly varies over time and across countries, and it appears less important as an explanation of declining volatility in the US than it does in the UK. Changes in openness appear to be at least as important in explaining the decline in US output volatility.

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[1] corresponding author. National Institute of economic and Social research (NIESR), 2 Dean trench Street, Smith Square, London SW1P 3HE, RBarrell@niesr.ac.uk.
[2] National Institute of Economic and Social Research (NIESR), 2 Dean Trench Street, Smith Square, London SW1P 3HE SGottschalk@niesr.ac.uk . We have benefited from discussions with Martin Weale and James Mitchell. We thank James Mitchell and Ian Hurst for providing the business cycle data and Patricia Oliver for the FDI data. All remaining errors are ours.

1. Introduction

It is now a well documented fact that output volatility in the U.S. has declined dramatically in the last twenty years, particularly during the 1990s, as shown by Blanchard and Simon (2000), McConnell and Perez-Quiros (2000), Kahn, McConnell and Perez-Quiros (2002), Stock and Watson (2002), among others. However, there is less consensus on the causes of its decline. Better control of inventories is presented as a cause for lower volatility by Taylor (2000), and Kahn, McConnell and Perez-Quiros (2002). Blanchard and Simon (2000) find evidence that output volatility has declined with inflation volatility. Blanchard and Simon (2000), Taylor (2000) and Romer (1999) suggest that more effective monetary and fiscal policies may have contributed to the reduction of business cycle volatility. Finally, all these authors agree that the shocks that hit the G-7 economies have been fewer and smaller in the last twenty years.

Another strand of literature examines the role of international trade and international financial integration. Razin and Rose (1992) and Buch, Dopke and Pierdzioch (2002) try to find empirical evidence that greater commercial and financial openness can explain the decline of output volatility in many countries. Both use panel data analysis to support their hypothesis. Razin and Rose (1992) estimate a panel of 130 countries over the post-war period, while Buch, Dopke and Pierdzioch (2002) restrict their panel analysis to OECD countries in the past 40 years. However, both papers fail to find links between openness and output volatility over the period considered.

In this paper, we examine the causes of the decline of the output gap volatility in the UK and US between 1970 and 2001. Unlike most of the papers cited above, we encompass several hypotheses in the same econometric framework, since analysing hypotheses individually may lead to omitted variable biases in the proposed explanations for the decline of the output gap. Although Blanchard and Simon (2000)'s model is quite parsimonious and produces consistent results, various commentators on the paper have pointed out that the assumption of exogeneity of inflation volatility is possibly misleading.

We show that inflation volatility is not the only variable that can account for the reduction in volatility in the G7. Inventories appear to have little explanatory power. However, we found evidence that the increase in trade and financial openness, domestic financial liberalisation, *along with* the reduction of inflation volatility can account for the reduction of the volatility of the output gap during the past three decades in the G7. Our results are consistent with the theoretical literature that shows that trade and financial liberalisation allow intertemporal risk- sharing, that more sophisticated financial markets help individual smooth their consumption decisions over time, and that better monetary policies help reduce output volatility.

Section 2 reviews the main empirical results explaining the decline in volatility. In Section 3, the data and the main econometric results are presented. Section 4 concludes.

2. Background

In this section we survey the most recent empirical literature on business cycle volatility. We first examine the evidence on the dampening of the business cycle and the main proposed explanations.

Has output volatility dampened?

Most of the research based on post-World War II data finds evidence of an increase in volatility during the 70s, with a subsequent decline in the mid-80s and 90s. This is the main finding of Blanchard and Simon (2000), McConnell and Perez-Quiros (2000), Kahn, McConnell and Perez-Quiros (2002), Stock and Watson (2002), who analyse the volatility of the US output growth rate between 1953 and 2000. Similar conclusions are reached by Backus and Kehoe (1992) and Dalsgaard, Elmeskov, and Park (2000) who investigate 13 and 25 OECD countries, respectively, from 1960 to 2000, and Barrell and Mitchell (2003), who focus on the US, the UK, France and Germany.

Papers emphasizing a longer term historical perspective are generally less positive regarding the decline of output volatility. Although most of these papers conclude that during the post-World War II period volatility has been decreasing, the levels of post-World War II output fluctuations are found to be analogous to those observed during the Gold Standard, and not substantially lower. Bergman, Bordo and Jonung (1998) and Basu and Taylor (1999) reach this conclusion by investigating the volatility of the business cycle in 13 and 15 countries respectively from 1870 to 2000, dividing the period into 4 main sub-periods: Gold Standard (1870-1914), Inter War (1919-1939), Bretton Woods (1945-1972) and the Floating Regime (1972-present). Bergman, Bordo and Jonung (1998)'s sample includes only OECD countries, whilst Basu and Taylor (1999) considers 14 OECD countries and Argentina which was as prosperous as a number of other members of the sample before World War II. Romer (1999) does not find a striking difference between the volatility of US output before World War I and after World War II, unlike Backus and Kehoe (1992).

