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Emmanuel De Veirman and Andrew Levin

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Measuring Changes in Firm-Level Volatility: An Application to Japan*

Emmanuel De Veirman and Andrew Levin †

Abstract

This paper develops a new technique for estimating earnings and employment volatility at the firm level, and applies it to Japanese firms. Unlike earlier studies for the United States, we estimate instantaneous volatility for every year, rather than a rolling ten-year average of volatility. In addition, our technique allows us to estimate the firm-specific component of firm volatility separately, by controlling for variation in firms' earnings and employment growth induced by aggregate and sectoral factors. We find that firm-specific sales volatility was substantially higher before the 1990 stock market crash than in the following fifteen years. The conditional variance of earnings and employment growth stayed relatively constant until the late 1990s, but increased substantially from 1999 onwards.

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† Emmanuel De Veirman (corresponding author), Reserve Bank of New Zealand, PO Box 600, Wellington, New Zealand. *Email address:* emmanuel.deveirman@rbnz.govt.nz, Andrew T. Levin, Board of Governors of the Federal Reserve System, Washington DC.
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1 Introduction

This paper develops a new technique for estimating the volatility of firm-level earnings and employment growth, and applies it to a panel of Japanese firms.

An elaborate literature has documented that in the United States, aggregate real GDP growth has tended to be less volatile in the period stretching from the mid-1980s until a few years ago, as compared to the preceding two and a half decades.[1] Recently, these results on aggregate volatility have been complemented by a number of studies on the volatility of US firm-level variables. Authors such as Comin and Philippon (2005) and Comin and Mulani (2006) document a trend increase in sales growth volatility for publicly traded US firms. On the other hand, Davis, Haltiwanger, Jarmin, and Miranda (2006) found that firm-level volatility displays a trend decline in a dataset which comprises virtually the entire population of US firms, both publicly traded and privately held.

Comin and Philippon (2005), Comin and Mulani (2006) and Davis et al (2006) all measure firm-level volatility based on rolling ten-year standard deviations of sales growth and/or employment growth. Their approach differs from ours in two major ways.

First, we estimate the instantaneous cross-sectional average of firm-level volatility for every year. Rolling standard deviations are insightful for learning about longer-term trends in firm-level volatility, but are not instructive about year-on-year changes in volatility. One way to see this is that this procedure yields ten-year averages of volatility, and therefore 'smooths out' annual changes in volatility. Another way to see this is that a change in any firm's rolling standard deviation from one year to the next depends both on the new observation which enters the ten-year window and on the older observation which drops out after the ten-year window has been rolled forward. In short, changes in measured volatility between two years do not purely reflect changes in actual volatility between those two years.

A second difference between the predominant methodology and ours is that rolling standard deviations capture the overall variation in firm-level earnings growth, without distinguishing between variation induced by firm-specific factors and volatility due to aggregate or sector-wide developments. In

[1] Noteworthy papers in the literature on aggregate stabilization include Kim and Nelson (1999), McConnell and Perez-Quiros (2000), Blanchard and Simon (2001), Stock and Watson (2002), Ahmed, Levin, and Wilson (2004), Dynan, Elmendorf, and Sichel (2006), and Gali and Gambetti (2009).

this paper, we separately estimate the idiosyncratic component of firm-level volatility, which is novel for earnings and employment volatility, but is inspired by the literature on US stock market volatility.[2]

The empirical literature on firm-level earnings and employment volatility has focused on the United States. By estimating firm-level volatility for listed Japanese firms, we are able to assess how year-on-year changes in firm-level volatility relate to factors which have been particularly prominent in Japan, such as financial market turmoil and a gradual increase in labor market flexibility since the mid-1990s.

While the present study is the first to characterize firm-level volatility of non-financial variables for Japan, it complements a paper by Hamao, Mei, and Xu (2007) which estimates firm-level stock return and stock turnover volatility for companies listed on the Tokyo Stock Exchange. As we will discuss, our results suggest that the pattern of firm-specific sales growth volatility over time is reasonably similar to that of firm-specific stock return volatility as documented by Hamao et al (2007).

We find that idiosyncratic sales growth has been substantially less volatile after 1990 than during the bubble period of the late 1980s. On the other hand, operational profit and employment growth were more volatile from 1999 on than in the preceding decennium. Our findings hold quite broadly across sectors and firm size quartiles.

Our paper is structured as follows. Section 2 discusses data and measurement issues. Section 3 lays out the estimation model. Section 4 discusses our baseline results. Section 5 summarizes results for separate sectors and firm size quartiles, and documents the robustness of our results to a model variation and alternative sample of firms. Section 6 compares our results on idiosyncratic sales growth volatility to the existing evidence for Japan on idiosyncratic stock return volatility and aggregate output growth volatility. Section 7 concludes.

[2] Campbell, Lettau, Malkiel, and Xu (2001) decompose stock market volatility into a market-wide, sector-specific, and idiosyncratic component. Recent contributions to the literature on firm-level stock market volatility include Fama and French (2004) and Fink, Fink, Grullon, and Weston (2005).

2 Data and Measurement

2.1 Data and Sample Selection

This paper characterizes firm-level volatility in the growth rates of net sales, Earnings Before Interest and Taxes (EBIT), and the number of employees.[3] Sales and earnings are in nominal terms, and the results reported in this paper are based on nominal sales and earnings data. However, our results are robust to deflating sales and EBIT by the aggregate Producer Price Index (PPI).

We extracted all company-level data for this paper from the Thomson ONE Banker Worldscope database. In particular, we downloaded data for the 4507 firms in Worldscope with country code corresponding to Japan. All of these firms trade equity securities on at least one of the Japanese stock exchanges. Data are available at an annual frequency. We use data for the period 1986-2005.

Given that the database only includes firms which are listed on the stock market, it can hardly be seen as a representative sample from the entire population of Japanese firms. In case the volatility of privately held firms follows a different pattern than the volatility of publicly traded firms, the former is likely to dominate, as in Davis, Haltiwanger, Jarmin, and Miranda (2006). However, reliable income statement data for the entire period 1986-2005 typically do not exist for privately held Japanese firms, and in any case are not included in any firm-level database which we are aware of.

Listed firms are typically substantially larger than their non-traded counterparts. These firms are interesting to study in their own right, in line with the finding of Gabaix (2009) that in the United States, the hundred largest firms explain a disproportionately large fraction of macroeconomic fluctuations.

In any case, the Worldscope database does include a substantial number of observations for smaller firms. For instance, it includes firms listed on

[3] Net sales equals gross sales, i.e. the amount of actual billings to customers for regular sales, minus cash discounts, trade discounts, and returned sales and allowances for which credit is given to the customer.
EBIT is computed as a firm's sales and other income minus its operating expenses, which include fixed costs, marginal costs, and depreciation, yet do not include interest and tax payments. Thus, EBIT reflects the profitability of the firm's operations, abstracting from tax expenditure, as well as from interest expenses and interest income.
The number of employees for any company includes both full-time and part-time employees, but excludes seasonal employees and emergency employees.

segments of stock exchanges for start-ups, such as the JASDAQ and Hercules segments of the Osaka Stock Exchange. Over 1986-2005, the median of annual net sales is 374 million USD; median annual EBIT is 14.9 million USD; and the median number of employees is 875. Five percent of all 44,655 observations are for net sales of 39.5 million USD or less; the fifth percentile for EBIT is -13.5 million USD (so it is a loss rather than a profit); and five percent of all observations correspond to a number of employees of 100 or less.

