# Firm-level and aggregate output volatility

The volatility of key economic variables affects the decisions of firms and households in a variety of ways. Obtaining a deeper understanding of how volatility patterns evolve and which factors determine such developments is therefore of great interest from an economic perspective. Many of the studies on macroeconomic volatility focus on aggregate variables, thus disregarding the firm level, at which the decisions that form the basis of the macroeconomic findings are taken. The present article is therefore the first of its kind to examine this dimension of volatility for the German economy and distinguishes two types of volatility. Purely firm-specific volatility changed only very little between 1974 and 2005. However, volatility that includes the response of individual firms' business activity to the macroeconomic environment or to economic structural changes was trending downwards, thus also matching the volatility profile of aggregate output. However, the abrupt end to the falling-volatility period due to the escalation of the financial crisis has also shown that a supposedly stable environment can also have deceptive elements.

## Output volatility and economic activity

Economic activity is generally characterised by ups and downs at both macroeconomic and microeconomic (ie firm and household)

*Fluctuations are characteristic of key macroeconomic variables ...*

levels. Business activity, firms' investment decisions and households' consumption, to name a few examples, are all affected by such fluctuations.

*... and are not intrinsically "good" or "bad"*

Economically speaking, such volatility cannot be regarded as intrinsically bad or good. The fact that the business cycle and economic developments are inevitably characterised by a certain degree of ups and downs often reflects a dynamic, changing economy. In the tradition of Schumpeter's concept of "creative destruction", it is only such change that can clear the way for the new and thus improve the longer-term outlook for growth.[1] At the micro level, the volatility of individual firms' sales and profits is often what makes it possible in the first place for investors to diversify the risks in their asset management decisions.

However, volatility can also generate costs. At the aggregate level, there has been a long-standing and animated debate on the relationship between real sector volatility and longer-term growth. A raft of empirical studies – especially cross-sectional analyses of less-well-developed economies – confirm a negative link.[2] And, even when considering welfare aspects and given plausible assumptions about the preferences of households and firms, major variations in their economic circumstances are associated with welfare costs. Real sector volatility, via the fluctuations in labour and investment income that usually result, generally impacts negatively on households' decisions to smooth consumption over time in an attempt to increase their long-run overall utility. Moreover, the uncertainty associated with such ups and downs can adversely affect the consumption decisions of risk-averse households: imperfect insurance markets prevent households from fully shielding their consumption against income fluctuations, and social welfare systems can pick up only part of the slack. By the same token, it is quite rational for investors, facing temporarily large uncertainty about future economic developments and thus future earnings, to put off irreversible investment decisions for the time being. Other things being equal, economies with a high level of cyclical uncertainty may therefore display a lower level of investment and thus a lower rate of growth.[3]

*Deeper understanding of micro volatility also key to macroeconomic issues*

Given that economic fluctuations are one of the determinants of key macroeconomic developments, interest in empirical analyses of economic volatility has been rising strongly for quite some time. One increasingly popular strand of research about a phenomenon in the past few years which is known collectively as the "Great Moderation" addresses the use of aggregated volatility measures. Studies

1 See J Döpke (2004), How robust is the empirical link between business cycle volatility and long-run growth in OECD countries? International Review of Applied Economics, Vol 18, No 1, pp 103-121.
2 See, for instance, V Hnatkovska and N Loayza (2005), Volatility and growth, in Managing economic volatility and crises. A practitioner's guide, J Aizenman and B Pinto (eds), Cambridge, pp 65-100, as well as P Aghion, G-M Angeletos, A Banerjee and K Manova (2005), Volatility and growth: credit constraints and productivity-enhancing investment, NBER Working Paper 11349, Cambridge MA.
3 By contrast, uncertainty can also create incentives to invest if entrepreneurs are successful in optimising their output to adjust to a changing environment. However, econometric studies seem to indicate that uncertainty mostly dampens investment activity. See Deutsche Bundesbank, Uncertainty, freedom of action and investment behaviour – empirical findings for Germany, Monthly Report, September 2001, pp 71-86.

analysing volatility at the microeconomic level, or firm level, are fewer and further between. It is, in particular, the volatility of firms' activity and the factors influencing it that provide valuable insights for a host of issues that are also relevant from a macroeconomic perspective. For instance, households' ability to smooth consumption hinges on the availability of alternative ways to diversify risk. Diversification potential is determined by the extent to which firm risks are affected by macroeconomic developments, ie aggregate and structural developments, which affect a large number of firms in a similar manner, and by firm-specific, ie idiosyncratic, factors. It is crucial in this context that developed and functioning financial markets enable market participants to disperse idiosyncratic firm-level risks. Furthermore, risks are easier to diversify if the individual firms respond differently to macroeconomic developments.

