Assessing the Sources of Changes in the Volatility of Real Growth

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In much of the world, growth is more stable than it once was. Looking at a sample of twenty-nine countries, we find that in seventeen, real GDP growth is less volatile today than it was twenty years ago. And these declines are large, averaging more than fifty percent. Why is real growth more stable than it was in the 1970s and early 1980s? We survey the evidence competing explanations and find support for the view that improved inventory management policies, coupled with financial innovation, adopting an inflation targeting scheme and increased central bank independence have all been associated with more stable real growth. Furthermore, we find evidence suggesting that increased commercial openness has come along with increased output volatility.

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1. Introduction

Today the world appears to be a much calmer place than it was a quarter century ago. At the beginning of the 1980s, nearly two-thirds of the countries in the world were experiencing inflation in excess of 10 percent per year. Today, it is one in six. Growth has risen as well. Two decades ago nearly one country in three was contracting. Today, five in six countries are growing at a rate in excess of 2 percent per year.[1] But this isn't the end of the story. Not only is inflation lower and output higher, they both appear to be more stable. The question is why.

Declines in the level and volatility of inflation are not that much of a mystery. The answer is almost surely better policy. Substantial changes in the operational framework of central banks over the past few decades have produced better inflation outcomes. Increased independence, as well as improved accountability and transparency have all played a role.[2] In an early paper, we find that improved monetary policy has been the driving force behind the improved economic performance of the past decade.[3] But there we focus on weighted averages of output and inflation variability; and usually on cases in which inflation variability has a relatively high weight. Concluding that low and stable inflation is a consequence of better monetary policy is, therefore, not a big surprise.

In this paper we move to an examination of the output volatility alone. Using techniques pioneered by McConnell and Perez Quiros (2000) in their study of U.S. GDP, we confirm the basic finding that the volatility of output growth has declined.[4] In fact, it has fallen in 17 of the 28 countries we study – it is unchanged in 8 and rose in 3. And on average, for the countries in which it fell, the standard deviation of innovations to output growth is cut in half. But, as we will discuss in more detail, the timing of the volatility declines is far from synchronized.

[1] All of these numbers are computed from the International Monetary Fund's World Economic Outlook database.
[2] For a detailed discussion of these issues see Cecchetti and Krause (2001 and 2002).
[3] See Cecchetti, Flores-Lagunes, and Krause (forthcoming).
[4] For the U.S., the fact that volatility of GDP growth fell in 1984 has been confirmed by virtually everyone who has looked at the data. See, for example, Nelson and Kim (1999), Stock and Watson (2002), and Ahmed, Levin and Wilson (2002);

Documenting the fact that the world has become more stable is only the first step. We go on to survey various possible explanations. There are five major ones:

(1) Improved inventory management policies cited by McConnell, Mosser, and Perez Quiros (1999), McConnell and Perez Quiros (2000), Kahn, McConnell, and Perez Quiros (2002), and McConnell and Kahn (2005);

(2) Better monetary policy as discussed in Clarida, Galí and Gertler (2000), as well as our previous work;

(3) Financial innovation and improvements in risk sharing, as discussed in Dynan, Elmendorf and Sichel (2005);

(4) Increased international commercial openness, as suggested in Barrell and Gottschalk (2004).

(5) Luck in the form of smaller shocks, the answer given by both Ahmed, Levin and Wilson (2002); and Stock and Watson (2002);

Additional explanations include the possibility that the change in the composition of output, away from more volatile manufacturing and toward more stable services; and that the reduced volatility is a consequence of changes in the methods used to construct the data.

The evidence is broadly consistent with improved inventory policy accounting for some portion of the decline in 12 of the 14 countries where we have the appropriate data. The better monetary policy hypothesis fares substantially worse, accounting for declines in output volatility in 10 of the 24 countries for which we have results. This is unsurprising given the fact that monetary policy faces a tradeoff between inflation and output volatility, and that in the past two decades we have witnessed a dramatic shift toward keeping inflation low and stable.

While we have something to say about the implications of increased openness, our focus is primarily on the likely impact of financial innovation. To foreshadow our conclusions, we find that the volatility of output is moves along with a structure of a country's financial system and the independence of its central bank. Volatility fell by more in countries where credit became more available. Furthermore, we find that more commercial openness, as measured by the ratio of imports plus exports to GDP, is negatively correlated with volatility across countries.

The remainder of the paper is divided into four parts. In Section 2 we outline the econometric testing procedures used to identify breaks in the volatility of output growth, and then report the results for both the timing and size of the changes in volatility. Section 3 presents a discussion of the numerous candidate explanations for the changes in output volatility, and Section 4 presents the second stage of our empirical analysis where we present evidence in an attempt to distinguish them. Section 5 summarizes our conclusions. Unfortunately, our analysis is sufficiently crude that we are only able to establish a set of correlations that are suggestive of which way to go next.

2. Identifying and Estimating the Changing Volatility of Growth

We begin our analysis by looking for structural breaks in the volatility of GDP growth. We do this in a series of steps. First, we estimate an equation of the form

(1) $\Delta y_t = \mu + \rho \Delta y_{t-1} + \varepsilon_t$

where y_t is the log of GDP or the price level, Δ indicates the first time difference, μ is a constant, ρ is a parameter representing the persistence of GDP growth, and ε is an innovation that is independent over time, but need not be identically distributed. Equation (1) is estimated allowing for breaks in the persistence of output growth.[5]

The result of this first step is a series of estimated residuals, $\hat{\varepsilon}_t$. As noted by McConnell and Perez Quiros (2000), the transformed residuals, $\sqrt{\frac{\pi}{2}} | \hat{\varepsilon}_t |$, are unbiased estimators of the standard deviation of ε_t. Using these, we proceed to the second step, which is to search for breaks an equation of the following form:

(2) $\sqrt{\frac{\pi}{2}} | \hat{\varepsilon}_t | = \alpha + u_t.$

That is, we look for breaks in the mean (α) of scaled absolute value of the estimated residuals from the simple regression (1), after allowing for the possibility of structural breaks in μ and ρ.

[5] Our primary results use the first-difference of data deviations of log GDP from its HP-filtered trend. This is exactly analogous to removing a time-varying mean.

(The details of the econometric procedures, which require a number of decisions, are described in a technical appendix.)