Another issue, which we account for, is that changes in the composition of our sample are not likely to be representative for compositional changes in the population of firms listed on the stockmarket. The number of Japanese firms for which data are available in Worldscope steadily increases from about 700 in 1985 to about 3800 in 2005, at a rate of increase which substantially exceeds the rate at which new firms entered the Japanese stockmarket. Worldscope seems to have gradually expanded its coverage of listed firms. By so doing, it has gradually relaxed the (implicit or explicit) criteria for inclusion in the database. For instance, our understanding is that Worldscope has used a threshold minimum level of stock market capitalization, which has gradually reduced over time. Therefore, once a firm is included in the sample, it tends to stay, as long as it continues to exist.

As Figure 1 illustrates, this is reflected in a trend decline in net sales, operational profit and the number of employees for most parts of the distribution, a decline which we do not take to be representative for the overall population of firms. In the Figure, large diamonds indicate the median in a given year, small diamonds indicate the 25th and 75th percentiles, and the dashed line indicates the mean. Note that the mean substantially exceeds the 75th percentile, suggesting skewness in the distribution of firms.

It is a stylized fact that smaller firms tend to be more volatile. Therefore, a non-representative reduction in average firm size in our sample may bias our results towards finding an increase in firm-level volatility over time. We deal with this issue in a number of ways. In the baseline, our sample includes only the 577 firms for which all three firm-level growth rates have been continuously available over the period 1986-2005. By considering the same firms at every point of time, we control for changes in average firm size and industry, to the extent that these characteristics are relatively stable over time. In addition, we investigate robustness of our results to subdividing the data in firm size quartiles. In that case, all observations in a subsample are within well-defined bands as far as firm size is concerned, which is a way of holding size relatively constant.

The sample of 577 firms has the following drawbacks. First, the sample selection criterion tends to favor the inclusion of larger, less volatile, smoothly growing firms, possibly implying selection bias. Over 1986-2005, median annual net sales in the restricted sample is 1332.8 million USD; median EBIT is 54.5 million USD; the median number of employees is 2726. Figure 3 suggests that, while median profitability declined through the 1990s, there is no generalized trend decline in firm size in the sample of continuously available firms. The combined sales of the 577 firms tend to increase at a faster rate than aggregate GDP does, suggesting that their composite value-added accounted for an increasingly large share of overall production. The fact that firm size increases somewhat over the sample may tend to bias our results towards finding a decline in volatility.

Therefore, we examine robustness by estimating an alternative model on the entire sample of 4507 firms. In that exercise, we control for firm fixed effects, implying that our estimate of average volatility is less affected by the gradual extension of the sample to firms that are intrinsically more volatile. Also note that we include the available observations for companies which became inactive before the last year of the sample, in an effort to avoid survivorship bias. As we will discuss, the results with the full Worldscope sample are similar to those obtained from the balanced panel of continuously available firms.

2.2 Measurement

We compute annual growth rates in net sales and employment.[4] For Earnings Before Interest and Taxes (EBIT), we cannot compute the growth rate for any year t in the regular fashion, since doing so would yield meaningless results when EBIT is negative in t and/or $t-1$. Therefore, we compute growth in operational profit based on the change in EBIT divided by lagged net sales:

$$\gamma_{it} \;=\; \frac{EBIT_{it} - EBIT_{i,t-1}}{SALES_{i,t-1}} * 100 \tag{1}$$

We windsorize the data in order to reduce the impact of outliers on our results. For every growth rate, we determine the 2.5th and 97.5th percentiles of all observations in the full sample of 4507 firms. We replace any (negative) growth rate which falls below the 2.5th percentile by the value of the growth

[4] We computed sales growth after dropping the three observations for which net sales is strictly negative.

rate at the 2.5th percentile. Similarly, we replace any (positive) growth rate exceeding the 97.5th percentile by the value of the growth rate at the 97.5th percentile. When restricting the sample to 577 firms, we use the data as windsorized based on the percentiles applicable to the unrestricted sample of firms. That is, we effectively windsorize even less than five percent of the restricted sample's observations.

Figures 2 and 4 graph the distribution of sales, EBIT, and employment growth for the full Worldscope sample and for the balanced panel of 577 firms, respectively. The time-path of the conditional mean and the growth percentiles are very similar in both samples. The growth distributions appear to be relatively symmetric at any point of time. Median sales growth of sampled firms plausibly corresponds to aggregate Japanese developments: it reflects the high-growth bubble of the late 1980s, the fact that GDP growth was subdued but still mostly positive in the first half of the 1990s, and the fact that the economy experienced a severe downturn in the second half of the 1990s, before recovering around 2003.

In Figure 3, note the large upward jump in employment in 2000. This reflects the fact that substantial changes in accounting standards have been implemented in Japan for business years ending on March 31, 2000 or later. In particular, the new standards have broadened the definition of subsidiaries which parent companies are required to include in their consolidated accounts. While the change in accounting standards may explain the temporary increase in the levels of sales and profit in 2000, the change in rules appears to have had most impact on reported employment figures. Before the change in accounting standards, parent companies had often assigned their excess employment (and excess debt) to affiliate companies which did not need to be included in the consolidated accounts at that time.

We deal with this issue by omitting employment growth data for 2000 and 2001 from the sample. Neither Figure 2 nor Figure 4 graph employment growth for those years, but one can readily infer from Figure 3 that the growth rates corresponding to the levels jump in employment levels in 2000 are extremely high. The issue appears less severe in the case of sales and earnings growth, and we do not omit observations for these variables. In any case, our technique is such that estimated volatility for other years is invariant to the inclusion of observations for 2000 and 2001.

3 Estimation Model

The present section describes our empirical strategy for estimating firm-level volatility. Throughout, we use growth rate data for the period 1986-2005. Our baseline model uses data for a balanced panel of 577 firms. To examine robustness, we estimate an alternative model based on an unbalanced panel for all 4507 firms.

3.1 Baseline Model: Time-Varying Firm Effects

The baseline model consists of two equations with a panel data structure. The first-stage regression is as follows:

$$\begin{aligned}\gamma_{it} \quad = \quad & c \; + \; \widetilde{\gamma}_{it}^{HP} \; + \sum_{\tau=1987}^{2005} b_\tau \; \lambda_\tau \; + \; \sum_{s=2}^{10} d_{s0} \; \varphi_s \; + \; \sum_{q=2}^{4} e_{q0} \; \vartheta_q \\ & + \sum_{s=2}^{10} \sum_{\tau=1987}^{2005} d_{s\tau} \; \varphi_s \; \lambda_\tau \; + \; \sum_{q=2}^{4} \sum_{\tau=1987}^{2005} e_{q\tau} \; \vartheta_q \; \lambda_\tau \; + \; \varepsilon_{it} \end{aligned} \tag{2}$$

Where γ_{it} represents net sales growth, employment growth, or EBIT growth between year $t-1$ and t for firm i. The effects of (unobserved) aggregate factors on firm growth are captured by the coefficients b_τ, $d_{s\tau}$ and $e_{q\tau}$ on the terms involving time dummies λ_τ. Sector dummies φ_s capture ten 2-digit sectors as classified according to the Global Industry Classification Standard (GICS).[5] To construct firm size dummies ϑ_q, we divide observations into quartiles according to their sales-to-GDP ratio.[6] By virtue of the dummy interaction terms, we allow aggregate factors to have a different impact on firm growth depending on the sector in which a firm operates, and depending on the firm's size.

To see the intuitive appeal of the dummy interactions, consider the following two examples. First, changes in exchange rates tend to have a different impact on firms in different sectors, depending on the degree to which a sector's firms tend to be export-oriented and/or import-dependent. Second, smaller

[5] The ten GICS sectors are: energy; materials; industrials; consumer discretionary; consumer staples; health care; financials; information technology; utilities; and telecom.

[6] Using the number of employees as the criterion to create firm size quartiles makes a barely noticeable difference for any of the results reported in the paper.

firms typically adjust their output prices less frequently than larger firms do, for instance because of fixed costs associated with information gathering. If smaller firms update prices less frequently, any aggregate shock will have a smaller short-run effect on their prices, and a stronger impact on their output and growth.[7]

In equation (2), c is a constant. The equation reflects the fact that, to avoid perfect collinearity, we drop one dummy each for the year, sector, and size effects, and any interaction terms in which these dummies appear.

