External MPC UNIT

Discussion Paper No.16

Diverging Trends in Aggregate and Firm–Level Volatility in the UK

by Miles Parker

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Abstract

This paper documents an increase in the volatility of output at the firm level in the United Kingdom, in keeping with recent research for the United States. Evidence at the sectoral level suggests that this may have arisen as a result of increased product market competition. This greater volatility at the firm level has also occurred at a time of greater macroeconomic stability, commonly referred to as the 'Great Stability'. National accounts data for 31 sectors in the economy show that the fall in aggregate volatility is mostly a result of lower covariance between sectors rather than individual sectors becoming less volatile. This suggests a possible role for structural change in explaining the causes of the 'Great Stability'.

Summary

Over the past decade, the United Kingdom has witnessed a sharp decline in the volatility of output growth and inflation — dubbed the Great Stability. Between 1960 and 1992 the standard deviations of annual GDP growth and inflation in the United Kingdom were 2.2 per cent and 5.5 per cent. Since 1993 these standard deviations have fallen to 0.7 per cent and 0.8 per cent respectively. This phenomenon has also occurred in many other industrial economies, particularly the US, leading to a debate as to whether the improvement has been brought about by structural change, better monetary policy ('good policy'), or by smaller shocks hitting the economy, ('good luck'). Understanding the causes of the Great Stability is clearly important for policy going forward but as yet there is little agreement as to the reasons behind the better macroeconomic climate.

To date, the majority of analysis on the Great Stability has been based on aggregate data. Despite this, many of the conclusions have relied on assumptions of behaviour at the microeconomic level. Recent research has drawn attention to an increase in firm–level sales volatility in the United States concurrent with the reduction in aggregate volatility. This increasing trend is found to be independent of the age, size or sector the firm operates in. The reduction in aggregate volatility is also found to be driven principally by a fall in the correlation between the growth rates of sectors, rather than a fall in the volatility of the sectors themselves.

This paper uses individual firm accounts from Thomson Financial Datastream to investigate whether firm–level volatility in the UK has followed a similar trend to that in the United States. It studies the results from two separate panels of data — one using the result from all firms where data are available, the second using a balanced panel of firms where data are available in each year throughout the sample period. Investigating the growth of real sales, it finds supporting evidence for an increasing trend in firm–level volatility in the UK over the period 1974–2004. This increase in volatility is found to accompany a widening of the distribution of firms' sales growth volatility both over time and cross–sectionally. These results hold even when firm–specific factors, including size and age, are taken into account.

We then divide the sample into nine broad industrial sectors. Within these sectors there is found to be an increase in volatility of the median firm. Over the same period, the covariance between the growth rate of sales of firms within sectors was found to decrease, resulting in a lowering of the volatility of sales growth at the sectoral level. Taking this analysis to a more aggregate level, the variance of total value added is decomposed, using data from UK national accounts, into the variance of the individual sectors and the covariance between sectoral growth rates. The main driver in the fall in aggregate variance is found to be the fall in covariance between sectors rather than the fall in the variance of sector growth.

Understanding the reasons behind the divergence in trends at aggregate and at micro–level may be crucial in discriminating between different hypotheses of the cause of the Great Stability. The results presented in this paper suggest that there is a role for structural change in the reduction of aggregate volatility. In particular, increased competition in product markets, possibly through deregulation or globalisation, may have changed firms' price–setting behaviour which may have led to greater flexibility and a better absorption of shocks.

1 Introduction

Over the past decade, the United Kingdom has witnessed a sharp decline in the volatility of output growth and inflation — dubbed the Great Stability. In the words of Benati (2006):

> *The post–1992 inflation–targeting regime appears to have been characterised, to date, by the most stable macroeconomic environment in recorded UK history. Since 1992, the volatilities of the business–cycle components of real GDP, national accounts aggregates, and inflation measures have been, post–1992, systematically lower than for any of the pre–1992 monetary regimes or historical periods…. The comparison with the period between the floating of the pound vis–à–vis the US dollar (June 1972) and the introduction of inflation targeting (October 1992) is especially striking, with the standard deviations of the business–cycle components of real GDP and inflation having fallen by about 50 and 70 per cent, respectively.*

This phenomenon has also occurred in many other industrial economies, particularly the US, leading to a debate as to whether the improvement has been brought about by structural change, better monetary policy ('good policy'), or by smaller shocks hitting the economy, ('good luck'). Understanding the causes of the Great Stability is clearly important for policy going forward but as yet there is little agreement as to the reasons behind the better macroeconomic climate.

To date, the majority of analysis on the Great Stability has been based on aggregate data. Despite this, many of the conclusions have relied on assumptions of behaviour at the microeconomic level. Recent research (e.g. Comin and Mulani (2004)) has drawn attention to an increase in firm–level sales volatility in the United States concurrent with the reduction in aggregate volatility. This increasing trend is found to be independent of the age, size or sector the firm operates in. Comin and Philippon (2005) also find that the reduction in aggregate volatility is driven principally be a fall in the correlation between the growth rates of sectors, rather than a fall in the volatility of the sectors themselves.

This paper uses individual firm accounts from Thomson Financial Datastream to investigate whether firm–level volatility in the UK has followed a similar trend to that in the United States. Investigating the growth of real sales, it finds supporting evidence for an increasing trend in firm–level volatility in the UK over the period 1974–2004. This increase in volatility is found to accompany a widening of the distribution of firms' sales growth volatility both over time and cross–sectionally. These results hold even when firm–specific factors, including size and age, are taken into account. As a further robustness check, a balanced panel of all 158 firms that report accounts in every year of the sample is analysed. The upward trend in firm–level volatility is found to hold, confirming that it is not an artefact of changing sample composition.

We then divide the sample into nine broad industrial sectors. Within these sectors there is found to be an increase in volatility of the median firm. Over the same period, the covariance between the growth rate of sales of firms within sectors is found to decrease, resulting in a lowering of the volatility of sales growth at the sectoral level. Taking this analysis to a more aggregate level, the variance of total value added is decomposed using data from UK national accounts for 31 sectors.

This divides the variance of aggregate value added into the variance of the individual sectors and the covariance between sectoral growth rates. The main driver in the fall in aggregate variance is found to be the fall in covariance between sectors rather than the fall in the variance of sector growth.

Understanding the reasons behind the divergence in trends at aggregate and at micro–level may be key in discriminating between different hypotheses of the cause of the Great Stability. The results presented in this paper suggest that there is a role for structural change in the reduction of aggregate volatility. In particular, increased competition in product markets, possibly through deregulation or globalisation, may have changed firms' price–setting behaviour which may have led to greater flexibility and a better absorption of shocks. These findings provide some additional insights to the burgeoning literature on the Great Stability, which for the most part has concentrated on the debate between 'good policy' and 'good luck'. The analysis here is unable to differentiate *ex post* between smaller aggregate shocks and improved policy better able to counteract aggregate shocks.

This paper is structured as follows. Section 2 reviews some of the literature on trends in aggregate and firm–level volatility. Section 3 sets out the methodology and firm–level data used in the paper. Section 4 presents the results from the firm level data. Section 5 studies sectoral effects in the firm–level data. Section 6 undertakes a decomposition of aggregate GDP growth using sectoral data from national accounts. Section 7 reviews the results of the data analysis, and how this may help discriminate between differing explanations of the Great Stability. Section 8 concludes.

