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When Did Firms Become More Different? Time-Varying Firm-Specific Volatility in Japan

Emmanuel de Veirman and Andrew Levin *

* Views expressed are those of the authors and do not necessarily reflect official positions of De Nederlandsche Bank.

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De Nederlandsche Bank NV
P.O. Box 98
1000 AB AMSTERDAM
The Netherlands

When Did Firms Become More Different?*

Time-Varying Firm-Specific Volatility in Japan

Emmanuel De Veirman and Andrew T. Levin[†]

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Abstract

We document how firm-specific volatility in sales, earnings and employment growth evolved year by year in Japan. Our volatility measure also indicates the evolution of firm turnover. We find that patterns in firm-specific volatility have changed when macroeconomic circumstances have. Firm turnover declined during the economic stagnation of 1991-1997. The deep downturn of fiscal years 1998-2002 coincided with a substantial increase in turnover in market, profit and employment shares. Firm volatility tended to decline during the recovery after 2002. We assess whether the rise in firm turnover and deep downturn in 1998-2002 indicate that after a period of stagnation, weak firms were finally allowed to shrink or fail. Our evidence suggests that the widening in the firm growth distribution at that time did not reflect weak firms shrinking relative to healthy firms, indicating that the two recessions in 1998-2002 were not “cleansing”.

JEL codes: C33, D22, E32, E44

Keywords: Firm volatility, firm health, zombie lending, cleansing recessions

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[†]Corresponding author: Emmanuel De Veirman, De Nederlandsche Bank, P.O. Box 98, 1000 AB Amsterdam, the Netherlands. Manu.Veirman@dnb.nl. Andrew T. Levin, Board of Governors of the Federal Reserve System, 20th Street and Constitution Avenue NW, Washington DC 20551, United States. Andrew.Levin@frb.gov. Andrew Levin is currently on detachment to the International Monetary Fund.

1 Introduction

This paper documents how the firm-specific component of volatility in sales, earnings and employment growth evolved over time in Japan. To our knowledge, our paper is the first that estimates changes in firm-level volatility in non-financial variables for Japan.¹

We estimate firm volatility using the measure of De Veirman and Levin (2011). This particular measure of firm volatility indicates the width of the firm growth distribution in any year, and in so doing reveals how the degree of turnover in firms' market, profit and employment shares evolved year by year.²

In Japan in particular, changes in the extent of firm turnover have potentially enormous macroeconomic implications. After the stock market crash of 1990, Japan entered a period of economic stagnation, followed by a deep downturn in 1998-2002, which ended with an export-led recovery in 2002.³ One plausible factor behind the long macroeconomic stagnation is the fact that unhealthy firms were often shielded from market forces in a variety of ways including continued bank lending to intrinsically insolvent firms ("zombie lending") and mutual protection among member firms within the same business group (keiretsu). By dampening the shrinking and reducing the failure rate of weak firms, such practices would also have hampered growth and entry of healthier firms, thereby reducing firm turnover and plausibly reducing aggregate productivity.⁴

¹Hamao, Mei, and Xu (2007) estimate changes in firm-specific volatility in Japanese stock returns.

²De Veirman and Levin (2011) focus on US firms. The remainder of the literature on US firm volatility, consisting of Comin and Philippon (2005), Comin and Mulani (2006), and Davis, Haltiwanger, Jarmin, and Miranda (2006), focuses on ten-year rolling standard deviations. This measure does not capture the width of the firm growth distribution. It indicates firm volatility in terms of rolling averages rather than for any specific year.

³See De Veirman (2009) for a description of aggregate output developments in Japan as well as the implications for inflation.

⁴See the theoretical section of Caballero, Hoshi, and Kashyap (2008) for a model in which the presence of less productive firms that receive subsidized bank lending dampens destruction and creation after a shock, and therefore reduces aggregate productivity. Other papers documenting zombie lending in Japan, as well as the influence of main bank and corporate group affiliations, include Smith (2003), Miyauchi (2003), Sekine, Kobayashi, and Saita (2003), Peek and Rosengren (2005), Ahearne and Shinada (2005), and Watanabe (2010). See also Peek (2004).

Against this background, this paper assesses whether firm turnover actually increased at any point of time, and if so, whether any such increase reflected weak firms shrinking relative to other firms. To the extent that weak firms were less productive, such a development would tend to raise aggregate productivity, and in so doing would lay the foundation for a sustainable domestically-led recovery.