$\widetilde{\gamma}_{it}^{HP}$ captures firm-specific effects, which are allowed to vary gradually over time. For every firm i, we construct $\widetilde{\gamma}_{it}^{HP}$ as the Hodrick-Prescott (HP) trend of γ_{it}, with smoothing parameter 500.[8] Note that regression (2) does not yield estimates for the HP trend. Instead, the HP trend is computed separately, and entered as such in the equation.

By allowing for time-variation in the firm effects, we capture the intuition that in Japan, the conditional mean of many firms' earnings and employment growth rates plausibly declined substantially over the period 1986-2005. In the aggregate, real output growth has been substantially lower in the period after the 1990 stock market crash than in the previous decade. The period 1991-2002 in particular can be characterized as a succession of recessions, interrupted only by brief or limited recoveries, with the deepest slump occurring towards the end of the sample, in 1998-2002. Likewise, aggregate employment growth has tended to be lower since the 1990 stock market crash than it was in the previous decade, with the lowest growth rates arising near the end of the sample.[9] If similar declining trends are present in firm-level earnings and employment growth rates, assuming a time-invariant

[7] This argument assumes that growth rates are in real terms. The reported results use nominal sales and EBIT data, which potentially confound quantity and price movements. However, in our case using nominal or real data turns out to be equivalent. The results are virtually unchanged when we deflate sales and EBIT by the Japanese PPI.

[8] The smoothing parameter is five times larger than the parameter which Hodrick and Prescott suggest for use with annual data. Due to the fairly high degree of smoothing, the HP trends do not track the actual growth rates γ_{it} too closely. They should be interpreted as slowly evolving time-varying means.

[9] On average over the period 1981-1990, real GDP grew at an annual rate of 4.0 percent. In the period 1991-2005, average annual real GDP growth was 1.4 percent. From 1998 through 2003, growth in the number of regular employees was negative, although growth in overall employment (which includes part-time and temporary workers in addition to regular employees) was positive at some points during that period, in particular during the 2000/2001 recovery which led to the Bank of Japan's brief interruption of the zero interest rate policy between August 2000 and March 2001.

mean growth rate for every firm would bias the estimated standard deviation of the residuals, $\widehat{\sigma}_{\varepsilon,it}$, upward for observations at the endpoints of the sample. When comparing the estimates from the baseline HP filter model with those from a model assuming time-invariant mean growth rates, both estimated on the sample of 577 firms, we found that the inclusion of the HP trend tends to lower estimated firm-level volatility, in particular at the first and last three years of the sample.

To estimate the baseline model, we create a balanced panel, consisting of all 577 firms for which the sales, employment, and EBIT growth rates have been continuously available over the period 1986-2005. This ensures that the time windows over which the HP trends are computed are not only sufficiently long, but also of equal length for all firms. See section 2.1 above for further discussion on sample selection.

The first-stage regression, equation (2), is related to Kim and Nelson (1999) and McConnell and Perez-Quiros (2000), who model instantaneous aggregate volatility as the variance and standard deviation, respectively, of the error term of an autoregressive process in real GDP growth.

Given that we control for aggregate factors λ_τ in equation (2), the regression residual ε_{it} captures the firm-specific component of the deviation of firm growth from its time-varying mean. The residual is assumed to be normally distributed with mean zero and variance $\sigma^2_{\varepsilon,it}$. In analogy with McConnell and Perez-Quiros (2000), we proxy the standard deviation $\sigma_{\varepsilon,it}$ by $\sqrt{\frac{\pi}{2}}\ |\widehat{\varepsilon}_{it}|$, a term proportional to the absolute value of the first-stage residual. If ε_{it} is normally distributed, this is an unbiased estimator of the standard deviation of ε_{it}.

Our second-stage regression is as follows:

$$\widehat{\sigma}_{\varepsilon,it} \ = \ k \ + \sum_{s=1987}^{2005} f_s \ \tau_s \ + \ \sum_{j=2}^{588} g_j \ \zeta_j \ + \ \nu_{it} \tag{3}$$

Equation (3) entails regressing the idiosyncratic component of firm-level volatility on time and firm effects. The coefficients on the time dummies τ_s capture the cross-sectional average of idiosyncratic firm-level volatility in any year s. The error term ν_{it} is in principle independently and identically distributed with mean zero and variance σ^2_ν.

Plotting the coefficients on the second-stage time dummies τ_s and their standard errors over time yields a visualization of the time-path of average firm-level volatility, controlling for firm fixed effects. In particular, the constant k captures average idiosyncratic volatility in 1986, while we compute average firm-level volatility for any other year s as $k + f_s$.

The firm fixed effects ζ_j implicitly control for time-invariant characteristics such as sector and for pseudo-stable characteristics such as firm size. These unit effects will become important when we use the full Worldscope sample, but do not affect the point estimates in the balanced panel of 577 firms. In that sample, computing the cross-sectional averages of $\widehat{\sigma}_{\varepsilon,it}$ for every year yields the same estimates of firm-level volatility as estimating equation (3). In that case, equation (3) can be seen as a convenient way of obtaining standard errors around the volatility estimates.

3.2 Alternative Model: Firm Fixed Effects

In the baseline model with time-varying mean firm growth rates, we had to restrict the sample to those firms for which data have been continuously available over the period 1986-2005. In the present subsection, we discuss an alternative model which imposes the restriction that the first-stage firm effects are time-invariant, but which therefore allows estimation to be based on the entire sample of 4507 firms. We report the results from this model in section 5.2.

The first-stage regression is now:

$$\gamma_{it} \;=\; c + \sum_{\iota=2}^{4507} a_\iota \mu_\iota \;+\; \sum_{\tau=1987}^{2005} b_\tau \, \lambda_\tau + \sum_{s=2}^{10} \sum_{\tau=1987}^{2005} d_{s\tau} \, \varphi_s \, \lambda_\tau + \sum_{q=2}^{4} \sum_{\tau=1987}^{2005} e_{q\tau} \, \vartheta_q \, \lambda_\tau + \varepsilon_{it} \tag{4}$$

Which differs from equation (2) in that the firm effects a_ι are assumed to be fixed over time. The other variables and coefficients are as defined for equation (2).

In the second-stage regression, equation (3), the inclusion of firm fixed effects implies that, if an intrinsically more volatile firm is added at some point in time, this shows up as a relatively high estimate for this firm's specific effect without necessarily implying an increase in measured average volatility.

4 Results

This section discusses the results from the baseline model with time-varying firm effects. In section 5, we will document that our results are relatively broadly applicable across firm size quartiles and across sectors. In that section, we also show that our main findings are robust to the alternative model specification as laid out in section 3.2.

The upper left diagram of Figure 5 suggests that net sales growth volatility was high during the bubble period in the second half of the 1980s. It declined substantially in 1991, in the aftermath of the stock market crash. Subsequently, volatility remained at its new, lower level through 2005, with the exception of upward peaks in 1995 and 2000, and a low-volatility period in 1996-97. Another way to interpret the graph is that sales growth has followed a trend decline from 1987 through 1997, and has tended to increase through about 2002, after which it has been declining somewhat.

The top row of Table 1 indicates that the average standard deviation of the first-stage residuals was 9.72 in the subsample 1986-1995, while it declined to 7.55 in 1996-2005. This decline of 2.17 points in the standard deviation is statistically significant at the 1 percent level, with an F-statistic of 192.62.