These studies generally use different definitions of output volatility. Measuring output volatility using either the standard deviation of GDP growth rates or the standard deviation of the filtered GDP has little influence on the final conclusion, as is made clear in Table 1. McConnell and Perez-Quiros (2000), Kahn, McConnell and Perez-Quiros (2002) and Stock and Watson (2002) favour the first measure, whereas Backus and Kehoe (2002), Dalsgaard, Elmeskov, and Park (2000) and Buch, Dopke and Pierdzioch (2002) prefer filtering the GDP series using a Baxter-King (1999) band pass filter which extracts the trend of GDP from the series whose volatility is studied. This differs slightly from the use of the volatility of output growth as it allows trend output growth to change over time without this polluting the volatility indicator.

Table 1: U.S. output volatility in percent.
Standard deviation of either the output growth rate or filtered output.

Post War Studies				
	1960s	*1970s*	*1980s*	*1990s*
Stock-Watson	2.2	2.7	2.6	1.5
Dalsgaard et al.	1.8	4.6	3.1	0.7
	1953:2-1968:4	*1969:1-1983:4*	*1984:1 2000:2*	
Kahn et al.	4.5	4.8	2.2	
Longer Term Studies				
	Pre-WWI	*Interwar*	*Post- World War II*	
Backus-Kehoe	4.3	9.3	2.3	
Romer	3.0	7.1	2.5	
	Gold Standard	*Interwar*	*Bretton Woods*	*Float (1973-1999)*
Basu-Taylor†	2.7	3.6	2.5	1.6

Source: Stock and Watson (2002), Dalsgaard, Bordo and Jonung (2000), Kahn, McConnell and Perez-Quiros (2002), Backus and Kehoe (1992), Romer (1999), and Basu and Taylor (1999).
In Stock and Watson (2002) the volatility by decade is expressed as a ratio of the volatility of the period 1960-2000, which is 2.3%.So, in their paper, the output volatility in the 60s is reported as 0.98%.
†: Mean of pooled data: Argentina, Australia, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Spain, Sweden, UK, US.

The division into sub-periods and the overall time span also differ between studies. Stock and Watson (2002) and Dalsgaard, Elmeskov, and Park (2000) divide their sample period in decades from 1960 to 2000. Although the absolute values of the volatility are different due to the choice of filtering, both papers find that output volatility increased during the 70s, and gradually declined from the 80s onwards. Kahn, McConnell and Perez-Quiros (2002) present their descriptive statistics in line with the findings of their previous research (McConnell and Perez-Quiros 2000), where the authors show that the volatility of U.S. output growth suffered a structural break in the mid-80s. The period covering the 70s, i.e., 1969-1983, has a higher volatility than the previous and subsequent period.

2.2. What are the causes of the dampening of the business cycle?

There are many reasons why cycles have become more damped, as appears to have happened. The existing literature stresses three major factors, the decline in inflation volatility, which can be a consequence of better policy design, the improved management of stocks, and, finally, global commercial and financial liberation.

Blanchard and Simon (2000) emphasize the role of inflation volatility in the decline of output growth volatility. They and others link this to the effectiveness of monetary policy. They first observe the existence of a strong graphical correlation between the path of the 20-period moving average volatility of the US inflation and the 20-period moving average volatility of US output. As correlation does not necessarily imply causality, the authors turn to the evidence from other G7 countries and estimate a panel consisting of all the G7 countries, bar Japan, where the volatility of output growth is a function of the inflation level, a time trend and inflation volatility. Their modelling rationale for adopting a panel approach is that the major common factor affecting inflation and output volatility during the post war period were the supply shocks of the 70s, which affected the G7 countries. This panel thus allows them to estimate a relationship between output volatility and inflation volatility, controlling for supply shocks. Their results show that inflation is not a significant explanatory variable, but the fall in inflation volatility over the period 1953-1999 appears to explain most of the decline in output volatility. However, the authors admit that controlling for factors common to the G7 countries through the use of panel regression, does not establish causality between the volatility of inflation and the volatility of output growth. In the published discussion some of the commentators on Blanchard and Simon (2000) note that it would have been more appropriate to assume instead that inflation volatility is endogenous and attribute the decline in both variables to other common factors.

Kahn, McConnell and Perez-Quiros (2002) concentrate on a single explanation of the decline in volatility, and found that the volatility of sales did not decline from the mid-80s onwards, whilst the volatility of manufacturing production was falling. This discrepancy can be accounted for by changes in inventory management, and they find statistical evidence that most of the decrease in output growth volatility in the US may be attributed to the fall in the volatility of sales, which in turn can be explained by better management of inventories in the mid-80s onwards. Blanchard and Simon (2000) and Stock and Watson (2002) reject this hypothesis on the grounds that the discrepancy in the behaviour of the volatility of manufacturing output and the volatility of output is not robust to the method of analysis, to the series used and to the frequency of data. For instance, Stock and Watson (2002) find statistical evidence of a break in the variance of total final sales and final sales of durable goods around 1983. Their results are consistent with Ahmed, Levin, and Wilson (2002) and Herrera and Pasavento (2002). Stock and Watson (2002) agree with Kahn, McConnell and Perez-Quiros (2002) that the standard deviation of quarterly growth in manufacturing production of durables has declined by less than the standard deviation of quarterly growth in sales in the period 1984-2001. However, the standard deviations of annual growth in both series seem to have declined by very similar amounts.