We find that patterns in firm-specific volatility have changed when macroeconomic circumstances have. Firm turnover declined during the economic stagnation of 1991-1997. The deep economic slump of fiscal years 1998-2002 coincided with a substantial increase in turnover in market, profit and employment shares. During the post-2002 recovery, firm volatility tended to decline.

Both declining firm turnover and economic stagnation in 1991-1997 are consistent with the hypothesis that weak firms were protected during that time. At any rate, Hamao, Mei, and Xu (2007), whose finding of declining firm volatility in Japanese stock returns after 1990 mirrors our finding of declining volatility during the same time, interpret their finding as reflecting the protective effect of the main bank system and keiretsu on weak firms in Japan.

The fact that the Japanese economy entered a severe downturn from 1998 onwards raises the possibility that weak firms were finally allowed to shrink or fail at that time. We do find that firm turnover rises at the same time, which is equally consistent with the possibility that weak firms were less protected from that point on.

We provide two types of evidence to evaluate the hypothesis that rising volatility in 1998-2002 reflects a decline in the protection of weak firms. First, we assess whether in that timeframe, firm volatility increased the most in sectors where the prevalence of zombie lending declined the most. We do so by comparing our results on changes in firm volatility by sector to evidence by

Caballero, Hoshi, and Kashyap (2008) on changes in the fraction of zombie firms by sector.

That evidence is mixed, in the sense that the hypothesized negative relation between changes in firm volatility and changes in the fraction of zombie firms holds for some sector comparisons but not for others.

Second, we assess whether firms with a history of low profit growth or increasing leverage were worse affected than healthier firms by the two recessions in business years 1998-2002,⁵ and whether any resulting gap in growth rates according to health status can explain the rise in firm volatility during that time.

We find that weak firms do not systematically grow less than other firms from fiscal year 1998 onwards. In years where previously unhealthy firms did grow less, the growth differential between unhealthy and healthy firms mostly accounts for a trivial part of firm volatility. Therefore, our finding that firm volatility increased in 1998-2002 does not reflect shrinking of weak firms.

We conclude that the two recessions within the timeframe of business years 1998-2002 cannot be understood as “cleansing” recessions that would imply a shift towards more productive firms and therefore lay the foundation for a vigorous domestically-led recovery.

Finally, we also find that firms that reduced leverage the most in 1991-1997 did not systematically gain market, profit or employment shares during the post-2002 recovery. This suggests that in our sample of firms, debt restructuring did not make firms more likely to benefit from the recovery.⁶

Our paper is structured as follows. Section 2 characterizes the data and discusses sample

⁵Since most Japanese firms operate on business years ending in March, for most firms business years 1998-2002 correspond to the period April 1997-March 2002. This period contains two recessions as indicated by the Economic and Social Research Institute (ESRI) recession dates: May 1997-January 1999 and November 2000-January 2002.

⁶Fukuda and Nakamura (2011) find that zombie firms were more likely to recover along with the macroeconomic recovery, the more they had sold fixed assets and downsized employment. They consider a wide range of differences in restructuring among zombie firms, while we assess the effect of differences in debt restructuring in particular for a sample intended to represent all firms.

selection and data treatment. Section 3 details our approach for estimating firm-specific volatility in firm growth rates. Section 4 presents our volatility estimates. Section 5 evaluates what our findings say about changes in the degree of protection of weak firms. Section 6 concludes.

2 Data and Measurement

In this section, we characterize our data on sales, earnings and employment of Japanese firms. The first subsection discusses levels data and sample composition. The second subsection discusses growth data and data treatment. In subsequent sections, we will characterize volatility in these firm-level growth rates.

2.1 Sample Selection

Using annual data from the Thomson Worldscope database, we compute firm-level growth rates in nominal net sales, nominal Earnings Before Interest and Taxes (EBIT), and the number of employees for the period 1986-2005.⁷

We downloaded data for all 4,507 Japanese firms in Worldscope. These firms constitute our “full sample” or “unbalanced panel”. All of these firms are incorporated in Japan and have their primary listing on one of the Japanese stock exchanges.

We also construct a “balanced panel” containing the subsample of 577 firms for which we can compute all three growth rates (sales, earnings and employment) for each of the twenty years in the sample. This is an effort to control for changes in sample composition.