The top right diagram of Figure 5 graphs the time-path of volatility in EBIT growth. From 1986 through 1998, EBIT volatility followed a slight downward trend, barely noticeable on the graph. Subsequently, volatility increased steeply until it reached its peak in 2002. After that, EBIT volatility has been decreasing steeply, although it had not quite reached its 1998 level by the end of our sample. The second row of Table 1 documents that the average standard deviation of the first-stage residual increased from 2.48 in the first half of the sample period to 3.71 in the second half. This increase is statistically significant at the 1 percent level, with an F-statistic of 356.64.

The bottom diagram of Figure 5 suggests that employment growth volatility stayed relatively constant through 1996. Volatility increases steeply in the period 1997-2002. After that, it declines substantially through the end of the sample. Recall from section 2.2 that we omit employment growth observations for 2000 and 2001.

The bottom row of Table 1 documents that employment volatility increased from 5.03 to 6.06 from the first to the second subsample. This increase is again significant at the 1 percent level, with a comparatively 'small' F-statistic of 42.75. Note that in this case, average volatility over the subsample 1996-2005 is computed over eight years only.

In conclusion, we find that employment and EBIT growth volatility displayed relatively similar patterns. Both volatility measures have significantly increased from the first to the second half of the sample. On the other hand, sales growth volatility has tended to decrease. Throughout the sample, the ratio of sales growth volatility to either earnings or employment volatility has declined.

When comparing the volatility patterns across variables, bear in mind that sales and EBIT volatility may be affected by the decline in the volatility of Japanese inflation, while employment volatility is not. In any case, our results are robust to deflating the former two variables by the Japanese PPI.

5 Robustness

5.1 Results by Sector and Firm Size

This subsection reports more disaggregate results obtained by subdividing the balanced panel of continuously available firms into sectors and firm size quartiles. Throughout, we include the HP trend in the first-stage regression as a measure of the conditional mean of every firm's growth rate.

First, we discuss the results by sector. In our database, firms are classified according to the Global Industry Classification Standard (GICS). There are ten two-digit GICS sectors.[10] In practice, many of these sectors comprise a heterogeneous set of firms. For instance, the sector 'industrials' contains not only manufacturers of products such as defense equipment, power-generating equipment and heavy trucks, but also the distributors of these products. That same sector also contains businesses providing commercial services such as printing or human resources services. The sector also includes transportation firms such as airlines and railroad companies.

To make our results more intelligible, we use data on eight-digit GICS subindustries to assign all firms to three broad sectors: manufacturing, services, and 'other sectors'. Beyond service companies in the strict sense, we define our services sector so that it includes wholesalers and retail traders. 'Other' sectors comprise the sectors education, utilities, health, financial services, transport, agriculture, and mining. Out of the 577 sampled firms, we assign

[10] Recall that the ten GICS sectors are: energy; materials; industrials; consumer discretionary; consumer staples; health care; financials; information technology; utilities; and telecom.

381 to the category manufacturing, 123 to the broadly defined services sector, and 73 to the 'other' category.

We estimate volatility for every sector using a variant of equation (2) as well as equation (3), the only difference being that we omit sector dummies and sector interaction terms from the first-stage regression.

Figure 6 reports the volatility patterns, with each column corresponding to a different sector. Table 2 reports tests for statistically significant change in volatility between the first ten years and the last ten years of the sample. Overall, the findings are relatively similar across sectors. At any rate, the findings from section 4 are representative for the manufacturing sector.

Second, we divide the observations into four quartiles for 1986-2005 according to firm size as measured by the sales-to-GDP ratio.[11] The first-stage regression is as in equation (2), except for the fact that we drop the firm size dummies and their interaction terms.

The top row of Figure 7 graphs the results for net sales growth volatility. The left column applies to the quartile of smallest firms, with columns further to the right pertaining to increasingly larger firms.

The volatility patterns are not precisely the same across size quartiles, but are still reasonably comparable to the overall result from section 4. Throughout the sample period, volatility tends to be higher for the first and second quartiles than for observations where firm size is above the median. This is consistent with the stylized fact that smaller firms tend to be more volatile. The first row of Table 3 reveals that for all size quartiles, there was a statistically significant decrease in sales volatility from the first to the second subperiod, at the 1 percent level.

The second rows of Figure 7 and Table 3 suggest that section 4's results for earnings growth volatility hold irrespective of firm size.

The third rows of the same Figure and Table suggest that the overall increase in employment growth volatility has predominantly been driven by smaller firms.

5.2 Alternative Model

As a robustness check, we estimate the model in which firm effects are assumed to be time-invariant in the first- as well as the second-stage regression.

[11] Results are virtually identical when measuring firm size by the number of employees.

As a guide to interpreting the results, remember from section 3.1 that in this model, the volatility estimates are likely to be upward biased, in particular in the first and last few years of the sample. As discussed, we use data for all 4507 firms to estimate the alternative model.

Figure 8 graphs the volatility paths. Table 4 summarizes average volatility levels for the two ten-year periods in our sample, and tests the null hypothesis that volatility did not change between the two subperiods. Notice that, notwithstanding the difference in model specification and the substantial differences in sample composition, the results are comparable to those for the baseline model. (See Figure 5 and Table 1 for comparison.) Average volatility is higher in the full Worldscope sample than in the restricted sample of continuously available firms, which is not surprising since the latter tends to select large, smoothly growing firms from the full sample. The decline in sales growth volatility, as well as the increase in earnings and employment volatility, continue to be significant at the 1 percent level.

6 Comparison to related results for Japan

This section takes a broader perspective: it compares our results to existing results on firm-level Japanese stock market volatility, as well as to results on aggregate output volatility.

First, Hamao, Mei, and Xu (2007) estimate the time-path of the idiosyncratic component of firm-level stock return and stock turnover volatility over the period 1975-1999, for firms listed on the Tokyo Stock Exchange. Our results suggest that idiosyncratic sales growth volatility followed a relatively similar path in Japan as idiosyncratic stock return volatility did.

As in Hamao et al (2007), we find that firm-level volatility tends to be lower after the 1990 stock market crash than before. The major difference is that, unlike idiosyncratic stock return volatility, idiosyncratic sales growth volatility does not display a temporary, sharp increase around the time of the stock market crash, but instead declines substantially in the immediate aftermath of the crash. Another difference is that, while sales volatility did increase around the time of the 1997 and 1998 financial crises, the increase is not nearly as steep, relative to past volatility changes, as the upward jump in idiosyncratic stock volatility. Hamao et al (2007) attribute the high levels of idiosyncratic stock return volatility from 1997 on to an increase in bankruptcies associated with the 1997 and 1998 banking crises. The fact that we detect a smaller increase in sales growth volatility should be seen in light of the fact that our volatility estimates do not account for entry or exit.

Second, Blanchard and Simon (2001) document an increase in the volatility of aggregate real GDP growth in Japan from the mid-1980s through the mid-1990s.[12] We detect a simultaneous decrease in firm-level sales growth volatility. This can be interpreted as a negative comovement between aggregate and idiosyncratic output volatility over that period, not unlike what Hamao et al (2007) find to be true for market and idiosyncratic stock return volatility. However, from the mid-1990s onwards, our three measures of firm-level volatility comove positively with aggregate output volatility.

Papers such as Comin and Philippon (2005) and Comin and Mulani (2006) found that in the United States, there was a negative relation between the trend in the volatility of listed firms' sales growth on the one hand, and the trend in aggregate volatility on the other hand. Based on this finding of a negative trend comovement in the United States, this literature conjectures that there are fundamental economic reasons why it should hold in general.[13]

Given that our sample only comprises twenty years of data, our results hardly allow for a formal test of the above hypothesis. However, the fact that aggregate and firm-level volatility comove positively in the second half of our sample tends not to favor the general applicability of theories implying a negative comovement.

[12] Since firm-level sales are expressed in nominal terms, the corresponding aggregate measure is nominal GDP. At any rate, the rolling twenty-quarter standard deviation of quarterly nominal GDP growth (not reported) displays a very similar pattern as its analogue for real GDP as reported in Blanchard and Simon (2001).

