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The cross-sectional dynamics of German business cycles: a bird's eye view

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Abstract:

We establish some stylised facts for Germany's business cycle at the level of the firm. Based on longitudinal firm-level data from the Bundesbank's balance sheet statistic covering, on average, 55,000 firms per year from 1971 to 1998, we analyse the reallocation across individual producers and, in turn, the connection of this reallocation to aggregate business cycles. The empirical results indicate a pronounced heterogeneity of real sale changes across firms. Moreover, the distribution of growth rates of firm's real sales is influenced by business cycle conditions. In particular, the cross-section skewness of real sales changes is strongly counter-cyclical. The results confirm most of the findings for the UK and the US by Higson et al. (2002, 2004) and are, therefore, robust stylised facts of the business cycle.

Keywords: business cycles, cross-sectional moments, firm growth

JEL-Classification: E32, D21, D92

Non technical summary

The paper investigates so-called "stylised facts" of Germany's business cycle at the level of the firm, going thus beyond the traditional focus on co-movements and correlations in macroeconomic aggregates. Until now, such facts have been analysed almost entirely at the macroeconomic level. For example, we ask whether the cross-section distribution of real sales across firms depends on the cyclical situation. To this end, we use the unique data sets from the Bundesbank's balance sheet statistics, which cover, on average, 55,000 firms per year from 1971 to 1998. The empirical results indicate a pronounced heterogeneity of real sale changes across firms. Moreover, the distribution of growth rates of firm's real sales is influenced by business cycle conditions. In particular, the cross-section skewness of real sale changes is strongly counter-cyclical. Furthermore in the light of various robustness checks, we are also able to confirm results from similar studies for the USA and the UK namely, that rapidly growing or rapidly declining firms are significantly less sensitive to aggregate shocks than firms in the middle of the growth range. The conformation of earlier findings, for example, by Higson et al. (2002, 2004), is particularly interesting, given that we use a much larger set of both quoted and non-quoted firms. By contrast Higson et al (2004) confine themselves to the UK quoted population which means only about 1000 firms a year. Thus, the results should be considered as robust stylised facts of the business cycle.

Nicht technische Zusammenfassung

Das Papier untersucht so genannte „stilisierte Fakten“ des deutschen Konjunkturzyklus auf der Unternehmensebene und erweitert somit die traditionelle Fokussierung auf Korrelationen makroökonomischer Zeitreihen. Zuvor waren stilisierte Fakten nahezu ausschließlich auf der makroökonomischen Ebene untersucht worden. Beispielsweise fragen wir, ob die Querschnitt-Verteilung realer Umsätze der Firmen von der konjunkturellen Lage abhängt. Zu diesem Zweck nutzen wir Einzeldaten aus der Bilanzstatistik der Deutschen Bundesbank. Der Datensatz umfasst durchschnittlich 55 000 Unternehmen pro Jahr für den Zeitraum 1971 bis 1998. Die empirischen Ergebnisse zeigen zunächst ein erhebliches Maß an Heterogenität der Umsatzveränderungen. Die Verteilung der Umsatzveränderungen ist abhängig von der konjunkturellen Lage. Insbesondere die Schiefe der Verteilung der Umsatzveränderungen ist stark anti-zyklisch. Wir können ebenfalls – unter Berücksichtung verschiedener Prüfungen auf Robustheit der Ergebnisse – die Ergebnisse ähnlicher Studien für die USA und Großbritannien bestätigen, nach denen stark wachsende oder stark schrumpfende Firmen weniger konjunkturreagibel sind als solche mit mittleren Umsatzveränderungen. Die Bestätigung der Ergebnisse von Higson u.a. (2002, 2004) ist bemerkenswert, da die vorliegenden Analyse auf einem weit umfangreicheren Datensatz beruht, der sowohl börsennotierte als auch nicht börsennotierte Firmen umfasst. Insgesamt sollten die dokumentierten Ergebnisse daher als recht robuste stilisierte Fakten des Konjunkturzyklus angesehen werden.

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THE CROSS-SECTIONAL DYNAMICS OF GERMAN BUSINESS CYCLES: A BIRD'S EYE VIEW[1]

1 Introduction

Until recently, business cycle research has focussed almost exclusively on analysis of major aggregate macroeconomic variables. The cross-sectional behaviour of firm-specific variables, such as real sales, has rarely been used to characterise business cycle fluctuations. However, Higson et al. (2002) and Higson et al. (2002, 2004) have drawn the profession's attention to the usefulness of micro data sets for applied business cycle research. This strand of research departs from the traditional business cycle literature which relies on the paradigm of a representative agent. By contrast, this paper emphasises heterogeneity and highlights the heterogeneous behaviour of agents and its implications. For example, Caplin and Spulber (1987) show the importance of the distribution across firms for the timing of price adjustment for aggregate fluctuations in models with a micro foundation. Several other papers have also pointed to the consequences of the distribution of certain variables across agents at the microeconomic level for the macro outcome (e.g. Abadir and Talmain (2002), Caballero and Engel (1993a), Caballero and Engel (1993b), Caballero and Hammour (1996) and Caballero et al. (1995)).

Moreover, since Lucas' influential paper (1977), it has been common for business cycle models to be compared to stylised facts to access their empirical relevance. The stylised facts collected so far are regularities appearing in aggregate data. Considering

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the increased interest in heterogeneity in macro models it might also be useful to establish stylised facts for firm behaviour over the business cycle as a way of evaluating theoretical models with heterogeneous firms.

This paper establishes a set of stylised facts at the microeconomic level, following the approach of Higson et al (2002, 2004). For example, how universal are the statistical properties of these earlier studies when different countries are taken into consideration? What is more, these studies focused on large quoted firms. Hence there is a further issue regarding the robustness of the findings when smaller firms are analysed. To achieve a better understanding of these issues, we investigate the unique Bundesbank balance sheet database that covers, on average, more than 55 000 firms per annum for the period from 1970 to 1998 and perform an analysis of the growth properties of German firms.

A significant improvement over the previous analysis is that we use a much larger set of both quoted and non-quoted firms, with up to 65,000 firms in each year. By contrast, Higson et al (2004) confine themselves to the UK quoted population, which means only about 1000 firms a year were included in their analysis. We also explore the robustness of the result produced with German data by varying the rules which have been used to exclude outliers in the data. Moreover, there is a sub-population of roughly 3500 firms that survive all the way through the sample. This cohort allows us to examine in more detail the dynamics of the cross section of the business cycle and to help to identify the extent to which the counter-cyclical skewness arises from the churning of the population of firms.

The paper proceeds as follows: section 2 briefly sketches the framework used to discuss the interaction of business cycles and the moments of cross-section data advocated by Higson et al. (2002, 2004). Section 3 describes the data set. The next section presents a "microscopic" statistical analysis of real sales growth rates across firms. Here we address in particular, the change over time of the higher moments of the distribution. Section 5 discusses the extend to which the growth rate of real sales itself may serve as an indicator for the behaviour of firms during the business cycle. The last section offers conclusions and some considerations regarding future research.

2 A framework and testable hypotheses

A simple framework for the following analysis is given by Higson et al (2002, 2004). It starts with firms that produce output under a standard production function. Since the firms operate in a stochastic environment, each firm's output is the results of a number of shocks. In particular the output of firm *i* in period *t*, is driven by firm-specific (ξ_{it}), industry-specific (ζ_{jt}) and economy-wide (η_{it}) shocks. Thus, the overall shock witnessed by the firm is given by:

$$\varepsilon_{it} = \xi_{it} + \zeta_{jt} + \eta_t \qquad (1)$$

Consequently, the observed growth rate of an individual firm may be written as a weighted sum of its responses to shocks:

$$g_{it} = \iota_{it}\xi_{it} + \kappa_{it}\zeta_{jt} + \lambda_{it}\eta_t \qquad (2)$$

In other words, the growth rate of the *i*th firm in period *t* is given by its response to the growth of the aggregate economy (λ_{it}), its response to the growth of the respective industry (κ_{it}) and its response to idiosyncratic shocks which are unique to the firm (ι_{it}).