The present article is therefore the first to analyse firm-level volatility and its key drivers specifically for Germany. Using the Deutsche Bundesbank's Corporate Balance Sheet Statistics, the volatility – captured by the fluctuation of real sales – of an average of up to 30,000 firms per year from various sectors of the German economy will be analysed cross-sectionally and in a historical perspective.[4] Fluctuations in business activity may be caused by macroeconomic factors as well as by firm-specific factors. In particular, given the debate about the "Great Moderation", it is particularly interesting to analyse the determinants of firm-level volatility separately. Therefore, the volatilities of firm activity which are based on macroeconomic factors and on idiosyncratic factors are modelled in the present article separately and analysed over time for an extended observation period. This is followed by an analysis of volatility at the aggregate level. The article concludes with a brief look at the influence of the financial crisis – and its causes – on output volatility.

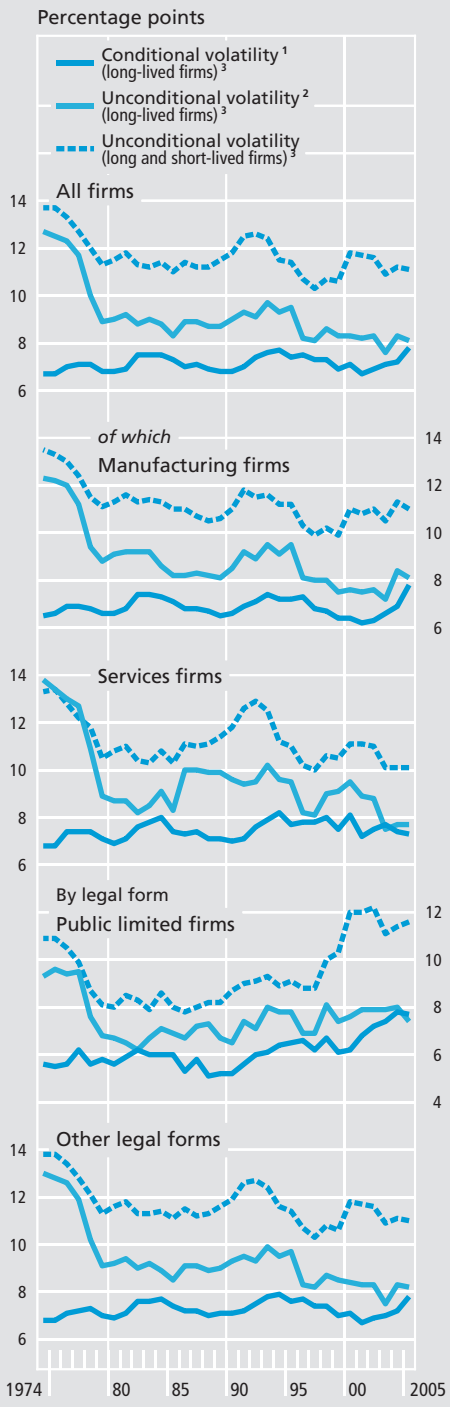
## Firm-level output volatility

*Unconditional and conditional firm-level volatility*

Firm-level volatility is measured here by the standard deviation of rates of change in real sales.[5] This measure is also referred to as "unconditional volatility". By contrast, "conditional" volatility is based only on the firm-specific, idiosyncratic component of sales growth.[6] This is based on the idea that firms' decisions are not only influenced by circumstances which affect all firms similarly, such as price movements in international commodity and financial markets or domestic and external aggregate demand, but also depend on firm-specific factors such as changes in their production structures. The idiosyncratic component of sales growth is calculated econometrically by adjusting the rates of change of real firm sales for macroeconomic influences using a time series regression (see the annex on pages 46-48). This approach requires a sufficiently long reference period for the estima-

4 For characteristics of the dataset, see Deutsche Bundesbank, German enterprises' profitability and financing – an analysis based on a new dataset, Monthly Report, October 2005, pp 31-67.
5 Firm sales are adjusted with the sectoral deflators of gross value added from the national accounts.
6 For more about the methodology see C M Buch, J Döpke and K Stahn (2009), Great moderation at the firm level? Unconditional vs. conditional output volatility, The B E Journal of Economic Analysis & Policy, Contributions, Vol 9, Issue 1, Article 20, pp 1-25.

Firm-level output volatilities*




* Median of five-year centred rolling standard deviations of year-on-year percentage growth in real sales. — **1** Based on the firm-specific component of sales growth. — **2** Total standard deviation. — **3** Long-lived: 37 years, short-lived: six to 36 years.

Deutsche Bundesbank

tion. Below, conditional volatility will therefore be analysed for those firms whose sales figures are available for the entire observation period – in this case, 1971 to 2007. These firms are called "long-lived" because they do not enter or exit the market during this period of business activity. Estimates have shown that firms with low sales growth and low leverage, as well as large firms and public limited companies, are more likely to belong to this group of firms (see the annex, pages 46-48). It will be shown below that both large firms and public limited companies display a relatively low level of conditional volatility as well as a relatively low level of unconditional volatility. In addition, the sales growth of shorter-lived firms is more volatile by nature. The volatilities of long-lived firms, analysed first in this article, are therefore likely, in a sense, to form a lower bound.