The roles of commercial and financial liberalisation and of monetary regimes have been stressed in papers analysing the volatility of international business cycles. Bergman, Bordo and Jonung (1998) investigate whether lower output volatility can be viewed as inherent to certain monetary regimes. In their paper, the whole sample period 1870-1998 is divided in 4 sub-samples: Gold Standard (1870-1914), Interwar (1919-1939), Bretton Woods and post-Bretton Woods. They found that the periods with the lowest volatility of the business cycle were the Gold Standard and the post-Bretton Woods period. As these two periods have exactly opposite monetary regimes, the authors argue that it is difficult to relate the lower output volatility exclusively to the monetary regime. Their result upholds Baxter and Stockman (1989) who found no relationship between monetary regime and business cycle volatility. However, Bergman, Bordo and Jonung (1998)'s study lends support to the hypothesis that financial and commercial openness contribute to the reduction of output fluctuations. Although the two periods of lowest output volatility during 1870-1998 have different monetary regimes, both periods were characterised by high commercial and financial integration. In contrast, during the interwar period the volatility of the business cycle was very high, and commercial and financial integration very low. Basu and Taylor (1999) argue convincingly that the causes of the similar levels of output volatility during the Gold Standard and the post-Bretton Woods period may be the low level of trade barriers, the absence of capital controls and higher labour mobility.

The hypothesis that openness can explain the decrease in business cycle volatility is tested by Razin and Rose (1992) and Buch, Dopke and Pierdzioch (2002). Neither found evidence of a relationship between openness and the volatility of the business cycle. This result prompts us to consider that the decline in output volatility may not be exclusively attributed to one or two factors, and that a more encompassing approach should be adopted. The coincidence between the low levels of output volatility in the Gold Standard and the post-Bretton Woods periods and the high level of trade and financial integration in these two periods is compelling. It is clearly not a sufficient explanation, however. Globalisation may have lead to the increased ability to spread shocks across countries, and hence limit them through risk sharing. However, domestic financial liberalisation also means that risks can be transferred over time by individuals. In particular, the reduction in liquidity constraints on consumers allows them to distribute shocks to their income over a number of time periods. This should reduce the volatility of output as long as shocks do not affect all individuals in the country in the same way. Sophisticated domestic financial markets are a characteristic of the post- Bretton Woods period exclusively, and should be incorporated in a model explaining the volatility of output.

We can express the existing set of hypotheses within a simple New Keynesian 3 equation framework following Svensson (2000) for instance. Output y_t depends on the proportion of liquidity constrained or inertial consumers, γ_1, whose consumption grows at a constant rate ($\beta>1$)

and is influenced by shocks, and on the remainder who follow an Euler equation that depends on the expected real interest rate, (r_t- Δp_t^e) and who are also influenced by shocks. The proportion of liquidity constrained consumers will depend inversely on the stock of net financial assets relative to income. We may write this relationship as follows, where ε_t represents structural shocks

$$y_t = \gamma_1(\beta \ y_{t-1}) + (1-\gamma_1)(y_{t+1}^e - \theta(r_t - \Delta p_t^e)) + \varepsilon_t \tag{1}$$

Shocks to output, ε_t, can be come from shocks to the value of holdings of foreign assets, and can be dispersed by shocks to the value of liabilities to foreigners. Shocks to output can also come from stock building. Prices are set in a Philips curve relationship, where ϖ_t is represents structural shocks. The structural shocks to this equation will include shocks to the exchange rate.

$$p_t = p_{t+1}^e + \vartheta y_t + \varpi_t \tag{2}$$

The slope of the Philips curve will depend on the openness of the economy to trade and production. Domestic prices will be less influenced by domestic output in a more open economy and hence ϑ will be smaller the more open the economy. The same argument will hold where FDI ensures that production is more integrated into the rest of the world.

There is also a monetary policy feedback rule of the form

$$r_t = \lambda \Delta \mathrm{p}_\mathrm{t}^\mathrm{e} \tag{3}$$

We may write the expected volatility (or variance) of output as

$$\begin{aligned}\mathrm{var}(y_t) = & (((1-\gamma_1)/(1-\gamma_1\beta))^2\theta^2(\lambda-1)^2 \ \mathrm{var}\,\omega_t + (1/(1-\gamma_1\beta))^2 \ \mathrm{var}\,\varepsilon_t) \\ & /(1-((1-\gamma_1)/(1-\gamma_1\beta))^2\theta^2(\lambda-1)^2\vartheta^2)\end{aligned} \tag{4}$$

This falls as the number of liquidity constrained consumers, γ_1 also falls and hence falls as net financial wealth rises as a proportion of nominal income. It rises with the factors that increase the variance of the output equation shocks, ε_t and hence increases with stock building, and the value of gross foreign assets, and declines with the value of gross foreign liabilities. Some assets and liabilities enter net financial wealth, and hence any consumption smoothing role they play will operate through that channel, and we will isolate only their shock propagation effects directly. The volatility of output rises with the slope of the Philips curve, and hence should decline with openness and FDI.