The main focus of the following analysis is, to obtain insights into the influence of the business cycle on the cross-sectional distribution of growth rates across firms.[2] In

2 In recent research using firm-level panel data, a pervasive finding is that idiosyncratic factors dominate the distribution of growth rates of output across firms. During severe recessions virtually all industries decline, but within each industry a substantial fraction of firms grow. Likewise, during robust recoveries, a substantial fraction of firms contract. Simply put, the underlying gross changes at the micro-level dwarf the net changes that we observe in published aggregates.

this context, we assume that the cycle is merely characterised by aggregate shocks. Thus, the prime focus of the discussion is the heterogeneity of firms' responses to economy-wide disturbances. To put this another way: it is likely that the coefficient λ_{it} is not equal across firms, implying that aggregate shocks have different impacts on individual firms. One might describe the firm-specific responses to shocks in two different ways. First, aggregate shocks may alter the link between the growth of the firm and the firm's other characteristics. For example, large firms may well grow faster in recoveries than small firms. Second, the response of an individual firm to an economy-wide disturbance may depend on the relative position of the firm in the entire range of all firms. For example, a negative aggregate shock might not affect firms that have previously witnessed strong growth, as strongly as it does firms with a history of relatively moderate growth rates. On the other hand, a positive aggregate shock may have a limited effect on firms that have already grown fast, as they may find themselves overstretched. To sum up, firms at the extreme of the distribution of growth rates may possibly react less to aggregate shocks than firms in the middle range of growth. Thus, if the firms are listed in ascending order of growth rate, the responsiveness to an aggregate shock should look like an inverted U-shape function, ie the λ_i should increase up to a certain value, declining thereafter. This also has implications for the higher moments of the cross-sectional distribution of real sales as well. For example, in the case of a positive aggregate shock, firms with a growth rate below the mean will pushed toward the mean, whereas firms with growth rates above the mean will respond less strongly to the shock. Thus, the dispersion of the growth rate will decline (and the kurtosis increase) in an expansion. By contrast, in a contraction, firms with a growth rate below the mean will face declining growth rates and, therefore be pushed further away from the mean, while firms with higher-than-average growth rates will not regress toward the mean to the same degree. Consequently, dispersion will increase and kurtosis will decline in the face of a negative aggregate shock.

All in all, the considerations, which are presented more formally and in greater detail in Higson et al. (2002, 2004), come down to two testable implications: First, the λ_i should follow an inverted U-shape pattern. Second, the higher moments of the cross-sectional distribution should be related to the state of the business cycle. With these hypotheses at hand, we are in position to turn to the data.

3 The data

For the following analysis the Bundesbank's unbalanced corporate balance sheets statistics database (*Unternehmesbilanzstatistik*, UBS for short) is used. This is the largest database of non-financial firms in Germany. It should be stressed at the outset that owing to the way the data were collected the sample is not a random sample of German firms. The Bundesbank has collected the data when offering rediscounting and lending operations on a strictly confidential basis.[3] Section 19 of the Bundesbank Act (§ 19 BBankG) stipulates that enterprises have to submit their financial statements to the Bundesbank in connection with bill-based rediscount and lending operations. Under the provisions of the Bundesbank Act, the Bundesbank was authorised to perform credit assessments in line with its obligation to purchase and lend only bills of exchange, which fulfil stringent eligibility criteria, such as backing by three parties which are known to be solvent. Most of the data stems from the industrial sector as well as the construction and retailing sectors, owing to the fact that the trade bill is a particularly important instrument of finance particularly in these sectors of the economy. To enable the Bundesbank to carry out an extensive evaluation of their creditworthiness, the enterprises submitted their annual accounts to the branch offices of the German State Central Banks (*Landeszentralbanken*). They were then recorded electronically, audited, and evaluated for purposes of trade bill transactions. The Bundesbank received around 60,000 annual accounts per annum. In addition, the Bundesbank performed checks for logical errors and missing data in the database as well as consistency checks and error corrections. According to Stoess (2001), the unbalanced panel dataset comprises only about 4% of the total number of enterprises in Germany but about 60% of the total turnover of the corporate sector. The latter fact means that although the sample is non-random and therefore affected by a possible selection bias, the firms in the sample nevertheless track German *GDP* very well. This view is supported by the fact that the correlation coefficient between the *GDP* growth rate and the mean growth rate of the firms covered in the sample turns out to be 0.89 over the sample period 1971 to 1998.

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3 The unbalanced panel dataset has frequently been used in economic research. See, for example, Chirinko and von Kalckreuth (2002) and von Kalckreuth (2003). For more details regarding the dataset see Deutsche Bundesbank (1998) and Stoess (2001).

Another key advantage of the database is that it comprises both incorporated and unincorporated firms. This has some appeal since the small and medium-sized firms in Germany ("*Mittelständische Wirtschaft*") show up in our sample.[4] Our micro database therefore gives a faithful representation of the German economy and enables us to identify a coherent story about the cross-sectional dynamics of German business cycles. In contrast to previous studies, we were able to use data from 1971 to 1998 for most of the analysis.[5] Even though the number of rediscount lending operations dropped sharply with the start of European Monetary Union at the beginning of 1999, the Bundesbank tries to continue its comprehensive review of the credit standing of German enterprises involved in rediscount transactions. However, eligible enterprises now submit their balance sheets to the European Central Bank. This change of competence is the reason why 1998 is the last year of the period covered.[6]

Since we are mainly interested in the development of real sales we have relatively few data losses owing to incomplete and inconsistent reporting. Real sales growth is calculated for each firm by deflating the firms' sales with the deflator of real GDP and afterwards taking the difference of the logarithm of real sales.[7] Following Higson et al. (2002, 2004), we take into account outliers by employing several cut-off rates, ie a fraction of, say a ±50% growth rate, is truncated from the data. Some kind of cut-off seems to be necessary as some changes in real sales might be influenced, for example, by mergers. It is clear that a cut-off is a rather crude method to get rid of outliers and

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4 More than 80% of the included enterprises are small and medium-sized enterprises (SME's) with an annual turnover less than 100 million DM, and more than half of the dataset consists of unincorporated firms.

5 We thank the Statistics Department of the Deutsche Bundesbank, in particular Tim Körting, for excellent research assistance.

6 Due to changes in the sectoral definitions, the dataset had to be restricted to the years 1971 to 1995 whenever industry dummies were used.

7 One might argue that each sector should be deflated with its respective deflator. With only a few exceptions, e.g. computer manufacturing, the sectoral deflators all move closely together so that the GDP-deflator appears to be a good approximation.

mergers. Unfortunately, no variable was included in the dataset to indicate whether a merger had occurred or not.[8]

Thus, the best way to deal with that problem seems to use a cut-off which is not too restrictive and subsequently conduct a sensitivity analysis by using larger and smaller cut-off ranges. The basic cut-off will be ±50% for the growth rate of real sales. This appears to have the advantage of not being too restrictive while getting rid of most of the outliers and a lot of the mergers.

Table 1: Summary statistics for the data-set – growth rates of real sales (50% Cut-Off)

Year	Mean	Median	Standard deviation	Skewness	Kurtosis	Obs.
1972	0.026	0.023	0.16	-0.01	3.59	29,319
1973	0.030	0.029	0.17	-0.02	3.42	30,965
1974	-0.005	-0.006	0.18	0.03	3.14	32,987
1975	-0.018	-0.018	0.18	0.06	3.10	37,561
1976	0.065	0.065	0.17	-0.19	3.43	46,596
1977	0.046	0.042	0.16	-0.06	3.67	54,902
1978	0.002	0.002	0.16	-0.05	3.82	61,136
1979	0.058	0.052	0.16	-0.05	3.70	65,630
1980	0.030	0.028	0.16	-0.01	3.69	65,006
1981	-0.020	-0.022	0.16	0.14	3.70	59,974
1982	-0.030	-0.034	0.16	0.20	3.78	60,368
1983	0.015	0.012	0.16	-0.02	3.74	61,871
1984	0.030	0.023	0.16	0.02	3.68	63,408
1985	0.019	0.017	0.17	-0.04	3.62	63,322
1986	0.016	0.014	0.16	-0.08	3.73	63,263
1987	0.010	0.008	0.16	-0.01	3.85	62,059
1988	0.044	0.040	0.16	-0.07	3.94	61,243
1989	0.055	0.051	0.15	-0.12	4.05	59,427
1990	0.064	0.058	0.16	-0.11	3.77	56,991
1991	0.064	0.063	0.17	-0.19	3.50	55,415
1992	-0.011	-0.018	0.17	0.19	3.55	55,218
1993	-0.063	-0.064	0.17	0.29	3.50	55,334
1994	0.016	0.009	0.17	0.06	3.58	55,570
1995	0.017	0.011	0.16	0.04	3.67	55,804
1996	-0.006	-0.009	0.16	0.07	3.83	53,299
1997	0.023	0.018	0.15	-0.04	4.04	49,620
1998	0.017	0.013	0.15	-0.01	4.07	38,796
All	0.019	0.016	0.17	-0.01	3.57	1,455,084

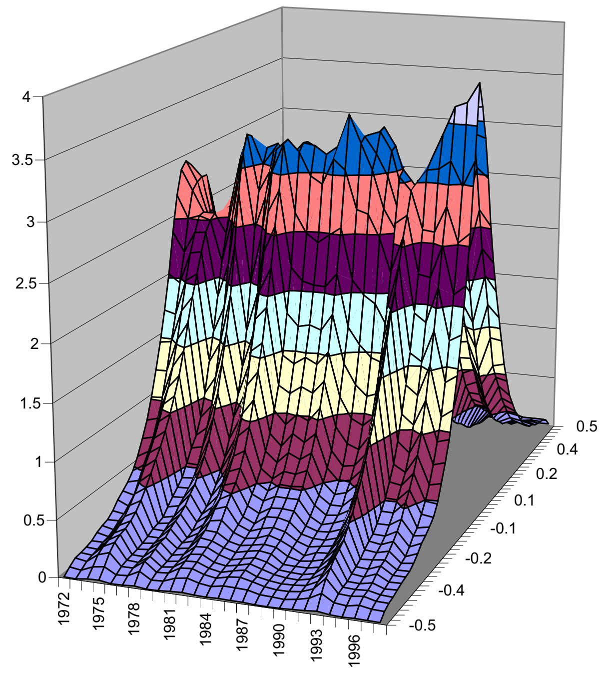
8 The cut-off may also eliminate some newly founded firms as well as firms going bankrupt. Note that numerous other studies suffer from similar problems.