*Ways of measuring output volatility*

The measure of volatility used with the standard deviation is not the only available option. Volatilities in economic activity are usually determined with their cyclical component. There are various ways of adjusting the development of (aggregate or firm-level) output variables for their growth trend. One option is to use a filtering method; however, its specification needs to be fitted to the given observed output variable and, in the present case of a broad analysis of micro data, does not always produce plausible results. By contrast, the standard deviation used here, which is calculated for the year-on-year change in output, is a very tractable measurement. The use of moving time windows captures shifts in the respective volatilities over time.[7] Here,

**7** Trend shifts affect the standard deviation inasmuch as it is not normalised here.

the unconditional volatility and the conditional volatility are defined as the rolling standard deviation of firm sales growth or its idiosyncratic component, centred over a five-year period.[8] The time profile of the firm median, ie the median of the volatilities calculated for all firms in a given period, can be interpreted as the trend pattern of firm-level volatility.

*Conditional volatility nearly unchanged ...*

The results show that the conditional volatility of long-lived firms has changed little over time. In each decade it averaged 7 percentage points. Only during the 1990s was it ¼ percentage point higher. However, in the past four years, conditional volatility rose by just over 1 percentage point, thus showing a weak trend rise. This is confirmed by microeconometric studies which found a trend rise – albeit a small one – in conditional volatility for long-lived firms as a whole (see table on this page and the annex, pages 46-48).

*... but affected by several firm-specific factors*

A number of firm-specific conditions come into consideration as factors influencing the pattern of conditional volatility. Firm size probably plays a role. For instance, large firms are likely to be able to diversify risk more widely internally, which should tend to dampen fluctuations in individual sub-areas and reduce overall volatility. The firm's growth momentum is also likely to be relevant: rapidly growing firms might be vulnerable to major setbacks, which would appear to indicate a positive relationship between firm growth and volatility. In addition, inventory behaviour could influence the volatility of business activity. Firms attempt to offset fluctuations in demand by keeping inventories of their final products so that, as the marginal costs of the production process rise, they can cushion falls in profits by smoothing their output. Firms' financing conditions might be an additional determinant. This is indicated not only by an analysis of the conditional volatility of firms of varying legal forms, economic sectors and size categories but also by empirical studies. This type of volatility can also be plausibly explained in the econometric analysis merely by the idiosyncratic components of firm-specific factors. In addition, the estimation outcome is corrected for the effect of looking only at

Factors affecting conditional volatility °

| Regressor | Estimated coefficient |
|---|---|
| Idiosyncratic component of ... | |
| ... asset growth (t) | 0.032*** |
| ... asset growth (t-1) | 0.014*** |
| ... inventory-to-sales (t) | – 0.049*** |
| ... leverage (t) | – 0.000 |
| 0/1 dummy for German unification 1 | 0.000 |
| Linear time trend | 0.000*** |
| Inverse Mills ratio | 0.026*** |
| Constant | 0.201 |

° Panel estimation with robust standard errors and time, legal form and sector fixed effects. — 1 Value of 1 for the 1991-1995 period. — ***/ **/ * indicate significance at the 1%/ 5%/ 10% levels respectively.

Deutsche Bundesbank

8 Although this is shorter than the median length of business cycles in Germany, the results of the study are just as valid for a rolling ten-year observation period.

long-lived, more stable firms (see the annex, pages 46-48).[9]

Several of these potential determinants of conditional volatility will be examined more closely below. In many cases, the cross-sectional dimension – specifically, the question as to how these determinants have impacted on volatility across the observed firms or sectors – is of interest.

*Conditional volatility and legal form, ...*

The time profile of conditional volatility shows only slight fluctuations for nearly all categories of firms. Public limited companies are the exception: in the 1970s, their conditional volatility was still well below the average, yet since the early 1990s it has risen by 2½ percentage points and, in the current decade, has matched the level of firms of other legal forms.

*... inventory behaviour, ...*

Moreover, conditional volatilities also vary among the individual economic sectors. Microeconometric studies can shed light on whether or not these differences are due to inventory behaviour. At the firm level, the idiosyncratic component of the ratio between inventory stocks and sales is used as an indicator. For the manufacturing industry, it is found that a higher inventory-to-sales ratio is associated with weaker conditional volatility.[10] The negative relationship indicates that firms with a generally highly volatile demand can dampen the impact of such swings on production by adjusting their inventory stocks. This finding is consistent with traditional approaches which assume that, at the micro level, sales exhibit a greater variability than output and that inventory management therefore has a countercyclical or stabilising effect on firms' business activity.[11]

*... firm size, ...*

As regards the firm size, the conditional volatility of small firms turns out to be larger than for large firms. This is consistent with the other results inasmuch as the smaller firms are likely to belong, above all, to the services sector. Moreover, the assumption that internal diversification opportunities dampen the volatility of large firms relative to smaller firms is confirmed. The influence of firm size is also supported by the econometric finding that volatility rises in line with the growth of firms – measured in terms of the idiosyncratic part of their total assets.