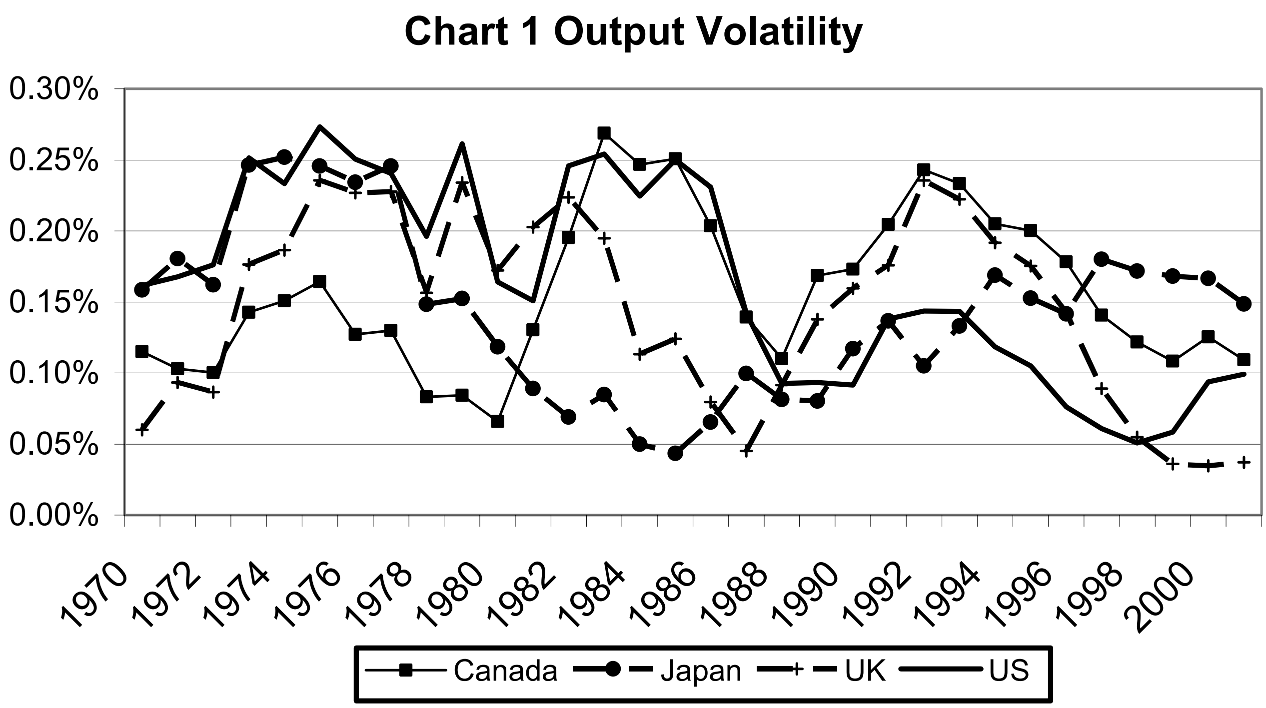
3. Econometric analysis

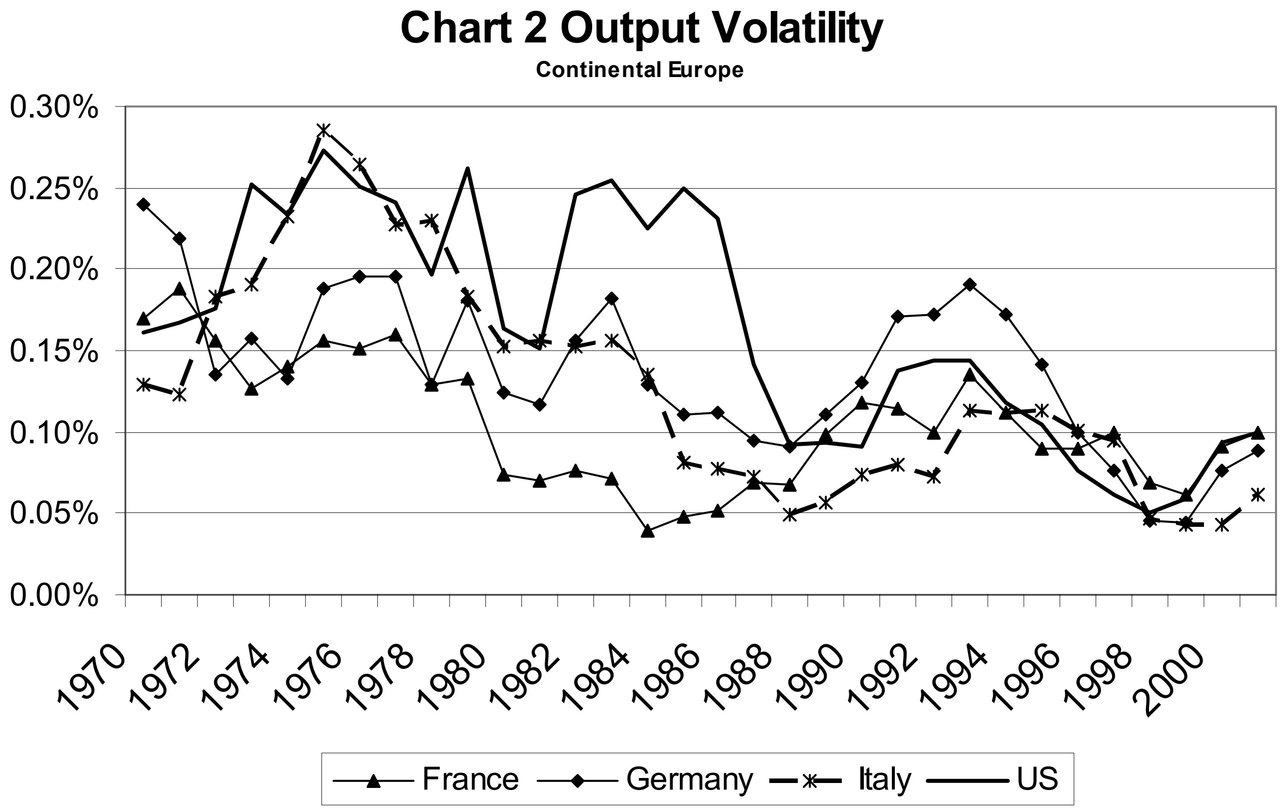
As was seen in Section 2 above, previous research suggests that the level of volatility of the output gap will depend upon the inflation rate (INF), and the volatility of the inflation rate (INFVOL), commercial openness (OPEN), stock building and financial integration and liberalisation. Unlike trade openness, there is no single measure of financial integration and liberalisation. We can thus include several variables that capture capital market integration and financial liberalisation. In order to ensure comparability with other studies as well as congruence with theory we argue that we should include stocks of outward foreign direct investment, gross foreign assets and gross foreign liabilities. These stock variables are more relevant if we wish to capture inter temporal risk spreading than are flow variables, as used by Buch, Dopke and Pierdzioch (2002) and Razin and Rose (1992). The existence of a stock of assets allows an individual and a country to absorb the shock by running down or increasing asset stocks, but these changes may not be strongly related to observed changes in assets, and indeed the existence of the stocks may ensure the economy is more stable as the provide insurance as well as reserves. Finally, we include the net wealth of households in our econometric analysis to capture the fact that sophisticated financial markets allow individuals to absorb shocks and smooth their consumption over time.

The business cycle is computed using a Baxter-King low bandpass filter on GDP and the output gap at point *t* is the difference between GDP in *t* and trend output in *t*. We have estimates for GDP on a consistent (quarterly) basis from the early 1960s, and we use these to construct our output gap estimates. The first few years of the output gap series is, however, not used in our econometrics because of the time restriction on reliable data on foreign direct investment and holdings of foreign assets and foreign liabilities. Our sample of rolling widows for the volatility of the output gap therefore covers the period 1970-2001. The inflation rate is computed from the consumer price index, and its volatility is the 5- year rolling window standard deviation.