2 Previous literature on aggregate and firm–level volatility

The decline in aggregate volatility worldwide is well documented, and the subject of a large literature. Stock and Watson (2002) note that the standard deviation of annual growth rates of US GDP was 2.7% over the period 1960–1983, but only 1.6% from 1984–2001. They attribute 20–30% of this decline in volatility to better monetary policy by the Federal Reserve, 20–30% to identifiable 'good luck' in the form of smaller shocks, and 40–60% to other unknown forms of 'good luck' which lead to smaller forecast errors. Canova and Gambetti (2004) use a structural VAR to assess the impact of monetary policy in the United States. They find that the monetary policy transmission mechanism has changed little over the past 25 years and that the improvement vis–à–vis the 1970s is a result of smaller shocks — or 'bad luck' in the 1970s. Benati (2006) looks at output and inflation data for the UK under different monetary regimes. Starting in 1662 with the *de facto* silver standard he charts the course of macroeconomic volatility over the course of three and a half centuries. He finds that the post–1992 period has to date been characterised by the most stable macroeconomic environment in recorded UK economic history.

Cecchetti *et al.* (2004) investigate the causes of the fall in output volatility across 24 countries over the period 1983–1998. Acknowledging the existence of a trade–off between output and inflation volatility, Cecchetti *et al.* recognise this improvement could be a result of better monetary policy or a reduction in the prevalence and amplitude of supply shocks. They find that monetary policy became more efficient in 21 out of the 24 countries, including the UK and US. Furthermore, in 20 out of the 21 countries that experienced more stable macroeconomic conditions, better monetary policy accounted for over 80% of the measured gain. However, they also concede that the improvement in monetary policy will have benefited from supply–side policies in the goods and labour market. Their method is unable to distinguish between these policies and other supply–side shocks. They also note that were they to focus merely on output volatility, as opposed to the combination of output and inflation, then the role played by policymakers in reducing volatility is much lower.

Another explanation given in the literature for the reduction in aggregate volatility (e.g. McConnell and Perez–Quiros (2000)) is that new production techniques at firms, such as just–in–time, enable them to manage better their inventories, reducing the level of output volatility at the firm level, and consequently at the aggregate level.

However, Comin and Mulani (CM) (2004) show that the decline in aggregate volatility has been matched by an **increase** in firm–level volatility of real sales in the United States over the period 1950–2002. They undertake several tests on a panel of firm–level data drawn from the COMPUSTAT database of accounts of listed US companies. They find that this increase in volatility at the firm level is widespread, and not a function of the age of the firm, or the sector in which it operates.

Comin and Philippon (CP) (2005) further investigate the divergence in trends between aggregate and firm–level volatility. Using a panel of 28 OECD countries, including the United Kingdom, they find a common thread of a negative correlation between volatility at the firm level and at the aggregate level. Furthermore, firm–level volatility appears to increase after deregulation in the goods market. They find an increase in the turnover of market leaders (measured in terms of operating income or market value), suggesting an increase in product market competition.

In a comment on CP (2005), Eberly (2005) draws attention to how their results change when studied at a shorter time horizon. When the firm–level volatility is calculated at the five–year rather than the ten–year horizon, the upwards trend in volatility is less discernable. Indeed, the data appear to show an increase in volatility over the early 1990s which subsequently tails off. Eberly (2005) consequently questions whether the rise in firm–level volatility is best described as an increasing trend, or merely an episode of higher volatility.

Evidence from employment data also suggests that there may be some compositional biases in CP (2005)'s work. Using a large panel of both listed and unlisted firms, Davis *et al*. (2006) find that the volatility of firm–level volatility has fallen in the United States since 1976. This is attributed to the fall in employment volatility of unlisted firms which dominates the increase in employment volatility of listed firms found by CP (2005).

CP (2005) also decompose the aggregate volatility into the average volatility of sectors and the correlation between the growth rates of individual sectors. They find that the decline in aggregate volatility is mostly a result of the decline in correlation between sectors. This result is supported by Irvine and Schuh (2005) who find that 80 per cent of the reduction of the variance of goods output growth is attributable to the reductions in the covariance among 2–digit and 3–digit SIC industries. Using a 'heterogeneous–agent' VAR(1), which explicitly parameterises the dynamic structural relationship between industries as well as the structural relationships between aggregate variables, Irvine and Schuh find evidence that the reduction in aggregate volatility can be attributed principally to changes in the structure of the economy, rather than a reduction in aggregate shocks. In particular they find a role for reduced correlation between sales and inventory investment.

3 Methodology and data

This paper creates a measure for firm–level volatility based on published accounts available on Datastream. Following Comin and Mulani (2004), the volatility measure used is the standard deviation of the growth rate of real sales(2). In order to avoid overdue influence from outliers, firms exhibiting an annual nominal growth rate above 75%(3) are excluded from the analysis. Ideally to make accurate comparisons nominal sales growth for each firm should be deflated by its individual price index. However, since these data are not available, the nominal sales for each firm have been deflated by the aggregate producer price index (PPI).The growth rate of real sales are calculated for each company, and the standard deviation of this growth rate is then calculated over the previous five and ten years to arrive at the volatility in that year for that firm.

More formally, the ten–year volatility measure for each firm, indexed by *i*, is computed as:

$$\sigma_{it}(x) = \sqrt{\frac{1}{10}\sum_{s=0}^{9}(x_{it-s} - \bar{x}_{it})^2}$$

(1) See Fratantoni and Schuh (2003) for a full description of a heteregenous-agent VAR.
(2) Unfortunately the coverage of employment data within the data set is insufficient to compute reliable series for volatility of workers or sales per worker. CP (2005) find an increase in volatility of employment, whereas Davis *et al.* (2006) find a decrease in volatility of employment across all firms, although an increase within listed firms.
(3) For example, a merger or large acquisition could skew the results for one firm. In practice this restriction has very little bearing on results. Indeed even a 50% cut-off barely affects the results presented here.

where x_{it} is the growth rate of real sales for company *i* in year *t*, and $\bar{x}_{it}$ is the average growth rate of real sales for company *i* over the ten year period to time *t*. The five–year measure is computed analogously. The ten–year measure has the advantage of being more likely to encompass a complete cycle, while the five–year measure will pick up recent cyclical trends. Note that this measure differs slightly from CM (2004) in the labelling of years. The volatility measure for the ten years 1995–2004 is attributed to 2004 in this paper, whereas CM (2004) label it as 2000.

The data set used below is drawn from accounts of listed UK companies available on Thomson Financial Datastream over the period 1974 — 2004[(4)], and has been used in several Bank of England *Working Papers* (see for example Benito (2001) and Bunn and Trivedi (2005)). It covers a longer time period than COMPUSTAT GLOBAL (used by CP (2005)) for the UK, thus providing us with more observations to conduct our time series analysis. The raw data set contains roughly 1200 non–financial firms in each year, and includes companies that have subsequently been delisted or failed. The data used below are restricted by the requirement that each company must have at least 6 years of observations for sales, the minimum required to compute a five–year volatility of real sales growth measure.