From a statistical point of view, this cut-off also seems plausible as the residuals from the conducted regressions were shown to be normally distributed, suggesting that outliers are not a huge problem in the case of this cut-off. However, to undertake some robustness checks we will also use cut-off ranges of ±100% or ±25%. Some descriptive statistics for the data set using the 50% cut-off are presented in Table 1.

4 The cyclical patterns of cross-sectional moments

The next obvious step in our analysis is to look at the cyclical patterns of cross-sectional moments. We take a first glance at the evidence by presenting a three-dimensional plot of Kernel densities for each year under investigation in Figure 1.[9]

Figure 1: Kernel densities of growth rates of sales, 1972-1998



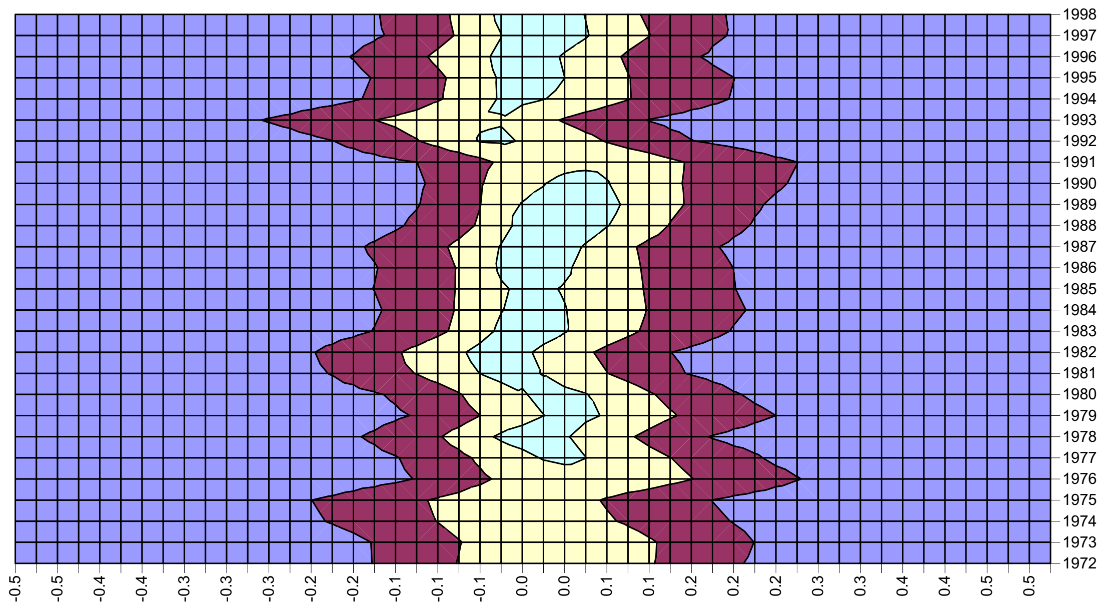
It becomes apparent that the distribution shows marked deviations from what can be considered as a normal distribution. The figure indicates that there is large

9 Associated with the kernel fitting approach is the important issue of bandwith selection. We have used a Gaussian kernel and chosen the bandwith according to the rule suggested by Silverman (1986).

heterogeneity among the firms. Some firms are shrinking even during boom phases while other firms manage to achieve positive growth rates during recessions. Apparently, some of the most pronounced deviations from normality stem from years with marked changes in the state of the business cycle. This is visible in Figure 2, which shows the contour of the Kernel density estimates.

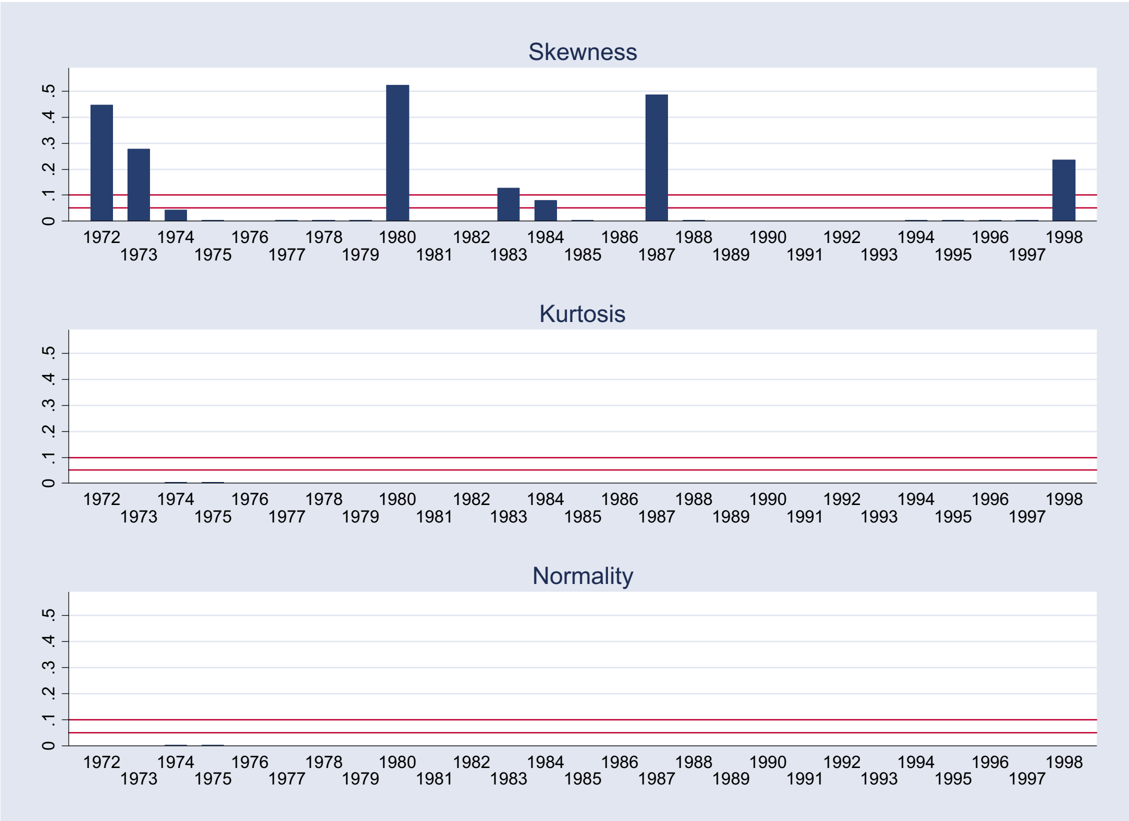
The distribution is particularly skewed in years normally associated with recessions such as 1975, 1982, and 1993, Or with periods of pronounced expansion of the German economy such as 1991, 1976 and, to a lesser degree, 1979. Apparently, the cross-section distribution depends on the current stance of the business cycle. This is further supported by Figure 3, which shows p-values for tests of significance for skewness, kurtosis and normality for each year.

Figure 2: Contours of kernel densities of growth rates of sales, 1972-1998



For every single year the hypothesis of normally distributed growth rates of real sales is rejected by the normality test developed by D'Agostino et al. (1990) using standard significance levels. This is actually based on two tests: one with the null hypothesis that skewness is zero and the second with the null hypothesis that the kurtosis is equal to the kurtosis of a normal distribution. Both tests are then combined to test for normality. From the Jarque-Bera-test it is known that a normality test based only on two moments might lead to low power but together with the Kernel-densities it is clear that the rejection of normality is correct. For most years, the skewness is significantly different from zero. In all years, the kurtosis is significantly different from a normal kurtosis. We return to this characteristic shape and time profile in the parametric analysis below.