*... and financing conditions*

By contrast, according to the empirical study, the idiosyncratic leverage of a firm – the ratio between debt and equity capital adjusted for macroeconomic influences – has no perceptible influence on conditional volatility.

*Unconditional volatility down perceptibly over time*

When looking at unconditional volatility, however, what is striking is that the overall volatility of long-lived firms is, on average,

9 To do this, the Heckman procedure is used. See J Heckman (1976), The common structure of statistical models of truncation, sample selection, and limited dependent variables and a simple estimator for such models, Annals of Economic and Social Measurement, Vol 5, pp 475-492.
10 The estimation used total inventory stocks. Moreover, in the balance sheet information it is impossible to determine whether the finished goods therein are self-produced or purchased from other firms.
11 It is also assumed that the covariance of sales and inventory changes is negative. See E Langmantel (2005), Identifying the German inventory cycle. A multivariate structural time series approach using survey data, Journal of Economics and Statistics (Jahrbücher für Nationalökonomie und Statistik), Vol 225, Issue 1, pp 675-687. This theory is supported by the empirical finding that, for the firms analysed here, the firm median of the (unadjusted) inventory-to-sales ratios is declining over time. See the annex (pp 46-48) for more information.

2 percentage points higher than conditional volatility. Moreover, it becomes clear that the unconditional volatility has declined noticeably. During the second half of the 1970s, a period that was characterised by the recession associated with the 1975 oil price crisis, it still averaged as much as 11¼ percentage points and fell in the 1980s to an average of 8¾ percentage points. This trend was interrupted by the increase in volatility in the first half of the 1990s owing to the post-German unification adjustment processes and the opening-up of the central and east European economies. The fluctuations in business activity, however, increased only temporarily. In the current decade, unconditional volatility fell to 8 percentage points. This means that it has fallen by a substantial 3¼ percentage points in total since the 1970s.

With firm-specific volatility remaining constant, the decline in overall volatility at the firm level was due to economic developments which affected firms in a similar way. This raises the question as to which conditions common to firms could have led to the observed decline in sales growth volatility. To explain the (aggregate) volatility trend, three main transmission channels are cited.[12] One line of argument holds that the intensity of economic cycles could have been reduced by appropriate monetary and fiscal policy (the "good policy" hypothesis). Another emphasises the influence of smaller exogenous shocks, such as oil price fluctuations (the "good luck" hypothesis). A further possibility is that the volatility trend is dependent on structural change in the economy, such as technological progress, the underlying conditions for corporate finance or globalisation, understood here as the growing integration of the international goods and financial markets. However, despite intensive research, a final consensus has not yet been reached.[13]

*Differences in firms' response to macroeconomic trends ...*

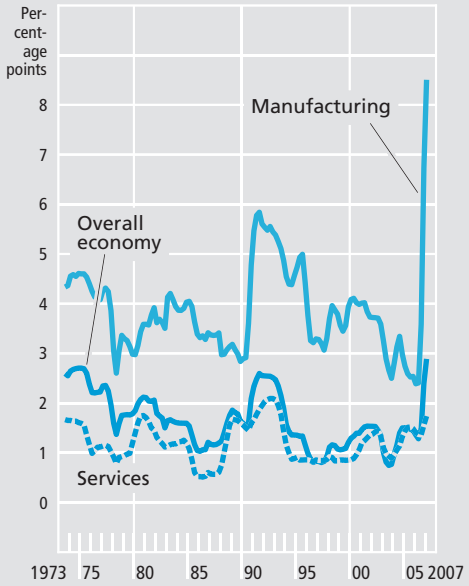
Including the firm level for analysing the influence of macroeconomic factors on the volatility pattern provides an interesting and detailed picture of the strength of these factors. The Bundesbank's econometric studies show that, in isolation, macroeconomic factors can explain up to 60% of the variance in sales growth of a long-lived firm.[14] However, on average across firms, the explanatory power of the individual macroeconomic developments is only between 4% and 8%. This indicates significant differences between firms with regard to the effects of the common conditions on sales growth volatility.