Throughout what follows, reference will be made to two separate samples from the raw data:

- **Full Sample**. This includes every firm in the raw data set that contains at least six consecutive observations, that is at least one observation on volatility. As such, the composition of the panel will change between years as new firms enter and some old firms disappear. For the ten–year volatility measure, which requires 11 consecutive observations, there are a total of 1470 firms over the period, representing a total of 13304 firm–year observations, an average of over 9 observations per firm. See Table A1 in the appendix for a breakdown by year of the number of firms in the sample for the ten– and five–year measures.
- **Balanced panel**. This is a panel consisting of the 158 companies that have observations for sales in every year from 1974 to 2003, providing 20 volatility observations for each firm. 2004 was excluded to allow a slightly larger panel.

4.1 Results for full panel

Volatility of firm–level sales

Chart 1 shows the evolution of the mean ten–year volatility of firms in the full sample, both unweighted and weighted by sales. There is an increase in firm–level volatility over the period. However, rather than the fairly smooth increase found by CM (2004) for the United States, volatility in the United Kingdom is better characterised as hump–shaped. There is a large increase in volatility in the middle of the sample, tailing off to a lower level at the end of the period, albeit still higher than at the start. This is similar to the pattern found by Eberly (2005)

(4) A year refers to the accounting year-end.

when examining the findings of CP (2005) at a shorter time horizon. The mean five–year volatility of real sales is shown in Chart 2. Again there is an increase over the period, with a peak in volatility in the middle of the sample.

Chart 1: Mean ten–year volatility of real sales growth

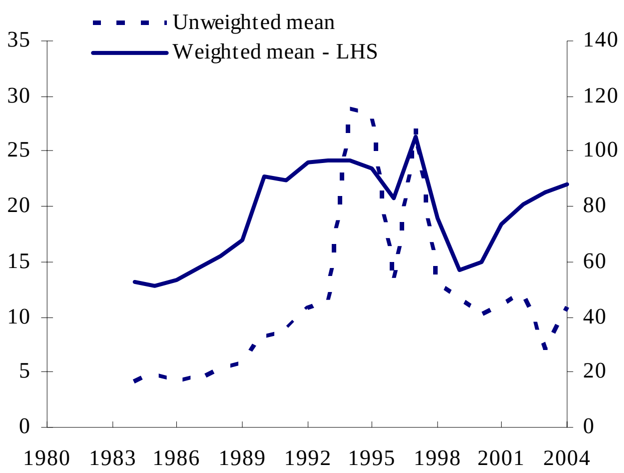
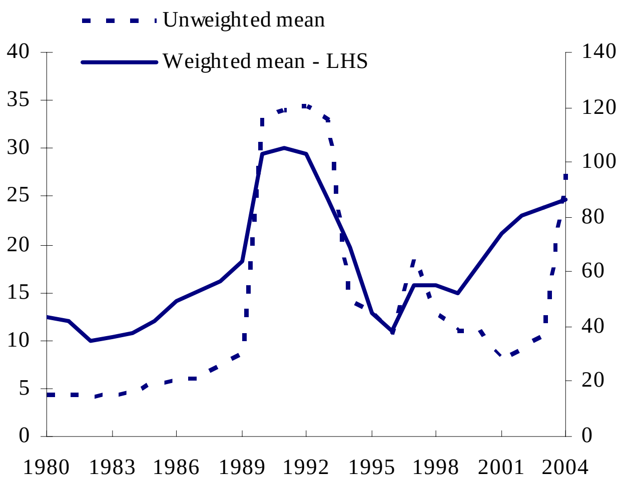


Chart 2: Mean five–year volatility of real sales growth



How sure can we be that this is a secular increase in volatility, and not some function of changes in the composition of the sample or other explainable factors? Below we undertake a number of robustness checks on the full sample, and Section 4.2 uses a balanced panel to remove any influence that changing composition of the panel may have on the final results.

Distribution of firm–level volatility

One way to examine the pervasiveness of the increase in volatility is to examine the distribution of firm–level volatility throughout the sample (Chart 3). The results of this exercise are quite persuasive. There has been a slight increase in the 25th percentile firm's volatility over the past twenty years. This increase is more marked when the median firm is considered, and even more so with the 75th percentile firm. Thus the increase in firm–level volatility is widespread, with over three quarters of the distribution of firms' volatility showing an increase in volatility over the period, and a noticeable widening of the distribution.

The volatility measure used above calculates the volatility over time for a particular firm. A further test for the robustness of the increasing trend in volatility it to examine the contemporaneous cross–sectional volatility of firms. Chart 4 shows the standard deviation of the growth rate of real sales in each year for all firms in the sample. This also shows an increasing trend over the sample period, so not only is the volatility over time of the average firm increasing, but the distribution of firms' sales growth in any given year has also widened over the period 1974–2004.

Chart 3: Distribution of ten–year volatility of real sales growth

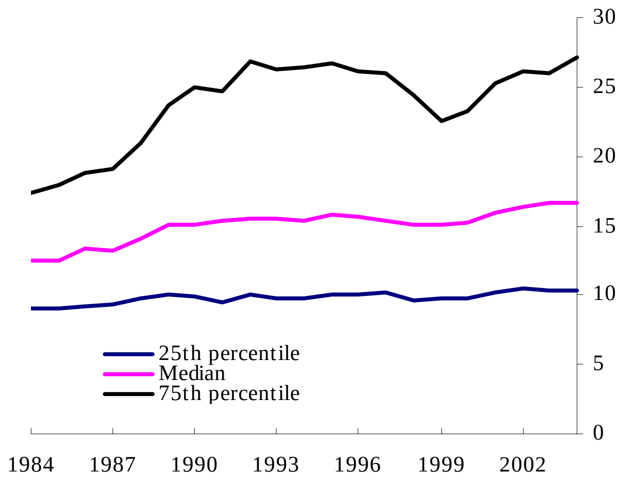
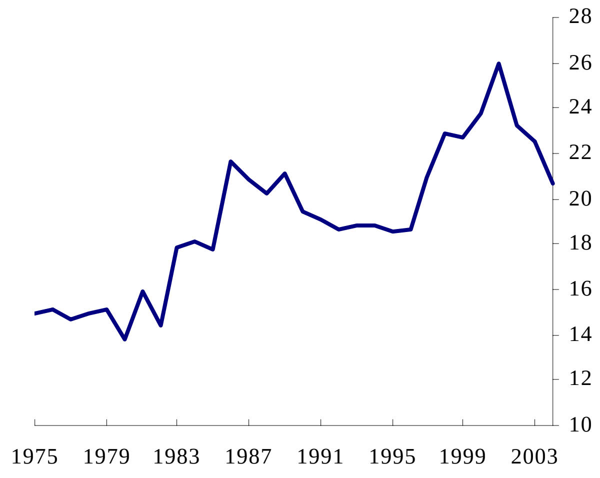


Chart 4: Standard deviation of real sales growth in each year



Estimation results

CM (2004) carry out a pooled regression to strip out volatility in their sample that can be explained by firm characteristics, controlling for the size and age of the firm. The motivation for this is the hypothesis that larger, or more established, firms may be less volatile than newer or smaller firms. Thus younger firms entering towards the end of the sample could be more volatile and consequently raise the average volatility of the sample. Measuring age is difficult in our data set, since the only statistic available is the date when the firm entered the sample. Given that the dataset covers listed companies, this may be a result of a stock market listing of an already old company. Consequently, year of entry can at best be used as a control for cohort effects.