The case for analysing the volatility of filtered output, especially over long periods, is strong, as it allows the trend rate of growth of output to vary over time. Filtered output can be used to produce estimates of the output gap. Our estimates of the output gaps we use are based on the Baxter-King low band pass filter and are the difference between actual and potential output. These gap indicators are discussed in Barrell and Mitchell (2003) and in Mitchell, Massman and Weale (2003), and are regularly used in policy analysis. The gap will vary in exactly the same way as filtered output, but with the opposite sign. Barrell and Mitchell (2003) present decade average indictors that show that output gap volatility has been declining in the major four economies since 1970. For the purposes of this paper it is more useful to construct rolling window estimates of the volatility of the output gap. The volatility indicator we use is a five period moving average of the root mean squared deviation of the output gap.

In Charts 1 and 2 we show our estimates of the volatility of the output gap in the G7 using the US as a comparator. The most recent cycle seems to be significantly damped in comparison to cycles over the last 30 years or so, but the universal decline in output volatility is not absolutely clear. The US and the three major continental European economies have a relatively continuous decline in volatility, but the UK and Canada have periods of high volatility around and just after 1990, although overall volatility of the output gap does appear to be declining. Although Japanese output gap volatility is lower in the 1990s than in the 1970s, it is higher than in the 1980s[3].





[3] Barrell (2003) discusses some of the problems with extracting output gaps in Japan where trend output growth has declined noticeably between the 1980s and 1990s.

The choice of a rolling standard deviation for measuring volatility over time requires care in estimation. Rolling window volatility measures are characterised by strong persistence over a number of subsequent time periods at least equal to the size of the window[4].. However, persistence of this nature invalidates the assumption of independent errors, which may lead to inconsistent estimators, and bias *t* statistics. We address this issue by using the Generalized Method of Moments (GMM), and also by correction for moving average errors. This procedure has been shown to produce consistent estimators, even in the case of heteroskedastic and serially correlated errors (Hansen (1982) and Hansen and Singleton (1982))[5].

