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Aggregate and Firm-Level Volatility in the Japanese Economy

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Abstract

In this paper, we investigate the volatility of sales at the firm and the aggregate level using the longitudinal dataset of the *Financial Statements Statistics of Corporations* (FSSC). The main findings are as follows: (1) Firm-level volatility decreased until the mid-1990s but then increased again. (2) Aggregate-level volatility steadily decreased until the mid-1990s and has remained low since. (3) Decomposing the total variance of the growth rate of aggregated sales, we find that the divergence between firm-level and aggregate-level volatility is caused by the drastic decline and subsequent low level of the covariance of sales growth between different firms and the increase in individual firms' volatility.

Keywords: Firm-level Volatility, Aggregate-level Volatility
JEL classification: C33, D21, E23, E32

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1. Introduction

Output volatility at the aggregate level has declined significantly in most advanced economies (see, e.g., McConnell and Perez-Quiros, 2000; Blanchard and Simon, 2001; and Stock and Watson, 2002). Japan is no exception, having also experienced a dramatic decline of output volatility at the aggregate level, in what has been called the "Great Moderation" (see Kimura and Shiotani, 2007; and Osada and Kawamoto, 2007). Kimura and Shiotani (2007) using the *Index of Industrial Production* (IIP) compiled by the Ministry of Economy, Trade and Industry showed that output volatility declined dramatically in Japan in the 1980s. They also examined three potential explanations, such as changes in the sales process, smaller cost shocks, and improved business practices, for the decline in aggregate output volatility. They concluded that the decline in output volatility was due to improved inventory management through, for example, just-in-time techniques and flexible manufacturing systems. Osada and Kawamoto (2007), moreover, observe a common long-term downward trend in output volatility in Japanese manufacturing industries. Thus, they provide empirical evidence that the decline in cross-industry co-movements is key to understanding the "Great Moderation [1]

Despite the "Great Moderation" in economic activity at the aggregate level, recent empirical studies for the United States found that economic activity at the firm level has become more volatile (Comin and Mulani, 2006; Comin and Philippon, 2005). However, studies by Davis et al. (2007) for the United States and Thesmar and Thoenig (2011) for France suggest that the rise in volatility at the firm level is limited to listed firms only. Whether the *decline* in aggregate-level volatility in Japan has also gone hand-in-hand with an *increase* in firm-level volatility, as in the United States, and what the potential causes for any divergence are has, to our best knowledge, not yet been examined.[2] Against this background, the purpose of this study is to examine the trend of firm-level volatility in Japan and whether it has developed in the opposite direction as aggregate volatility, using panel data from the *Financial Statements Statistics of Corporations* (FSSC) spanning the 25-year period from 1982 to 2007. We find that indeed such a divergence between micro- and macro-level trends can be observed and attempt to examine the causes.

The increase in micro-level volatility means that managers may be inclined to postpone decisions on investment, hiring, firing, and exiting from the market, which in turn may negatively affect economic growth. Despite its potential importance for economic growth, volatility at the micro level has not been sufficiently studied. It goes without saying that it is important to accurately

[1] The determinants of the "Great Moderation" are still not clear. Other potential explanations of the "Great Moderation" that have been proposed are improved monetary policy (Clarida, Cali, and Gertler, 2000), financial innovation and global integration (Dynan, Elmendorf, and Sichel, 2006)), and good luck in the form of smaller exogenous shocks (Stock and Watson, 2002).

[2] A notable exception is the study by De Veirman and Levin (2010), which examines the change in volatility at the firm level in Japan using listed firm data. However, they did not compare trends in volatility at the aggregate and firm level.

understand trends in volatility at the micro level in order to better grasp dynamics in the economy and formulate appropriate policies. Our paper provides first steps to understand trends in volatility in the Japanese economy from a long-term perspective.

The paper is organized as follows. Section 2 explains the dataset and presents our findings with regard to firm-level volatility, while Section 3 addresses volatility at the aggregate level. Section 4 then provides an attempt to explain the divergence between macro- and micro-level volatility. Finally, Section 5 concludes.

2. Firm Level Volatility: Trends and Determinants

2.1 Data

There are several potential data sources to examine volatility in the Japanese economy. For example, the DBJ Databank is a longitudinal dataset of firm-level information going back all the way to 1960. Unfortunately, however, it only includes listed firms, whose behavior may differ from that of unlisted firms. Another candidate is the *Basic Survey of Business Structure and Activities* conducted by the Ministry of Economy, Trade and Industry (METI). This dataset provides a great deal of information covering both listed and unlisted firms, but has the drawback that it covers only the relatively short time span from 1991. However, a long time span is essential for a meaningful analysis of volatility. Yet another potential data source is the *Census of Manufactures*, also conducted by METI, which covers the period from 1980 but, as the name implies, only covers the manufacturing sector and, moreover, surveys establishments, not firms.

Therefore, the dataset we primarily rely on in our analysis is the *Financial Statements Statistics of Corporations* (FSSC) provided by the Ministry of Finance. The FSSC dataset covers both listed and unlisted firms in the manufacturing and non-manufacturing sectors from 1982.

Table 1 shows the number of firms included in the FSSC for each year as well as the number of year-firm observations by industry for the period we focus on, 1982 to 2007. As can be seen, the number of firms in the dataset increased over the years (up until 2002) and, as a result, was about twice as large in the 2000s as in the 1980s, which may result in a composition bias. In addition, the table shows that about 42% of the firms in the dataset fall into the manufacturing sector and about 18% are in wholesale and retail trade. We supplement the FSSC data with industry-level data from the Japan Industrial Productivity (JIP) Database 2010 such as input and output deflators.[3]

(Insert Table 1)

2.2 Trends

The simplest indicator for economic volatility probably is the standard deviation of output. Figure 1

[3] http://www.rieti.go.jp/jp/database/JIP2010/index.html.

depicts the mean and the standard deviation of the annual growth rate of sales of firms in the FSSC dataset. The average growth rate of sales seems to gradually fall, with cyclical fluctuations. The standard deviation moves cyclically without displaying a clear trend until the late 1990s; however, in the 2000s, it shows a clear, albeit weak, upward trend. These two indicators show that while the average growth rate of firms' sales declined during the period, the standard deviation of the growth of sales increased.

(Insert Figure 1)

Although the standard deviation of output growth represents a useful indicator, it has the important shortcoming that it does not necessarily show the volatility that individual firms face, because it does not capture the fluctuations in individual firms' output. Therefore, following Comin and Philippon (2005) and Comin and Mulani (2006), we measure the volatility individual firms face using the standard deviation of ten-year rolling windows of a variable, X:

$$\sigma(X_{it}) = \sqrt{\frac{1}{10}\sum_{\tau=t-5}^{t+4}\left(X_{i\tau} - \overline{X}_{it}\right)^2} \quad (1)$$

where $\overline{X}_{it}$ is the average of X_{it} between t-5 and t+4. X_{it} represents the annual growth rate of real sales between year t-1 and t of firm i. This method is also employed to measure aggregate-level volatility in Section 3.

For the calculation of this indicator, we restrict the sample to firms that have nonzero values of sales for any of the years in the observation period, so that firms with less than 11 year observations are excluded. Firms that exhibit gaps in the annual data on sales are also excluded. Given that we use ten-year rolling windows, we can calculate the indicator only for the period 1988 to 2003. The total nominal sales of the firms in the sample constitute, on average, 115% of nominal GDP.