Table 2.1: Timing of Breaks in Persistence and Volatility of GDP Growth

	Persistence		Volatility	
Country	**1st Break**	**2nd Break**	**1st Break**	**2nd Break**
Australia	1981Q3***		1984Q3***	
Austria	none		1988Q1***	
Belgium	1980Q1***		none	
Canada	1980Q4*		1987Q2***	
Chile	none		none	
Denmark	1976Q3***		1975Q3**	1994Q3**
Finland	none		none	
France	none		none	
Germany	none		1993Q3***	
Greece	none		1991Q1***	
Ireland	1997Q2***		1998Q4***	
Israel	none		1985Q2**	
Italy	1979Q4**		1983Q3***	
Japan	none		none	
South Korea	1992Q2*		1980Q3**	
Mexico	1984Q1***	1995Q1***	1980Q1***	
Netherlands	1978Q4***		1978Q3**	1983Q4**
New Zealand	none		1975Q3*	1987Q3***
Norway	none		none	
Peru	1990Q2*		1989Q3**	
Philippines	none		1988Q4***	1994Q1***
Portugal	1995Q1***		none	
South Africa	1976Q4***		1986Q3***	1996Q3*
Spain	1980Q2***	1992Q2**	1985Q2***	1993Q2***
Sweden	1992Q2***		1984Q3***	1993Q1***
Switzerland	1982Q3***		none	
United Kingdom	none		1981Q2***	1991Q4***
United States	none		1984Q2***	

Source: Breaks are estimated using the first-difference of deviations of log GDP from an HP-filtered trend, conditional on possible breaks in persistence. See the Appendix for details. All sample periods end in 2003Q4. Sample period begins in 1970 for all countries except Chile (1980), Israel (1980), Peru (1980), and Philippines (1981).

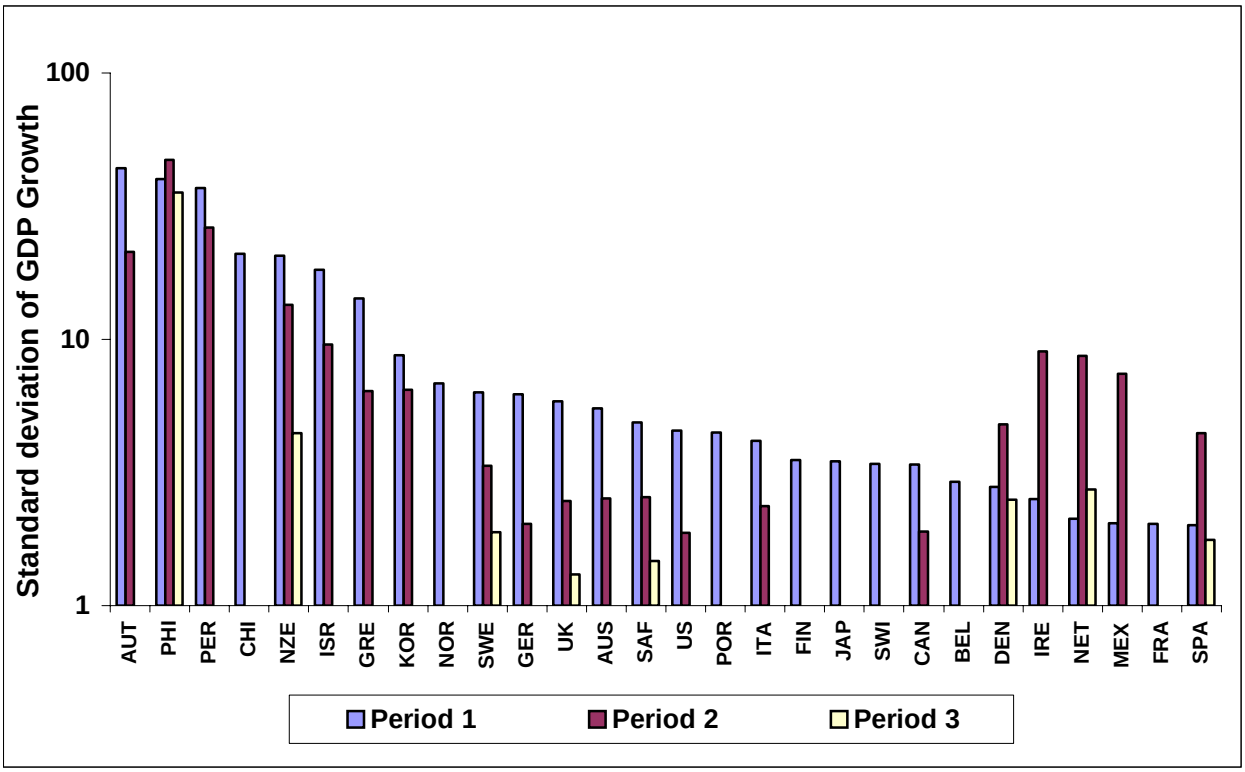
***: Significant at the 1% level
**: Significant at the 5% level
*: Significant at the 10% level

We examine shifts in the volatility of growth in 28 countries. Briefly, we begin by taking first-difference of deviations of the log of GDP from and HP-filtered trend, then look for breaks in persistence, and conditional on those search from breaks in volatility. Where available, we use quarterly data starting in 1970.[6] The results for this exercise are reported in Table 2.1. First, note that we identify at least one break in persistence for 16 of the 28 countries, with 2 breaks for two countries. We then find at least one break in volatility in all but eight countries (Belgium, Chile, Finland, France, Japan, Norway, Portugal and Switzerland), and two breaks in eight of the 28 countries we study (Denmark, Netherlands, New Zealand, Philippines, South Africa, Spain, Sweden and the U.K.). We allow for as many as five breaks, but in no country do we find more than two. While our dating of the breaks suggests that persistence and volatility often change simultaneously within a country, they are not synchronized across countries. Of the total of 28 breaks in volatility that we identify, 3 are in the 1970s, 16 are in the 1980, and another 9 are in the 1990s.[7]

Figure 2.1 plots the changes in the volatility of output before and after the estimated break dates. For countries for which we identified a single break, in all but two cases, Mexico and Ireland, volatility declined. In four of the countries for which we identified two breaks (New Zealand, Sweden, the UK and South Africa) there was a steady decline in output volatility, while the remaining four experienced an increase in volatility after the first break, and then a reduction in the period following the second break. Only the Netherlands (and Ireland and Mexico, as just noted) experienced an increase in the standard deviation of growth in the last period as compared to the first. The declines for all other 25 countries range from just over 10% for the Philippines to almost 80% for New Zealand (combining the 2 breaks). The average decline from the beginning to the end of each country's sample is close to 50%. In other words, these are not small numbers.

[6] Our results are robust to the use of unfiltered GDP growth, assuming that we allow for breaks in the mean growth rate, μ in equation (1), before testing for breaks in persistence.
[7] Our results confirm the findings of Smith and Summers (2002), who study Australia, Canada, Germany, Japan and the U.K.

Figure 2.1: Output Volatility before and after Estimated Structural Breaks



Estimated standard deviation of the real output growth (measured as deviations from HP filtered trend) before and after estimated break dates, conditional on breaks in persistence.