Our other indicators are not based on rolling windows. Our measure of openness (OPEN) is the traditional ratio of total trade volumes (exports plus imports) to GDP. We also use stock building as a percent of real GDP (DS), aggregate Gross Assets as a percent of nominal GDP (GA), aggregate Gross Liabilities as a percent on nominal GDP (GL), the outward stock of Foreign Direct Investment as a percent of nominal GDP (FDI), and Net Financial Wealth of the personal sector as a percent of nominal GDP (NW). The assets, liabilities, FDI and net wealth ratios all trend upward over time.

The literature we survey can be seen as constructing a sequence of hypotheses, and it is important that we can replicate these on our data set before we draw conclusions. We therefore start with the Blanchard and Simon (2000) assumption that output volatility is be determined by the level and volatility of inflation and by a time trend. In section 4 Table 2 we use a fixed effect GMM panel with and without MA error correction to look at a simple relationship of the form:

$$VOL_i=F_1(INF,INFVOL,TIME) \qquad (5)$$

Blanchard and Simon (2000) discuss the potential role of openness but do not test for its effects. Kahn, McConnell and Perez-Quiros (2002) argued that the decline in the volatility of stocks as reflected in the level of stock building had been an important determinant of the decline in volatility. However, neither they nor Blanchard and Simon (2000) tested this as an alternative hypothesis within the framework of other explanations. In section 4 Table 3 we use a G7 GMM panel with and without MA error correction to investigate the competing hypotheses on inflation, inflation volatility, openness and stock building that were considered in this US centred debate and we look at relationships of the form

$$VOL_i =F_2(OPEN,DS,INF,INFVOL,TIME) \qquad (6)$$

Rose and Razin (1992) and Buch, Dopke and Pierzdoch (2002) tested whether foreign direct investment and financial and commercial openness might explain output volatility, but they did not consider the role of inflation volatility, nor did they sue stocks of assets and liabilities. We therefore

[4] See Alexander (1996) for instance.
[5] Using a rolling window does not seem to affect the fact that volatility has declined in the U.S. Blanchard and Simon (2000) measure the volatility of output with a rolling standard deviation, and reach the same conclusion as McConnell

consider the competing hypotheses on financial openness and liberalisation and estimate the following encompassing relationship in a G7 GMM panel with MMA error corrections.

$$VOL_i = F_3(DS,OPEN,INF,INFVOL,TIME,NW,FDI,GA,GL) \qquad (7)$$

Our results for this hypothesis are reported in section 4 Table 4, and we explore them further as they encompass the alternatives. At this stage we feel we have a relatively well specified model that does not suffer from omitted variables biases, and we can therefore address the important issue of the simultaneous determination of output volatility and inflation volatility using an IV panel estimator assuming that INFVOL is a jointly endogenous variable in section 4 Tables 5. We report results using GMM panel estimates with MA error correction and robust errors[6].

4. Results

It is relatively easy for us to recover the standard Blanchard Simon (2000) result, as can be seen from the fixed effect Generalised Method of Moments estimator in Table 2. These results would lead us to suppose that there was an unexplained trend in the reduction of output volatility which could be the result of a number of factors that we discuss above. It appears that the reduction in the volatility of the output gap has been driven by the reduction in the level of inflation and the reduction in the volatility of inflation that goes with better operation of monetary policy. The test of overindentifying restriction is rejected if the serial correlation of errors is not taken into consideration. When serial correlation is corrected, the instruments are found to be valid.

Table 2. Blanchard-Simon Model

	Without MA errors		With MA(5)errors	
Variable	Estimate	t-statistic	Estimate	t-statistic
INF	0.00002083**	1.99	0.00002859*	3.56
INFVOL	0.00041068*	4.90	0.00028660*	3.67
TIME	-0.00002193*	-4.21	-0.00002172*	-7.74

GMM estimation. Model without MA errors: Test of overidentifying restrictions (J Test):chi^2(11)=25.3969[.008]. Model with MA errors: J Test:chi^2(11)=5.87208[.882]; LR test:chi^2(3)=-0.13[1.00]. In this and all subsequent tables, * and ** indicate significance at the 1% and 5% levels, respectively.

However, we should be cautious about the use of unexplained trends when explaining a series such as the volatility of the output gap, and we can utilise the other indicators that Blanchard and Simon (2000) and others were suggesting might be of importance. Table 3 adds our openness indicator, which generally trends upward, but in different ways in different countries, unlike a time trend. We also add stock building to see if the widely circulating single variable explanation of lower output volatility holds up in a comparative context. There is clearly a strong role for openness, and it knocks out the time trend, but there appears to be no separate role for stock building. This latter result does not surprise us, as stock building and stock holding and imports are clear substitutes in

and Perez-Quiros (2000), Kahn, McConnell and Perez-Quiros (2002) and Stock and Watson (2002) and Dalsgaard, Elmeskov, and Park (2000) who compute the standard deviations of output growth over fixed periods

[6] (1), (2) and (3) were estimated in TSP 4.5 by the GMM procedure, with correction for 5-lag moving average errors.

the production process, and a more open economy should need fewer stocks. Hence the explanation of the declining volatility of output by stocks alone appears inadequate. The model specified in Table 3 leaves a strong role for the policy related variables, but augments the simpler explanation in Table 2 with more economic content. Adjustment for moving average errors reduces the significance of inflation, and in general reduces the size of coefficients, but it does not change the structure of our results.