[13] In Philippon's (2003) model, an increase in the degree of competition, reflected in an increase in the elasticity of substitution, magnifies the effect of idiosyncratic taste shocks on any firm's profitability, thus raising firm-level profit volatility. On the other hand, such an increase in the elasticity of substitution increases the loss to firms of deviating from their optimal price, which induces firms to adjust prices more frequently. More frequent price adjustment reduces the short-term impact of aggregate shocks on aggregate output, and therefore implies a decrease in aggregate volatility.

In Comin and Mulani (2005), an increase in the frequency of R&D innovations, which benefit mostly the innovating firm, increases the rate of change in market shares, implying an increase in firm-level volatility. On the other hand, such an increase in market turnover implies a decrease in the value of leading firms. The model assumes that general innovations, such as innovations in personnel practices or inventory management, tend to be undertaken by leading firms. Conditional on that assumption, a decrease in the value of leading firms implies a decrease in the frequency of general innovations. This in turn tends to reduce the correlation of growth rates among sectors, thereby tending to reduce aggregate volatility.

7 Conclusion

This paper has characterized earnings and employment volatility of Japanese firms using a new methodology. Like the predominant method, we compute the deviation of every firm's growth rate from a medium-term average growth rate. However, based on the insight that this does not need to restrict us to computing medium-term average deviations, we develop a method that allows us to estimate a (standard) deviation for every year separately.

We find that sales growth volatility was high during the bubble years of the second half of the 1980s. The period 1991-1997 witnessed a gradual decline in sales growth volatility. During this period, the stock and real estate bubbles had burst, but authorities and financial institutions were reticent to recognize the underlying problem of deteriorating asset quality. As a result, resources continued to be allocated to stagnant, poorly performing firms, which is consistent with our finding that sales volatility declined during that period.

After the financial crises of 1997 and 1998, when several financial institutions failed and Japan's lingering financial system imbalances came to the surface, sales volatility increased somewhat, and profit volatility increased markedly. This increase in volatility coincided with the deepest macroeconomic downturn. As our levels data show (see the upper right diagram of Figure 3), it also coincided with a period in which firms were struggling to remain profitable.

Another interpretation for the increase in firm volatility since the mid-1990s is that it reflects an increase in flexibility of the Japanese economy, which arguably occurred as a response to the crisis. One particular example of this is an increase in labor market flexibility. Morgan (2005) explains that from the mid-1990s on, Japanese firms increasingly hired flexible types of labor, such as part-time and temporary workers. Taken by itself, this development should have enabled firms to adjust their labor stock more flexibly in response to changes in idiosyncratic (and other) conditions, which could explain the observed increase in firm-specific employment volatility.

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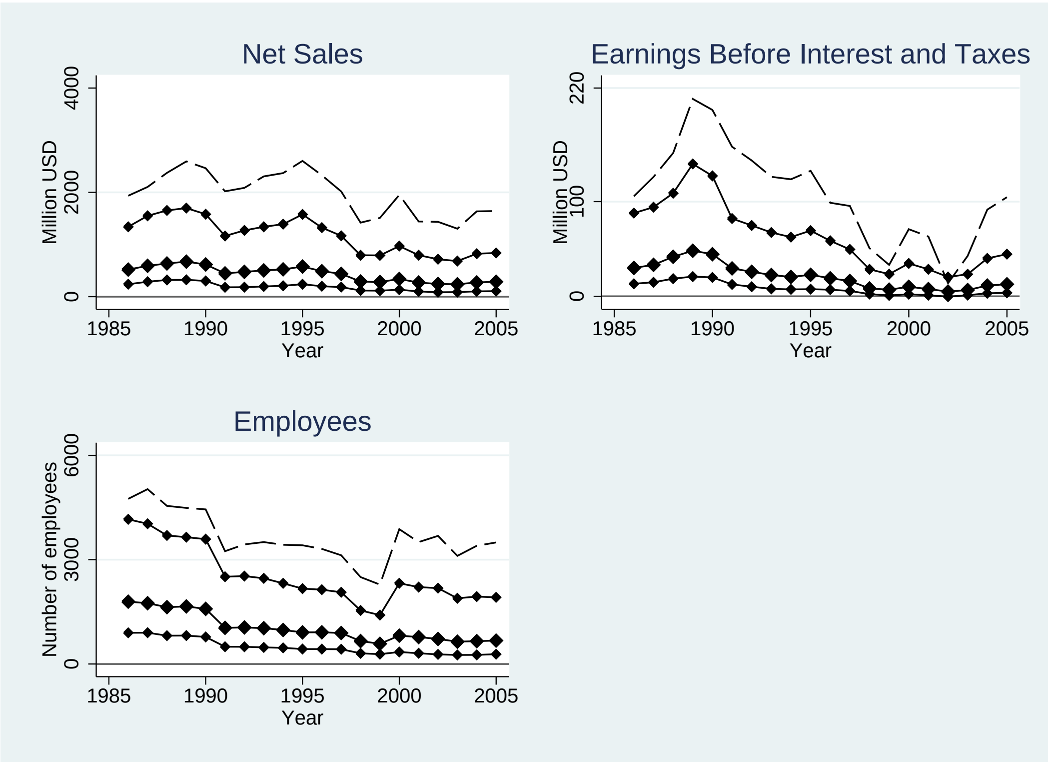
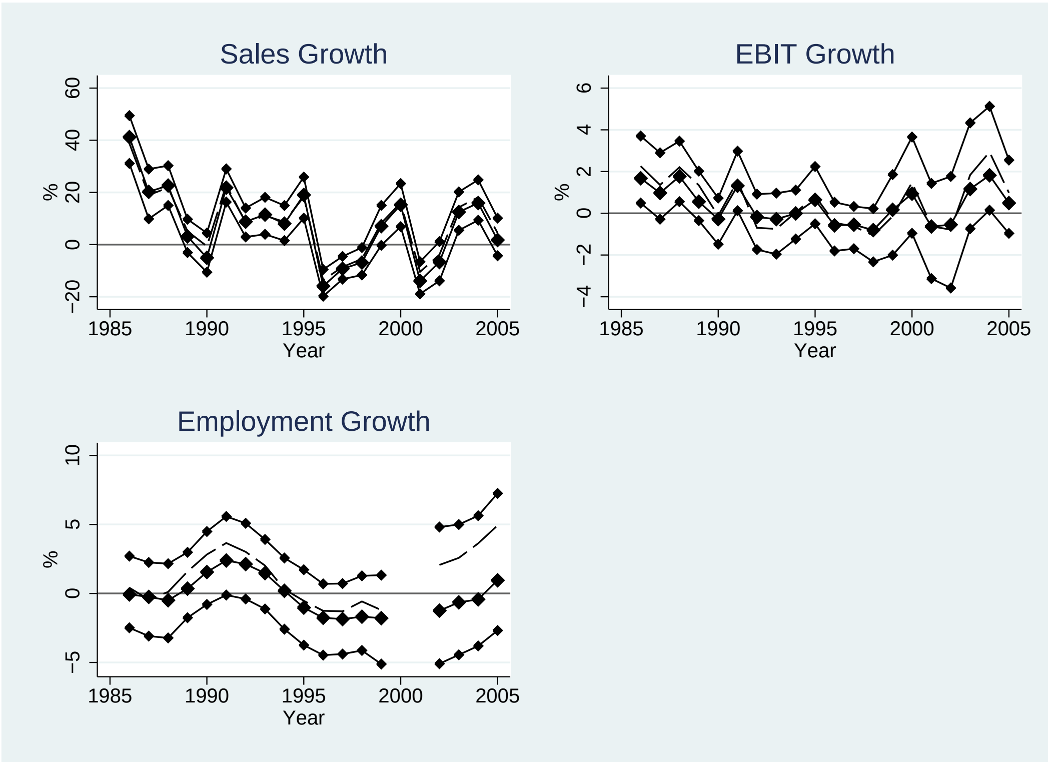
Appendix: Figures and tables