3. Explaining the Decline in the Volatility of Growth

Previous authors have delineated five possible explanations for the observed decline in output volatility. These include shifts to just-in-time inventory control methods, improvements in monetary policy, financial innovation, increases in openness to international trade, and luck. We summarize each of these, together with a discussion of some of the evidence drawn from the U.S. case. In the next section we explore the possible explanations for the cross-country declines in volatility documented in the previous section.

Before getting started, there are two hypotheses that we do not investigate or discuss: That the change in the variability of growth is a result of changes in fiscal policy and that it is a change in data construction techniques. Both of these have been dismissed in the U.S. case (see the appendix to Dynan, Elmendorf, and Sichel (2005) for a summary). Data construction techniques

have not changed all that markedly in the past 30 years and there is little evidence that the stabilizing ability of fiscal policy has improved.[8] This still leaves a set of five possible explanations.

3.1 Changes in Inventory Control Policies

While inventory changes accounts for a very small portion of GDP, averaging about ½% and rarely exceeding 1%, and account for virtually none of trend growth. Even so, changes in private inventories account for something like 20% of the volatility in quarterly GDP growth. From 1959 to 2003 the standard deviation of quarterly U.S. total GDP growth, measured at a quarterly rate, was approximately 1 percentage point. Exclusive of inventory changes, the standard deviation of quarterly growth falls to 0.8 percentage points.

Given the importance of inventories in aggregate fluctuations, changes in inventory management policies could easily have an impact on the volatility of GDP. Improvements in technology that allow flexible production, smaller batch sizes, better monitoring of real-time sales, and the like have created substantial opportunities for such improvements. Today, an automobile assembly plant keeps only a few hours worth of parts on hand; the rest are in transit to the factory, timed to arrive at just the right moment. Similarly, a supermarket or superstore like Wal-Mart or Target will hold only one to two days' supply of most products. The result is a great deal of flexibility in responding to changes in demand and sales.[9]

McConnell and Perez Quiros (2000), Kahn, McConnell and Perez Quiros (2002), and Kahn and McConnell (2005) marshal evidence in support of the view that changes in inventory management policies are the source of output's increased stability. They begin by noting that the volatility of output growth in the durable goods sector has fallen dramatically, and go on to note

[8] We note, but do not investigate, the possibility that fiscal consolidations had an impact on the financial system leaving it freer to accommodate private credit needs.

[9] Recent press reports suggest that these large retailers have gone even further, no longer holding their store inventories on their own books. For example, a tube of Procter and Gamble produced toothpaste on a Wal-mart store shelf will be on Procter and Gamble's books until it is sold to the final consumer. Only when they are sold, does Wal-mart actually pay for the items that are in their stores. This change in accounting has the potential to drive reported retail inventories to very low levels, as well as reducing the volatility of measured inventories.

that the variance of final sales growth did not. McConnell and coauthors go on to show that inventory levels have fallen noticeably, and that the decline was most pronounced in the mid-1980s.[10] And this is clearly consistent with the results in Table 3.1. The data show that the standard deviation of quarterly real GDP growth (measured at a quarterly rate) dropped from 1.09 to 0.53, or 0.56 percentage points. Meanwhile, the standard deviation of GDP growth excluding inventories fell by 0.32 percentage points. This clearly suggests that changes in inventory behavior accounted for a substantial fraction of the decline.

Table 3.1: Standard Deviation of Real Growth and Growth Contributions, Quarterly at Quarterly Rates

	1959-1983	1984-2003	Decline
Gross domestic product	**1.09**	**0.53**	**0.56**
Consumption			
Durable goods	0.29	0.24	0.05
Nondurable goods	0.20	0.12	0.08
Services	0.14	0.13	0.01
Investment			
Nonresidential	0.27	0.24	0.04
Residential	0.28	0.10	0.17
Change in private inventories	0.76	0.44	0.32
Net exports	0.33	0.24	0.09
Government			
Federal	0.25	0.15	0.10
State & Local	0.12	0.07	0.05

Standard deviation of quarterly real GDP and its components, seasonally adjusted at quarterly rates. Real data are constructed by splicing chained 1952, 1972, 1982 and 2000 series, component by component, Table 1.1.6, 1.1.6B, 1.1.6C, and 1.1.6D; all data are from www.bea.gov/bea/dn/home/gdp.htm.

Cross-country comparisons point in the same direction. Table 3.2 reports the change in the GDP volatility and the change in the volatility of the growth contribution attributable to inventory accumulation for a subset of fourteen countries in our sample.[11] In all but two cases, Ireland and

[10] Ramey and Vine (2004b) take issue with the inventory-sales ratio evidence used by Kahn, McConnell, and Perez-Quiros (2002), noting that the drop seen in the nominal data are not mirrored in the real data. That is, when looking at the ratio of real, deflated, inventories to real sales, the drop emphasized by Kahn et. al is no longer apparent.
[11] We reports results for all countries that both exhibit at least one break in volatility and for which the OECD reports inventory data.

Mexico, the decline in the standard deviation of the growth contribution of the changing in inventories is large. Furthermore, it is usually a substantial fraction of the overall decline in volatility growth. The average of the ratio for the countries of the two differences is more than 40%.

Table 3.2 The Changing Volatility of Inventory Accumulation

Country	Beginning of Sample	Break Date	Standard Deviation of Quarterly GDP Growth at Quarterly Rate			Standard Deviation of Growth Contribution from Inventories Accumulation		
			First Subperiod	Second Subperiod	Difference	First Subperiod	Second Subperiod	Difference
Australia[+]	1974Q3	1984Q2	1.36	0.68	0.68	0.93	0.73	0.21
Canada[*]	1979Q1	1987Q3	1.05	0.64	0.41	0.78	0.59	0.18
Denmark[*]	1975Q3	1994Q3	1.25	0.67	0.57	1.49	0.96	0.53
Germany	1970Q1	1993Q3	1.78	0.56	1.22	0.73	0.48	0.25
Ireland	1970Q1	1998Q4	0.86	2.44	-1.58	0.72	1.31	-0.59
Italy	1970Q1	1983Q3	1.09	0.64	0.45	1.06	0.86	0.20
Korea	1970Q1	1980Q3	2.39	1.69	0.70	1.38	0.88	0.50
Mexico	1970Q1	1980Q1	0.60	1.92	-1.31	0.43	0.96	-0.52
Netherlands[*]	1978Q3	1983Q4	2.20	0.74	1.46	1.63	0.95	0.69
New Zealand[*]	1975Q3	1988Q3	3.39	1.21	2.18	1.72	1.04	0.68
Spain[*]	1985Q2	1993Q2	1.24	0.46	0.77	1.16	0.88	0.28
Sweden[*]	1984Q3	1993Q1	0.95	0.43	0.52	0.92	0.81	0.11
United Kingdom[*]	1981Q2	1991Q4	0.73	0.36	0.37	0.81	0.49	0.32
United States	1970Q1	1984Q2	1.20	0.51	0.69	0.55	0.37	0.18

[+]Australia inventory data begins in 1974Q3.
*In each of these seven countries there were two breaks in the volatility of GDP. For these countries, the dates reported in the column labeled "Beginning of Sample" reports the dates of the first or second break. The "First Subperiod" of the standard deviation of GDP growth" and the analogous column for inventory accumulation are computed for the data between the first and second break dates.
Source: OECD Economic Outlook No. 76, December 2004. Changes in inventories are the series labeled "Stockbuilding". Real GDP is volume data at market prices. All data are real, seasonally adjusted. Break dates are determined by the procedure described in the text, using the first difference of the HP-filtered log of GDP, starting in 1970.