Controlling for changes in sample composition is important because Worldscope has expanded

⁷The estimated volatility paths are virtually unchanged when we deflate sales and EBIT by the aggregate Producer Price Index (PPI). Net sales equals gross sales minus cash discounts, trade discounts, and returned sales and allowances for which credit is given to the customer. EBIT is sales and other income minus operating expenses, without subtracting net expenditure on interest and taxes. The number of employees accounts for full-time and part-time employees, but excludes seasonal and emergency employees.

its coverage of listed firms over time.⁸ Therefore, when a new firm appears in the database, this does not necessarily reflect a new listing. On the other hand, firms in the sample tend to stay as long as they continue to exist as listed companies. By expanding its coverage of listed firms, Worldscope has implicitly relaxed the criteria for inclusion in the database. In particular, smaller firms tend to have been included at a later date than larger firms. This change in sample composition matters for our purposes because of the stylized fact that smaller firms tend to be more volatile.

Figure 1 illustrates that this gradual inclusion of small firms implies a trend decline in the level of net sales, operational profit and the number of employees in the unbalanced panel. In Figures 1 through 3, large diamonds indicate the median in a given year, small diamonds indicate the 25th and 75th percentiles, and the dashed line indicates the mean. In the levels data, the mean substantially exceeds the 75th percentile, suggesting skewness in the distribution of firms.

While the balanced panel aims to control for changes in sample composition, it comes with its own disadvantages. To see this, note that the balanced panel contains a disproportionate fraction of large firms, which tend to be less volatile. The fact that the balanced panel only includes firms that have never ceased to exist also means that, for firms of any given size, it tends to focus on stable firms with comparatively few observations with high volatility.

Furthermore, note that even if the balanced panel considers the same firms at any point of time, it does not quite hold sample composition constant in terms of firm size. The firms in the balanced panel tend to grow at a faster rate than aggregate output, implying that firm size gradually increases relative to the size of the economy. In that respect, we are close to having the

⁸The number of Japanese firms for which data on all three growth rates (sales, EBIT and employment) are available in Worldscope increases steeply from 765 in 1986 to 2,064 in 1992, at an average annual growth rate of 18.81 percent, which far exceeds the actual growth rate in the number of firms listed in Japan. After 1992, the number of firms in the unbalanced panel increases at a more moderate pace to 3,652 in 2005, with an average annual growth rate of 4.78 percent.

opposite issue as in the unbalanced panel. At any rate, Figure 2 does not indicate a generalized trend decline in firm size in the balanced panel, although profitability declined through the 1990s.

Because of these disadvantages of the balanced panel, we investigate robustness on two counts. First, we divide the balanced panel into quartiles according to firm size, defined by the sales-to-GDP ratio. In that case, all observations in a subsample are within well-defined firm size bands, which is a way of holding firm size reasonably constant. To our knowledge, this is a new way of controlling for changes in sample composition in the literature on firm-level sales and employment volatility.

Second, we estimate volatility in the unbalanced panel. In that exercise, we control for firm fixed effects. By doing so, we aim to prevent the gradual inclusion of intrinsically more volatile firms from affecting our estimate of average firm volatility. This is similar to Comin and Philippon's (2005) and Comin and Mulani's (2006) controlling for firm size and age in their paper on firm-level volatility in the United States. For every company in the unbalanced panel, we include all available observations, whether or not the company still exists at the end of the sample.

As will become apparent when we discuss results in Section 4, most of our conclusions hold for the balanced panel, the unbalanced panel, and apply across firm size quartiles. This level of robustness suggests that our conclusions are not driven by changes in sample composition.

2.2 Measurement

Having discussed levels data, we now turn to growth rates. We compute annual growth rates in net sales and employment.⁹ For Earnings Before Interest and Taxes (EBIT), we cannot compute the growth rate for any year t in the usual fashion, since doing so would yield meaningless results

⁹We compute sales growth after dropping the three observations for which net sales is strictly negative. We compute sales growth of firm i in year t as $\gamma_{it} = \frac{SALES_{i,t} - SALES_{i,t-1}}{SALES_{i,t-1}} * 100$, and analogously for employment growth.

when EBIT is negative in t and/or $t - 1$. Therefore, we compute earnings growth based on the change in EBIT divided by lagged net sales:

$$\gamma_{it} = \frac{EBIT_{i,t} - EBIT_{i,t-1}}{SALES_{i,t-1}} * 100 \quad (1)$$

Note that we assign an observation to year t when it reflects a business year ending in that year. For example, a business year beginning in February of year $t - 1$ and ending in March of year t is assigned to year t . This is a relevant example because most Japanese firms operate on business years ending in March.