Figure 3: Tests for normality of the distribution of real sales growth 1971 to 1998

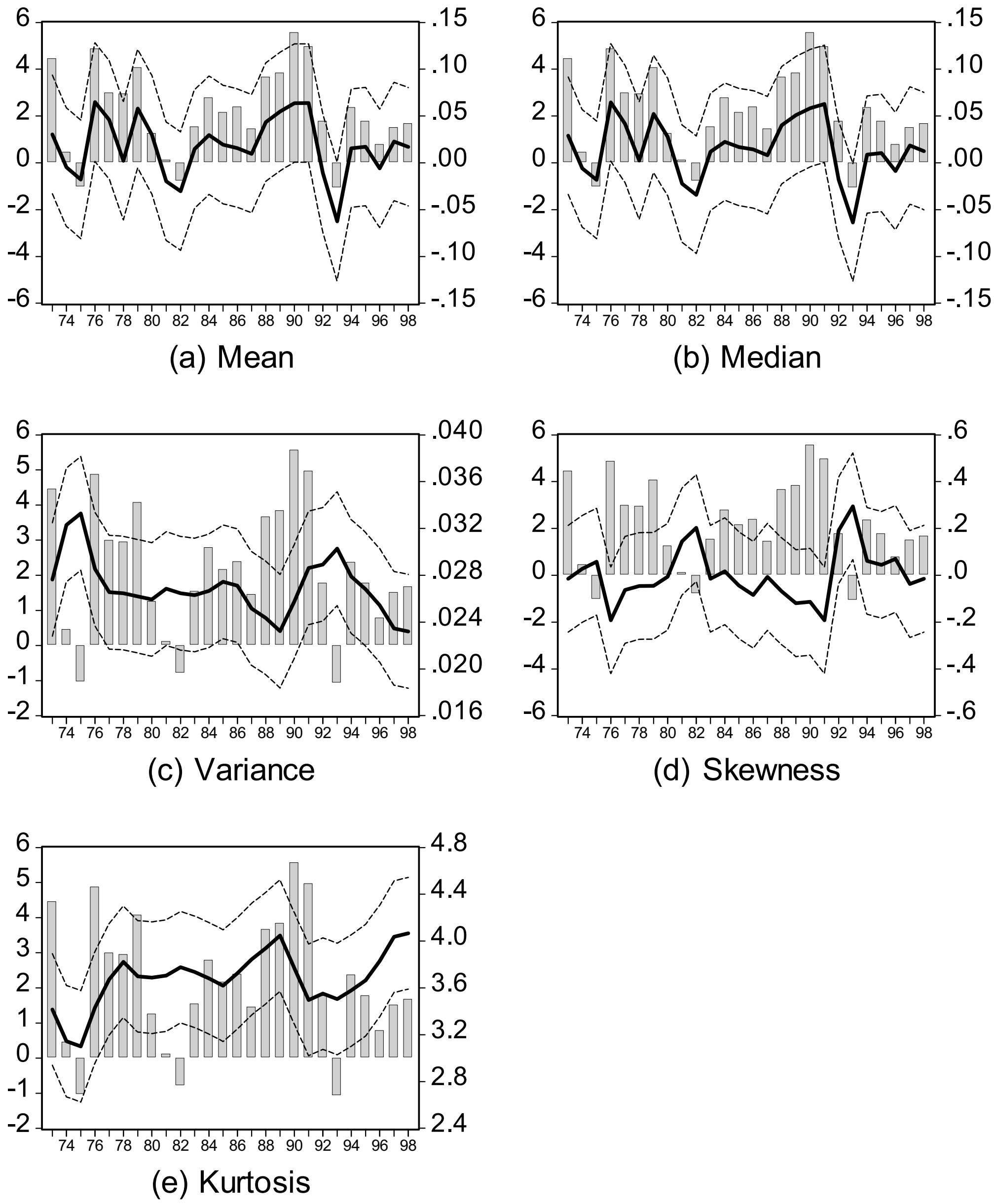


Notes: The numbers indicate the p-values of the tests for significant cross-section skewness, kurtosis and normality, respectively using the tests suggested by D'Agostino et al (1990). The two vertical lines denote the p-values of 0.05 and 0.1, respectively.

In Figure 4 the moments of the annual growth rate of real sales are shown together with the growth rate of real *GDP* as a measure for business cycle conditions.

As mentioned in the previous section the mean and median growth rate of real sales move in close correspondence with the growth rate of real *GDP*. The cross-section variance seems to be decreasing over time except during German reunification where it is increasing. A counter-cyclical pattern is emerging for the variance. The kurtosis on the other hand is increasing over time and appears to be pro-cyclical. Moreover, it becomes apparent that the skewness of the distribution shows signs of counter-cyclical patterns.

Figure 4: Moments of truncated (50%) growth cross-section distribution against GDP growth, 1973-1998.



Note: Dashed lines represent ± 2 standard errors.

The cyclical patterns of variance, skewness and kurtosis are in line with results from Higson et al. (2002, 2004) for the UK and the USA. The decreasing variance and the increasing kurtosis were not present in the UK and US data. Instead, the UK and US data show increasing variance and decreasing kurtosis. As is well known, German real *GDP* growth was lower in the 1990's than the growth in the UK and the USA and was also decreasing over time. Therefore, a comparison of the variation coefficient appears to be necessary if one wants to make a cross-country comparison. Interestingly, the pattern is constant for different years of recession implying that the change in the distribution is the same for supply shocks (eg 1975) and demand shocks (eg 1993).

All in all, the descriptive analysis lends considerable support to the hypothesis outlined in section 2, namely, that the moments of cross-sectional distribution of firm growth is closely related to the business cycle. With this rather informal evidence at hand, we now turn to a more formal testing procedure and estimate regressions of the type:

$$\begin{aligned} M_{k,t} &= \alpha_{0k} + \alpha_{1k} M_{k,t-1} + \alpha_{2k} M_{k,t-2} + \\ &\quad \lambda_{1k}\, dlog\left(GDP\right)_t + \lambda_{2k}\, dlog\left(GDP\right)_{t-1} + u_t \end{aligned} \tag{3}$$

where M denotes the respective cross-section moment and dlog(GDP)$_t$ is the growth rate of real *GDP*. The equations are estimated by means of OLS. Following our suggested methodology we ran this regression for different cut-off values, ie we omitted growth rates outside the range of ±25, ±50% and ±100%, respectively from the dataset. The results summarised in Table 2 reveal that the mean and median of the growth rates of real sales are pro-cyclical, indicating that the behaviour of firms covered in the sample is indeed of interest for the present analysis. The patterns for kurtosis and variance are, in part, confirmed by the regression analysis in so far as the sign of the coefficients is as expected yet insignificant. The counter-cyclical behaviour of the cross-section skewness is fairly robust against varying cut-off-values. The coefficient has the expected sign and is significant for the 25% and 50% cut-off. Only in case of the 100% cut-off is the relationship not significant, presumably stemming from the fact that there are too many outliers in this sample.

Table 2: Regression of firm growth cross-section moments on GDP growth

	Mean	Median	Variance	Skewness	Kurtosis
	25 % Cut-off				
Constant	-0.010	-0.013	0.004	0.103	1.028
	(0.008)	(0.003)	(0.009)	(0.002)	(0.002)
Moment, t-1	0.103	0.105	1.211	0.127	0.899
	(0.124)	(0.150)	(0.000)	(0.129)	(0.000)
Moment, t-2	-0.240	-0.214	-0.527	-0.193	-0.304
	(0.015)	(0.031)	(0.006)	(0.069)	(0.131)
GDP growth, t	1.053	1.191	-0.006	-8.077	0.618
	(0.000)	(0.00)	(0.163)	(0.000)	(0.559)
GDP growth, t-1	(-)	(-)	0.011	(-)	(-)
			(0.045)		
Adj. R 2	0.856	0.839	0.810	0.808	0.544
Test for autocorrelation, order 1	0.236	0.279	0.255	0.287	0.145
Test for autocorrelation, order 2	0.491	0.548	0.189	0.547	0.097
Test for heteroskedasticity	0.501	0.390	0.060	0.309	0.931
Test for functional form (RESET)	0.980	0.714	0.778	0.916	0.516
Test for GDP's = 0	(-)	(-)	0.071	(-)	(-)
Test for normality	0.829	0.871	0.907	0.778	0.658
	50 % Cut-off				
Constant	-0.012	-0.015	0.009	0.108	1.407
	(0.021)	(0.007)	(0.001)	(0.003)	(0.000)
Moment, t-1	0.070	0.078	1.119	0.087	1.269
	(0.211)	(0.223)	(0.000)	(0.551)	(0.000)
Moment, t-2	-0.242	-0.218	-0.485	-0.112	-0.649
	(0.008)	(0.021)	(0.000)	(0.324)	(0.000)
GDP growth, t	1.556	1.531	-0.031	-5.504	-0.005
	(0.000)	(0.000)	(0.084)	(0.00)	(0.979)
GDP growth, t-1	(-)	(-)	0.049	(-)	(-)
			(0.014)		
Adj. R 2	0.875	0.858	0.706	0.682	0.735
Test for autocorrelation, order 1	0.369	0.261	0.360	0.244	0.549
Test for autocorrelation, order 2	0.649	0.252	0.479	0.135	0.296
Test for heteroskedasticity	0.237	0.328	0.167	0.092	0.748
Test for functional form (RESET)	0.927	0.759	0.480	0.505	0.676
Test for both GDP's = 0	(-)	(-)	0.028	(-)	(-)
Test for normality	0.885	0.823	0.730	0.301	0.418

Table 2, cont.