The natural interpretation of these results has a potential flaw arising from the possibility that the increased stability of inventories could be a consequence of more stable demand. When demand is stable, firms see less reason to hold inventories. With smaller shocks overall, everything will be smoother.[12] This argument is the centerpiece of the work of Herrera and Pesavento (forthcoming), who find that reduced volatility is shared by both inventories and shipments. But

[12] For a discussion see Ramey and Vines (2004a).

their use of shipments rather than final sales data (which do not exist at the disaggregated levels they wish to study) makes their results less convincing.

3.2 Better Monetary Policy

The second candidate explanation for the decreased volatility of output growth is that it is a result of improved monetary policy. Beginning in the mid-1980s, the structure of central banks changed in many parts of the world. There was an increase in independence and transparency, as well as a new-found commitment to low, stable inflation. And, as central bankers often emphasize, price stability is the foundation for high growth. Inflation is bad for growth.

Today economists have a much better understanding of how to implement monetary policy than they did as recently as twenty years ago. To succeed in keeping inflation low and stable while at the same time keeping real growth high and stable, central bankers must focus on raising interest rates when inflation goes up and lowering them when inflation goes down.

There are several pieces of evidence supporting the view that improved macroeconomic outcome can be traced to better monetary policy. For the case of the U.S., Clarida, Galí and Gertler (2000) show that the actions of the 1970s implied a policy reaction curve, or Taylor rule, in which inflation increases were met with insufficiently aggressive nominal interest rate increases. Under Chairman Arthur Burns, when inflation went up, the Federal Reserve increased their policy-controlled interest rate by less than one for one, so the real interest rate went down. The result was instability – instability both in inflation and output growth.

In an earlier paper, Cecchetti, Flores-Lagunes and Krause (forthcoming), we develop a method for measuring the contribution of improved monetary policy to observed changes in macroeconomic performance and then use it to explain the observed increase in macroeconomic stability in a cross-section of countries. Our technique involves examining changes in the variability of inflation and output over time. We estimate a simple macroeconomic model of inflation and output for each of 24 countries, and use it to construct an output-inflation variability efficiency frontier. Specifically, for each country we specify the dynamics of inflation and output

as a function of the interest rate – our measure of the central bank policy instrument – and some additional exogenous variables. Using the estimated model, we are able to compute the output-inflation variability frontier describing the best possible outcomes that a policymaker can hope to

Table 3.3: Monetary Policy and Improved Economic Performance

Country	Output volatility (actual)			Output volatility (optimal)			Proportion of Improved Performance due to Better Policy
	1983-90	1991-98	Change	1983-90	1991-98	Change	
Australia	5.49	2.21	3.28	2.19	0.53	1.66	0.49
Austria	5.41	8.80	-3.39	0.51	2.03	-1.52	-0.55
Belgium	4.05	6.19	-2.14	1.63	2.48	-0.85	-0.60
Canada	8.20	5.76	2.44	2.12	0.56	1.56	0.36
Chile	68.29	14.02	54.27	26.27	3.38	22.90	0.58
Denmark	7.53	7.19	0.34	3.87	3.11	0.75	-1.23
Finland	5.69	11.94	-6.25	1.46	1.52	-0.06	-0.99
France	2.62	4.31	-1.69	0.61	1.75	-1.14	-0.33
Germany	3.99	6.82	-2.83	1.51	1.05	0.46	-1.16
Greece	5.47	1.99	3.48	3.34	1.13	2.21	0.36
Ireland	12.90	8.34	4.56	3.85	4.07	-0.22	1.05
Israel	9.20	4.49	4.71	3.56	1.14	2.42	0.49
Italy	3.29	5.34	-2.06	1.77	0.41	1.35	-1.66
Japan	14.80	9.08	5.73	0.82	1.94	-1.12	1.20
Korea	21.83	16.53	5.30	8.46	4.69	3.77	0.29
Mexico	9.20	16.11	-6.91	3.97	2.94	1.03	-1.15
Netherlands	4.38	3.23	1.15	2.37	1.09	1.28	-0.12
New Zealand	13.83	10.92	2.91	6.31	2.38	3.94	-0.35
Portugal	7.89	16.97	-9.08	3.72	3.22	0.50	-1.06
Spain	3.03	8.54	-5.52	1.90	0.84	1.06	-1.19
Sweden	5.69	12.73	-7.04	4.07	3.25	0.82	-1.12
Switzerland	10.15	4.98	5.17	5.09	2.94	2.15	0.58
U.K.	3.64	2.90	0.74	1.38	0.38	1.00	-0.36
U.S.	4.10	1.75	2.35	1.24	0.17	1.07	0.54

Source: Computed using techniques described in Cecchetti, Flores-Lagunes, and Krause (forthcoming). Actual output volatility is computed from standard deviation of the growth in deviations of log industrial production for an HP-filtered trend. Column labeled "Proportion of Improved Performance due to Better Policy" is the ratio of the (Change in the Actual – Change in the optimal) divided by the Change in the Actual.

achieve. Movements toward this frontier are interpreted as improvements in monetary policy efficiency. Our estimates suggest that improved monetary policy has played a stabilizing role in 21 of the 24 countries. Seventeen countries experienced reduced supply shock variability, but overall this had a modest impact on performance.

Table 3.3 is derived from the results in that paper. The columns labeled "Output volatility (actual)" report the observed change in the volatility of output growth (measured using industrial production) from the 1980s to the 1990s. Output volatility fell, so these are positive, in 14 of the 24 cases. Next, in the columns labeled "Output volatility (optimal)," the table reports the minimum attainable variance of output computed from an estimated structural model. This is the best performance that could have obtained if policymakers focused all of their attention on output stabilization (and none on inflation stabilization). In all but six of these cases, the best attainable outcome was lower output volatility so innovation variances fell – there was some "good luck." The difference between these two – the change in actual minus the change in optimal output volatility – is a measure of policy effectiveness. We do not report this difference to simplify the table presentation.. And the final column shows the proportion of the volatility change that can be attributed to policy; a negative number here implies that policy contributed to an *increase* in output volatility.