*... reflect firm-specific factors ...*

These divergences are probably due to firm-specific factors. There is empirical evidence that large firms' sales growth is more sensitive to changes in price competitiveness than that of smaller firms. This is probably because the business activity of large firms is generally geared relatively strongly to international sales markets. In addition, commodity prices

12 See, for instance, A Pescatori (2008), The Great Moderation: Good luck, good policy, or less oil dependence?, Economic Commentary, March, Federal Reserve Bank of Cleveland; L González Cabanillas and E Ruscher (2008), The Great Moderation in the euro area: What role have macroeconomic policies played?, Economic Papers 331, June, European Commission; and G Young (2008), On the sources of macroeconomic stability, Quarterly Bulletin 2008 Q2, Bank of England, pp 174-183.
13 In some cases, the results also depend on which econometric models are being used. See Young, op cit, p 179.
14 The partial coefficients of determination of the macroeconomic factors are estimated for each firm.

Aggregate output volatility*




* 20-quarter rolling centred standard deviation of seasonally and calendar-day adjusted year-on-year percentage change in gross value added at previous-year prices.

Deutsche Bundesbank

have a lesser impact on the sales growth of services firms than in other sectors because, for instance, imports of raw materials do not play a significant role in service providers' production process.

A look at the unconditional volatilities of various categories of firms provides further clues. It becomes clear that macroeconomic developments tend to have led to a decline in volatility for all firms – following high levels on the heels of the first oil price crisis and German unification. Although the overall volatility of public limited companies, unlike other types of firms, has displayed a trend rise since the early 1980s, this is largely due to an increase in their conditional volatility in the past two decades, as mentioned earlier.[15]

*... and sectoral business activity*

By contrast, differences in sectoral business activity are likely to be the main reason why volatilities in manufacturing and services have diverged. The boom and bust period in the IT industry around the turn of the millennium coincided with relatively strong volatility of sales growth in services during the 1998-2002 period, whereas the volatility of long-lived manufacturing firms changed only little. However, it can be seen that the unconditional volatility of the services sector – as well as the conditional volatility – has, on average, been above that of manufacturing (+¾ percentage point). This is not least because the wholesale and retail trade, which has a higher volatility than many goods-producing firms, is very strongly represented among the observed firms.

*Shorter-lived firms with higher volatility*

Moreover, market entries and exits of firms also influence volatility. In order to incorporate this effect, the present article will proceed by adding shorter-lived firms to the analysis. This group includes all firms for which sales growth figures are available for at least five consecutive years and also includes the long-

15 Similar discrepancies between listed and unlisted firms in terms of unconditional volatility can be observed for the United States, France and the United Kingdom. See S J Davis, J Haltiwanger, R Jarmin and J Miranda (2006), Volatility and dispersion in business growth rates: publicly traded versus privately held firms, NBER Working Paper 12354, Cambridge, MA; D Comin and T Philippon (2005), The rise in firm-level volatility: causes and consequences, in NBER Macroeconomics Annual, M Gertler and K Rogoff (eds), Cambridge MA, pp 167-201; D Thesmar and M Thoenig (2004), Contrasting trends in firm volatility: theory and evidence, CEPR Discussion Paper 7135; and M Parker (2006), Diverging trends in aggregate and firm-level volatility in the UK, Bank of England, External MPC Unit, Discussion Paper 16.

lived firms examined earlier.[16] It is found, firstly, that the volatility of this sample of firms tends to have fallen much less, at only 1½ percentage points between the 1970s and the current decade, than that of long-lived, stable firms. Secondly, the volatility is, on average, 2½ percentage points higher. In the first instance, this finding is a reflection of the fact that, as other studies have shown, newly established firms have a higher sales volatility, which goes as far as the possibility of exiting the market altogether.

*Stable macroeconomic environment favours low firm-level volatility*

Since macroeconomic factors were the main reason for the reduction in unconditional volatility, it may be concluded that a stable macroeconomic environment has encouraged low firm-level volatility. Aggregate developments thus also form a basis for firm-level volatility. Therefore, the picture of aggregate volatility over time is likewise an important element of a comprehensive analysis.

## Aggregate output volatilities

*Macro and micro volatilities have similar time profile*

The aggregate volatilities under examination are defined as rolling standard deviations of the annual rates of change of real value added as defined in the national accounts. On balance, this calculated volatility has a time profile that is similar to that of the volatility calculated for the firm level as a whole. In the last few decades before the financial crisis, both variables were trending down-

16 No distinction is made between whether firms leave the market permanently after at least five years or whether the balance sheet ratios are incomplete over the observation period.