Measuring volatility in this way, however, does not control for changes in the composition of firms included in each year. As mentioned above, the number of firms in the sample roughly doubled from the 1980s to the 2000s. In order to address the potential composition bias resulting from this, we run a pooled regression of firm-level volatility on the log of the share of firms' sales (S_{it}) in the sample:

$$\sigma_{it} = \beta_0 + \beta_1 S_{it} + \varepsilon_{it}^{\sigma}, \quad (2)$$

where the error term ($\varepsilon_{it}^{\sigma}$) represents firm-level volatility.

To check the robustness of our results, we also regress firm-level volatility on the log of the share of firms' sales and industry-specific dummies;

$$\sigma_{it} = \beta_0 + \beta_1 S_{it} + \beta_2 D_j + \varepsilon_{it}^{\sigma}, \tag{3}$$

where D_j is a set of industry dummies and the error term ($\varepsilon_{it}^{\sigma}$), as before, represents firm-level volatility.

Finally, we use firm-specific dummy variables to remove firm fixed effects in firm-level volatility:

$$\sigma_{it} = \beta_0 + \beta_1 S_{it} + \alpha_i + \varepsilon_{it}^{\sigma} \tag{4}$$

where α_i is a set of firm dummies and the error term ($\varepsilon_{it}^{\sigma}$) represents firm-level volatility.

The trend in the firm-level volatility of sales measured using equation (1) is shown in Figure 2(a). As can be seen, sales growth at the firm level became gradually less volatile until 1994, but after that exhibits a significant upward trend, which is different from the pattern in Figure 1.

Measuring volatility in this manner, however, does not control for firms' size. Thus, to control for firm size, we also calculated the weighted average of the firm-level standard deviation of sales growth using real sales as weights. The trend in weighted average volatility is very similar to that in unweighted volatility. In addition, to control for possible composition bias and industry-specific and firm-specific effects, we ran regressions using equations (2), (3) and (4), with the results shown in Figures 2(b), 2(c), and 2(d), respectively.

(Insert Figures 2(a), 2(b), 2(c) and 2(d))

However, even after controlling for these factors, the results remain largely unchanged. Thus, regardless of which measure we use to gauge firm-level volatility, we find that Japanese firms' sales gradually became more stable until the mid-1990s, but then turned more volatile after that. These results are also consistent with the results of previous studies for the United States (e.g., Comin and

Mulani, 2006).

Next, we divide firms by sector and examine whether trends in firm-level sales volatility differed between the manufacturing and the non-manufacturing sector. The results are displayed in Figure 3 and suggest that while the pattern in the manufacturing sector is similar to the sample overall, that for the non-manufacturing sector appears to differ.

(Insert Figures 3(a) and 3(b))

These results raise at least two questions: (1) Why did firm-level volatility increase from the second half of the 1990s? And (2) why do trends in firm-level volatility differ between the manufacturing and the non-manufacturing sector? De Veirman and Levin (2010) interpret the increased firm-level volatility after 1994 as reflecting the possibility that the Japanese labor market became more flexible and that product market competition intensified.

2.3 Determinants

In order to investigate the determinants of firm-level volatility, we regress the firm-level volatility derived from equation (1) on the log of firm sales, industry variables such as the IT ratio (defined as the ratio of IT capital stock over the total capital stock in the industry), the ratio of university graduate employees, the ratio of the number of the workers over 55 years old, the Herfindahl-Hirschman Index (HHI), and industry dummies.[4]

We conduct the regression for the whole sample, for the manufacturing sector only, and for the non-manufacturing sector only. The results are shown in Table 2 and indicate that the effect of firm size is negative and significant in all regressions. This suggests that the larger a firm is, the less volatile is its sales growth. As might be expected, the coefficients on the IT ratio are notably large and statistically significant. This result is consistent with the findings obtained by Brynjolfsson et al. (2007) and Chun et al. (2008) who report that IT is associated with an increase in volatility. We also find that the ratio of university graduate employees is associated with greater firm-level volatility.

In contrast with the coefficients on the IT ratio and the ratio of university graduate employees, those on the ratio of the number of workers over 55 years old are significantly negative. This result indicates that firm level volatility is lower in more mature industries and industries in which technical change is slow.

Looking at the results for the sub-samples, we find that in the manufacturing sector, the coefficients on firm size, the IT ratio, and the ratio of university graduate employees are very similar to those for the whole sample. The other coefficients are insignificant. On the other hand, regarding the non-manufacturing sector, we find that the coefficients on firm size, the ratio of the number of

[4] The various industry variables are taken from the JIP Database 2010.

workers over 55 years old, and the HHI are similar to those for the whole sample, while the coefficients on the IT ratio and the ratio of university graduate employees are insignificant or only weakly significant. This implies that IT capital and human capital are not important sources of firm-level volatility in the non-manufacturing sector. The coefficient on the HHI is negative and significant, meaning that greater competition plays an important role in increasing firm-level volatility.

(Insert Table 2)

We now turn to the impact that firm-level volatility has on firms' behavior. As mentioned in the introduction, more volatile conditions may lead firms to postpone investment plans. To test whether volatility does indeed affect investment, we regress the investment rate of a firm at time t on the volatility of the firm's sales at time t-1. The results are shown in Table 3, where the column labeled (1) shows the result for the basic specification. As can be seen, volatility has a significant negative effect on investment. Next, because investment is also strongly affected by productivity, in specification (2), we added firms' productivity as an additional independent variable. The result shows that more productive firms invest more and, crucially, that even when controlling for productivity (as well as industry and year effects) volatility has a negative impact on investment. As before, we also conducted separate regressions for the manufacturing and the non-manufacturing sector to examine whether the impact of volatility on investment behavior differs between the two. The results – comparing specifications (5) and (6) on the one hand and (9) and (10) on the other – indicate that volatility has a greater impact on the investment behavior of the manufacturing firms.

On the other hand, in the productivity growth regression models, we do not find any evidence that volatility has any impact on productivity growth. Although the coefficient on volatility is significantly negative for the manufacturing sector, it is not significant for the sample as a whole or the non-manufacturing sector.

(Insert Table 3)

In addition to the effect of firm-level volatility on individual firms' investment and TFP growth, we also examine the effect of industry-level volatility on industry-level investment and TFP growth. The results are shown in Table 4 and indicate that in none of the specifications volatility at the industry level has an impact on industry-level investment. On the other, it does have a negative and significant effect on industry-level productivity growth even after controlling for industry-specific effects (specifications (3) and (4)). Running the regressions for the manufacturing and the non-manufacturing sector separately shows that the effect works mainly in the non-manufacturing sector (specifications (11) and (12)).

(Insert Table 4)

3. Aggregate Volatility

We now turn to aggregate-level volatility. Macro-level volatility can be measured in two ways: based on the aggregation of the micro data of the FSSC, and based on macro-level data (such as the JIP Database 2010, which we use here). In the case of both measurements, as will be seen, the trend in volatility at the aggregate level differs from that at the micro level discussed in the previous section.

Figure 4 plots the time series movement of the standard deviation of the growth rate of aggregated real sales from FSSC data set and that of real gross output in the JIP Database. Interestingly, the pattern of aggregate-level volatility based on the two different datasets is very similar except in 1988. Specifically, macro-level volatility (based on the JIP Database) follows volatility calculated from the micro-level FSSC data with a lag of about 3 years. In both cases, aggregate-level volatility decrease until the first half of the 1990s, which is consistent with the pattern of micro-level volatility. However, thereafter, macro-level volatility remains unchanged, which is different from micro-level volatility, which increased.