	100 % Cut-off				
Constant	-0.008	-0.015	0.019	0.090	2.348
	(0.128)	(0.008)	(0.002)	(0.386)	(0.008)
Moment, t-1	0.043	0.075	1.151	0.080	1.103
	(0.413)	(0.223)	(0.000)	(0.802)	(0.000)
Moment, t-2	-0.239	-0.220	-0.574	0.317	-0.465
	(0.005)	(0.019)	(0.000)	(0.116)	(0.002)
GDP growth, t	1.767	1.607	-0.047	-2.373	-0.187
	(0.000)	(0.000)	(0.042)	(0.328)	(0.978)
GDP growth, t-1	(-)	(-)	0.087	2.790	(-)
			(0.000)	(0.065)	
Adj. R 2	0.868	0.860	0.773	0.045	0.578
Test for autocorrelation, order 1	0.983	0.318	0.476	0.557	0.176
Test for autocorrelation, order 2	0.941	0.599	0.774	0.777	0.099
Test for heteroskedasticity	0.200	0.249	0.343	0.426	0.755
Test for functional form (RESET)	0.942	0.730	0.357	0.973	0.978
Test for both GDP's = 0	(-)	(-)	0.000	0.142	(-)
Test for normality	0.812	0.796	0.939	0.636	0.263

Notes: For all tests p-values are reported. The p-values for the t-tests (in brackets) are based on a robust covariance matrix calculated using the Newey and West method (1987). The test for autocorrelation is a Breusch/Godfrey test (Godfrey 1988), the test for heteroskedasticity is a White (1980)test, the RESET test is a Ramsey (1969) test for functional form. The test for normality is the Jarque/Bera (1981) test.

In order to obtain additional insight into the relationship between cross-sectional moments and the business cycle we have also explored other macroeconomic variables. The results are presented in table 3. To begin with, one might argue that the simple growth rate of real GDP is a rather crude measure of the business cycle. Thus, we estimated the equations with a simple output gap obtained with the help of the filter suggested by Hodrick and Prescott (1997).[10] Moreover, the measures tell nothing about the nature of the underlying shocks. To take into account the possibility that demand and supply shocks have different effects on the cross-section moments, we report results using demand and supply shocks as independent variables. These shocks have been identified from SVAR containing real GDP and the deflator of real GDP by means of the methods suggested by Blanchard and Quah (1989).[11] Finally, we also looked at a

10 As regards the smoothing variable, we follow Ravn and Uhlig (2002) and use 6.25.

11 The shocks are identified based on a bivariate VAR containing the growth rate of real GDP and the change in the GDP deflator. The lag-length is determined by the minimum Schwarz information criterion and set equal to 2. With regard to deterministic components, the VAR contains a constant, but not deterministic trend.

possible impact of the interest rate spread between long (10 years) and short-term (§ months) interest rate spreads on the cross-section moments.

Table 3: Regression of firm growth cross-section moments on other macroeconomic variables

	Mean	Median	Variance	Skewness	Kurtosis
	Output Gap				
Constant	0.014	0.011	0.010	-0.002	1.409
	(0.007)	(0.020)	(0.005)	(0.872)	(0.000)
Moment, t-1	0.333	0.364	0.958	0.361	1.267
	(0.009)	(0.002)	(0.000)	(0.002)	(0.000)
Moment, t-2	-0.069	-0.039	-0.339	0.094	-0.649
	(0.583)	(0.760)	(0.010)	(0.353)	(0.000)
Output gap, t	0.014	0.013	<0.000	-0.031	(-)
	(0.004)	(0.005)	(0.975)	(0.024)	
Output gap, t-1	-0.022	-0.022	0.001	0.074	(-)
	(0.000)	(0.000)	(0.065)	(0.000)	
Adj. R 2	0.777	0.766	0.681	0.622	0.747
Test for autocorrelation, order 1	0.509	0.503	0.415	0.516	0.581
Test for autocorrelation, order 2	0.659	0.614	0.679	0.791	0.350
Test for heteroskedasticity	0.270	0.245	0.661	0.113	0.833
Test for functional form (RESET)	0.711	0.699	0.172	0.435	0.623
Test for both gaps = 0	0.000	0.000	0.058	0.001	(-)
Test for normality	0.653	0.558	0.492	0.911	0.413
	Interest rate spread				
Constant	0.006	0.003	0.011	0.041	1.219
	(0.120)	(0.518)	(0.002)	(0.125)	(0.003)
Moment, t-1	0.247	0.265	0.860	0.210	1.010
	(0.261)	(0.203)	(0.000)	(0.255)	(0.000)
Moment, t-2	-0.168	-0.152	-0.234	-0.029	-0.437
	(0.168)	(0.227)	(0.135)	(0.856)	(0.003)
Spread, t	(-)	(-)	(-)	(-)	(-)
Spread, t-1	0.009	0.009	-0.001	-0.036	0.032
	(0.001)	(0.000)	(0.028)	(0.003)	(0.071)
Adj. R 2	0.330	0.341	0.709	0.342	0.784
Test for autocorrelation, order 1	0.502	0.501	0.243	0.853	0.722
Test for autocorrelation, order 2	0.238	0.196	0.462	0.485	0.772
Test for heteroskedasticity	0.521	0.476	0.136	0.027	0.205
Test for functional form (RESET)	0.183	0.264	0.788	0.341	0.237
Test for both spreads = 0	(-)	(-)	(-)	(-)	(-)
Test for normality	0.441	0.391	0.922	0.797	0.519

Table 3, cont.

	BQ-Demand shock				
Constant	0.016	0.013	0.012	0.001	1.409
	(0.000)	(0.002)	(0.000)	(0.939)	(0.000)
Moment, t-1	0.651	0.676	1.179	0.565	1.267
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Moment, t-2	-0.493	-0.478	-0.625	-0.275	-0.648
	(0.003)	(0.003)	(0.000)	(0.125)	(0.009)
Shock, t	3.219	3.201	-0.098	(-)	(-)
	(0.002)	(0.002)	(0.083)		
Shock , t-1	1.996	2.054	0.127	5.920	(-)
	(0.006)	(0.004)	(0.021)	(0.090)	
Adj. R 2	0.581	0.565	0.732	0.177	0.767
Test for autocorrelation, order 1	0.708	0.713	0.119	0.311	0.581
Test for autocorrelation, order 2	0.216	0.217	0.128	0.211	0.350
Test for heteroskedasticity	0.194	0.109	0.076	0.289	0.833
Test for functional form (RESET)	0.468	0.450	0.366	0.013	0.623
Test for both shocks = 0	0.000	0.000	0.031	(-)	(-)
Test for normality	0.954	0.829	0.654	0.925	0.413
	BQ-supply shock				
Constant	0.018	0.014	0.013	0.003	1.436
	(0.002)	(0.011)	(0.004)	(0.876)	(0.000)
Moment, t-1	0.348	0.375	1.107	0.396	1.255
	(0.024)	(0.011)	(0.000)	(0.013)	(0.000)
Moment, t-2	-0.402	-0.389	-0.548	-0.218	-0.644
	(0.020)	(0.024)	(0.001)	(0.192)	(0.001)
Supply shock, t	1.221	1.206	(-)	-4.969	(-)
	(0.007)	(0.007)		(0.002)	
Supply shock, t-1	(-)	(-)	(-)	(-)	-2.457
					(0.091)
Adj. R 2	0.334	0.338	0.587	0.322	0.752
Test for autocorrelation, order 1	0.861	0.784	0.705	0.753	0.646
Test for autocorrelation, order 2	0.460	0.460	0.187	0.820	0.340
Test for heteroskedasticity	0.257	0.418	0.895	0.250	0.723
Test for functional form (RESET)	0.307	0.231	0.651	0.027	0.483
Test for both shocks's = 0	(-)	(-)	(-)	(-)	(-)
Test for normality	0.468	0.487	0.012	0.383	0.316

Notes: For all tests p-values are reported. The p-values for the t-tests (in brackets) are calculated based on a robust covariance matrix calculated using the Newey and West (1987) method. The test for autocorrelation is a Breusch/Godfrey test (Godfrey 1988), the test for heteroskedasticity is a White (1980) test, the RESET test is a Ramsey (1969) test for functional form. The test for normality is the Jarque/Bera (1981) test.

The results regarding the output gap suggest that the relationship of cross-sectional moments with the business cycle does not depend on a specific measure of the cycle, but holds for trend deviations as well. However, it is worth noting that the coefficient of the lagged output gap mirrors the coefficient of the contemporaneous output gap to some extent, but with the opposite sign. This suggests that it is not the stance of the business cycle itself that correlates with the cross-sectional moments, but the change of the cyclical situation. The correlation with the interest term spread reveals that the contemporaneous spread appears to be insignificant in all regressions. The lagged interest rate spread, however, mirrors the coefficients found for the growth rate of real GDP. This, of course, is due to the fact that the spread is a leading indicator for the business cycle. Insofar as one can attribute the spread to the monetary policy stance the results point to a causality running from macroeconomic shocks, i.e. monetary policy in this case, to the cross-sectional moments rather than vice versa. However, a very cautious interpretation is needed here, as a lot of factors influence the interest rate spread and, consequently, this number is not easy to interpret.