In Section 2.1, we mentioned that new appearances in the sample do not necessarily reflect actual entries. For that reason, we do not account for firm entry or exit, in the sense that we require two consecutive observations on sales, EBIT, or employment in order to compute a growth rate.

Even in the unbalanced panel, we only include observations for which data are available on all three growth rates. This ensures that the sample is the same for each of the three growth rates.

We winsorize 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 unbalanced panel. We replace any (negative) growth rate which falls below the 2.5th percentile by the value of the growth 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. We do not apply additional winsorizing to the balanced panel.

Figure 3 graphs the distribution of the sales, EBIT, and employment growth data that we use for estimation in the balanced panel. The corresponding graph for the unbalanced panel (unreported) is very similar. 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 from fiscal year 2003 onwards.

In our baseline estimations, as well as in Figure 3, we omit employment growth data for 2000 and 2001. This has to do with the large upward jump in the measured level of employment in 2000 that is apparent in Figure 2, and is also present in Figure 1. This level shift plausibly reflects the fact that for business years ending on March 31, 2000 or later, Japanese companies implemented a change in accounting rules which implied a broadening of the definition of subsidiaries that parent companies are required to include in their consolidated accounts.¹⁰ Before the rules change, parent companies had often assigned their excess employment (and excess debt) to such affiliate companies, plausibly to appear more productive and in better financial health.

The large upward jumps in the level of employment reflect massive firm-level employment growth rates in 2000 and high mean employment growth in 2001. If the accounting change affected recorded employment in 2000, it is likely that it would have had some effect in 2001 as well: firms with business years ending in January or February only implemented the rules change from business years ending in January or February 2001 onwards. This is why we omit employment growth for 2001 as well as 2000.

In Section 4.3, we provide evidence indicating that the accounting change did not have a major effect on firm-specific sales and earnings growth volatility in 2000 and 2001. Therefore, we do not omit sales and earnings growth rates for those years.

¹⁰We thank Fumio Ohtake for pointing us to this change in accounting standards.

3 Estimation

In this section, we describe our procedure for estimating firm volatility. By implementing the approach that De Veirman and Levin (2011) apply to US firms, we estimate firm-specific volatility in sales, earnings and employment growth for every individual year.

In the first subsection, we discuss the regression we use to estimate the firm-specific component of variation in firm-level growth rates. In the second subsection, we discuss the construction, properties and interpretation of our estimator for average firm-specific volatility.

3.1 Growth Rate Regression

In the balanced panel and its subdivisions, our volatility measure is based on the residual of the following regression:¹¹

$$\gamma_{it} = c + \tilde{\gamma}_{it}^{HP} + b_t + e_q + d_s + be_{tq} + bd_{ts} + \varepsilon_{it} \quad (2)$$

Where γ_{it} represents net sales growth, EBIT growth, or employment growth from year $t - 1$ to t for firm i . The constant is c . $\tilde{\gamma}_{it}^{HP}$ captures firm i 's time-varying mean growth rate at time t . For every firm i , we construct $\tilde{\gamma}_{it}^{HP}$ as the Hodrick-Prescott (HP) trend of γ_{it} , with smoothing parameter 500.¹² Note that regression (2) does not yield estimates for the HP trends. Instead, we compute the HP trends in a first step and enter them as such in equation (2).

Due to the presence of the time-varying mean growth rate $\tilde{\gamma}_{it}^{HP}$, the residual ε_{it} depends on the deviation of a firm's growth rate from its time-varying mean growth rate. We assume that the residual ε_{it} is normally distributed with mean zero and standard deviation $\sigma_{\varepsilon, it}$. In the next

¹¹We do not weigh observations by firm size. Section 4.2 shows that most of our conclusions apply for every firm size category. This suggests that assigning more weight to larger firms would not alter these conclusions.

¹²The smoothing parameter is five times larger than the value which is typically used with annual data. Due to the relatively high degree of smoothing, the HP trends do not track the actual growth rates γ_{it} too closely, and can be interpreted as slowly evolving time-varying means.

subsection, we will discuss our estimator $\hat{\sigma}_{\varepsilon,it}$ for the standard deviation of the residuals ε_{it} .