### Output volatility and value-added shares by sector

| Sector | 1971 to 1979 | 1980 to 1989 | 1990 to 1999 | 2000 to 2007 |
|---|---|---|---|---|
| Output volatility (percentage points) 1, 2 | | | | |
| All sectors | 2.2 | 1.8 | 1.9 | 1.5 |
| *of which* | | | | |
| Agriculture, forestry and fisheries | 3.1 | 6.9 | 6.1 | 12.1 |
| Manufacturing | 3.8 | 3.7 | 4.4 | 3.5 |
| Construction | 6.5 | 6.5 | 5.2 | 4.6 |
| Services | 1.3 | 1.1 | 1.7 | 1.3 |
| Trade, hotels and restaurants | 2.7 | 2.5 | 3.3 | 1.9 |
| Financing, renting and business services | 1.7 | 1.1 | 2.2 | 2.0 |
| Public and private services | 1.5 | 1.0 | 1.2 | 0.9 |
| Value added shares (percentages) 2 | | | | |
| All sectors | 100.0 | 100.0 | 100.0 | 100.0 |
| *of which* | | | | |
| Agriculture, forestry and fisheries | 2.5 | 1.7 | 1.2 | 1.0 |
| Manufacturing | 30.1 | 27.4 | 22.0 | 20.6 |
| Construction | 6.5 | 5.4 | 5.6 | 3.9 |
| Services | 48.5 | 53.5 | 59.3 | 62.5 |
| Trade, hotels and restaurants | 17.0 | 15.9 | 16.1 | 16.0 |
| Financing, renting and business services | 14.5 | 18.9 | 23.5 | 26.0 |
| Public and private services | 17.1 | 18.6 | 19.7 | 20.5 |

1 Standard deviation of annual percentage changes in gross value added at previous-year prices. — 2 Calculations based on quarterly data.

Deutsche Bundesbank

Pairwise correlation of sectoral contributions to growth *

| Sector | Manufacturing | Construction | Services |
|---|---|---|---|
| | 1971 Q1 to 1979 Q4 | | |
| Agriculture, forestry and fisheries | 0.08 | – 0.17 | 0.03 |
| Manufacturing | | 0.43 | 0.66 |
| Construction | | | 0.70 |
| | 1980 Q1 to 1989 Q4 | | |
| Agriculture, forestry and fisheries | – 0.09 | – 0.07 | – 0.25 |
| Manufacturing | | 0.46 | 0.63 |
| Construction | | | 0.51 |
| | 1990 Q1 to 1999 Q4 | | |
| Agriculture, forestry and fisheries | – 0.01 | – 0.30 | – 0.07 |
| Manufacturing | | 0.27 | 0.41 |
| Construction | | | 0.13 |
| | 2000 Q1 to 2007 Q4 | | |
| Agriculture, forestry and fisheries | 0.23 | 0.00 | – 0.15 |
| Manufacturing | | 0.25 | 0.44 |
| Construction | | | 0.49 |

* Contributions to gross value added at previous-year prices. Measures in terms of the correlation coefficient.

Deutsche Bundesbank

wards. However, the largely uniform trend patterns of these two variables over time is not self-evident. In fact, their time profiles are quite capable of diverging. One reason is that, in the national accounts, the individual firms' output reports are first compiled and the volatility is then calculated using these condensed variables. For instance, using this method of calculation – and unlike the micro-level view – volatility in manufacturing was an average of 2½ percentage points higher than that in services. Compilation on the aggregate level, as well as the micro-level composition of firms, are thus very much capable of influencing sectoral volatility.

*Macro volatility and value added components*

Another potential reason for differences in firm-level and aggregate volatility profiles could lie in fluctuations in the contributions of individual firms to gross value added. This effect is difficult to quantify at firm level. At an aggregated level, by contrast, the increasing importance of services output for the economy as a whole, owing to services' low volatility, could also have led to a reduction in the volatility of gross domestic product (GDP).

It should be noted, however, that the overall variance (and thus the volatility) of the rate of change of overall gross value added depends not just on the weighted sum of partial variances of individual firms' rate of change (or sectors' rate of change at aggregate level). It is also affected by the covariance of firm-level (or sectoral) changes in value added, ie the type and intensity of the common dispersion. If the percentage of low-volatility firms or sectors rises while the degree of synchronicity between individual firms or sectors also increases, the volatility of GDP might even increase. Accordingly – in an aggregate view – it is possible that, despite the growing significance of the services sector, the intensity of GDP fluctuation increases if, at the same time, the synchronicity between activity in the services sector and that in other economic sectors increases.

At firm level, statistical dispersion measures such as the interquartile range, ie the difference, calculated for each year, between the sales growth of the firms with the lowest 25% and the highest 25% rates of change, provides evidence of the degree of synchronicity between firms. It turns out that the divergence between the sales fluctuations of shorter-lived firms has, on an average of the current decade, declined compared with the

1970s. This tendency has been especially pronounced for long-lived firms and may be interpreted as greater synchronicity of firm-level business trends. By contrast, the correlation between the service sector's contribution to GDP and that of goods and construction output has decreased noticeably, implying lower synchronicity of sectoral trends. This supports the hypothesis that the greater significance of the services sector contributed to the subsiding volatility of German economic activity.

*"Great Moderation" in many industrial countries*

The decline in aggregate volatility in Germany over the past few decades is consistent with observations in other industrial countries that short-term volatility has been undergoing a similarly pronounced fall not just in terms of the underlying trend but also quantitatively. This is a sign that the "Great Moderation", as this stylised fact is also called in the literature, is due to reasons that are common to many developed economies. This is consistent with the empirical firm-level finding that macroeconomic factors are the main reason for the reduction in volatility in Germany. This outcome can also make a major contribution to explaining the volatility trend during the current financial crisis, which has left a severely changed macroeconomic environment for the German economy in its wake.