A pooled regression was carried out on the full sample, regressing firm–level ten–year standard deviations of real sales growth on a constant, the log of the firm's real sales and a time trend (Regression A in Table 1). Larger firms were found to be less volatile, and the time trend was found to be positive and significant. However, when the firm's year of entry into the dataset was added to the regression (Regression B), the time trend was no longer significant; instead the year of entry was found to explain the rise in firm–level volatility over the sample period.

This raises an important question regarding the increase in volatility at the level of the firm. Is it caused by all firms in the economy becoming more volatile, or is it because newer firms in the economy (as proxied by firms entering the sample later) are more volatile than older firms? The latter case would be interesting of its own right — why are newer firms more volatile at a time when the aggregate climate is more stable? Support for this case is offered by Regression C which weights Regression B by the firm's share in total sales. This gives smaller weight to the newer firms which are typically smaller. In this regression the trend and year of entry are found to be insignificant.

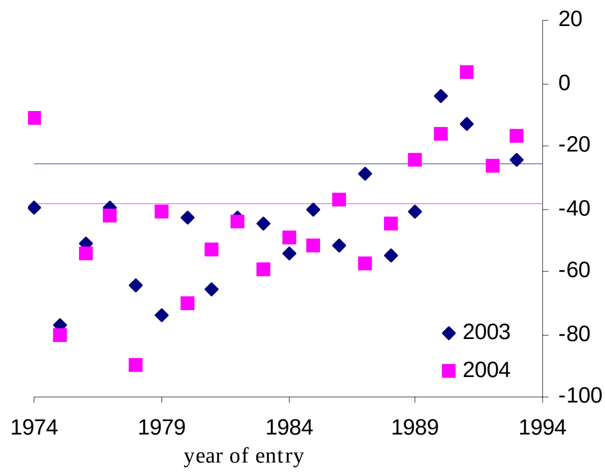
Table 1: Regression results from full sample

Regression		Constant	Log (real sales)	Year of entry	Trend
A Full panel	Coefficient *t–probability*	**94.93**** (0.000)	**-10.62**** (0.001)		**2.559**** (0.012)
B Full panel	Coefficient *t–probability*	**87.51**** *(0.001)*	**-9.089**** *(0.006)*	**4.697**** *(0.002)*	**0.707** *(0.549)*
C Full panel, weighted by sales	Coefficient *t–probability*	**57.35**** *(0.000)*	**-9.912***** *(0.000)*	**0.548** *(0.184)*	**0.297** *(0.273)*
D Restricted panel	Coefficient *t–probability*	**60.68**** *(0.000)*	**-6.381**** *(0.000)*	**0.182** *(0.717)*	**1.679**** *(0.000)*
E Restricted panel, weighted by sales	Coefficient *t–probability*	**48.17**** *(0.000)*	**-3.044**** *(0.000)*	**0.031** *(0.880)*	**0.306*** *(0.015)*
F Restricted panel, Fixed effects	Coefficient *t–probability*	**-75.62**** *(0.000)*	**13.87**** *(0.000)*		**0.764*** *(0.020)*

*Significant at 5% level. **significant at 1% level.

A further way of disentangling the varying influence of the trend and year of entry on volatility is to consider the part of volatility that is unexplained by the above equations. Chart 5 shows the mean residual ten–year volatility by year of entry into the sample in 2003 and 2004. This is calculated as the residual volatility from subtracting the fitted values from Regression A from the actual firm–level volatility figure. Firms that entered the sample post–1989 appear more volatile than firms that entered the sample earlier. This would lend support to the argument that the increase in volatility is caused by new, more volatile, firms entering the sample. However one caveat is that these firms have very few observations within the sample, so year of entry into the sample may dominate any effects arising from a long–run increasing trend.

Chart 5: Mean residual firm–level volatility of real sales growth, by year of entry[(a)]



(a) Solid lines show average for all firms

Furthermore, year of entry is a potentially poor measure of a firm's age; the firm may have been trading for many years before listing. If this were the case, and there were an upward trend in volatility for all firms then a regression may spuriously allocate more weight to year of entry rather than to the true trend. One solution is to place an additional restriction on the sample that firms must have at least five observations for volatility. This reduces the total number of firms in the sample to 955. The number of firm–year observations falls to 12130, an average of 12.7 observations per firm. Regression B was re–run on this reduced sample (Regression D in Table 1). The time trend is now found to be significant and the year of entry insignificant. This also holds true if the regression is weighted by share in sales (Regression E). However it is important to note that the restriction on observations will by definition remove the firms that entered the full sample after 1990.

As a more stringent test of the upward trend in volatility, a fixed effects panel regression was carried out on this reduced full sample (regression F). This includes a firm–specific fixed effects dummy for each firm in the sample. A significant positive trend in volatility was still found to hold, although the sign on the log of real sales becomes positive, implying that larger firms are more volatile than smaller firms, contrary to the previous results.

One further way of eliminating any bias arising from changing sample composition is to study the evolution of firm–level volatility in a cohort of firms. The following section studies volatility of one such cohort — a balanced panel of all 158 firms in the sample with results in each year over the period 1974–2003.

4.2 Results for balanced panel

A similar analysis to that above was carried out on a cohort of firms that report results in every year 1974–2003. The advantage of this method is that it strips out any influence of newer firms entering the sample. Thus if an upward trend in volatility is found to hold it will be indicative of a trend affecting all firms, rather than a function of changing sample composition. The disadvantage of this method is that it reduces the number and total sales of the firms to around a quarter of that of the full sample. Charts 6 and 7 show the mean volatility of real sales of the 158 firms in the balanced panel. Two things are apparent from these charts. First, there appears to be an increase in volatility over the sample period. Second, the level of volatility is lower for the balanced panel than for the full sample reported in Charts 1 and 2. This could reflect the fact that younger firms in the sample are indeed more volatile than older firms. However, it could also be a result of the survivor bias inherent in choosing firms that have remained in the sample throughout the period — exiting the sample through bankruptcy is likely to be preceded by a period of volatile sales.

To further test whether this increase in volatility is significant, a fixed effect panel regression was carried out on the balanced panel. This regressed the firm–level standard deviations of real sales growth on a firm–specific fixed effect term, the log of real sales and a time trend (Table 2). The time trend was found to be positive and significant, even after controlling for fixed effects. Therefore the increasing trend in firm–level volatility is not solely a function of changing sample composition, and there is evidence for an increasing trend in volatility independent of the age of the firm.