Equation (2) also controls for time fixed effects b_t , firm size effects e_q , sector effects d_s , as well as time-size interactions be_{tq} and time-sector interactions bd_{ts} . The time fixed effects capture economy-wide developments in sales, earnings and employment growth. The size and sector effects in combination with the interaction terms capture sector-wide developments as well as changes in growth rates that are common to firms of a similar size. The specification of equation (2) implies that the residuals are cleaned from aggregate, sector- and size-specific developments. The significance of this will become clear in Subsection 3.2. At this stage, note that because we include time-sector interactions in equation (2), any growth differentials across sectors do not affect the residuals nor our measure of firm-specific volatility.

To construct the firm size effects e_q , we divide all observations in the balanced panel into quartiles according to the sales-to-GDP ratio. e_q is a set of four dummy variables, one for every firm size quartile. We will also use these quartiles when we consider volatility patterns for every firm size category separately in Section 4.2. All of the results in this paper are virtually unchanged when we construct size quartiles based on the number of employees.

To construct sector dummies d_s , we classify firms in five sectors which are meant to match those of Caballero, Hoshi, and Kashyap (2008). The five sectors we use are: manufacturing; wholesale and retail trade; construction; services; and other sectors.¹³ The “other” sector includes firms in activities such as education, financials, real estate, utilities, health, transport, agriculture, and mining.

We use heteroskedasticity-robust standard errors throughout this paper. As the results in Section 4 reveal, the typical standard deviation of ε_{it} changes substantially over time, which

¹³We used disaggregate data on eight-digit sub-industries according to the Global Industry Classification Standard to assign each firm to one of our five sectors.

indicates that accounting for heteroskedasticity is important.

In the unbalanced panel, firms differ in terms of the span of available data, such that we cannot estimate a time-varying mean in a way that is consistent across firms. Therefore, in the unbalanced panel we instead estimate a time-invariant mean growth rate for every firm. We do so by estimating firm fixed effects a_i instead of including HP trends $\tilde{\gamma}_{it}^{HP}$:

$$\gamma_{it} = c + a_i + b_t + e_q + be_{tq} + bd_{ts} + \varepsilon_{it} \quad (3)$$

Once we include the firm fixed effect, any sector fixed effect would not capture any independent variation, and therefore would be perfectly collinear with a_i . Therefore, we omit sector effects from the regression, while keeping the corresponding interaction term bd_{ts} . We construct the size quartile effect e_q and the interaction terms in equation (3) in the same way as we described for equation (2). For the purposes of equation (3), we use sales-to-GDP quartiles specifically computed for the unbalanced panel.

For sales, earnings as well as for employment growth, Hausman tests reject the null hypothesis that in equation (3), the firm fixed effect is uncorrelated with the regressors at the 1 percent level. The random effects estimator is inconsistent under the alternative. This motivates the fact that we report results with the fixed effects estimator.¹⁴

3.2 Estimator for Firm-Specific Volatility

Because equations (2) and (3) control for time, sector and size effects, the residuals only capture firm-specific variation. In particular, they capture deviations of a firm's growth rate from its

¹⁴ As a robustness check, we also performed Hausman tests for regressions like equation (3) but which omit one or several regressors. One specification omits size effects and their interactions; a second specification omits time-sector interactions; and the third specification omits all these, such that it only has firm and year effects. In all cases, the Hausman test rejects the null hypothesis that the fixed effect is uncorrelated with the regressors at the 1 percent level.

average growth rate for reasons other than economy-wide or sectoral developments or events shared with other firms that are similar in size. In this subsection, we use these residuals to construct our estimator of firm-specific volatility.

For either equation (2) or (3), we estimate the standard deviation of the residual by a term proportional to the absolute value of the estimated residual $\widehat{\varepsilon}_{it}$:

$$\widehat{\sigma}_{\varepsilon,it} = \sqrt{\frac{\pi}{2}} |\widehat{\varepsilon}_{it}| \quad (4)$$

Therefore, we estimate every firm i 's volatility at any point of time t from a single observation.¹⁵

Next, we translate the estimates for $\widehat{\sigma}_{\varepsilon,it}$ into a single measure for every year t . In the balanced panel, we do so by regressing:

$$\widehat{\sigma}_{\varepsilon,it} = k + \delta_t + \nu_{it} \quad (5)$$

Equation (5) entails regressing firm-specific volatility on a constant k and time fixed effects δ_t . We assume that the error term ν_{it} has a normal distribution with mean zero and variance σ_ν^2 , and is independently and identically distributed.