(Insert Figure 4)

Next, we examine whether macro-level volatility differs between the manufacturing and the non-manufacturing sector. Figure 5 shows that the time series pattern of volatility is almost the same in both sectors.[5]

(Insert Figure 5)

Comparing the patterns of firm volatility in Japan with those in the United States, certain differences emerge. First, in Japan, the volatility of output was high from the late 1980s through the mid-1990s, whereas, in the United States, it was high from the late 1960s through the early 1980s, as can be seen by comparing Figures 5 and 6. Second, comparing Figure 6 with Figure 7, which depicts

[5] Figure 6 suggests that the volatility of macro-level output was lower in the 1980s than in the 1990s. While this raises interesting questions, reliable micro-level data covering the period unfortunately are not available. That is, although financial data of listed firms for the period do exist, they may be biased. We therefore leave the analysis of this period for future work.

the volatility of firm-level sales and of aggregate sales in the FSSC dataset, shows that whereas in the United States, the trends in micro- and macro-level volatility clearly diverged from the mid-1970s (with the former increasing and the latter decreasing), in Japan micro- and macro-level volatility moved in tandem and only diverged from the mid-1990s onward.

(Insert Figures 6 and 7)

4. Explaining the Divergence of Volatility at the Aggregate and Firm Level

These observations give rise to the question what causes the divergence between micro- and macro-level trends. To examine this question focusing on Japan, we decompose the volatility of aggregate sales.

To do so, we define the variance of the growth rate of aggregated sales as follows:

$$V\left(\left[g_t\right]_{t-5}^{t+4}\right)=\frac{1}{10}\sum_{\tau=t-5}^{t+4}\left(\sum_i g_{i\tau}s_{i\tau}-\frac{1}{10}\sum_{\tau=t-5}^{t+4}\sum_i g_{i\tau}s_{i\tau}\right)^2 \tag{5}$$

where $g_\tau=\sum g_{it}s_{it}$ denotes the growth rate of aggregate sales at time τ.

This variance can be decomposed into two terms:

$$\begin{aligned} V\left(\left[g_t\right]_{t-5}^{t+4}\right)&=\sum_i s_i^2 V\left(\left[g_{i\tau}\right]_{t-5}^{t+4}\right) \\ &+\sum_i\sum_{j\neq i} s_i s_j Cov\left(\left[g_{i\tau}\right]_{t-5}^{t+4},\left[g_{j\tau}\right]_{t-5}^{t+4}\right) \end{aligned} \tag{6}$$

where the first term is the variance and the second is the covariance and it is assumed that $s_{it}=s_i$ for all firms i and all years t. The variance term is the weighted average of the firm-level variance of the growth rate of sales, although it should be noted that the weight is different from that used in Figure 2: in Figure 2, the weight is the share in sales, whereas in equation (6), the weight is the square of the share in sales, so that the variance term in the equation is expected to be similar to the weighted average of firm-level volatility. The covariance term refers to the covariance between the sales growth rate series of different firms and shows the extent to which the volatility that firms face is similar.

The result of the decomposition is shown in Figure 8. The first point that the figure shows is that the variance follows a similar pattern as the weighted average of firm-level volatility, which is what we would expect based on the way the equation above is specified. The second point is that the covariance term almost monotonically decreases in the observation period. The third point is that, in terms of magnitude the variance of the growth rate of sales of each firm plays a negligible role in determining the total variance. Rather, it is the covariance of the growth rate of sales between different firms that is the driving force of aggregate level volatility, which means that the decrease in macro-level volatility is caused by the continuous drop in the covariance of firms' growth of sales. Even though the volatility that individual firms face increased (as in Figures 2(a) to 2(d)), the covariance steadily declined, although it rose somewhat in the 2000s.

(Insert Figure 8)

Figure 8 suggest that even though the volatility each firm faces increased from the mid-1990s onward, this greater volatility did not diffuse to other firms. To understand why the covariance term decreased to the extent it has, we need to better understand the propagation mechanisms of productivity, or in other words, spillovers through inter-firm relationship, such as transactions, ownership, or supply chains.

One possible explanation is that recent technical progress may consist of innovations that are largely firm-specific, i.e., the benefits are appropriated by the innovating firm, rather than involving general purpose technology (GPT). Firm-specific innovation is likely to result in firm-specific fluctuations in sales, whereas GPT is more likely to result in fluctuations in the sales of a large number of firms. If recent investment in information and communication technology (ICT) plays the role of GPT, it could be expected to increase the between-firm covariance. However, in Figure 8 we find that the covariance actually declined during the 1990s, i.e., when investment in ICT rose. This is contrary to the results obtained by Chun et al. (2008).

Another potential explanation is deindustrialization. Many production processes have been moved overseas, so that inter-firm relationships may be weakening. Osada and Kawamoto (2008), for example, found that a shock hitting a certain industry is less likely to propagate to other domestic industries due to the greater international division of labor.

However, at the moment, all of this is little more than conjecture. To gain a better understanding of these issues, it is necessary to investigate the relationship between firms with more detailed information, which is beyond the scope of this paper. We leave examining these issues for future research.

5. Conclusion

In this paper, we investigated the volatility of sales at the firm and the aggregate level using FSSC data covering both manufacturing and non-manufacturing firms from the 1980s onward. Our results are as follows: greater competition plays an important role in increasing firm-level volatility.

(1) At the firm level, volatility decreased until the mid-1990s, but then increased again. As for determinants of firm-level volatility, IT and human capital plays an important role in increasing firm-level volatility. In the non-manufacturing sector, the maturity of the industry and the degree of competition are important determinants of firm-level volatility.
(2) Aggregate-level and macro-level volatility steadily decreased until the mid-1990s and remained low after that.
(3) Decomposing the total variance of the growth rate of aggregated sales, we found that the divergence between firm-level and aggregate-level volatility is caused by the drastic decline and subsequent low level of the covariance of sales growth between different firms and the increase in individual firms' volatility.

To gain a better understanding why aggregate volatility has stagnated and firm-level volatility has increased since the mid-1990s, additional theoretical and empirical research on inter-firm relationships and their impact on volatility and productivity is needed, which we leave as a task for the future.