Overall, the results suggest that policy was a stabilizing force in only 10 of the 24 countries. In the remaining 14, the contribution of policy is to increase the volatility of output. This should come as no surprise since, as we show in our other paper, the primary impact of policy during this period was to stabilize inflation. By focusing on inflation stability, policymakers moved along an output-inflation volatility frontier and made output more volatile, not less.

It is worth emphasizing that it is likely to be very difficult to distinguish better policy decisions from a better institutional environment, regardless of the actual macroeconomic outcomes. As two of us discuss in Cecchetti and Krause (2001), the acumen of policymakers is irrelevant if they are operating in an institutional environment in which monetary policy is ineffective. There are a number of examples of changes that improve the ability of policymakers' actions to influence inflation and output. The traditional ones include the degree of a central bank's

political independence and the implementation of explicit inflation targeting regimes. As noted by Krause and Méndez (2005), these sorts of institutional changes, as well as membership in the European Monetary Union, as associated with higher relative preference for inflation stability. For a country operating on its inflation-output variability frontier, this could lead to an increase in output volatility.[13]

Changes in financial structure can also influence the efficacy of monetary policy. For example, movements away from a government controlled banking system can result in improved macroeconomic outcomes that are likely indistinguishable from those that come from improved policymaking itself. With that in mind, we now turn to a discussion of changes in the financial system.

3.3 Financial Innovation

Dynan, Elmendorf, and Sichel (2005) provide a detailed study of whether the decline in the volatility of U.S. GDP growth can be traced to the financial innovations of the 1980s. These include the development of active secondary markets for loans, the increased popularity of junk bonds, the phasing out of deposit interest-rate controls, regulatory changes aimed at creating access to credit for low-income households, and the eventual elimination of the prohibition on interstate banks.

Two examples are instructive. First, there is the case of home mortgages. Prior to the mid-1980s, households wishing to borrow for the purpose of purchasing a home had to obtain financing from a local financial intermediary. This meant that they were reliant on the ability of bankers to obtain sufficient deposit liabilities to provide the needed loan. If funds were plentiful in one local, but scarce in another, there was no way for the funding to flow to where it was needed. The creation of asset-backed securities changed all of this.

[13] Cecchetti and Ehrmann (2002) find modest evidence that inflation targeting countries experience slightly higher output volatility than non-inflation targeting countries.

In 1970, Government National Mortgage Association (GNMA) issued the mortgage-backed securities. These were pass-through securities composed of government guaranteed mortgages. (FNMA) mortgage-backed securities backed by private insurance in 1981. Because of prepayment uncertainties, these initial asset-backed securities had durations that could not be computed with confidence. The real innovation came in 1983 when Federal Home Loan Mortgage Corporation (FHLMC) issued the first tranched collateralized mortgage obligations (CMOs). CMOs divided the pool of mortgages into maturity categories based on when they are prepaid, and reduced the prepayment risk. The result is a very liquid mortgage market. McCarthy and Peach (2002) provide a detailed discussion of these changes to the U.S. mortgage market, and find that it has slowed the response of residential fixed investment to changes in monetary policy.

Today, mortgages are just the tip of the asset-backed security iceberg. With the exception of certain types of small-business loans, virtually every type of credit is securitized. This includes credit-card debt, student loans, and auto loans. The last provide another interesting example. In early 2005 the business news reported the downgrading of U.S. auto manufacturers. For example, Moody's and Standard and Poor's lowered General Motors long-term credit rating to the lowest investment grade level. At the same time, asset-backed auto loan debt was receiving triple-A ratings. The default rate on auto loans is predictable, so pools have very little uncertainty in them.

All of this has come along with a dramatic increase in the use of debt by both households and businesses. Individuals can better smooth consumption in the face of short-term income variation, while firms can invest more steadily even when faced with transitory revenue fluctuations.[14] Overall, risk is able to flow those best able to bear it, thereby increasing the efficiency of the economy as a whole.

[14] Campbell and Hercowitz (2005) link the reduced volatility of output to the increase in household borrowing resulting from the relaxation of collateral constraints in the 1980s. The point to increases in the availability of home equity loans as a potentially important source of individual's ability to smooth consumption in the face of income volatility.

The improved ability of financial markets to efficiently distribute risk is consistent with Comin and Philippon's (2005) observation that firm level volatility has risen even as aggregate volatility has fallen. In a world with poorly functioning financial markets, high transactions costs make it costly for investors to obtain diversified portfolios. As a result, they will push firms to diversify internally, creating large conglomerates like General Electric. GE produces everything from light bulbs to power generating plants to jet engines to financial services. Diversification of this sort clearly reduces the risk of the enterprise as a whole. This is clearly good for the managers of GE. And if financial transaction costs high, it is good for investors, too. But as financial markets become deeper and more liquid, investors will prefer to choose their own portfolio weights on the different sectors, and there will be a push toward smaller firms with more volatility. But at the same time, aggregate volatility will fall.