To obtain further insight into the relationship of cross-sectional moments with macroeconomic shocks we also tested for the relation of the moments with supply and demand shocks as derived from a standard Blanchard/Quah (1989) decomposition of Germany's real GDP.[12] It turns out that there are some interesting differences between the correlations of the two shocks with the cross-sectional moments. To begin with, the lagged demand shock appears to be significant in both the equations for the mean and the median. In contrast, only the contemporaneous supply shocks are significant. This suggests that the dynamics of demand shocks and supply shocks are not the same with respect to the cyclical behaviour of the firm. A further investigation, however, requires a higher frequency of the data than we have available. Moreover, the negative correlation of a contemporaneous demand shock with the cross-section variance suggests that in the face of a demand shock firms tend to move more closely together. There is no corresponding finding for supply shocks. Supply shocks show a negative correlation with the cross-sectional skewness. This reflects the fact that both shocks are positively correlated with each other and with real GDP growth and mirrors the result of the counter-cyclical behaviour of the cross-sectional skewness presented already above. However, the coefficient for the demand shock shows up only with a lag and is hardly

[12] The model includes the growth rates of both real GDP and consumer prices and uses the assumption that a demand shock has no long-run effect on the level of real GDP for identification. For the sake of brevity we do not document the model at full length, but details are available upon request from the authors.

significant. Beyond this, it shows an unexpected sign. Again, a very cautious interpretation is required, since the number of observations is rather small. However, we take these correlations as an indication that a more careful investigation of cross-sectional moments may also be of interest for the identification of the shocks that dominate at the macro level. However, given the limitations of our data set, in particular its annual frequency, we leave these questions to future research. To sum up, the previous section has provided strong support for the hypothesis that the moments of the cross-sectional distribution of real sales across firms are closely linked to the business cycle and may potentially help in obtaining further insight into the nature of the cycle.

5 Regressions by percentiles

The discussion in the previous sections shows that the cyclical pattern of higher moments for firm growth rates could not be explained by systematic factors, such as industry effects. Another explanation for the emerging pattern is that the growth rate itself is the determining factor for the change in the distribution of growth rates. This relationship might be explained by the fact that firms with high growth rates have capacity constraints, which means that during a boom phase they cannot grow more rapidly. On the other hand, firms with very low growth rates might take serious steps during an economic downturn to try to avoid a further deterioration of their position. If this is the case, firms with high absolute growth rates react less to changing business cycle conditions than firms experiencing more intermittent growth. This would explain the counter-cyclical behaviour of the growth rate distribution. To check this hypothesis the percentiles of the distribution of growth rates were calculated for each year.

Table 4 shows the correlation matrix for the growth rate deciles and the growth rate for GDP calculated for all years for the 50% cut-off. The last row in Table 4 indicates that firm growth rates in the intermediate range react more strongly to changes in the GDP growth rate while the reaction of firms with higher absolute growth rates in the first and last deciles are less pronounced with respect to GDP fluctuations.

Table 4: Correlation across deciles, 1971 - 1998

	10 % decile	20 % decile	30 % decile	40 % decile	50 % decile	60 % decile	70 % decile	80 % decile	90 % decile	Δ% *GDP*
10 % decile	1.00									
20 % decile	0.99	1.00								
30 % decile	0.98	0.99	1.00							
40 % decile	0.97	0.99	0.99	1.00						
50 % decile	0.94	0.96	0.98	0.99	1.00					
60 % decile	0.90	0.94	0.96	0.98	0.99	1.00				
70 % decile	0.87	0.91	0.93	0.96	0.99	0.99	1.00			
80 % decile	0.83	0.87	0.90	0.93	0.97	0.98	0.99	1.00		
90 % decile	0.78	0.82	0.85	0.89	0.93	0.96	0.98	0.99	1.00	
Δ% *GDP*	0.84	0.86	0.87	0.88	0.89	0.89	0.88	0.87	0.84	1.00

Given the different percentiles of the distribution as time series one can estimate the following equation:

$$\begin{aligned} p_{kt} = \alpha_{0k} + \alpha_{1k} p_{k,t-1} + \alpha_{2k} p_{k,t-2} \\ + \lambda_{1k} dlog\left(GDP\right)_{t-1} + \lambda_{2k} dlog\left(GDP\right)_{t-1} + u_t \end{aligned} \tag{4}$$

p_{kt} is the k-th percentile of the growth rate of real sales for time t and dlog(GDP)$_t$ is the growth rate of *GDP* at time t.[13] Equation (4) was estimated for every percentile which makes it possible to characterise the entire conditional distribution of the dependent variable given the set of regressors.

Table 5 shows the results for selected percentiles. The coefficients of interest, λ_{1k} , are declining for higher percentiles. This suggests that firms with high growth rates react less to fluctuations in the *GDP* growth rate.[14]

13 Of course, we have a potential estimation problem here, since the assumed exogenous variable may, in fact, be endogenous. However, a Hausmann/Wu test is unable to reject the hypothesis of GDP being (weakly) exogenous.

14 This points to the need to supplement OLS (or any other econometric estimation procedure that focuses on the conditional mean of a dependent variable) by studying the data by percentiles, when investigating the behaviour of heterogeneous firms. Or, as Buchinsky (1994, p. 453) put it: "on the average" has never been a satisfactory statement with which to conclude a study on heterogeneous firms. Surveys of recent advances of the semi-parametric technique

Table 5: Regression of growth rates of firms at deciles of log size and GDP, 1972 to 1998

	α_0	α_1	α_2	λ_1	λ_2	R^2	LM(2)	Hausman/ Wu
5	-0.25	0.39	-0.25	1.68	-0.60	0.77	0.59	0.67
	(-4.02)	(2.10)	(-2.34)	(7.64)	(-1.58)			
30	-0.07	0.32	-0.24	1.61	-0.44	0.86	0.30	-0.23
	(-4.39)	(1.92)	(-2.93)	(10.37)	(-1.44)			
50	-0.01	0.12	-0.22	1.50	-0.07	0.85	2.38	-0.26
	(-2.46)	(0.66)	(-2.63)	(10.259	(-0.23)			
70	0.06	0.13	-0.21	1.51	-0.08	0.81	6.19	-0.36
	(4.74)	(0.67)	(-2.25)	(9.04)	(-0.23)			
95	0.30	0.11	-0.17	1.17	0.02	0.67	9.58	-0.05
	(4.30)	(0.529	(-1.36)	(6.29)	0.06			

Notes: LM(2) is a Breusch/Godfrey test (Godfrey 1988) for autocorrelation up to order 2. Hausmann/Wu is a Hausmann (1978) test of exogeneity. We use the change of a stock market index divided by the producer price index (which may be interpreted as a proxy for Tobins's Q, see Funke 1992), short term and long term interest rates as additional exogenous variables.

Figure 5 shows that firms at both ends of the growth rate distribution react less to *GDP* fluctuations then firms that are located in the middle of the distribution. Since the λ_{2k} are insignificant Figure 5 shows only the λ_{1k} s for each percentile.

This means that during an upturn the growth rates of firms with intermediate growth rates increase more than the growth rates of firms at the ends of the distribution. During a downturn the growth rates of firms in the middle of the distribution decrease more than the growth rates of firms at the ends of the distribution. The difference in responsiveness with respect to *GDP* movements is what drives the movement of the higher moments of the distribution of firm growth rates. This graph was calculated for a cut-off of ±50% for the growth rate of real sales.

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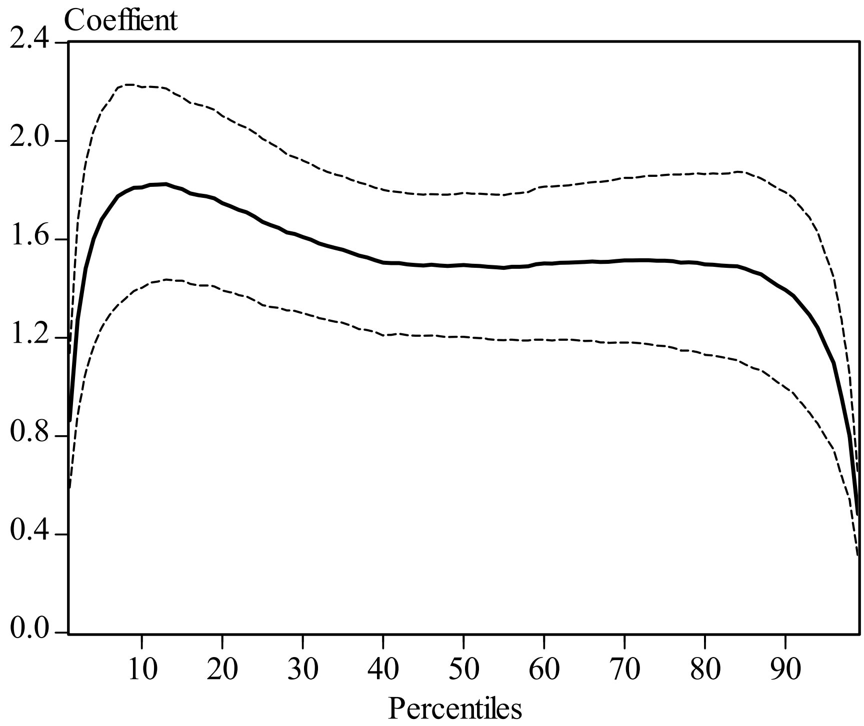
of quantile regression are available in Buchinsky (1998), Koenker and Hallock (2001) and Yu et al. (2003).