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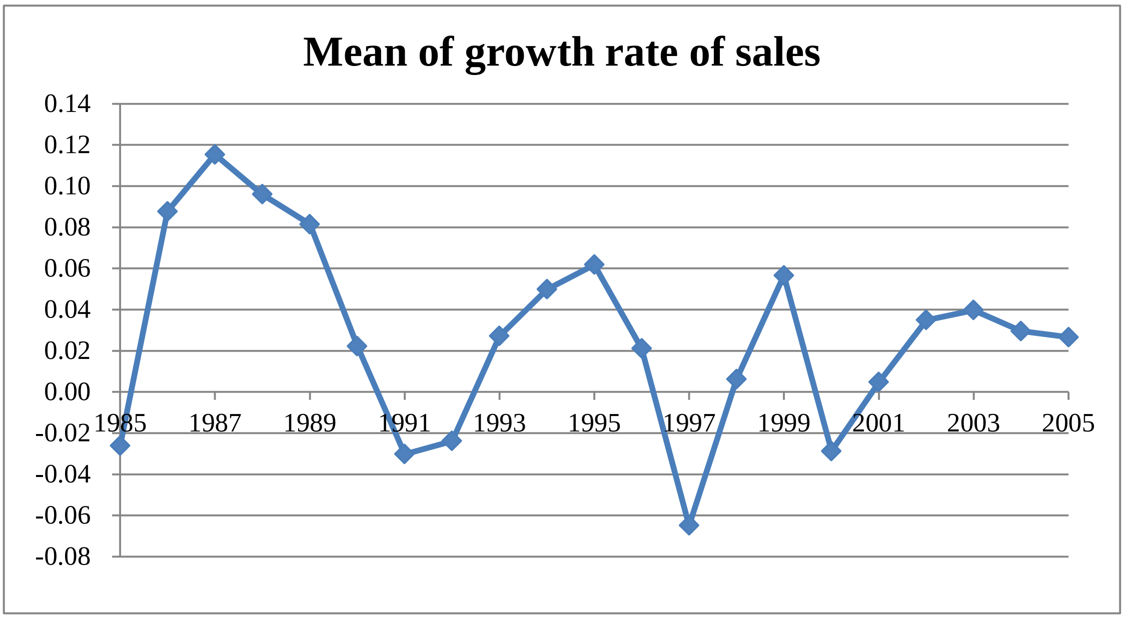
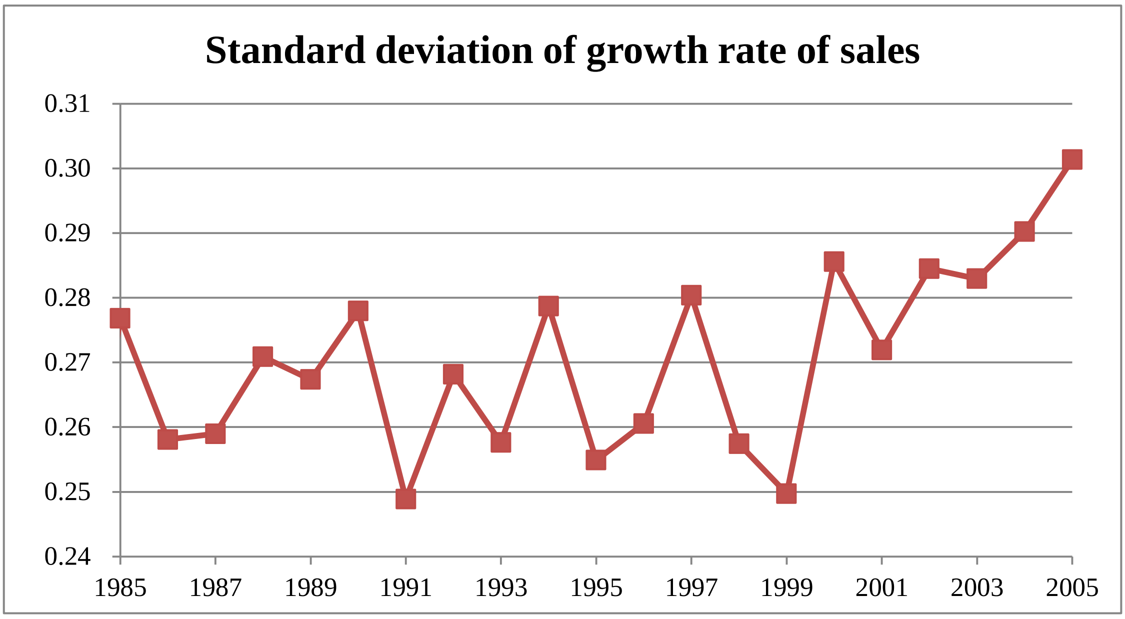
Table 1. Observations by year and by industry

Year	Obs.
1982	3,129
1983	3,270
1984	3,385
1985	3,529
1986	3,694
1987	3,983
1988	4,316
1989	4,757
1990	5,108
1991	5,372
1992	5,652
1993	5,896
1994	6,082
1995	6,291
1996	6,382
1997	6,440
1998	6,450
1999	6,495
2000	6,523
2001	6,580
2002	6,616
2003	6,500
2004	6,458
2005	6,358
2006	6,257
2007	6,096
Total	141,619

Industry	Obs.	(%)
Food and Beverages	5,617	(4.0)
Textiles	1,472	(1.0)
Wearing Apparel, Dressing and Other Textiles	634	(0.5)
Lumber and Wood Products	279	(0.2)
Pulp, Paper and Paper Products	1,392	(1.0)
Printing	1,002	(0.7)
Chemical and Allied Products	9,820	(6.9)
Petroleum and Coal Products	862	(0.6)
Other Non-Metallic Mineral	2,601	(1.8)
Iron and Steel	2,337	(1.7)
Non-ferrous Metal Products	2,225	(1.6)
Fabricated Metal Products	2,887	(2.0)
General Purpose Machinery	6,564	(4.6)
Electrical, Information and Communication Electronics Equipment	10,066	(7.1)
Transportation Equipment	4,863	(3.4)
Precision Instruments	1,978	(1.4)
Other Manufacturing	4,621	(3.3)
Agriculture	132	(0.1)
Forestry	31	(0.0)
Fishing	107	(0.1)
Mining	2,421	(1.7)
Construction	7,550	(5.3)
Electricity	952	(0.7)
Gas, Heat Supply and Water Supply	968	(0.7)
Information and Communications	9,423	(6.7)
Road Transportation	2,316	(1.6)
Water Transporation	1,151	(0.8)
Other Transporation	4,190	(3.0)
Wholesale	14,543	(10.3)
Retail	10,489	(7.4)
Real Estate	10,513	(7.4)
Accommodation	3,471	(2.5)
Personal Services	612	(0.4)
Entertainment	2,906	(2.1)
Services for Business	6,294	(4.4)
Medical, Social Welfare, Education and Other Services	4,330	(3.1)
Total	141,619	(100.0)

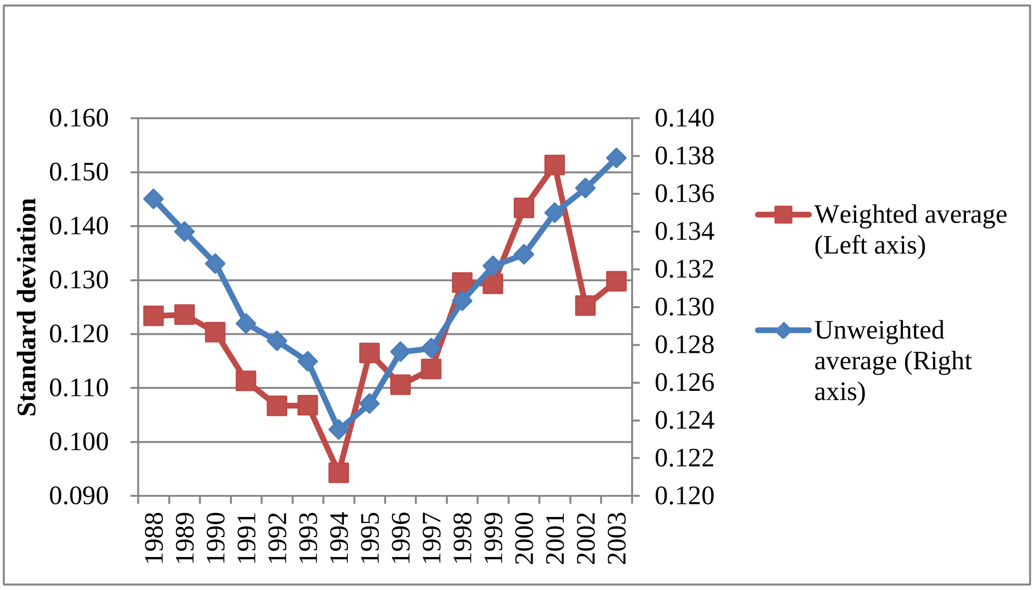
Figure 1. Mean and standard deviation of growth rate of sales