Figure 3.1: Household Debt and the Volatility of U.S. Consumption

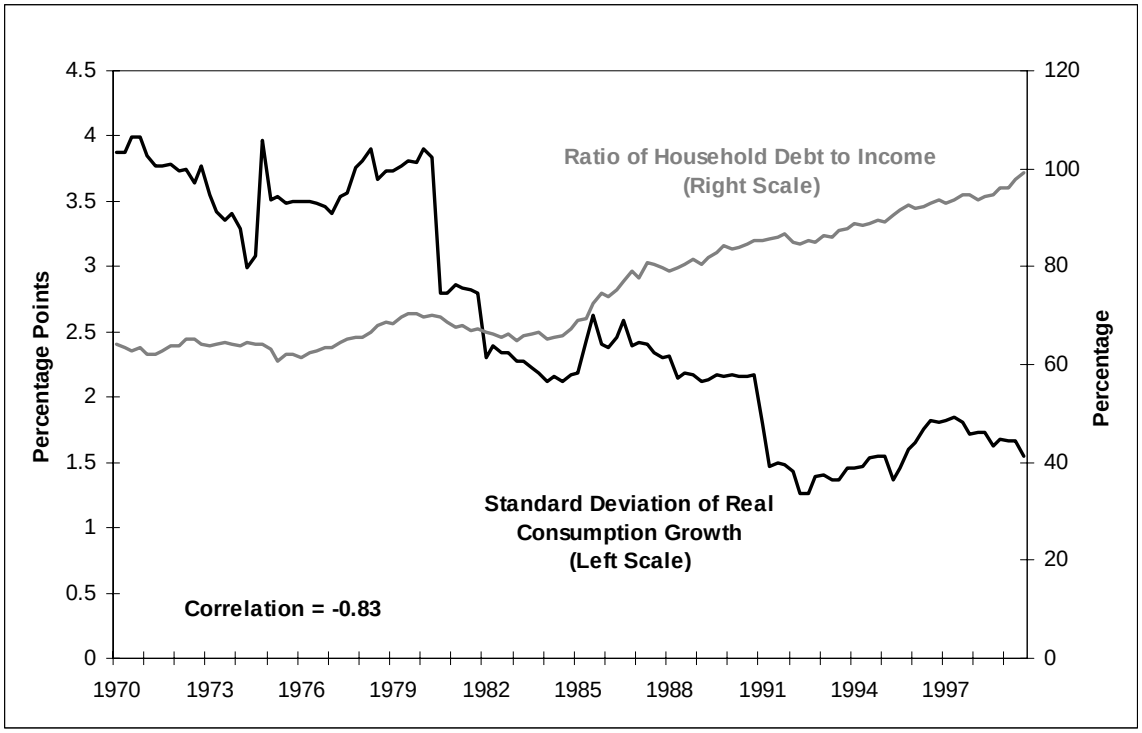


Figure plots the ratio of average total household debt, including mortgages and consumer credit, to personal income (gray line) and the standard deviation of quarterly real consumption growth at an annual rate over the next five years (black) line).

Sources: Flow of Funds Accounts from the Board of Governors of the Federal Reserve System and Bureau of Economic Analysis of the Department of Commerce.

Returning to the case of households, Figure 3.1 provides some evidence that debt has improved the ability of households to smooth consumption in the face of income shocks. The figure plots the ratio of total American household debt to personal income (the gray line on the right-hand scale) together with the rolling five year lagging standard deviation of consumption growth (the black line on the left-hand scale). These two series have a remarkably high negative correlation of -0.83! And the impact is large. A bivariate regression shows that a 10 percentage point increase in household debt to income forecasts a reduction of 0.8 percentage points in the standard deviation of consumption growth over the following five years. (The R-squared of this regression is nearly 0.7.) While we make no attempt to prove that increased debt has *caused* consumption to be smoother, we note that many of the legal and regulatory changes that allowed financial innovations to occur during the late 1980s and 1990s seem independent of consumption growth.

3.4 International Openness

Over the last half of the twentieth century trade barriers were reduces or eliminated worldwide. The result has been a dramatic increase in the amount of cross-border trade in goods and services. In the U.S., for example, the ratio of imports plus exports to GDP has risen from just over 10 percent in 1970 to 26% today. Something similar has happened worldwide, with this measure of openness from 23% in 1970 to 54% in 2004.[15] With moves like the elimination of the multi-fiber agreement at the beginning of 2005, we can expect this trend to continue. And more trade has brought with it increased financial transactions as well. Current and capital account flows have both risen.

More commercial and financial openness can affect aggregate volatility a number of ways. First, it provides an opportunity for international risk sharing – both purely financial and real. On the financial side, in the same way that mortgage financing in the U.S. doesn't have to come from the geographic home of the borrower, now financing can come from outside a country.[16] Households, firms, and governments in one country now have access to funds from elsewhere in

[15] These are the IMF World Economic Outlook Aggregates.
[16] In their study of 24 OECD countries, Buch, Döpke, and Pierdzioch (2002) find that business cycles are less pronounced in countries with more open financial markets.

the world. In the same way, demand for real goods and services comes both from inside and outside a country. As the importance of trade flows increases, fluctuations in domestic aggregate demand become less important for domestic production.

A second mechanism by which openness can lower volatility is by allowing developed countries to send their more volatile industries off shore. A developed country that is able to push its volatile manufacturing sector into the less-developed world will have a more stable domestic economy. Unfortunately, this seems unlikely to explanation doesn't look like it works well. The shift from goods to services in the U.S. accounts for virtually none of the fall in the volatility of real growth.

These arguments also imply that larger countries could be more stable just because they are better diversified. For smaller and more open economies, things may not work out so well. The economic structure of small countries is more likely to be concentrated in a few industries, making it more susceptible to certain shocks. The result could be more, not less volatility. Emerging market countries that are more open are more exposed to the impact of shocks arising from events like the Asian crisis of 1997. In the end, commercial openness could either raise or lower output volatility.

3.5 Smaller Shocks

A number of authors conclude that improved macroeconomic performance, especially in the U.S., is a consequence of smaller shocks. Ahmed, Levin, and Wilson (2002) and Stock and Watson (2002) provide the most detailed arguments for this case. Their results are based on the following logic. Any stochastic model of the economy can be thought of as combining some shocks with a propagation mechanism. If output volatility has declined it is either a consequence of a change in the shock process or a change in the propagation mechanism. Both sets of authors are unable to find changes in the later, so they ascribe the observed stabilization of the real economy to the former.[17]

[17] Ahmed, Levin and Wilson reach their conclusion by noting that output can be written as an infinite order moving average. The MA coefficients in this Wold representation correspond to a reduced form for coefficients in the

There are a number of issues that arise in evaluating the case for luck. First, there is casual empirical evidence. It is difficult to argue that the stability of the 1990s was mere good fortune. Surely, the decade was not a calm one for the financial markets. Major economic crises occurred in Latin America and Asia, and Long-Term Capital Management nearly collapsed, paralyzing the bond markets. Raw materials prices fluctuated wildly. The price of oil spiked at more than $35 a barrel late in 1990, then plunged below $12 a barrel at the end of 1998 before beginning a steady rise to $30 a barrel by the beginning of 2000.

Second, the observation that the shocks hitting the economy have been effectively smaller is completely consistent with the view that stabilization has been a consequence of improved monetary policy. One possibility, and the one consistent with the previous discussion, is that central bankers have both created smaller shocks of their own and succeeded in neutralizing the shocks that they have seen. The Clarida, Galí and Gertler result is clearly of the first type. Their finding that policymakers engaged in destabilizing behavior is consistent with the idea that central bankers were exacerbating rather than ameliorating shocks. In standard econometric analyses these will show up as the "monetary policy shocks" as identified from residuals in structural models.

Finally, Kahn and McConnell (2005) show that improved inventory control policies are also consistent with the finding of smaller shocks. The intuition of their result is the same as the one for monetary policy. Economic agents are doing a combination of neutralizing external shocks and making smaller mistakes. Again, the result is stability.

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transmission mechanism, and the innovations are simply the white noise shocks hitting the economy. Ahmed, et. al show that the primary source of stabilization is the reduction in the shocks. This result is also consistent with the work of Arias and Ohanian (2004), who suggest that the reduced volatility arises from smaller variance of real shocks.