The time fixed effect δ_t yields the estimated cross-sectional average of firm-specific volatility $(1/N) \sum_{i=1}^N \widehat{\sigma}_{\varepsilon,it}$ in year t . In Section 4, we characterize the evolution of firm-level volatility by plotting the time effects from equation (5) with respect to time.¹⁶

In the unbalanced panel, we instead regress:

¹⁵Kim and Nelson (1999) and McConnell and Perez-Quiros (2000) similarly estimate the variance and standard deviation, respectively, of aggregate output growth from a single observation. Our formula is the firm-level equivalent of McConnell and Perez-Quiros's (2000) formula for the volatility of aggregate output growth.

¹⁶To avoid perfect collinearity, we omit the time dummy for 1986. Correspondingly, k indicates average firm-specific volatility in 1986, while $k + \delta_t$ indicates volatility for any other year t .

$$\widehat{\sigma}_{\varepsilon,it} = k + \delta_t + \zeta_i + \nu_{it} \quad (6)$$

The inclusion of firm fixed effects ζ_i implies that, if an intrinsically more volatile firm enters the sample at some point of time, this shows up as a relatively high estimate for that firm's specific effect without necessarily implying an increase in measured average volatility.

We now discuss the bias and convergence properties of our estimator $(1/N) \sum_{i=1}^N \widehat{\sigma}_{\varepsilon,it}$ for the cross-sectional average of firm-specific volatility.

In the appendix, we show that, if the true error term ε_{it} is normally distributed with mean 0 and population variance $\sigma_{\varepsilon,it}^2$, i.e. $\varepsilon_{it} \sim N(0, \sigma_{\varepsilon,it}^2)$, equation (4) implies that $E(\widehat{\sigma}_{\varepsilon,it}) = \sigma_{\varepsilon,it}$. In the same appendix, we show that this implies that $(1/N) \sum_{i=1}^N \widehat{\sigma}_{\varepsilon,it}$ is an unbiased estimator of the true average standard deviation $(1/N) \sum_{i=1}^N \sigma_{\varepsilon,it}$, i.e.:

$$E \left[\frac{1}{N} \sum_{i=1}^N \widehat{\sigma}_{\varepsilon,it} \right] = \frac{1}{N} \sum_{i=1}^N \sigma_{\varepsilon,it} \quad (7)$$

We now turn to the speed of convergence. In particular, we assess whether the estimator $(1/N) \sum_{i=1}^N \widehat{\sigma}_{\varepsilon,it}$ converges to the truth quickly enough as N increases for us to be able to draw inference from our estimates given the empirical sample sizes we work with. For this purpose, we perform the following Monte Carlo procedure.

For different values of N , we simulate a population of N firms at time t , with any firm i 's idiosyncratic shocks distributed $N(0, \sigma_{\varepsilon,it}^2)$. For every firm, we draw true volatility $\sigma_{\varepsilon,it}$ from a uniform distribution $U(0, 20)$, such that the true average standard deviation $(1/N) \sum_{i=1}^N \sigma_{\varepsilon,it} = 10$. This yields a simulated population of firms ranging from very stable to very volatile.¹⁷

¹⁷The Monte Carlo results are conditional on our assumption that the cross-sectional distribution of true standard errors is uniform. On the other hand, conditional on using a uniform distribution, the choice of 20 as the upper bound of the support is without loss of generality.

For every firm, we draw a single observation for ε_{it} , and compute that firm's estimated standard deviation $\hat{\sigma}_{\varepsilon,it} = \sqrt{\pi/2} |\varepsilon_{it}|$ as in equation (4). From the individual firms' estimated standard deviations, we compute the estimator $(1/N) \sum_{i=1}^N \hat{\sigma}_{\varepsilon,it}$. This estimator depends on the particular draws of the ε_{it} 's. To evaluate the probability that the estimator is close to the truth, we repeat the drawing of the ε_{it} 's and the estimation of $(1/N) \sum_{i=1}^N \hat{\sigma}_{\varepsilon,it}$ one million times, and capture the percentiles of the distribution of $(1/N) \sum_{i=1}^N \hat{\sigma}_{\varepsilon,it}$.