Figure 1
All Firms: Mean and Quartiles of Levels Data



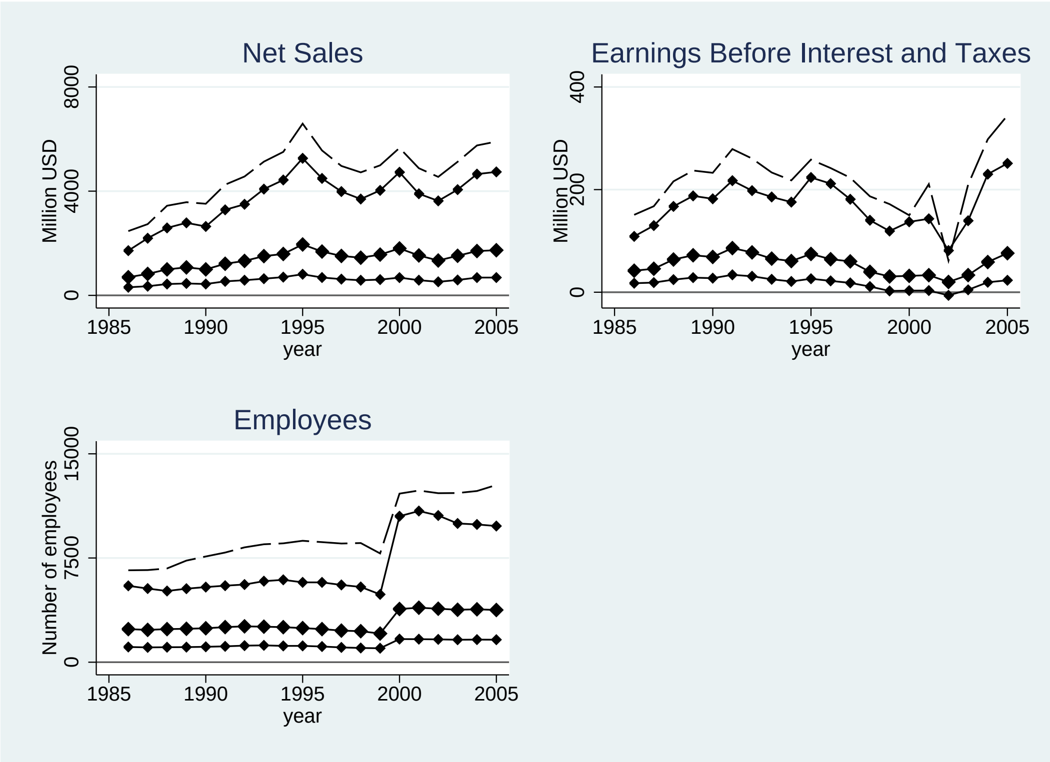
Notes: This figure documents the distribution of net sales, earnings and the number of employees in every year over the period 1986-2005 for all 4507 Japanese firms in the Worldscope database. Large diamonds indicate the median, while small diamonds indicate the 25th and 75th percentiles. The dashed line is the mean. Net sales and Earnings Before Interest and Taxes (EBIT) are in million USD. Employees stands for the number of employees.

Figure 2
All Firms: Mean and Quartiles of Growth Rates



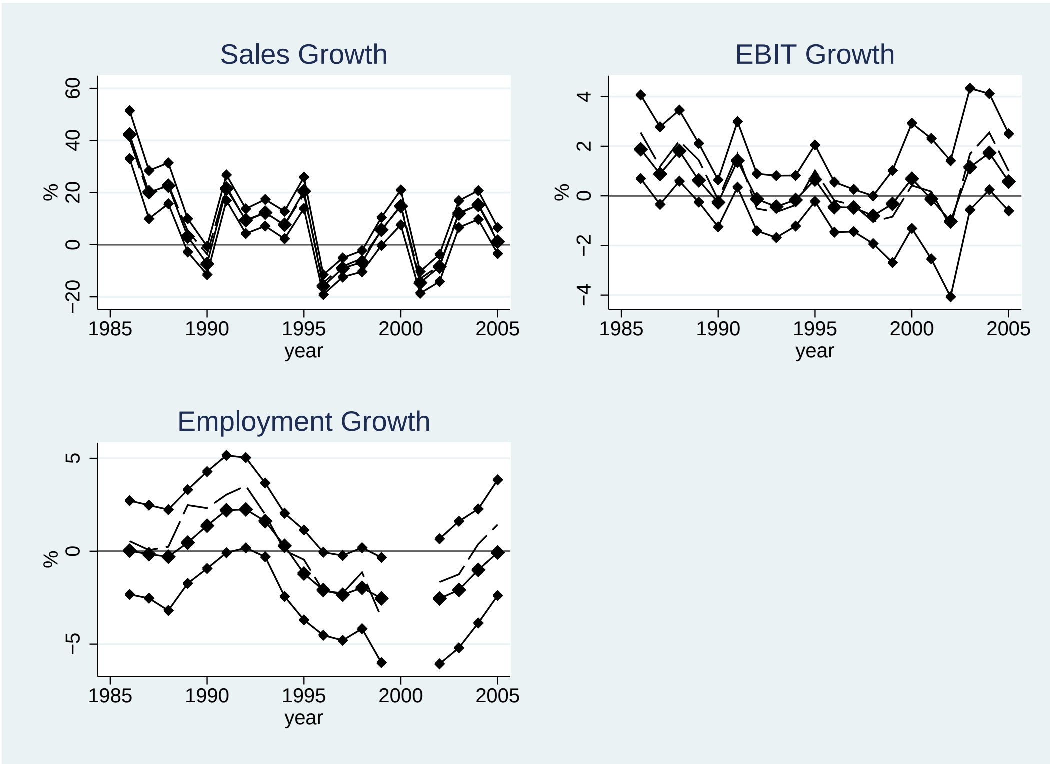
Notes: This figure documents the distribution of the growth rates of net sales, earnings and the number of employees in every year over the period 1986-2005 for all 4507 Japanese firms in the Worldscope database. Large diamonds indicate the median, while small diamonds indicate the 25th and 75th percentiles. All growth rates are in percentage terms.