4. Financial Development, Trade Openness, Central Bank Structure, and the Volatility Decline

In the previous section, we focused on possible explanations for the volatility decline in the U.S. The next step is to examine evidence for the panel of 28 countries. Is it possible to explain both the dispersion in the level of volatility real growth across countries as well as the change within countries? To see, we look at the correlation of estimates of the standard deviation of real GDP growth derived with measures of central bank structure, financial development, commercial openness, and the absolute size of country.

To assess the sources of changes in output volatility we use a country-specific fixed effects model, with the periods separated by the estimated structural breaks. So, for a given country we regress the difference in standard deviation of real growth (measured as deviations from the HP-filtered trend), before and after the estimated break date, on the change in the right-hand-side variables computed by the same break date. In order to avoid problems associated with extreme values (see Figure 2.1), we take the log of the standard deviation of output innovations.

Table 4.1: Possible Explanations for Variation in the Volatility of Growth

Financial Development and Openness to Trade

1) *Private Credit to GDP ratio*: Extent to which private sector activities are financed through bank lending.
2) *Trade in Goods to GDP:* The ratio of imports plus exports to GDP

Central Bank Structure:

3) *Central Bank Independence:* We compute an index that uses the average tenure of the central bank governor as a proxy for CBI as in Cukierman (1992), and de Haan and Kooi (2000). The turn-over ratio of the central bank governor (TOR) has the advantage that it can be computed for a larger set of countries and for different periods, so it becomes technically possible to use it to construct a measure of CBI for the periods separated by the structural break.
4) *Inflation Targeting:* We construct the variable by dividing the number of years an inflation-targeting regime has been in place for a particular country, by the number of years of the respective subperiod. For the information on the dates that inflation targeting was introduced we employ the data from Mishkin and Schmidt-Hebbel (2002).

Other Variables:

5) *Inflation variability:* The log of the standard deviation of inflation.

The results are quite striking. First, they suggest that a more developed financial system, measured by bank credit to the private sector, is associated with a lower volatility in GDP growth. The first row of the table shows that increases in this financial development variable are associated with large declines in volatility, and the effects are estimated precisely (p-values are all 0.05 or less).

Table 4.2: Output Volatility, Credit to the Private Sector and Trade (Periods determined by structural breaks)

Explanatory variable	**(1)**	**(2)**	**(3)**	**(4)**
1) Private Credit to GDP[a]	-1.65	-1.08	-1.28	-0.92
p-value	*(0.00)*	*(0.01)*	*(0.01)*	*(0.05)*
2) Trade in Goods to GDP[b]	2.19	1.83	2.00	2.53
p-value	*(0.04)*	*(0.06)*	*(0.07)*	*(0.01)*
3) CB Turnover Ratio	2.04			1.40
p-value	*(0.10)*			*(0.25)*
4) Inflation Targeting		-0.67		-0.64
p-value		*(0.02)*		*(0.03)*
5) Inflation Volatility			0.28	0.24
p-value			*(0.24)*	*(0.27)*
F-statistic for joint test	6.65	7.93	5.93	5.66
p-value	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*

[a] Ratio of private credit by deposit money banks to GDP.

[a] Ratio of exports plus imports to GDP.

P-values (in parentheses) are computed using standard errors that are robust to heteroskedasticity. The F-statistics are for the joint test that all of the slope coefficients in the regression are simultaneously zero.

An example helps to reinforce the size of the estimated effects. For the case of Korea, we identify a break in volatility in the first quarter of 1987. The ratio of private Korean credit rose from 48% of GDP before the break to 102% after. The estimates in Table 4.2 suggest that this doubling of credit would reduce the standard deviation of Korean GDP volatility by a factor

between 1.6 and 2.3.[18] In fact, the volatility fell by half. From this we conclude that financial development has played an important role in reducing the volatility of output.

Second, commercial openness is *positively* correlated with fluctuations in GDP growth. This result is not too surprising, considering that the countries that the countries that experienced the largest increases in commercial openness – Mexico and Ireland – are both small, open economies that show increases in output volatility. Focusing on the case of Mexico, trade increased form 12% of GDP before the 1980 break to 54% after. The estimates suggest that an increase of this size should results in growth volatility rising by a factor of between 2.2 and 2.9[19] – slightly below the 3.5 that we observe.

Turning to the importance of monetary arrangement, we find evidence supporting the view that higher central bank independence, measured by a lower average turn over ratio of central bank governors, is correlated with lower output growth volatility. The results for inflation volatility are similar: the higher variance of inflation, the higher variance of output. We note when we introduce these two variables simultaneously, as in column (4) of Table 4.2, the p-values on both rise above 0.2. This is consistent with the evidence provided by Cukierman (1992) and others of the high correlation between central bank independence and both the average and the variance of inflation.

Finally the analysis suggests that adoption of an inflation-targeting scheme is strongly correlated with reductions in the volatility of real growth. One possible explanation for this is that adoption of a disciplined monetary policy framework helps central bankers to move the economy toward the efficient frontier, reducing both output and inflation volatility. The evidence suggests that this effect is larger than the one associated with the trade-off faced by the policymaker who, under optimal or near optimal policies, may only be able to reduce inflation volatility at the expense of increasing GDP growth fluctuations.

[18] The estimated impact is equal to the *e* raised to the power equal to the change in the credit to GDP ratio times the coefficient estimate from the first row of Table 2.1.
[19] The estimated impact is equal to the *e* raised to the power equal to the change in the credit to GDP ratio times the coefficient estimate from the first row of Table 2.1.

A potential criticism the results in Table 4.2 is the fact that, by employing a fixed effects model, we are only able to include countries where we have econometrically identified structural breaks in the volatility of real growth. This means ignoring the information from eight of the twenty-eight countries in our sample. To address this problem, and include the entire sample of countries, we arbitrarily break our data into subperiods and examine changes between the initial and final 10 years of the entire sample period; that is, between the period 1970Q1-1979Q4 and the one from 1994Q1 to 2003Q4. This division has the advantage that 23 out of the 28 structural breaks fall within middle-period (1980Q1-1993Q4), suggesting that we have retained much of the integrity of the subdivision studied above.