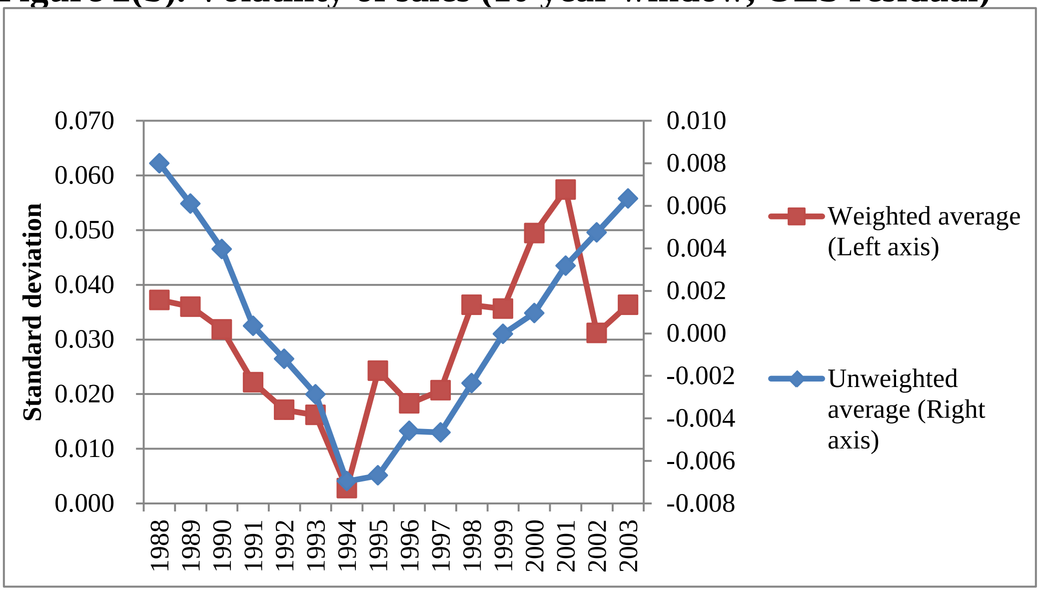
Source: Authors' calculation based on FSSC.

Figure 2(a). Volatility of sales (10 year window)



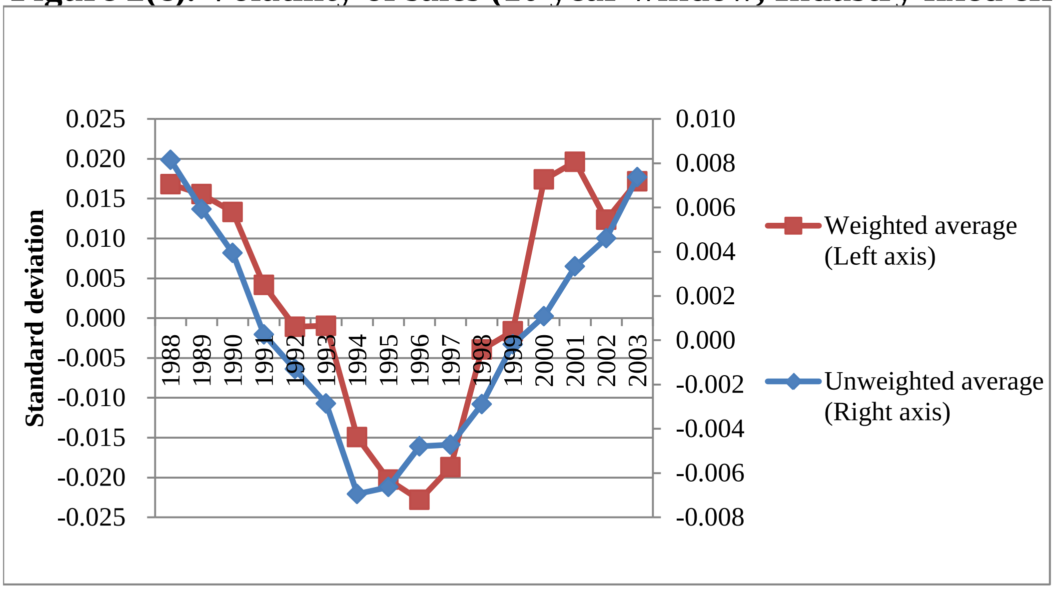
Source: Authors' calculation.

Figure 2(b). Volatility of sales (10 year window, OLS residual)



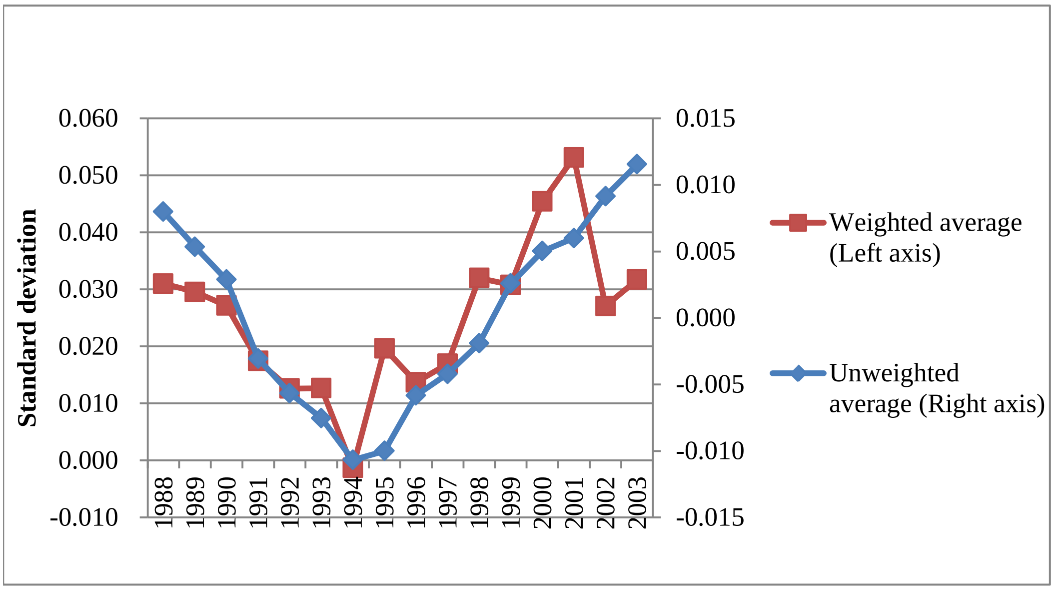
Source: Authors' calculation.