Figure 3
Balanced Panel: Mean and Quartiles of Levels Data



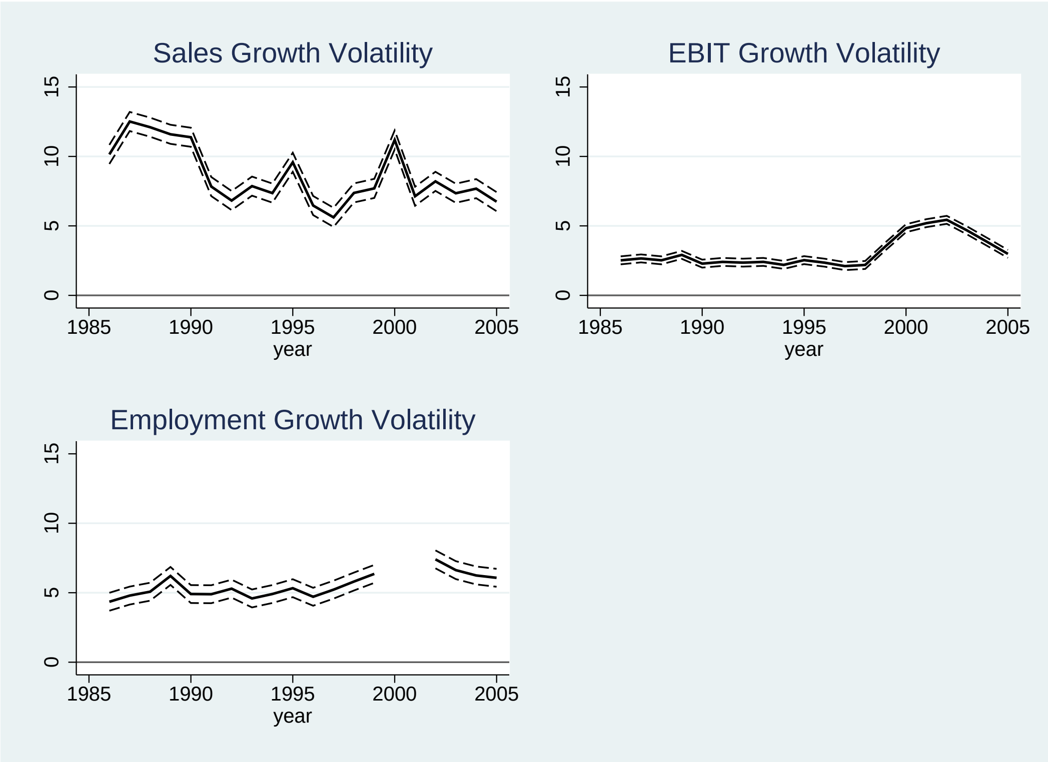
Notes: This figure documents the distribution of net sales, earnings and the number of employees in every year for the 577 Japanese firms in the Worldscope database for which data are continuously available over the period 1986-2005. Other notes are as under Figure 1.

Figure 4
Balanced Panel: Mean and Quartiles of Growth Rates



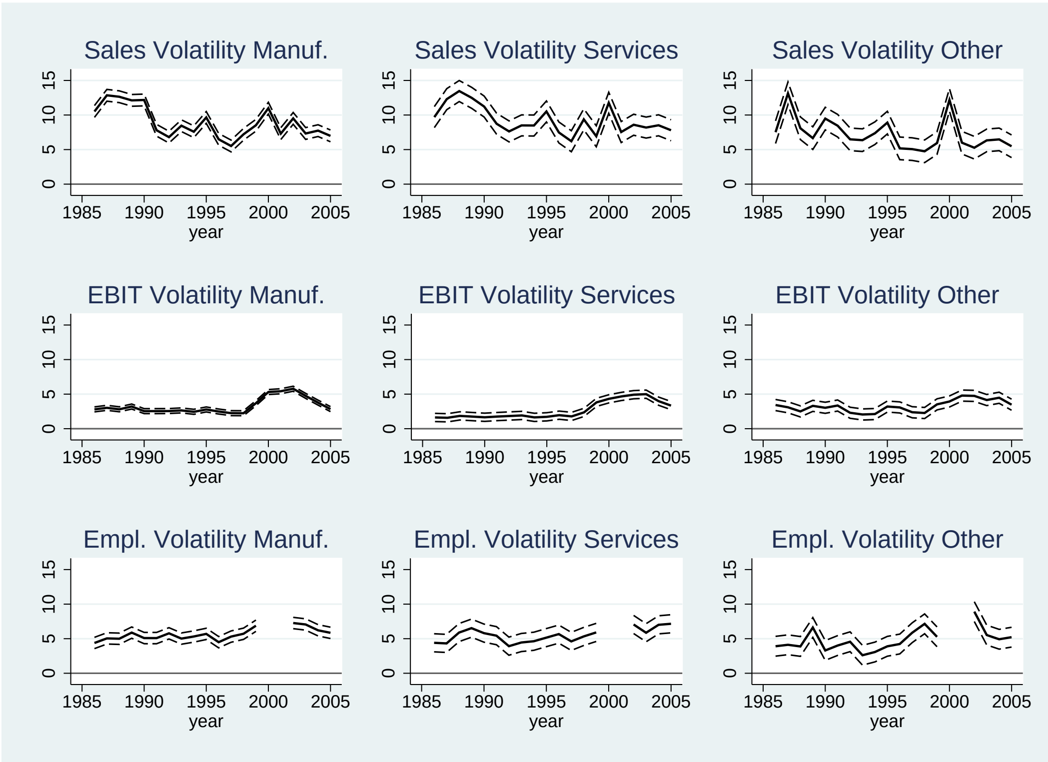
Notes: This figure documents the distribution of the growth rates of net sales, earnings and the number of employees in every year for the 577 Japanese firms in the Worldscope database for which data are continuously available over the period 1986-2005. Other notes are as under Figure 2.

Figure 5
Balanced Panel: Firm-Level Volatility



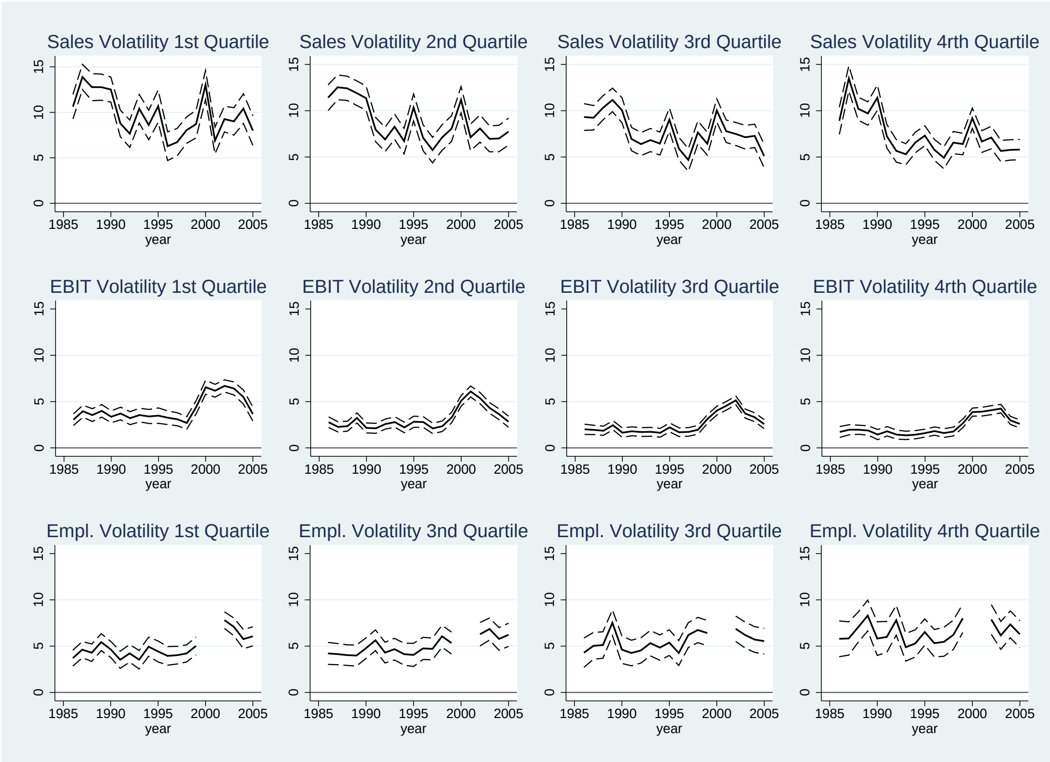
Notes: This figure graphs firm-level sales, earnings, and employment growth volatility for every year for the balanced panel of 577 firms for which data are continuously available over 1986-2005, along with a 95 percent confidence interval. Volatility is estimated from equations (2) and (3). The first-stage equation is exactly as in equation (2), with a HP filter trend to capture time-varying mean growth and with sector and size interaction terms as detailed under equation (2). Figure 5 graphs the estimated time effects in the second-stage equation (3). See Table 1, towards the end of the appendix, for corresponding statistics.