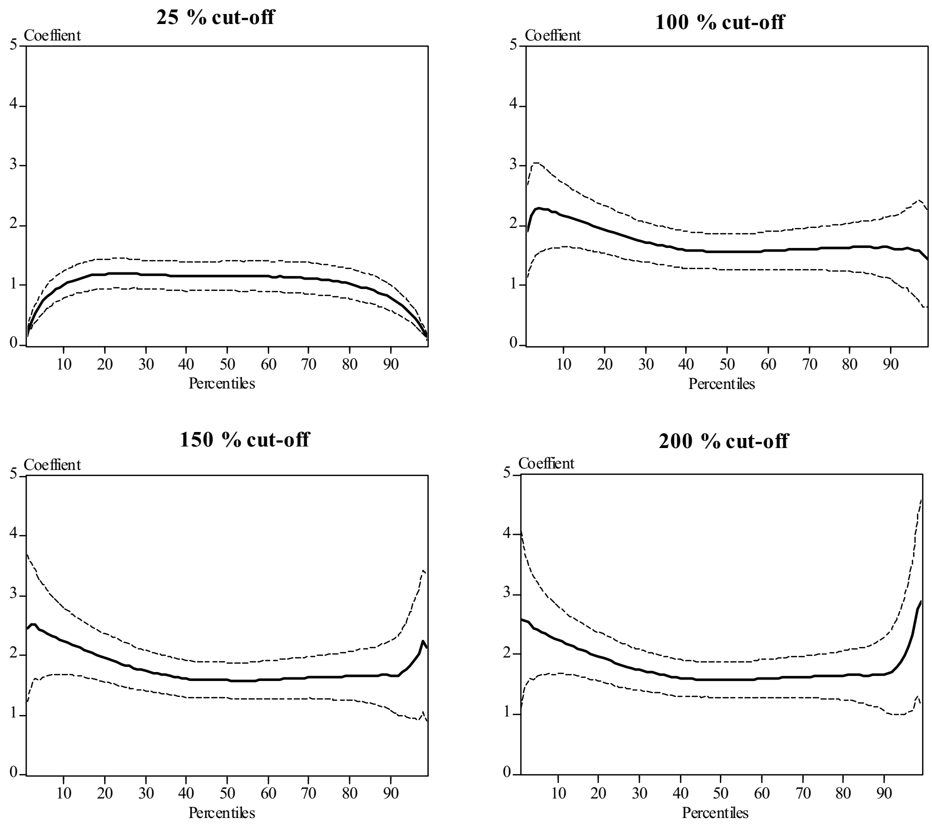
Figure 5:Estimates of λ_{1k} for growth rate percentiles



Note: Dashed lines represent ± 2 standard errors.

While this explanation may have some appeal, we caution against premature conclusions along these lines. Although inherently interesting, this explanation is fraught with interpretational difficulties. A cut-off point such as ±50% may be problematic when asking a question such as, how strongly do firms with different growth rates react to cyclical fluctuations?. A firm with a growth rate of 50% cannot improve during an upturn, not because it cannot grow faster but because of the cut-off. On the other hand, the growth rate can decrease during a downturn. To tackle this potential problem, we performed some robustness checks and have carried out the exercise with alternative cut-offs. The results of this task are shown in Figure 6.

Figure 6: Estimates of λ_{1k} for alternative cut-offs



Note: Dashed lines represent ± 2 standard errors.

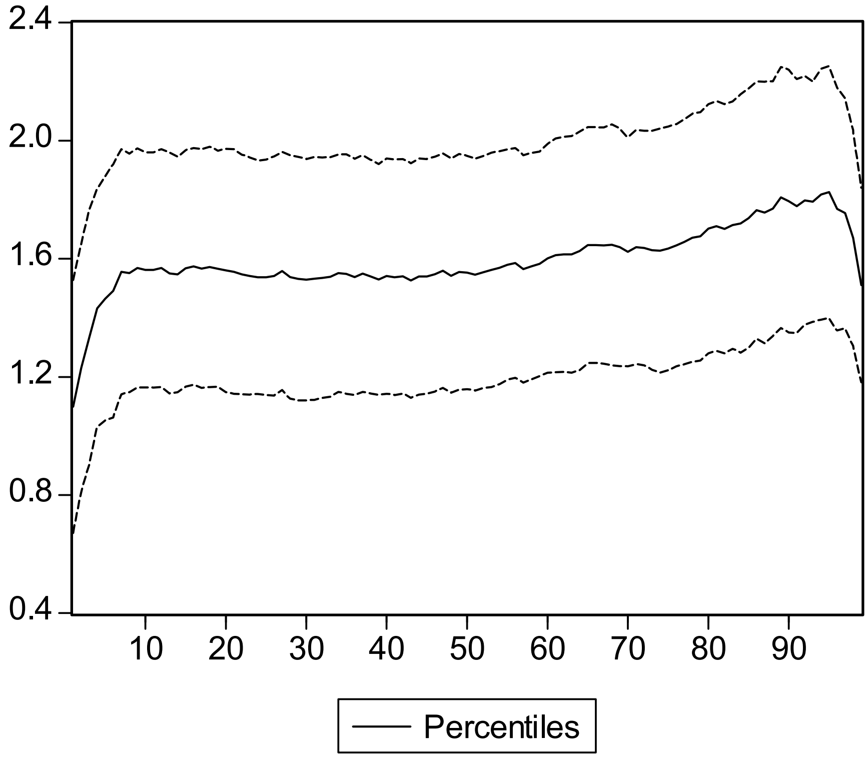
It appears that contrary to the impression given by the 50% cut-off the higher absolute growth rates at the lowest and highest percentiles react more strongly to changes in the GDP growth rate when cut-offs of 100% or even more are used. However, before attributing too much weight to these results, one should keep in mind that outliers are present in the dataset (especially in the graph without cut-off) that undoubtedly distort the results. On the other hand, the inverse U-shaped pattern becomes even more pronounced, when a cut-off lower that 50% is used. Thus, the results seem to be less robust against alternative choices of cut-off compared to the US and UK data (Higson et al. 2002, 2004).[15] These findings led us to perform some

15 To formally test the hypothesis that the coefficient representing GDP growth is not equal across the percentiles we have also estimated equation (7) as a panel with the number of percentiles as the panel dimension. We assumed all coefficients to be equal across all percentiles with one exception: the coefficient in front of GDP

additional robustness checks relying on a restricted data set relating to firms, which provides an observation every single year since 1971. This leaves 3463 firms. In this balanced data set, however, we used no cut-off at all, since extreme changes are rare. The results for this data set are given in figure 7.

Apparently, the results without any cut-off support the stylised fact found with the full data set when rather small cut-offs are used. Thus, we consider the fact that firms growing with medium growth rates react stronger to cyclical fluctuations as a quite robust stylised fact.

Figure 7: Estimates of λ_{1k} without cut-offs (restricted data set)



Note: Dashed lines represent ± 2 standard errors.

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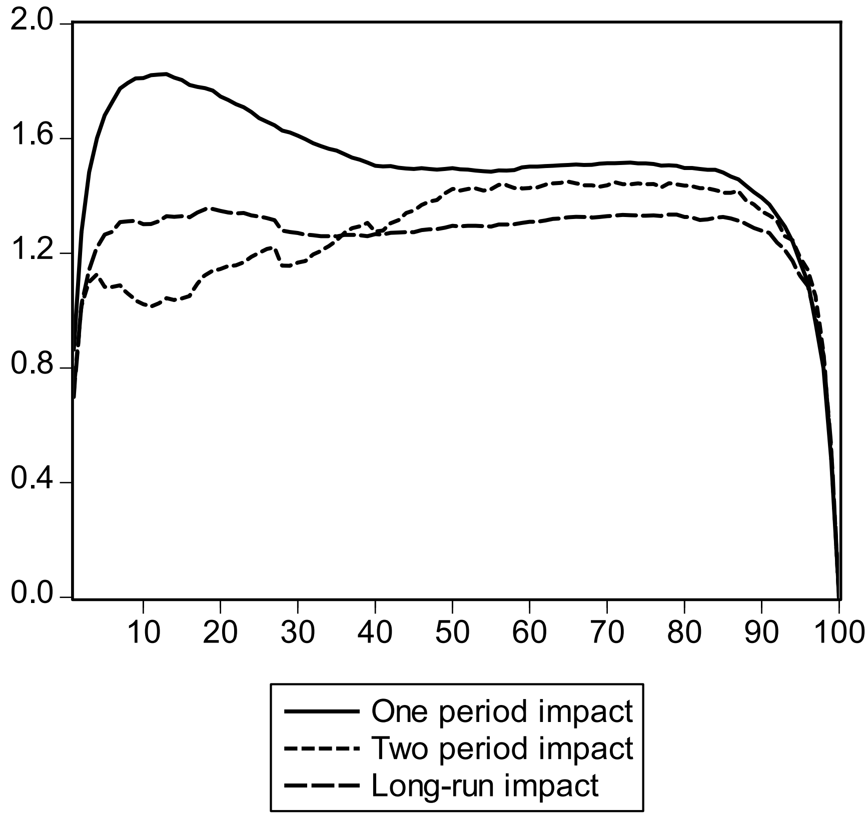
growth. Then, we performed a standard Wald-test for an equal coefficient for all percentiles. The hypothesis has to be rejected for standard p-values. Detailed results are available upon request from the authors.