Table 4.3: Output Volatility, Credit to the Private Sector and Trade (Comparison between 1970Q1-1979Q4 & 1994Q1-2003Q4)

Explanatory variable	**(1)**	**(2)**	**(3)**	**(4)**
1) Private Credit to GDP[a]	-1.528	-1.315	-1.169	-0.902
p-value	*(0.00)*	*(0.00)*	*(0.00)*	*(0.01)*
2) Trade in Goods to GDP[b]	1.549	1.750	2.058	2.284
p-value	*(0.04)*	*(0.01)*	*(0.01)*	*(0.00)*
3) CB Turnover Ratio	0.302			-0.581
p-value	*(0.84)*			*(0.68)*
4) Inflation Targeting		-0.400		-0.453
p-value		*(0.08)*		*(0.05)*
5) Inflation Volatility			0.308	0.330
p-value			*(0.10)*	*(0.06)*
F-statistic for joint test	11.86	14.59	14.36	10.16
p-value	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*

[a] Ratio of private credit by deposit money banks to GDP.

[b] Ratio of exports plus imports to GDP.

P-values (in parentheses) are computed using standard errors that are robust to heteroskedasticity. The F-statistics are for the joint test that all of the slope coefficients in the regression are simultaneously zero.

Table 4.3 reports these results. This alternative subdivision of the data does not affect the main results: financial development is negatively and significantly correlated with the standard deviation of growth in real GDP, while the effect of openness to trade on output volatility remains positive and significant.[20]

Conclusion

While everyone who has looked agrees with the McConnell and Perez Quiros (2000) observation that the volatility of real growth in the United States fell by more than one-third in the mid-1980s, there is substantial disagreement over the causes of the decline. Is it inventory policy, monetary policy, or just luck? Could it be changes in financial development or possibly commercial openness? The purpose of this paper is to address these questions by examining data from a broad set of countries to see first, whether volatility changes occurred in the rest of the world, and second to provide additional evidences to assess the causes of the changes.

Our first result is that output volatility has fallen in a broad cross-section of countries; twenty of the twenty-one countries with at least one break experienced lower volatility in the more recent period. In assessing the causes of the changes in the volatility or real growth, our primary findings link two previous results. For some time we have known that more stable economies growth faster.[21] We have also known that a sound financial system provides the foundation for economic development.[22] Countries with deeper, more sophisticated, financial systems grow faster. Our results show that financial development, as measured by the importance of bank lending, is linked to real economic stability.

[20] We perform other robustness exercises, such as expanding the analysis to include the decade of the 1960s (data available for a number of countries only) and restricting the analysis to the post 1980 period and beyond. We also use a measure of growth volatility without applying the HP filter. Our main conclusions are robust to these alternative measures and definitions of time periods.
[21] See Ramey and Ramey (1995).
[22] See Ross Levine's (1997) survey.

Beyond the importance of financial development, we also provide evidence in favor of the view that both improved inventory control policies and financial system development played a role in the more stable growth we have observed. Furthermore, increased commercial openness, measured by the ratio of imports plus exports to GDP, appears to contribute to less stable growth, not more.

Finally, we should note that what we have done is established a set of correlations. Real volatility is negatively correlated with bank lending and positively correlated with the importance of trade flows. And a significant fraction of the decline in the volatility of real GDP, for those countries where it fell, can be accounted for by changes in the behavior of inventory accumulation. What we have not done is show causal links. It is surely possible, for example, that financial systems are more prone to develop in countries that are more stable and that less stable countries may trade more. Determining what the ultimate causes of these changes are must be high on the agenda for future research.

Technical Appendix

Let Δy_t denote the rate of growth of HP-filtered log real GDP. We assume a simple AR(1) model for each of the two variables

$$\Delta y_t = \mu + \phi \Delta y_{t-1} + \varepsilon_t. \quad \text{(A1)}$$

Our first step, for each country, is to search for *multiple* breaks (up to five) in the AR(1) coefficient in equation (1), i.e. persistence (ϕ) in equation (A1).[23]

After finding any breaks in the persistence of Δy_t, that model specification is used for the country in obtaining the residuals $\hat{\varepsilon}_t$, respectively. Then, following McConnell and Perez Quiros (2000), each set of residuals follows a normal distribution and the transformations $\sqrt{\frac{\pi}{2}} \mid \hat{\varepsilon}_t \mid$ are unbiased estimators of the standard deviation of ε_t.[24]

Finally, we search for *multiple* breaks in the mean of the following volatility equation:

[23] The rate of growth of HP-filtered log real GDP does not show breaks on its mean for any country.

[24] Footnote 3 of McConnell and Perez-Quiros (2000) indicates that this absolute value specification of the error is more robust to departures from conditional normality. See also Davidian and Carroll (1987).

$$\sqrt{\frac{\pi}{2}} \mid \hat{\varepsilon}_t \mid = \alpha + u_t \qquad \text{(A2)}$$

$$t = T_{j-1} + 1, ..., T_j \qquad \text{for } j = 1, ..., m+1.$$

We search for multiple breaks in the different series above using the GAUSS code made available by Bai and Perron (2003) that is based on theoretical results in Bai and Perron (1998). The reason for considering tests for multiple breaks is that tests for a single break typically have low power in the presence of multiple breaks (Bai, 1997 and Bai and Perron, 2003).
Bai and Perron (1998, 2003) present a number of tests that are available in their GAUSS programs. To decide on the number of breaks and the break dates we employ the "sequential" method described below, which is reported by Bai and Perron (2003) to outperform other methods, based on simulations they conduct. First, we estimate up to 5 breaks in the series for each country. Second, we use the method proposed by Bai and Perron (1998) based on the sequential application of the $\sup F_T(l+1 \mid l)$ test, which is designed to detect the presence of ($l+1$) breaks conditional on having found l breaks (l = 0,1,…,5). The statistical rule is to conclude for a rejection in favor of a model with $(l+1)$ breaks if the overall minimal value of the sum of squared residuals (over all the segments where an additional break is included) is sufficiently smaller than the SSR from the model with l breaks. The dates of the breaks selected are the ones associated with this overall minimum.[25] We identify a break (or an additional break) if the test statistic allows rejection of the null hypothesis at a 10% level of significance or higher.

[25] All testing procedures allow for serial correlation and different variances across segments in the residuals. In addition, the variance-covariance matrices used in constructing the various test statistics are robust to heterogeneity and autocorrelation by using Andrews (1991) automatic bandwidth with AR(1) approximation and a quadratic kernel. The residuals used are pre-whitened.

Data Appendix

GDP data was obtained from the *International Financial Statistics CDROM* (December 2004) and the OECD Economic Outlook No. 76, December 2004.

Data on Private credit by deposit money banks and Trade on Goods come from the World Bank Development Indicators, December 2004

Turnover Ratio of the Central Bank Governor is constructed from information taken from each central bank's website, as well as inquiries to central bank staff.

Inflation Targeting: Data are taken from Mishkin and Schmidt-Hebbel (2002).

GDP and CPI inflation data was obtained from the *International Financial Statistics CDROM* (December 2004) and the OECD Economic Outlook No. 76, December 2004.

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