Chart 6: Mean ten–year volatility of real sales growth in balanced panel

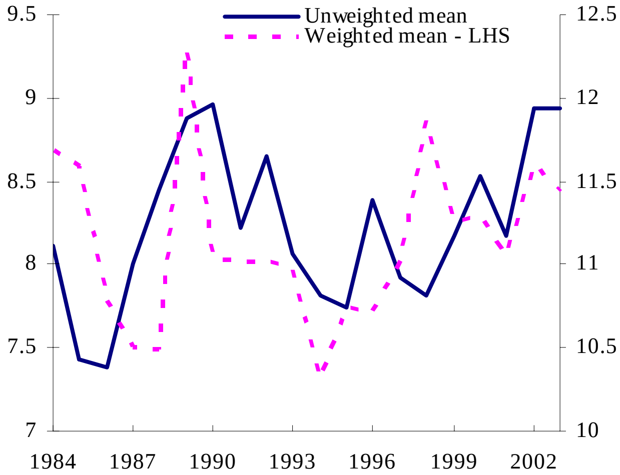


Chart 7: Mean five–year volatility of real sales growth in balanced panel

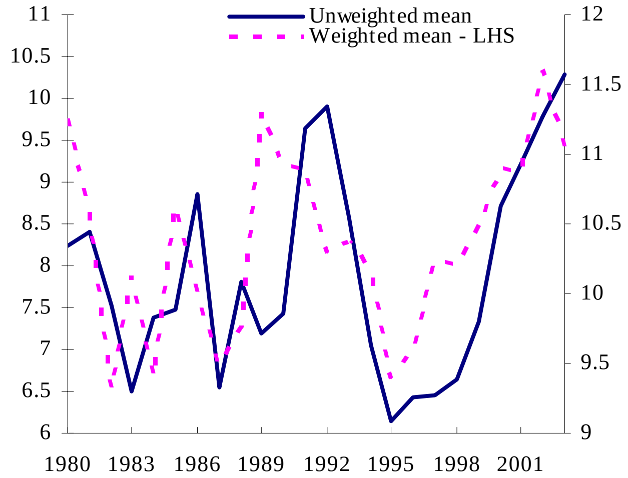


Table 2: Regression results from balanced panel

	Constant	Log (real sales)	trend
Coefficient	25.41**	-1.809**	0.0864**
t–probability	*(0.000)*	*(0.000)*	*(0.000)*

**Significant at the 1% level.

From the evidence of the above analysis, there would appear to be a secular increase in firm–level volatility over the period 1974–2004 in the United Kingdom. This has been accompanied by a widening in the distribution of both firm–level volatility and the cross–sectional distribution of real sales growth in each year. There also exists the possibility that the firms that joined the sample in the most recent few years are more volatile than those that joined earlier. This leads to the obvious question of how this greater firm–level volatility results in lower volatility at the aggregate level. The next section uses firm–level data to analyse changes in sectoral volatility to see whether this may account for changes in aggregate volatility.

5 Volatility of real firm–level sales growth relative to sector

One explanation offered for the Great Stability is that of structural change — the more stable service sector becoming increasingly important in aggregate GDP compared to the more volatile manufacturing sector. If firms in different sectors exhibit differing volatilities then the results of the previous section may be affected by sectoral effects. That is, if the changing composition of the sample changes the relative weight of sectors in the sample there may be an observed increase in volatility even if there is no change in volatility at the sectoral level. This section examines sector effects using firm–level data to see whether there is any evidence of this. There is a further motivation for assessing the change in volatility at the sectoral level. Previous studies (i.e. Eberly (2005) and Davis *et al.* (2006)) have pointed to the possibility of selection bias in using only listed firms. If the panel of firms used in this paper is to be taken as indicative of all firms in the economy then it also needs to explain the simultaneous small fall in sectoral volatility in the United Kingdom over the period.

The firms in the sample can be divided into nine broad sectors,[5] although in practice there are very few firms in the Agriculture, fishing and forestry and Electricity, gas and water supply sectors. When the median volatility of real sales for firms within each sector is computed (Chart 8) the upward trend in individual firm's volatility is apparent, so changing sectoral composition within the sample is not the cause of the increasing trend in firm–level volatility in the full sample.

We also analyse real sales growth volatility at the sectoral level. For each of the nine sectors, this is calculated as the sum of the growth rates of sales of all firms in the sector, weighted by the firm's sales. The ten–year standard deviation of the sectoral growth rate can then be calculated by the same method used previously. The results for a few selected sectors are shown in Chart 9. Although there is evidence of a peak in volatility in the middle of the sample period, the general trend for most sectors is downwards. Thus, the trend at the sectoral level is similar to that at the aggregate level.

Chart 8: Median firm–level ten–year volatility of real sales growth, by industry

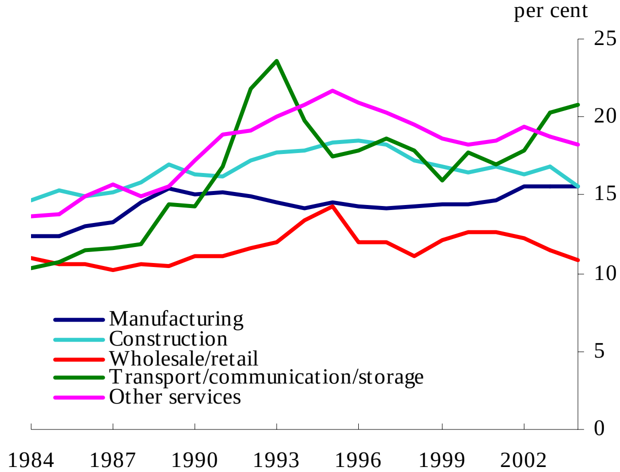
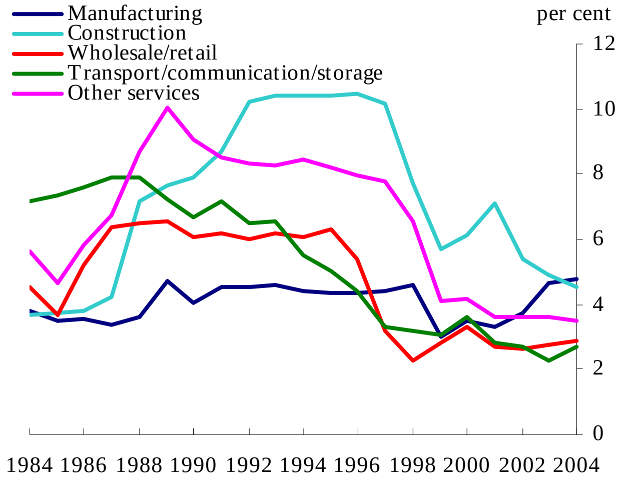


Chart 9: Ten–year volatility of sectors



If the variance of firm–level volatility is increasing in each sector, then it follows that in order for the sector as a whole to demonstrate falling volatility the growth rates of firms within a sector

(5) Agriculture, fishing and forestry; Mining, quarrying and oil; Manufacturing; Electricity, gas and water supply; Construction; Wholesale and retail trade; Hotels and restaurants; Transport, storage and communications; Other services

must be diverging. That is, the covariance of sales growth between firms must be falling. Calculating the covariance of growth rates of a large number of firms is a computationally intensive exercise. A simpler method is to calculate the divergence of firms' growth rates from the sector average. The closer the individual firms' growth rates are to the sector average, the greater the covariance between them. We calculate a measure of divergence from the sector as the deviation of a firm's growth rate from the sector's mean, rather than from its own mean growth rate over the ten previous years. This measure also appeals since by subtracting the sector mean growth rate it is robust to any bias arising from the unobserved true sector price index. More formally; for each firm *i* we have:

$$\sigma_{it}^*(x) = \sqrt{\frac{1}{10}\sum_{s=0}^{9}(x_{ijt-s} - \bar{x}_{jt-s})^2}$$