## Output volatility in the financial crisis

*Volatility up sharply owing to financial crisis*

The financial crisis which began around mid-2007 spelled an abrupt end to the long period of the "Great Moderation". The growing intensity of financial market turbulence in the late summer of 2008 triggered a global crisis of confidence and, in Germany, too, led to severe output losses which caused aggregate volatility to rise considerably. It is therefore likely that, over the next one and a half years, the volatility of German GDP will exceed the peak levels of the early 1970s and the period of German unification. For many industrial nations, which likewise saw their output fall considerably in the wake of the financial crisis, the outcome is expected to be much the same.

*Key determinants of the "Great Moderation"*

This raises the question of what kept firm-level and aggregate output volatility at a relatively low level since the mid-1990s. This finding may be regarded as the outcomes of multiple mutually reinforcing effects.[17] Such effects in this context include global financial market liberalisation, which made it much easier to obtain access to credit. Credit risk transfer instruments – above all, securitisations – were used to package, diversify and pass on individually illiquid microeconomic assets. This coincided with increased lending to firms and households and the expansion of a formerly more liquidity-constrained financing of their investment and consumption activities towards asset-backed financing. This made economic activity more susceptible to the influence of movements in asset values and the associated risks. In addition, the rapid advance of globalisation in the real sector, ie the rising number of countries participating in global trade, the vertical integration of production chains and the growing tradability of

17 See C Borio (2006), Monetary and prudential policies at a crossroads? New challenges in the new century, BIS Working Papers, No 216 and C Borio and I Shim (2007), What can (macro-)prudential policy do to support monetary policy?, BIS Working Papers, No 242.

services, led to a succession of positive supply shocks.

This led to a global expansion of aggregate demand, amplified by strong credit growth and the fact that financial market supervision was, in many cases, not adequate to the risk involved; this expansion came up against a growing supply of goods in the wake of globalisation. Added to this was a relatively long period of low (real) interest rates without any concurrent build-up of inflationary pressure. The outcome was an extended period of low inflation and high output growth. The extremely benign trends in the macroeconomic environment are also reflected by firm-level volatilities in Germany; the volatility of long-lived firms based on macroeconomic developments was shrinking sharply during the current decade up to the outbreak of the financial crisis. However, falling volatility in the real sector coincided with a distinct increase in the medium-term ups and downs in aggregated asset prices and lending in major industrial countries since the 1980s.

*Financial imbalances amplified business cycle*

The current financial crisis has shown that, in the global cyclical upswing, continuously rising asset prices, falling risk premia and expanded opportunities for obtaining debt finance enabled the development of self-reinforcing processes. These processes led to financial imbalances – ie high financial leverage and excessive balance sheet extensions in the banking system as well as, in the long term, unsustainable borrowing in some countries' private non-financial sectors. These imbalances led to dislocations in the real sector and, sooner or later, had to trigger painful processes of adjustment.

*Summary*

This analysis of the volatility of German firms' business activity has shown that idiosyncratic volatility has changed little since the 1970s, whereas the component of volatility which is based on macroeconomic factors was trending downwards up until the outbreak of the financial crisis. This initially appears to indicate a benign macroeconomic environment prior to the financial market turmoil. Nonetheless, the financial crisis has revealed that the empirically measured decline in real sector volatility at the end of the observation period also stemmed from developments that were unsustainable; seen in that light, the observed short-term stability harboured deceptive elements that emerged in all their virulence with the outbreak of the financial crisis.

## Annex

### The Pesaran multi-factor residual model

In order to adjust sales growth of individual firms for macroeconomic effects, this annex uses the model developed by Pesaran (2006), which assumes a multifactor structure for the residuals.[18]

$$(1)\ g_{it} = \alpha_i' d_t + \beta_i' x_{it} + \epsilon_{it},$$
$$(2)\ \epsilon_{it} = \gamma_i' f_t + u_{it},$$
$$(3)\ x_{it} = A_i' d_t + \Gamma_i' f_t + v_{it}.$$

18 See M H Pesaran (2006), Estimation and inference in large heterogeneous panels with multifactor error structure, Econometrica, 74 (4), pp 967-1012.

Equation (1) assumes that real sales growth of a firm $g_{it}$ is determined by a vector of observed macroeconomic factors $d_t$, a vector of firm-specific regressors $x_{it}$ and the error term $\epsilon_{it}$. In equation (2), the error terms $\epsilon_{it}$ are assumed to have a multifactor structure. They depend on a vector of unobserved macroeconomic factors $f_t$ and the idiosyncratic error terms $u_{it}$, which are assumed to be uncorrelated with either the observed macroeconomic factors or the firm-specific regressors. According to equation (3), the firm-specific regressors are affected by observed and unobserved macroeconomic factors alike. The error term $v_{it}$ is that component of the firm-specific variables on which macroeconomic factors have no effect. The error terms $u_{it}$ approximate the firm-specific, idiosyncratic component of a firm's sales growth and are used to calculate the conditional, idiosyncratic volatility of a firm.