Table 3. Augmented Blanchard Simon Model

	Without MA error correction		With MA(5) error correction	
Variable	Estimate	t-statistic	Estimate	t-statistic
INF	0.00002808*	2.41	0.00002642**	2.10
INFVOL	0.00079379*	5.91	0.00073359*	3.945
TIME	-0.00000231	-0.37	-0.00000714	-1.20
DS	0.01190200	1.33	0.00011091	0.01
OPEN	-0.00276366*	-4.56	-0.00224363*	-4.02

GMM estimation. Model without MA errors, J Test:chi^2(23)=66.77[.000]
.Model with MA errors: J Test:chi^2(23)=24.3072[.39].

Financial liberalisation and the removal of international capital controls in the last 30 years have had a major impact on the level of wealth held in economies and on its structure. There has been a rise in wealth to income ratios, and both gross assets held abroad (mainly by companies) and liabilities owed to foreign residents have also risen. Both domestic and foreign wealth stocks provide some sort of insurance, and should help on average to absorb shocks. If wealth stocks are high consumption can be smoothed in response to income shocks, at least on an individual basis, and this should reduce the volatility of output. In particular if fewer individuals are liquidity constrained then more of a fall in incomes can be absorbed by changing wealth rather than consumption, and hence we should expect to see more stable output. If assets are held abroad then consumption can be smoothed by a country by absorbing the shock in a change in the asset position and hence possibly exporting shocks to other countries.

A reduction in the level of assets total national held abroad absorbs the shock if it involves a sale of assets, and it exports part of the shock if it involves a reduction in the price of a liability, such as foreign holdings of domestic equities. Hence we would expect the growth of international portfolios to reduce the volatility of output. The growth of foreign direct investment also ensures that countries cycles are more linked by ensuring that production processes and levels of investment in productive capital are linked across countries within firms, but it is not clear that this will damp cycles. In Table 4 we add indicators of financial and international capital market integration (GA for gross foreign assets as a ratio of nominal GDP, GL for gross assets as a ratio of nominal GDP and FDI for the stock of outward FDI as a ratio of nominal GDP) to our expanded model in Table 3. We report only the estimates with MA error corrections.

Table 4 Encompassing Model Fixed Effect Estimator. Estimation with MA(5) errors.

Non-IV estimation			IV estimation					
			Full Model		Model 1		Model 2	
Variable	Estimate	t-stat.	Estimate	t-stat	Estimate	t-stat.	Estimate	t-stat.
INF	1.60E-05	1.63	1.94E-05	1.79				
INFVOL	6.48E-04*	5.12	6.89E-04*	4.96	7.18E-04*	5.71	5.47E-04*	3.05
TIME	9.13E-06	1.20	1.15E-05	1.68				
DS	2.99E-03	0.43	3.25E-03	0.49				
OPEN	-2.69E-03*	-3.50	-2.32E-03*	-3.19	-2.34E-03 *	-5.70	-2.0E-03*	-5.48
NW	-5.25E-04*	-2.77	-4.55E-04*	-2.63	-6.15E-04*	-5.60	-4.65E-04*	-3.53
FDI	-1.45E-03	-1.37	-1.19E-03	-1.22				
GA	5.99E-04*	2.80	4.62E-04*	2.40	5.50E-04*	3.07		
GL	-4.71E-04**	-2.27	-4.63E-04**	-2.45	-4.80E-04*	-2.70		

Non-IV estimation: Test of overindentifying restrictions (J-Test):chi^2(47)=46.44[.496].
IV estimation Full model: J-Test: chi^2(47) = 51.22 [.81],
IV estimation Model 1: J-Test: chi^2(65) = 50.32 [.91], LR Test: of deletions from full model chi^2(4) = 0.9 [0.92].
IV estimation Model 2: J-Test: chi^2(24) =28.92 [.22], LR Test: of deletions from Model 1 chi^2(2) =3.01[1.0].

In our encompassing regression in Column 1 the time trend and stock building remain insignificant. However, the pattern and significance of other variables is of interest. Inflation volatility appears to remain an important explanatory variable, whilst inflation is not significant. Openness remains significant and negative, suggesting that trade openness has a role to play in damping cycles with more open economies having less volatile output all else equal. Financial wealth appears to have a similar but less significant impact on volatility, suggesting that as liquidity constraints become less important output becomes more stable. However, the importance of wealth as a stabiliser at the macro level depends on the nature of shocks that the economy faces. If they are common to all individuals in the economy then wealth alone cannot act as a shock absorber unless a significant amount is held with non-residents. It is interesting to note that the larger are gross liabilities to other the smaller the volatility of output, suggesting that equity risk is shifted to others as liabilities increase. As the country faces solvency constraint gross assets and gross liabilities must grow approximately in line with each other. However, foreign assets pool risks from other countries, and our results indicate that a greater asset stock increases volatility as wealth changes for reasons external to the country in question. In particular an asset position makes a country vulnerable to asset price changes abroad, and form a major channel for the propagation of equity price shocks. Given that the coefficient on gross assets in this regression exceeds that of gross liabilities it is possible that increasing international portfolios increases output volatility across the major economies. However, some of the effects of holding foreign assets and liabilities will be reflected in the stabilising impact of net financial wealth, as some of the assets and liabilities are directly (and indirectly but transparently) held by the personal sector. The stock of FDI is not significant.