Figure 6
Balanced Panel: Firm-Level Volatility by Sector



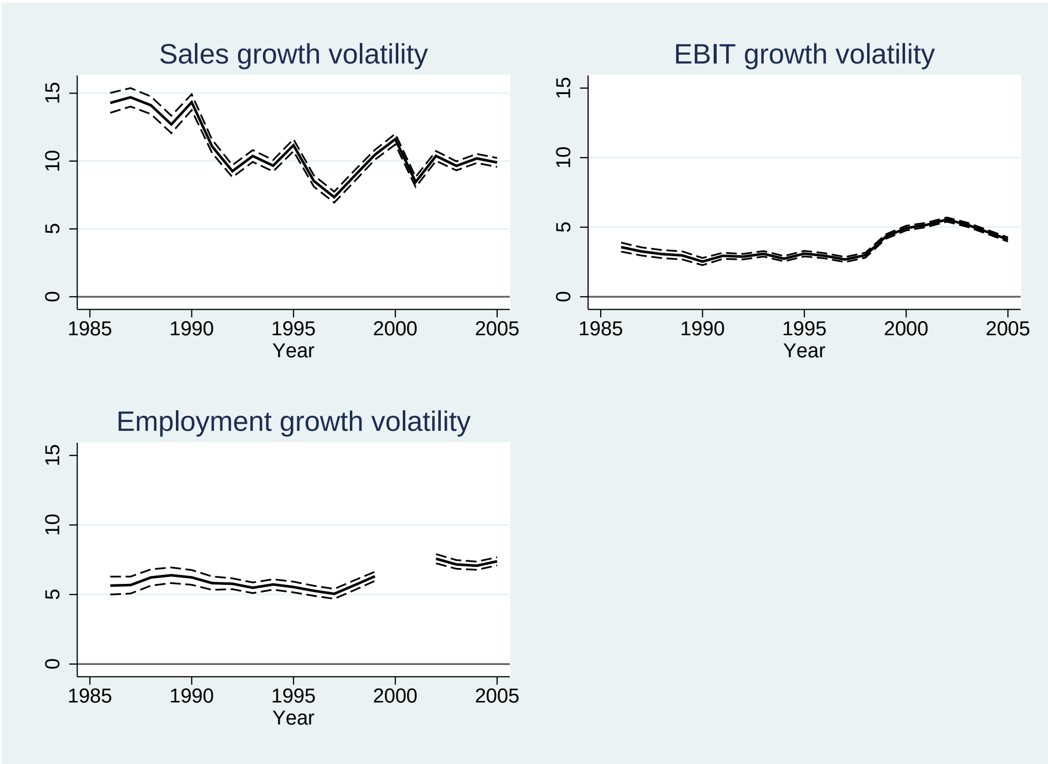
Notes: This figure graphs firm-level sales, earnings, and employment volatility when subdividing the 577 firms in the balanced panel into three broad sectors. The left column pertains to manufacturing firms, the middle column to service providers (including wholesalers and retail traders), and the third to firms in other sectors, containing companies involved in education, utilities, health, financial services, transport, agriculture, and mining. Volatility for every sector is estimated using equations (2) and (3), with the only difference that sector dummies and sector interaction terms were omitted from the first-stage regression. See Table 2 for corresponding statistics.

Figure 7
Balanced Panel: Firm-Level Volatility by Firm Size Quartile



Notes: This figure graphs firm-level sales, earnings, and employment volatility when subdividing observations into size quartiles for 1986-2005 according to the sales-to-GDP ratio. The left column applies to the smallest firms, with columns further to the right pertaining to increasingly larger firms. Volatility for every size quartile is estimated using equations (2) and (3), with the only difference that firm size dummies and size interaction terms were omitted from the first-stage regression. See Table 3 for corresponding statistics.

Figure 8
All Firms: Firm-Level Volatility



Notes: This figure graphs firm-level sales, earnings, and employment growth volatility for all 4507 Japanese firms in Worldscope for 1986-2005, along with a 95 percent confidence interval. Volatility is estimated with firm fixed effects in the first-stage regression, as in equation (4). See Table 4 for corresponding statistics.

Table 1
Balanced Panel: Firm-Level Volatility

	Average volatility 1986-1995	Average volatility 1996-2005	Change in volatility	F-statistic for significant change
Sales growth	9.72	7.55	-2.17***	192.62
	(0.11)	(0.11)	(0.16)	[0.00]
EBIT growth	2.48	3.71	1.23***	356.64
	(0.05)	(0.05)	(0.07)	[0.00]
Employment growth	5.03	6.06	1.02***	42.75
	(0.10)	(0.12)	(0.16)	[0.00]

Notes: This table pertains to Figure 5. Standard errors of F-tests for significance are in round brackets, and p-values are in square brackets. The first column indicates average firm-level volatility over a first subsample (1986-1995), and the second indicates average volatility over the subsample 1996-2005. For employment growth, the average of the second subsample is computed over eight years only, since employment growth observations for 2000 and 2001 were omitted. The third column reports the change in volatility from the first to the second subsample. *** indicates significance at the 1 percent level. The fourth column reports the F-statistic and p-value for the null hypothesis of no change in volatility between the two subsamples.

Table 2
Balanced Panel: Change in Volatility, by Sector

	Manufacturing		Services		Other Sectors	
Sales growth volatility	-2.30***	140.26	-2.06 ***	35.54	-1.98 ***	28.06
	(0.19)	[0.00]	(0.35)	[0.00]	(0.37)	[0.00]
EBIT growth volatility	1.12***	184.29	1.88***	193.19	0.84***	21.20
	(0.08)	[0.00]	(0.14)	[0.00]	(0.18)	[0.00]
Employment growth volatility	0.87***	19.29	1.02***	10.39	1.89***	29.74
	(0.20)	[0.00]	(0.32)	[0.00]	(0.35)	[0.00]

Notes: This table pertains to Figure 6. It indicates the change in average volatility from 1986-1995 to 1996-2005 for every sector, along with the F-statistic for the null hypothesis of no change in volatility. Standard errors are in round brackets, and p-values in square brackets. *** indicates significance at the 1 percent level.

Table 3
Balanced Panel: Change in Volatility, by Size Quartile

	First Quartile (smallest firms)		Second Quartile		Third Quartile		Fourth Quartile (largest firms)	
Sales growth Volatility	-2.24*** (0.36)	39.41 [0.00]	-2.37*** (0.34)	49.85 [0.00]	-1.63*** (0.31)	27.95 [0.00]	-2.19*** (0.28)	61.46 [0.00]
EBIT growth Volatility	1.32*** (0.17)	62.71 [0.00]	1.25*** (0.14)	82.44 [0.00]	1.28*** (0.12)	119.18 [0.00]	1.29*** (0.11)	134.95 [0.00]
Employment growth volat.	1.15*** (0.24)	23.27 [0.00]	1.35*** (0.30)	20.00 [0.00]	0.90** (0.36)	6.36 [0.012]	0.26 (0.39)	0.44 [0.51]

Notes: This table pertains to Figure 7. It indicates the change in average volatility from 1986-1995 to 1996-2005 for every size quartile according to the sales-to-GDP ratio, along with the F-statistic for the null hypothesis of no change in volatility. Standard errors are in round brackets, and p-values in square brackets. *** indicates significance at the 1 percent level, and ** to significance at the 5 percent level.

Table 4
All Firms: Firm-Level Volatility

	Average volatility 1986-1995	Average volatility 1996-2005	Change in volatility	F-statistic for significant change
Sales Growth Volatility	12.17 (0.10)	9.55 (0.06)	-2.62*** (0.12)	492.43 [0.00]
EBIT Growth Volatility	3.01 (0.04)	4.25 (0.03)	1.24*** (0.05)	551.99 [0.00]
Employment Growth Volat.	5.85 (0.09)	6.44 (0.06)	0.59*** (0.11)	28.30 [0.00]

Notes: This table pertains to Figure 8. Standard errors are in round brackets, and p-values in square brackets. Other notes are as under Table 1.