Where x_{ijt} is the growth rate of real sales for company *i* which is in sector *j* in year *t*, and $\bar{x}_{jt}$ is the weighted average growth rate of real sales across all firms in sector *j* at time *t*. An aggregate weighted mean can be constructed for this measure by weighting the individual firm's measure by their share in aggregate sales, where y_{it} is the sales of firm *i* at time *t*:

$$\sigma_t^*(x) = \frac{\sum_i y_{it}\sigma_{it}*}{\sum_i y_{it}}$$

Chart 10: Sector–adjusted real sales growth volatility

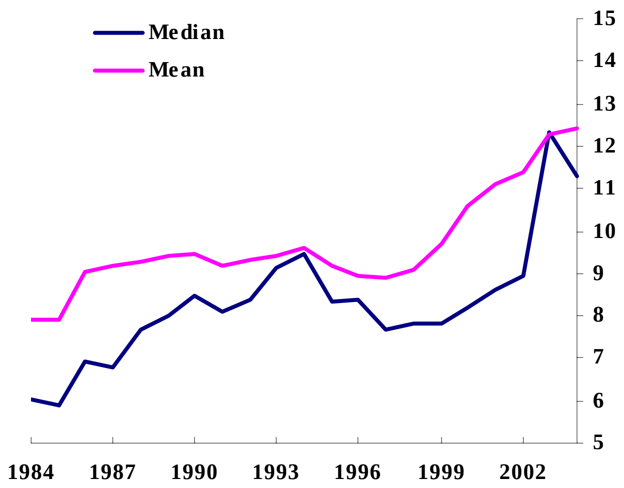


Chart 10 shows the evolution of the ten–year median and mean firm–level volatility relative to sector for the whole sample, weighted by real sales. On both measures, there is a clear increase in firm–level volatility. If firms' real sales growth rates are diverging more from the sector average, it implies that the covariance between firms' growth rates in each sector is falling. This is a potential explanation of the divergence of trends in aggregate and firm–level volatility — less correlated firm–level results within sectors leading to greater aggregate stability.

Increased competition within sectors

One explanation of an increased volatility of firms' sales growth relative to sector could be an increase in product market competition. We consider here two possible measures of product market competition — turnover of leader firms and margins. CP (2005) attribute some of the rise in firm–level volatility to an increase in turnover of the composition of leading firms within an industry.

We define turnover of leader firms in industry *j* at time *t* as the probability of a firm leaving the top quintile of sales for that industry over a five–year period,

$$Turnover = P\left(y_{ijt+5} < y_{t+5}^{top,j} \mid y_{ijt} > y_{t}^{top,j}\right)$$

where y_{ijt} is the sales of firm *i* in sector *j* at time *t*, $y_{t}^{top,j}$ is the 80th percentile of the distribution of sales at time *t* for all firms in sector *j*. A ten–year figure can be computed analogously. Chart 11 shows the average turnover for leader firms across all industries in the sample. Both measures have increased markedly over the past decade.

A further way of investigating trends in competition is to study profit margins of firms within sectors. We calculate the operating profit margin, defined as the ratio of operating income over sales for each firm in the sample. Chart 12 shows the average operating profit margin for firms over the sample period, either unweighted or weighted by sales. This latter measure is equivalent to the operating profit margin of the whole sample.

Chart 11: Turnover of leader firms

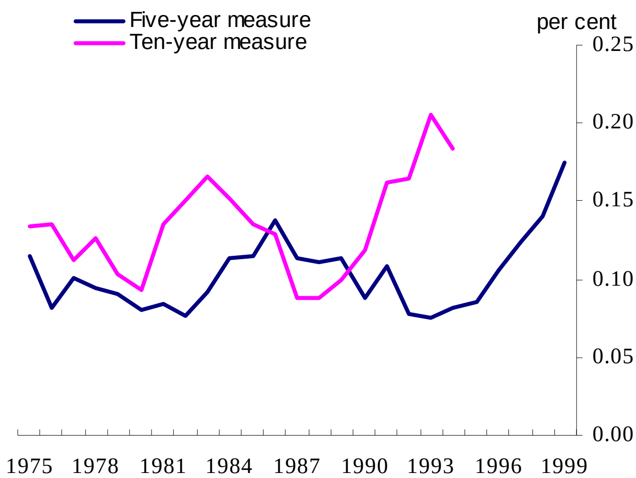
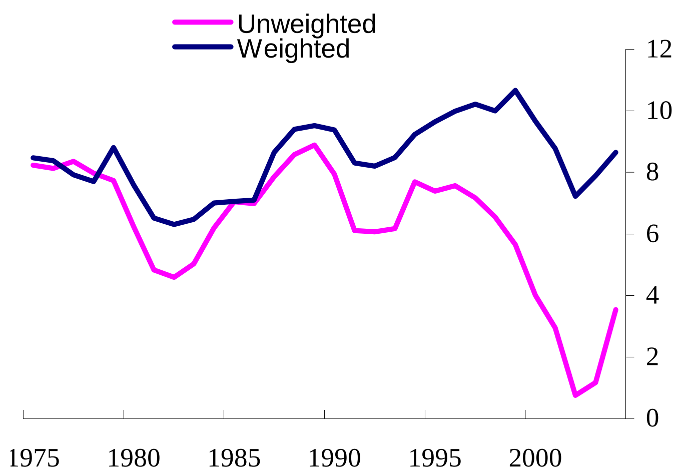


Chart 12: Operating profit margins



The stability of the weighted series reflects the fact that the largest firms in the sample continue to be as profitable as at the start of the sample. However, the fall in the unweighted series reflects the higher probability of firms leaving the top quintile of sales, and a great influx of new entrants, which have lower profit margins. Both the increased turnover of market leaders, and the divergence of profit margins between these leaders and the rest of the firms in the sample accord with the findings of CP (2005). It suggests a higher level of competition within sectors which may lie behind the increasing firm–level volatility. That aggregate margins have not declined with increased competition is a result of the fact that the largest firms within sectors have maintained the same level of margins, although the composition of that group of firms is becoming more changeable.

6 Decomposition of aggregate volatility

So far we have analysed the volatility of sales growth at the firm and sectoral level. CP (2005) also carry out a decomposition of the variance of aggregate GDP and find that the fall in aggregate variance of GDP in the US is attributable chiefly to a fall in the comovement between sectors, rather than a fall in the variance of sectors themselves. This is similar to the results found above, that a decline in sectoral volatility was caused by a fall in the comovement of firms' real sales growth which counteracted the rise in firm–level volatility.

This section uses ONS National Accounts data for 31 sectors (plus the adjustment for financial intermediation services indirectly measured) over the period 1978–2004 to verify whether a fall in covariance between sectors is also the main contributing factor to the fall in aggregate value added volatility in the UK. Sectoral growth rates are derived from the volume index for value added for each sector. The aggregate growth rate is constructed by the weighted growth rate of the sectors and differs slightly from the published rate (see Table A2 and Charts A1 and A2 in the appendix). Weights are derived using the 2002 weights published by the ONS, and the implied weights using sector growth rates from the volume indices.