Figure 2(c). Volatility of sales (10 year window, Industry fixed effe



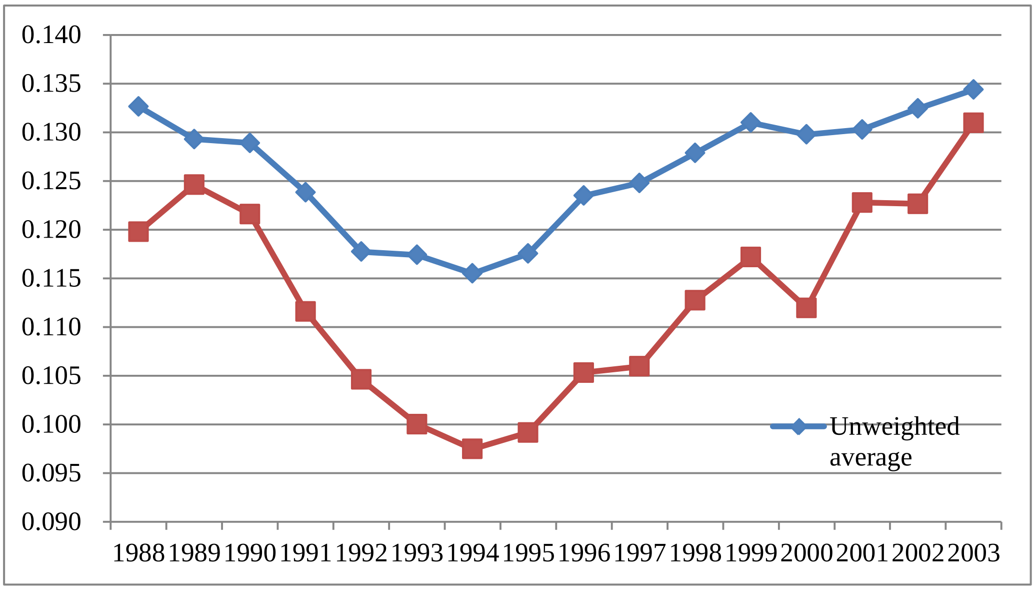
Source: Authors' calculation.

Figure 2(d). Volatility of sales (10 year window, Firm fixed effects



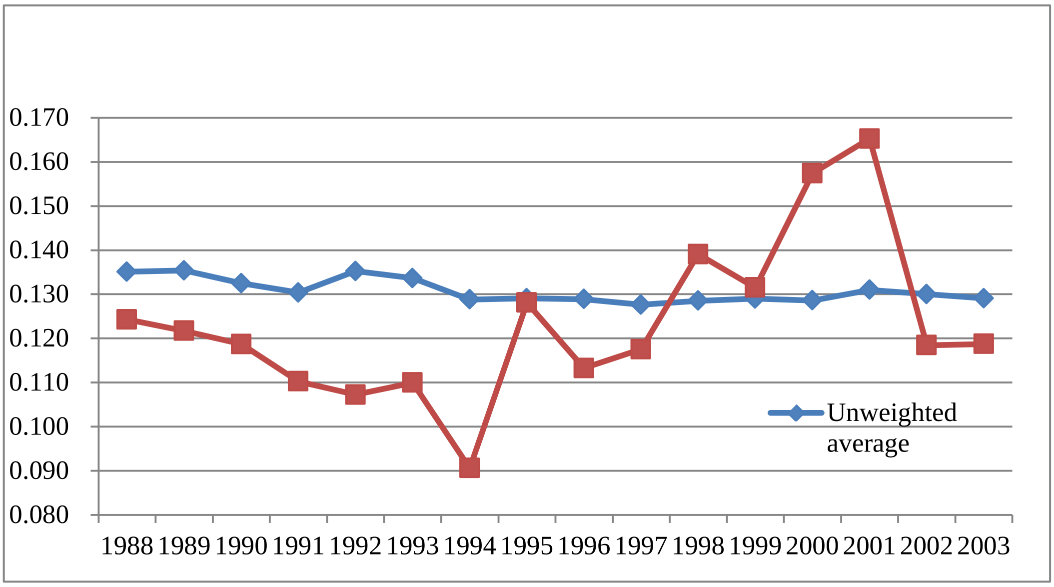
Source: Authors' calculation.

Figure 3(a). Volatility of sales in manufacturing sector (10 year window)



Source: Authors' calculation.

Figure 3(b). Volatility of sales in non-manufacturing sector (10 year windo



Source: Authors' calculation.

Table 2. Determinants of firm-level volatility

	Volatility $_{firm}$	(1)	(2)	(3)	(4)	(5)
Firm	lnSales	-0.012 ***	-0.012 ***	-0.012 ***	-0.012 ***	-0.012 ***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Industry	IT/K		0.372 ***	0.325 ***	0.285 ***	0.301 ***
			(0.059)	(0.063)	(0.063)	(0.064)
	University graduates / Total employees			0.16 **	0.129 *	0.095
				(0.072)	(0.072)	(0.075)
	Workers over 55 / Total workers				-0.298 ***	-0.292 ***
					(0.058)	(0.058)
	HHI					-0.058 *
						(0.032)
	Adj. R-squared	0.087	0.087	0.087	0.088	0.088
	Observations	54,297	54,018	54,018	54,018	54,018

Manufacturing sector

	Volatility $_{firm}$	(6)	(7)	(8)	(9)	(10)
Firm	lnSales	-0.01 ***	-0.01 ***	-0.01 ***	-0.01 ***	-0.01 ***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Industry	IT/K		0.375 ***	0.288 ***	0.292 ***	0.291 ***
			(0.083)	(0.092)	(0.092)	(0.092)
	University graduates / Total employees			0.229 **	0.196 *	0.204 *
				(0.108)	(0.116)	(0.117)
	Workers over 55 / Total workers				-0.068	-0.056
					(0.087)	(0.088)
	HHI					0.07
						(0.074)
	Adj. R-squared	0.081	0.081	0.082	0.082	0.082
	Observations	26,660	26,381	26,381	26,381	26,381

Non-manufacturing sector

	Volatility $_{firm}$	(11)	(12)	(13)	(14)	(15)
Firm	lnSales	-0.014 ***	-0.014 ***	-0.014 ***	-0.014 ***	-0.014 ***
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Industry	IT/K		0.228 **	0.162	-0.04	-0.044
			(0.110)	(0.115)	(0.121)	(0.121)
	University graduates / Total employees			0.212 **	0.22 **	0.127
				(0.105)	(0.105)	(0.112)
	Workers over 55 / Total workers				-0.449 ***	-0.435 ***
					(0.087)	(0.087)
	HHI					-0.103 **
						(0.042)
	Adj. R-squared	0.09	0.09	0.09	0.091	0.091
	Observations	27,637	27,637	27,637	27,637	27,637

Notes: Industry and year dummies are included in all regressions, but their coefficients are not reported.

* p<.1, ** p<.05, *** p<.01

Table 3. Effect of firm-level volatility

Whole sample

	Investment rate $_{firm\ t}$		TFP growth rate $_{firm\ t}$	
	(1)	(2)	(3)	(4)
Volatility $_{firm\ t-1}$	-0.027 ***	-0.013 **	0.003	-0.002
	(0.006)	(0.006)	(0.003)	(0.003)
lnTFP $_{firm\ t-1}$		0.176 ***		-0.093 ***
		(0.005)		(0.002)
Adj. R-squared	0.108	0.131	0.03	0.069
Observations	47,839	47,180	47,453	47,453

Manufacturing sector

	(5)	(6)	(7)	(8)
Volatility $_{firm\ t-1}$	-0.033 ***	-0.016 *	0.000	-0.007 **
	(0.009)	(0.009)	(0.004)	(0.004)
lnTFP $_{firm\ t-1}$		0.313 ***		-0.14 ***
		(0.010)		(0.004)
Adj. R-squared	0.122	0.16	0.076	0.13
Observations	24,055	23,808	23,813	23,813

Non-manufacturing sector

	(9)	(10)	(11)	(12)
Volatility $_{firm\ t-1}$	-0.025 ***	-0.01	0.005	0.000
	(0.008)	(0.009)	(0.004)	(0.004)
lnTFP $_{firm\ t-1}$		0.146 ***		-0.082 ***
		(0.006)		(0.003)
Adj. R-squared	0.084	0.104	0.014	0.05
Observations	23,784	23,372	23,640	23,640

Notes: Industry and year dummies are included in all regressions, but their coefficients are not reported.