The analysis so far was based on the one period impact of real GDP on the respective percentile of the growth rate of real sales, i.e. on the coefficient λ_1 in equation (4). However, it is also possible to allow for some adjustment processes and refer either to the two period impact $(\lambda_1 + \lambda_2)$ or to the long-run impact $(\lambda_1 + \lambda_2 /(1 - \alpha_1 - \alpha_2))$. Figure 8 reveals that taking into account these possibilities does not affect our main findings. While the two period impact appears to be a bit unstable (since λ_2 is often insignificant) all three plotted estimates show a lower responsiveness of real sales to changes in overall real GDP for firms with very large or very small changes in real sales than for firms with more moderate changes.

Figure 8: Estimates of λ , one period, two period, and long-run effect (50 % cut-off)



6 Conclusions

In order to understand the dynamics of economic growth, its underlying mechanism is an important issue. In this paper we provide a new dimension to business cycle analysis, going beyond the traditional focus on co-movements and correlations in macroeconomic aggregates. We establish stylised facts of Germany's business cycle on the firm level using micro-data from the Bundesbank's company database.[16] The data cover on average roughly 55000 firms for the period from 1971 to 1998. Our primary objective was to assess how certain stylised facts presented in the macroeconomic literature – largely relying on US and UK data – are confirmed by evidence from Germany, characterised by different economic structures, institutions and aggregate growth performances over the period analysed.

The conclusions of our study are almost as rich as the data on which the results are based. The preceding analysis of the growth dynamics of German business firms shows notable similarities to earlier work analysing firms in other countries. The list of similarities include the fact that the distribution of annual growth rates across firms, its mean and higher order moments is closely linked to the state of the business cycle.

Another core aspect that is roughly comparable across countries is the counter-cyclical movement of the skewness. In case of a 50% cut-off to the growth rates of real sales in our data set we are able to confirm the results already obtained by Higson et al. (2002, 2004) for the US and the UK, respectively, namely, that rapidly growing or rapidly declining firms are significantly less sensitive to aggregate shocks than firm in the middle of the growth range.

These results raise a variety of conceptual questions regarding our understanding of business cycle fluctuations and it would be insightful to have some plausible explanations for their existence in the data. The nature of firm-level adjustment costs in changing the scale of activity is one factor that is potentially important in this context. Accumulating evidence of lumpy microeconomic adjustment of inputs suggest the presence of nonconvexities in firm-level adjustment costs, or, at the very least, it implies highly nonlinear adjustment at firm level. The combination of nonlinear firm-level adjustment with firm heterogeneity, however, has important implications for aggregate fluctuations. One implication is time-varying elasticities of macroeconomic aggregates with respect to aggregate shocks. Roughly speaking, time-varying elasticities arise in this context because the impact of an aggregate shock depends on the distrubution of individual firms' relative positions to their adjustment thresholds.[17] In other words, characterising aggregate fluctuations requires tracking how the distribution of shocks and adjustments has evolved.

16 We have deliberately refrained from using more complex econometric procedures since, at this stage, we do not have a complete theoretical model formulation of the cyclical micro restructuring/reallocation phenomenon under study.

17 We are aware that this mechanism merely constitutes a point of departure for further explanatory lines of thought and may form the basis of richer and more structured models of firm dynamics.

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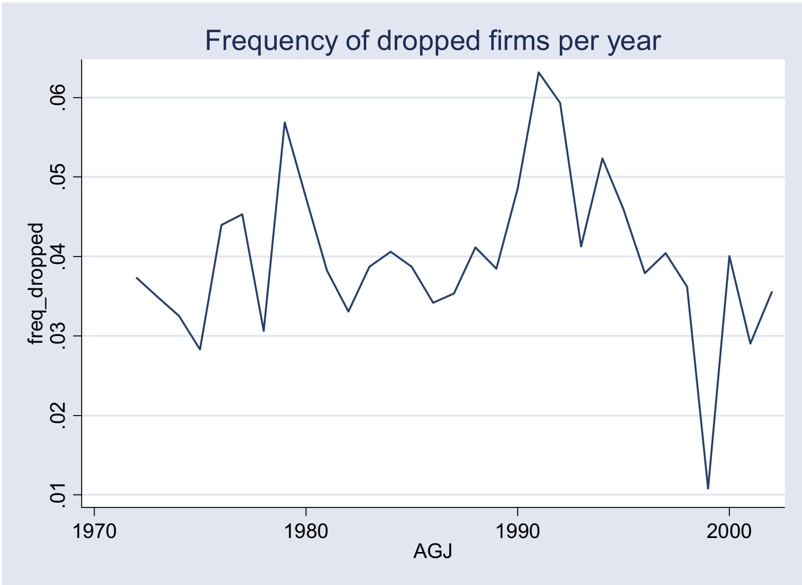
Appendix: Analysis of the excluded variables when using a 50 % cut-off

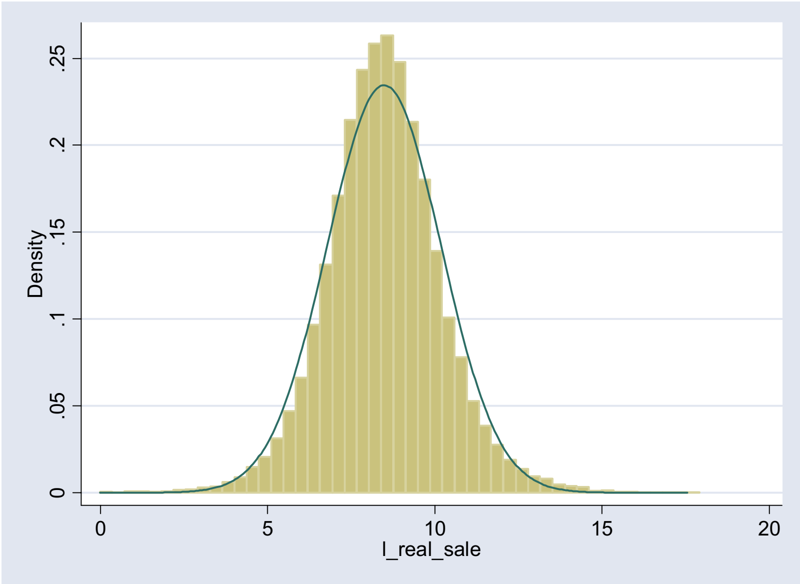
To ensure that by dropping firms no systematic exclusions were committed several enquiries into the nature of the dropped firms were deemed appropriate. Below follows a short examination of the firms dropped for a +/-50%cut-off.

Figure A1



In figure A1 the frequency of dropped firms is plotted against time. As seen, the percentage of dropped firms is roughly< 4% of total number of firms for each year and no clear pattern emerges implying that the dropping is random. The figure also shows a significant drop in the frequency for the year 1999, the year after the introduction of the euro, which stresses the necessity of restricting the data set to the period 1971 to 1998.

Figure A2



In figure A2 the density of the log size of dropped firms is plotted with a normal curve superimposed. It appears that there is no pattern which relates to the firm size to the probability of being dropped. This means that there is no discrimination of small start ups with high growth rates. The log size of dropped firms closely resembles a normal distribution. That normal distribution of the log size of firms is a common finding in the literature on the size distribution of firms and is known as Gibrats Law. This emphasises that the dropping of firms is unrelated to the size of the firms.

Figure A3

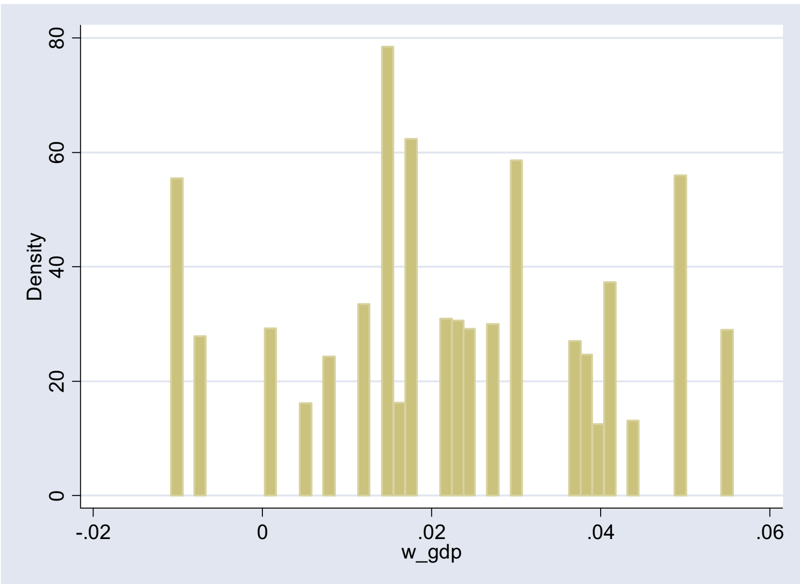


Fig. A3 shows the density of dropped firms plotted against the growth rate of real GDP. As can be seen, there is no systematic pattern, which means that the dropping is unrelated to business cycle conditions. That there are fewer bars for negative growth rates is due to the fact that there are far less years with negative growth rates.

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