Let $\gamma_{s,t}$ be the growth rate of value added of sector *s* in time *t*. Let $\omega_{s,t}$ be the share of value added of sector *s* in aggregate value added. Also let $M\left(\left[Z_T\right]_{t-9}^{t}\right)$ denote the mean of $\{Z_{t-9}, Z_{t-8}, ..., Z_t\}$, $V\left(\left[Z_T\right]_{t-9}^{t}\right)$ denote the variance of $\{Z_{t-9}, Z_{t-8}, ..., Z_t\}$ and $Cov\left(\left[Z_T\right]_{t-9}^{t}, \left[Y_T\right]_{t-9}^{t}\right)$ denote the covariance between $\{Z_{t-9}, Z_{t-8}, ..., Z_t\}$ and $\{Y_{t-9}, Y_{t-8}, ..., Y_t\}$. By definition, the aggregate growth rate is:

$$\gamma_t = \sum_s \gamma_{s,t}\omega_{s,t}$$

Using the definition of the variance:

$$V\left(\left[\gamma_T\right]_{t-9}^{t}\right) = \frac{1}{10}\sum_{\tau=t-9}^{t}\left(\sum_s \gamma_{s,\tau}\omega_{s,\tau} - \frac{1}{10}\sum_{\tau=t-9}^{t}\sum_s \gamma_{s,\tau}\omega_{s,\tau}\right)^2$$

It follows that the aggregate variance can be rewritten as:

$$V\left(\left[\gamma_T\right]_{t-9}^{t}\right)=\underbrace{\sum_s\left(M\left(\left[\omega_{s,T}\right]_{t-9}^{t}\right)\right)^2 V\left(\left[\gamma_{s,T}\right]_{t-9}^{t}\right)}_{variance\ \ component}+\underbrace{\sum_s\sum_{s\neq j}M\left(\left[\omega_{s,T}\right]_{t-9}^{t}\right)M\left(\left[\omega_{j,T}\right]_{t-9}^{t}\right)\ Cov\ \left(\left[\gamma_{s,T},\gamma_{j,t}\right]_{t-9}^{t}\right)}_{covariance\ \ component}+\ other\ terms$$

The first component is the sum of the variances of the growth in value added at the sector level. The second is the covariance between the growth rates of value added of the individual sectors. The other terms relate to the effects of changing weights within the ten year period of the variance. In practice, these terms are in general small, and have little impact on the results of the decomposition.

Chart 13 shows the results of the decomposition of the volatility of aggregate gross value added. While there has been a small reduction in the variance of individual sectors, the main driver of the fall in aggregate volatility has been the fall in the covariance between sectors. Indeed the fall in covariance accounts for 78% of the fall in aggregate variance over the period, compared with the 11% accounted for by the fall in sectoral variances.

Chart 14 shows a counterfactual experiment that uses the actual growth rate of sectors, but fixes the weight of sectors in aggregate value added to their 2002 values. The results remain essentially unchanged — that it is the fall in the covariance between sectors that lies behind the Great Stability in the UK rather than changing weights of sectors, or changes in volatility of individual sectors.

Chart 13: Decomposition of aggregate volatility (changing weights)

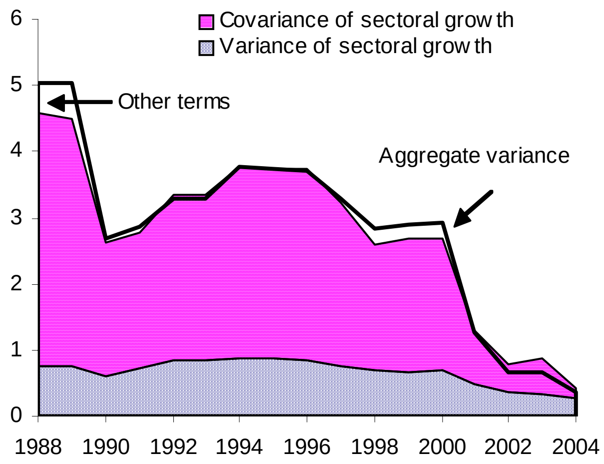
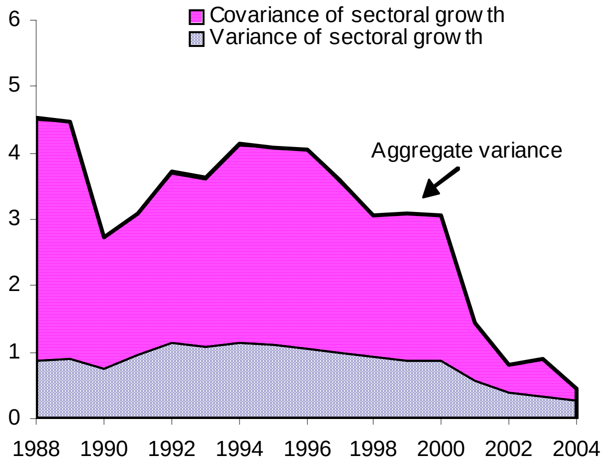


Chart 14: Decomposition of aggregate volatility (fixed weights)



7 . Discussion of results

The previous sections of data analysis has provided some useful stylised facts of the evolution of firms and sectors over the past few decades in the United Kingdom. Specifically, in a period of declining aggregate volatility sectors have become marginally less volatile individually, but have become markedly decoupled from each other. At the same time, individual firms have become more volatile overall, and potentially newer firms that have become listed over the period of greater stability in the economy are more volatile than older firms. Concurrently, the performance of firms within sectors has become more divergent. How can the above analysis help differentiate between potential causes of the Great Stability?

Sectoral change

To what extent has the shift from manufacturing to services in the UK contributed to the fall in output volatility? The answer would appear to be: very little. Evidence from firm–level data suggests that sectors have witnessed an increase in firm–level volatility, and sectors themselves have exhibited falling volatility. Using national accounts data and fixing the weights of the sectors in the economy gives a very similar picture to that using moving weights. Hence the change in relative weight of manufacturing and services within the economy does not appear to have been the major cause of the fall in aggregate volatility.

Increased product market competition

Philippon (2003) constructs a model to test whether an increase in competition in product markets can explain the divergence in aggregate and firm–level productivity. According to this model, in a competitive environment it is more costly for firms to deviate from the optimal price. It follows that firm–level sales growth may be more volatile, and price changes more frequent, with higher competition.(6) However, this increased flexibility enables the economy to react better to shocks, thus reducing aggregate volatility. Philippon calibrates the model for the volatility in firm–level output during the period 1965–1980, then increases competitive pressures in the economy such that the volatility of output of firms matches that in the period 1981–2001. Phillipon finds that this can explain 40 per cent of the reduction in the volatility of GDP. This accords with the findings of this paper. The evidence presented above suggests that competition has become stronger over the sample period.

Globalisation

Similar to an increase in product–market flexibility arising from higher domestic competition would be an increase in competition from global competitors. At the firm–level this may lead to a divergence of results between those firms that are directly exposed to international competition and those that are not, or indeed those firms that are active internationally and those firms that rely on the domestic market. At the sectoral level, some sectors could become more dependent on world–wide conjunctural developments and hence less aligned with domestic events. This could explain the fall in covariance between the sectors in the UK. This argument also appeals insofar as it would also hold symmetrically and help explain the fall in output volatility across the industrial world. One interesting line of future research would be to measure the correlation of growth rates of industries across countries.