* p<.1, ** p<.05, *** p<.01

Table 4. Effect of volatility at the industry level

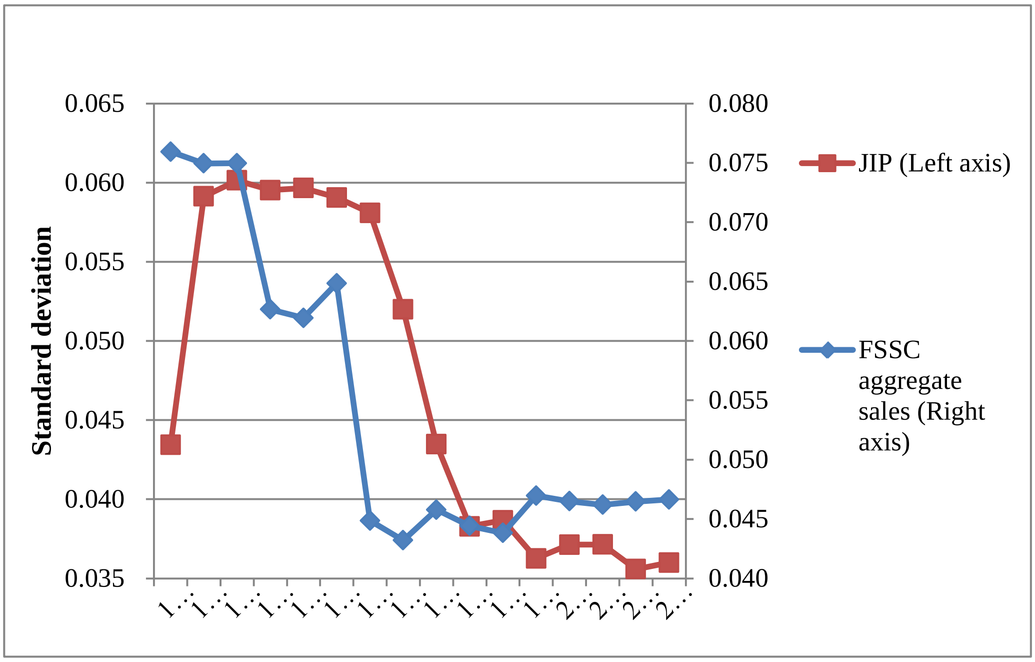
Whole sample

	Investment rate $_{industry\ t}$		TFP growth rate $_{industry\ t}$	
	(1)	(2)	(3)	(4)
Volatility $_{industry\ t-1}$	0.263	0.232	-0.203 ***	-0.176 ***
	(0.177)	(0.182)	(0.035)	(0.036)
lnTFP $_{industry\ t-1}$		0.091		-0.079 ***
		(0.123)		(0.024)
Adj. R-squared	0.192	0.191	0.162	0.179
Observations	508	508	508	508
Manufacturing sector				
	(5)	(6)	(7)	(8)
Volatility $_{industry\ t-1}$	-0.049	-0.016	0.056	0.044
	(0.276)	(0.273)	(0.072)	(0.070)
lnTFP $_{industry\ t-1}$		0.333 **		-0.121 ***
		(0.137)		(0.035)
Adj. R-squared	0.45	0.462	0.168	0.206
Observations	255	255	255	255
Non-manufacturing sector				
	(9)	(10)	(11)	(12)
Volatility $_{industry\ t-1}$	0.281	0.254	-0.237 ***	-0.211 ***
	(0.249)	(0.260)	(0.047)	(0.049)
lnTFP $_{industry\ t-1}$		0.066		-0.063 *
		(0.183)		(0.035)
Adj. R-squared	0.141	0.137	0.16	0.169
Observations	253	253	253	253

Notes: Year dummies are included in all regressions, but their coefficients are not reported.

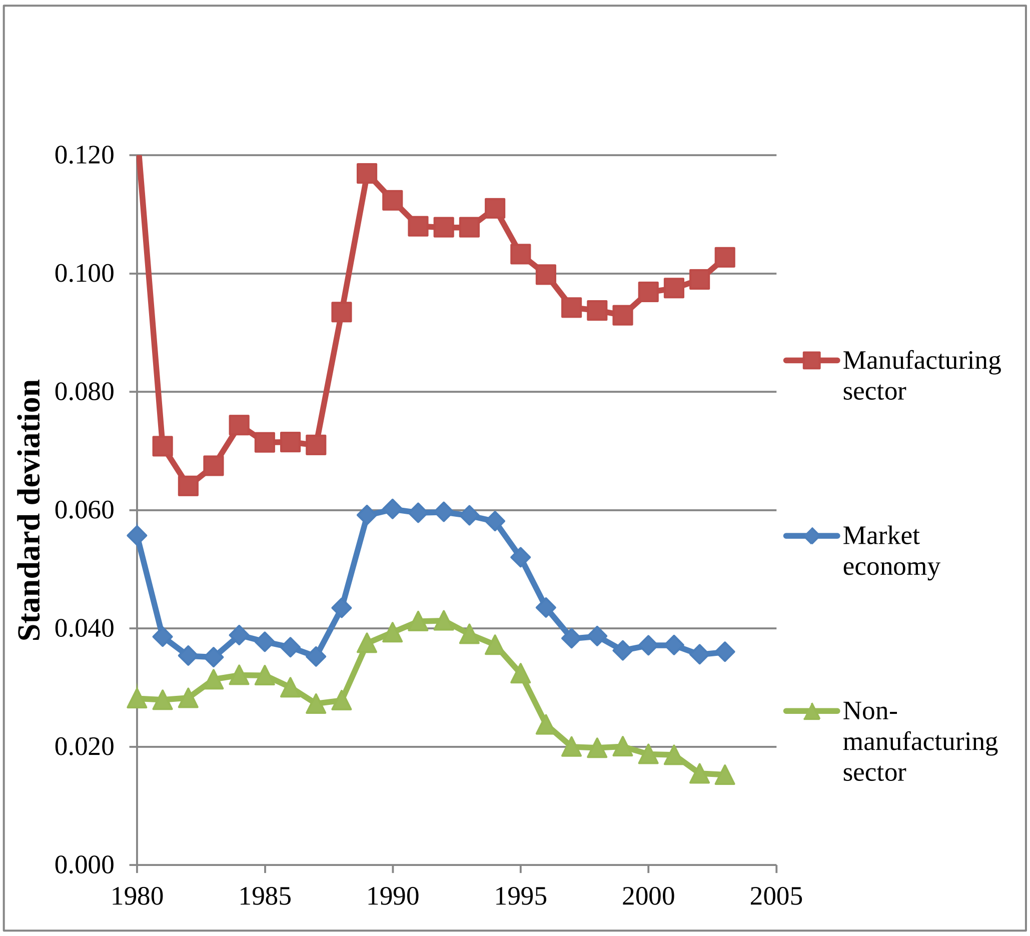
* p<.1, ** p<.05, *** p<.01

Figure 4. Volatility of aggregate sales (10 year window)