Although the wider explanation is pleasing, there remains the problem of the potential endogeneity of inflation volatility. If there is a policy regime change then we might expect that output volatility and inflation volatility would change in the same direction, with more volatile output being associated with more volatile inflation. Hence the unexplained change in output volatility would be potentially associated with the unexplained component of inflation volatility. In this situation the coefficient on inflation volatility in the output volatility regression is likely to be biased upward and look more significant. However, this will not always be the case, as some regime shifts, such as fixing the exchange rate or joining a monetary union, may reduce inflation volatility at the expense of greater output volatility. In either case the solution is to use an appropriate estimation technique. As our panel is static we can rely on panel IV within a GMM framework, where we specifically instrument inflation volatility with the lagged values of other regressors.

The pattern of results from Table 4, column 1, is generally maintained in column 2. Inflation volatility, openness, net wealth and gross assets and liabilities remain the only significant variables. The coefficient on inflation volatility rises marginally. Increased openness reduces output volatility, as does a greater stock of net financial wealth. The coefficients on assets and liabilities to foreigners are now equal and opposite in sign, suggesting that greater financial integration neither increases nor reduces volatility on average. There remains no significant role for inflation, stock building or FDI stocks, and the time trend is not significant.

The pattern of significance of the variables suggests that we can estimate a more parsimonious description of the data. Two reduced models were estimated, and are presented as Model 1 and Model 2 in Table 4. The first model follows directly from the estimation of Column 2, as it excludes the variables with insignificant coefficients. The second model includes only inflation volatility, openness and net wealth as gross assets and liabilities have approximately equal and opposite signs. All coefficients are significant and have the expected signs. Model 2 still allows a role for (household) net foreign assets in the reduction of output volatility, since NW includes some components of foreign gross assets and gross liabilities. The LR test of the validity of exclusion of inflation, FDI, Time and DS is accepted for model 1 and an analogous test for Model 2 is also accepted. Under the null, these tests are distributed as Chi^2(r) where *r* is the number of excluded variables[7].The tests of overidentifying restrictions are accepted in all cases, including for the reduced models.

We may take our most parsimonious model as a good representation of the factors affecting output volatility. They have varied over time, as has output volatility. We can summarise the relative importance of the factors for the UK and the US. A rise in openness of one percent of GDP would reduce UK output volatility by 5.8 per cent of its level in 2000, whilst a one percent reduction in the

[7] See Matyas (1999), Chapter 4. for details.

level of inflation volatility would reduce output volatility by 1.3 per cent of its level in 2000, and a one per cent of nominal income increase in net financial wealth would reduce output volatility by 1.3 per cent of its level in 2000. A rise in openness of one percent of GDP would reduce US output volatility by 2.2 per cent of its level in 2000, whilst a one percent reduction in the level of inflation volatility would reduce output volatility by 0.3 per cent of its level in 2000, and a one per cent of nominal income increase in net financial wealth would reduce output volatility by 0.5 per cent of its level in 2000.

Table 5. Impact of changes in openness, inflation volatility and household wealth on output volatility

	UK		US	
	80-70	***90-80***	***80-70***	***90-80***
Open	0.0081	0.0088	-0.2092	-0.0705
Infvol	-0.2093	-0.0433	0.0192	-0.0375
NW	-0.1412	-0.1901	0.0023	-0.1041

Note Impact of change in decade average value of independent variables

We can also use the same model to assess the relative contributions to the reduction in inflation volatility on a decade by decade basis. In Table 5 we give the contribution to the fall explained by the change in the average values of our indicators in the 1980s as compared to the 1970s (and 1990s as compared to1980s). Openness changes in the US made significant impacts on the level of output volatility in both the 1980s and 1990s whilst the increase in net wealth in the 1990s helped reduce output volatility. In the UK the reduction in inflation volatility in the 1980s was the main factor reducing output volatility, whilst in the 1990s increasing levels of net wealth wee more important. Clearly all three factors play an important role, but their importance varies from country to country and across time.

4.Conclusion

It is widely reported that output volatility has been declining in the last few decades, and a number of explanations have been offered. Three separate candidates have been discussed, with changes in policy regime taking precedence over improved stockholding as determinants of output volatility, whilst increased international integration has largely been disregarded as an explanation. We investigate output volatility in the G7 in a panel context treating these as competing explanations rather than as alternatives to be considered one at a time. We show that an encompassing panel has a significant role for both net financial wealth and openness to trade as factors stabilizing output volatility. The policy regime as indicated by inflation volatility does appear to continue to play a role even when we recognize its potential endogeneity and use appropriate econometric techniques. However, its importance clearly varies over time and across countries, and it appears less important as an explanation of declining volatility in the US than it does in the UK.

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