Real domestic absorption, global demand for imports and the German economy's price competitiveness are included as observed macroeconomic factors which reflect firms' common sales terms and conditions. General cost developments are modelled by commodity prices, the short-term interest rate and the domestic rate of inflation. The unobserved macroeconomic factors – in line with Pesaran – are approximated by the annual cross-sections of firm-specific variables, real sales and asset growth, the inventories-to-sales ratio, and leverage. Firms' average sales growth incorporates shifts in trend growth and thus also, for instance, technological progress, since general increases in productivity – such as those due to energy-saving measures – are associated with higher trend growth. The average inventories-to-sales ratio reflects technological progress with respect to inventory management and displays a declining trend. One possible reason may lie in innovative instruments that have improved the ability to forecast the pattern of demand for goods, resulting in a reduction in inventory stocks of final goods needed to ensure deliveries. Another is that improvements in inventory management may be related to "just in time" production and outsourcing, which relieve firms of the need to maintain large stocks of inputs and final products. The framework for corporate finance is taken into account by average leverage, which is also modified by firms in the wake of legislative changes in accounting rules or capital requirements. Average leverage tended to rise in the early 1990s before then receding distinctly. Trend developments in firm sizes are captured by firms' average asset growth.

In order to calculate the idiosyncratic component of business activity, sales growth of each firm over the entire 1972-2007 observation period is regressed on the observed and unobserved macroeconomic factors. The residuals of this estimation correspond to the error terms $u_{it}$ from equation (2). This approach enables the greatest heterogeneity between firms to be obtained.

### Panel estimation of conditional firm-level volatility

To analyse the effects of firm-specific factors on conditional firm-level volatility, a regression is performed for the firms pooled to a panel. That is, unlike the multifactor residual model, homogeneous coefficients are estimated. The conditional volatility used in the panel estimation is defined by the square of the idiosyncratic component of sales growth $u_{it}^2$ – ie sales growth, adjusted, in line with Pesaran's thinking, for the effects of observed and unobserved macroeconomic factors – and thus ap-

## Factors affecting firms' longevity °

| Regressor | Estimated coefficient |
|---|---|
| Sales | – 0.000 |
| Sales growth | – 0.009*** |
| Leverage | – 0.001*** |
| Average sales 1 | 0.000*** |
| Average sales growth 1 | – 1.179*** |
| Average leverage 1 | – 0.028*** |
| 0/1 dummy for public limited firms | 0.396*** |
| 0/1 dummy for large firms | 1.205*** |
| Constant | – 2.608*** |

° Probit estimation with robust standard errors and time, legal form and sector fixed effects. The estimated coefficients indicate the impact of each regressor on the dummy variable being 1, ie the firms being long-lived (37 years). — 1 Average for each firm across all periods. — ***/ **/ * indicate significance at the 1%/ 5%/ 10% levels respectively.

Deutsche Bundesbank

proximates the variance of the idiosyncratic component as

$$(4)\ u_{it}^2 = \lambda_0 + \lambda_1' v_{it} + \lambda_2 \tau + \lambda_3 n + \lambda_4' \delta_i + \lambda_5 m_i + w_{it}.$$

$\lambda_0$ denotes a constant and $w_{it}$ the residual. The vector of regressors $v_{it}$ is adjusted, in a first step, for macroeconomic effects with the time-series regression introduced above and thus contains only the idiosyncratic components of the following firm-specific factors: firms' asset growth, inventories-to-sales ratio and leverage. In order to capture longer-term size effects, one-period-lagged asset growth is also included. An additional a linear time trend $\tau$ is entered into the equation. The dummy variable $n$ models the adjustment processes following German unification, taking the value of 1 from 1991 to 1995 and otherwise zero. In addition, the vector of fixed effects $\delta_i$ models the influence of sectoral developments and legal form as well as a general specification of the time trend.

The estimation is corrected using the Heckman procedure since the results depend on looking only at long-lived firms, for which balance sheet data are available throughout the entire observation period. First, a probit model is used to test which firm-specific factors contribute to the longevity of a firm. The associated residuals can be used to calculate the Mills ratio. Its inverse $m_i$ enters the regression for conditional volatility as a determinant. Its significance might indicate the influence of the probit estimation results on the volatility estimation. $m_i$ turns out to be statistically significant. Consequently, the volatility estimate is influenced by the fact that firms with low sales growth and low leverage, as well as large firms and public limited companies, have a higher likelihood of being represented in the selection of firms (see the table above).