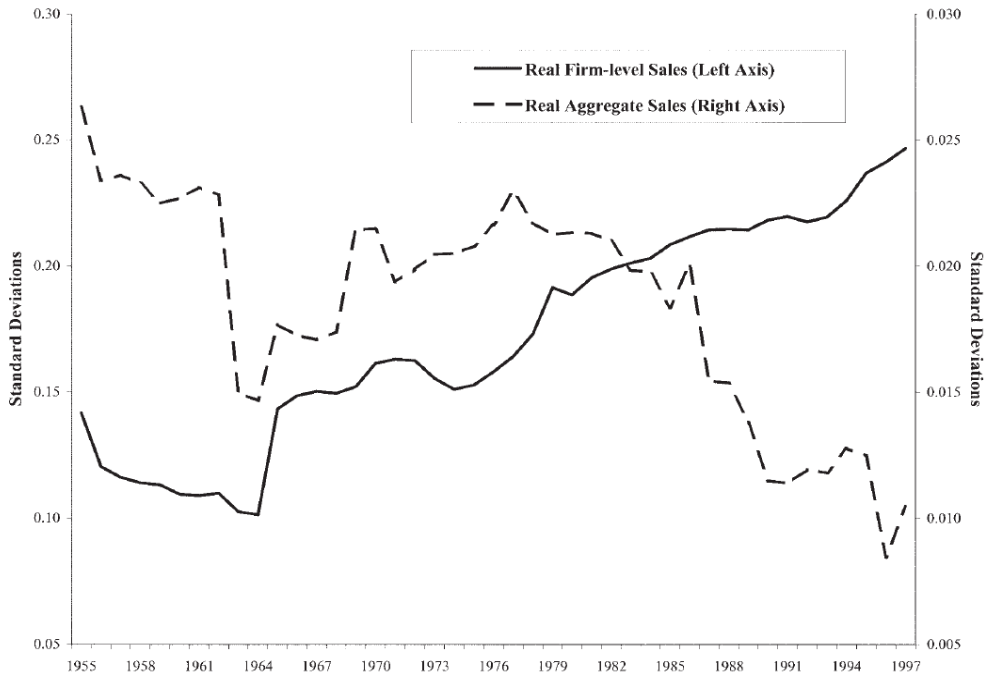
Source: Authors' calculation.

Figure 5. Volatility of sector- and macro-level output (10 year win



Source: Authors' calculation using JIP 2010 data.

Figure 6. Volatility of sales (United States)



Source: Comin and Mulani (2006).

Figure 7. Volatility of firm-level and aggregate sales

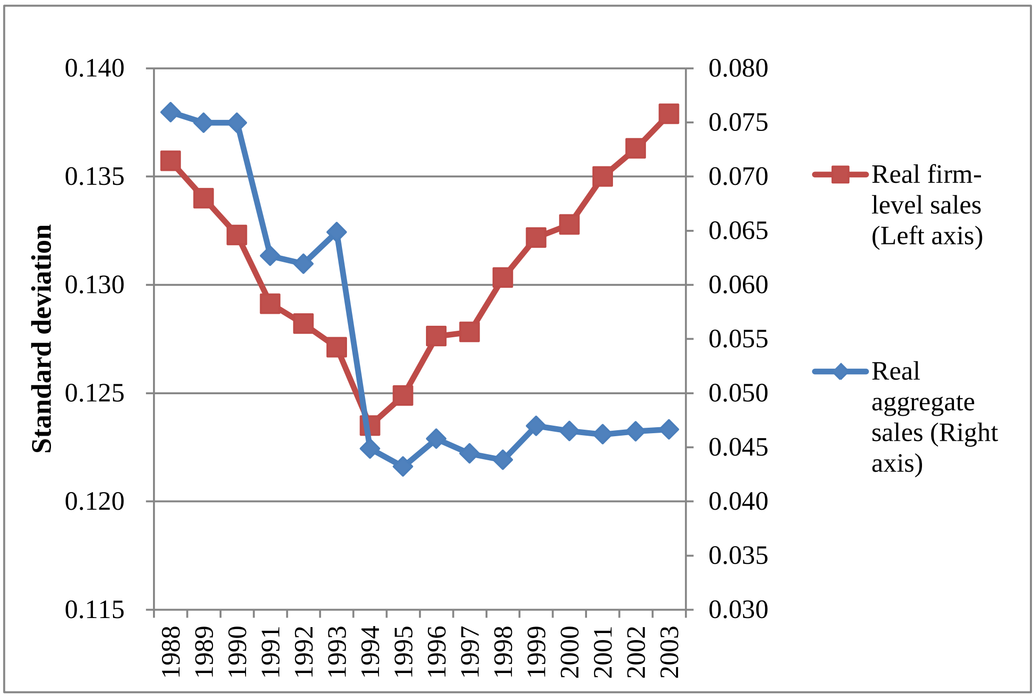
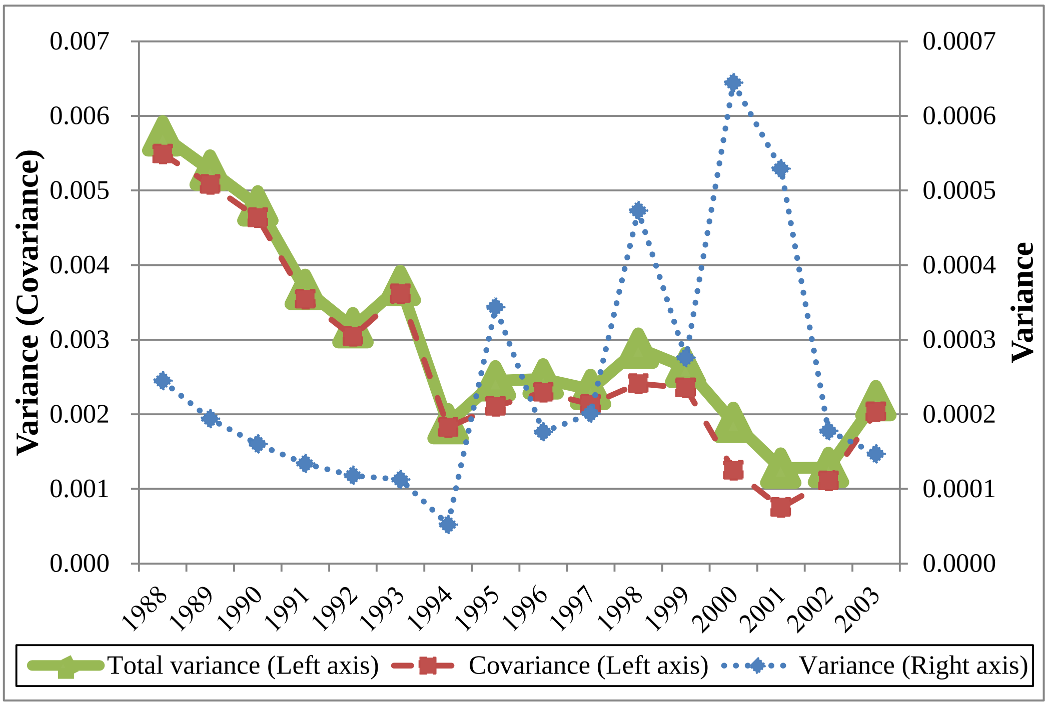


Figure 8. Variance-covariance decomposition



Source: Authors' calculation using FSSC data.