Globalisation could also work at the firm level by removing national barriers, allowing previously disparate domestic markets to integrate thereby increasing market size. According to Asplund and Nocke (2006), larger markets are endogenously more competitive, with price–cost margins smaller. As a result, idiosyncratic shocks are more likely to cause firms to leave the market, increasing the turnover of firms within the market.

Economic diversification

Acemoglu (2005) (in comments on CP (2005)) presents a model that looks at financial development and economic growth. As economies grow and the financial sector becomes deeper, firms are better able to borrow to finance risky projects. As a result, the firm–level volatility increases since firms are undertaking riskier projects. Simultaneously, as the economy becomes more diversified, the aggregate shocks become less prevalent since the covariance between firms falls. This leads to lower aggregate volatility.

The 1980s witnessed a large–scale deregulation of the financial markets in many countries, of which the United Kingdom was no exception. If this resulted in more capital available for riskier projects then existing firms may have decided to obtain finance for such projects. This would fit with the increased volatility of firms in the balanced panel. It also follows that firms undertaking riskier business may have been able to issue equity publicly at better terms, encouraging stock–market listings of riskier firms. If this were true then firms listing post–deregulation could be more volatile than those before deregulation. Given that the firm–level dataset used in this paper is of listed companies it may explain why firms that enter at the very end of the sample may appear more volatile. However, there may be other explanations and more data, notably of unlisted companies, is required before any firm conclusions could be reached.

Good policy or good luck?

The three previous candidate explanations all rely on a change in economic policy (product liberalisation, deregulation etc.). As such, any benefits arising can be considered as the result of 'good policy'. However the debate usually centres on the effects of improved macroeconomic stabilisation in the form of better monetary policy. Can the data differentiate between good monetary policy and good luck? Suppose sectoral growth rates are composed of three terms — a trend, a common demand shock affecting all sectors and an orthogonal idiosyncratic shock. If monetary policy becomes effective at counteracting the common shock then sector growth rates will chiefly be composed of the idiosyncratic shock. Since these by definition have no covariance with the idiosyncratic shocks of other sectors, the aggregate covariance, and thus

(6) This is supported by surveys of firms' price–setting behaviour, e.g. Hall *et al*. (1997) for the United Kingdom.

aggregate variance, will fall. This would certainly fit with the facts presented above that the covariance between sectoral growth rates has fallen. In practice it is difficult to differentiate *ex post* between smaller aggregate shocks to the economy and policy better able to counteract the aggregate shocks. What is clear from the data is that any good luck has been confined to smaller aggregate shocks, since the reduction in sectoral volatility accounts for little of the fall in aggregate volatility.

8. Conclusions

Previous research has highlighted a divergence in the trends of volatility of output at the aggregate and at the firm level in the United States. This paper uses firm–level data to investigate whether these divergent trends were also apparent in the United Kingdom. It finds evidence of an increasing trend of volatility at the firm level, reinforced by a widening of the distribution of the volatility of firm–level sales growth both over time and cross–sectionally. Analysis of a balanced panel of firms with accounts throughout the period suggests that this trend is not a function of the changing composition of firms in the sample, although there is evidence that firms that entered the sample post–1989 are more volatile than firms that entered earlier.

Within sectors, the sales growth performance of firms has become more divergent. This falling covariance results in a slight decline in the volatility of sectors, and gives insights into the mechanisms whereby aggregate volatility has fallen. This paper also carried out a decomposition of the variance of aggregate value added using UK national accounts data for 31 sectors. It finds that the principal driver of the fall in volatility at the aggregate level has been the fall in the covariance between the growth rates of the sectors in the economy, rather than the fall in the volatility of the sectors themselves.

Understanding the cause of the increasing volatility at the firm level and the decoupling of sectors at the aggregate level may well be crucial in discriminating between competing theories of the causes of the Great Stability, and have important implications for policy makers. The greater volatility at the firm level, together with a greater divergence of firms within each sector may well be indicative of increased competition. This in turn will have implications for firms' wage– and price–setting behaviour, with consequent effects on the transmission of both shocks and monetary policy in the economy.

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Data Appendix

Table A1: Number of firms in panel, by year

Year	Number of firms — ten–year volatility	Number of firms — five–year volatility	Number of firms with five observations for volatility
1980		1191	
1981		1150	
1982		1075	
1983		1026	
1984	917	956	652
1985	853	896	656
1986	767	822	646
1987	700	756	634
1988	650	726	634
1989	629	719	621
1990	618	738	613
1991	588	741	585
1992	597	774	584
1993	592	803	576
1994	609	833	587
1995	632	877	598
1996	646	876	599
1997	662	853	595
1998	643	787	588
1999	621	714	571
2000	559	663	530
2001	528	653	502
2002	513	698	487
2003	496	718	458
2004	484	707	414
Firm–years	13304	20752	12130
Number of firms	1470	2178	955

Table A2: Constructed weights of sectors in aggregate value added

Sectoral weights	1978	2004
Agriculture, hunting, forestry and fishing	11.1	9.9
Mining of coal	5.3	0.6
Extraction of mineral oil and natural gas	13.4	22.3
Other mining and quarrying	2.9	1.6
Food, beverages and tobacco	31.7	22.6
Textiles and textile products	18.3	5.5
Leather and leather products	2.7	0.6
Wood and wood products	4.9	2.7
Pulp, paper and paper products; publishing and printing	27.0	21.9
Coke, petroleum products and nuclear fuel	4.5	2.6
Chemicals	15.0	17.4
Rubber and plastic	9.3	8.5
Other non–metallic mineral products	10.4	5.7
Basic metals and fabricated metal products	32.3	16.1
Machinery	28.9	13.0
Electrical equipment	13.1	18.1
Transport equipment	25.6	17.2
Other manufacturing	16.4	7.1
Electricity, gas and water supply	16.7	17.7
Total production	*278.9*	*201.1*
Construction	64.2	58.9
Wholesale and retail	101.0	123.6
Hotels and restaurants	38.4	33.5
Transport and storage	43.8	48.4
Communication	11.6	31.5
Financial intermediation	55.9	68.0
Letting of dwellings and imputed rent	94.2	78.0
Other real estate, renting and business activities	72.3	162.2
Education	72.6	59.5
Health and social work	55.2	62.3
Other services	35.2	52.0
Public administration and defence	86.2	55.6
Total services	*666.4*	*777.4*
Adjustment for FISIM	-20.5	-44.3
All industries	1000.0	1000.0

Chart A1: True (ONS) and constructed aggregate growth rate

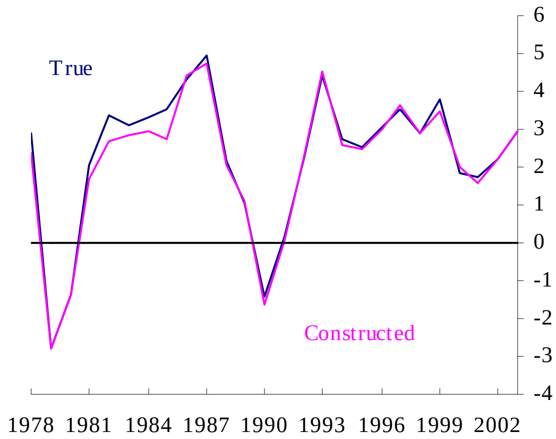

Chart A2: True (ONS) and constructed aggregate variance