For different values of N , Table 1 shows the median of the estimator $(1/N) \sum_{i=1}^N \hat{\sigma}_{\varepsilon,it}$, along with the 2.5th and 97.5th percentiles. For all simulated sample sizes in the table, the median estimator is at or near the true value of 10.00. This also applies to the mean of the estimator (unreported), which follows from unbiasedness. Table 1 confirms convergence, in the sense that the 95 percent probability intervals around the median shrink as N grows large. When $N = 577$, which is the sample size of our empirical balanced panel, the estimator lies in the interval (9.30, 10.71) with 95 percent probability. In our unbalanced panel, the number of firms varies between 765 in 1986 and 3,652 in 2005. With $N = 765$, the estimator lies in (9.39, 10.62) with 95 percent probability. The 95 percent probability interval for $N = 3,652$ is (9.72, 10.28).

These probability intervals are narrow compared to the estimated changes in volatility that we document in Section 4. This indicates that our estimator converges sufficiently quickly in order to allow us to draw inference about changes in volatility from our empirical samples.

Finally, we discuss the interpretation of our estimator. First, our estimator $(1/N) \sum_{i=1}^N \hat{\sigma}_{\varepsilon,it}$ is based on a single year's observation for every firm, and therefore captures volatility in a given year. This differentiates our measure from measures for firm-level sales and employment growth volatility applied to the US economy, other than that of De Veirman and Levin (2011). In particular, Comin and Philippon (2005), Comin and Mulani (2006), and Davis, Haltiwanger, Jarmin, and Miranda

(2006) all measure firm-level volatility based on rolling ten-year standard deviations of firm-level growth rates. That measure captures changes in firm-level volatility from one ten-year period to the next, but it smooths out year-on-year changes in firm volatility.

Second, because we control for aggregate and sector-specific factors in equations (2) and (3), we estimate the firm-specific component of variation in firm growth rates. This further distinguishes our measure from that of Comin and Philippon (2005), Comin and Mulani (2006), and Davis, Haltiwanger, Jarmin, and Miranda (2006). Their measures estimate total firm-level volatility without distinguishing firm-specific from aggregate and sectoral factors.

By capturing the firm-specific component of volatility in any year, we also capture the degree of dispersion in growth rates in any given year. To see this, note from equation (4) that when estimated firm-specific volatility $(1/N) \sum_{i=1}^N \hat{\sigma}_{\varepsilon,it}$ is high in any year, this indicates that the absolute value of estimated firm-level residuals tends to be high in that year. When firms' residuals from equations (2) and (3) are large in absolute value, that means that firms' growth rates differ substantially from those of other firms of similar size in the same sector. This implies a high degree of turnover in market, profit or employment shares, depending on whether we consider dispersion in sales, earnings or employment growth. Finally, note that since we effectively use de-meaned growth rates, we restrict attention to that part of firm turnover which reflects that year's specific developments, as opposed to changes in firm shares due to firms being generally on the rise or in decline within their industry.

4 Results: Time-Varying Volatility

This section characterizes the time-path of firm-specific volatility. In a first subsection, we discuss our main results, obtained from the balanced panel. In a second subsection, we establish robustness by providing evidence by firm size quartile and from the unbalanced panel. In a third subsection,

we provide estimates for firm volatility that take the changes in consolidation practices in 2000-2001 into account. We will provide economic interpretation in Section 5.

4.1 Balanced Panel

For the balanced panel, Figure 4 characterizes firm-specific sales, earnings and employment growth volatility for every year in the sample, estimated from equations (2), (4) and (5). Figure 5 plots the three volatility measures on one graph, after rescaling earnings and employment growth volatility so that their sample average equals the sample average for sales growth volatility.

In the present subsection we focus on Figure 5 since rescaling enables us to draw general conclusions about changes in sales, earnings and employment volatility without being distracted by differences in scale. On this point, note that in Figure 4, there is no straightforward interpretation anyway of levels differences across variables. To see this, note that the estimated level of volatility in Figure 4 depends on the way we scale the growth rates. For instance, the fact that we compute earnings growth with lagged sales in the denominator as in equation (1) affects the estimated level of earnings volatility.¹⁸

Recall that we assign an observation to year t when it reflects a business year ending in that year. Therefore, when we write “1990” below, we mean “the business year ending in 1990”. An analogous definition applies to other years.

Figure 5 reveals that firm-specific sales growth volatility is high in the second half of the 1980s. After 1990, it declines substantially, reaching its trough in 1997. From business years ending in 1998 onwards, sales volatility increases, with a peak in 2000.

Figure 5 also documents that firm-specific earnings volatility declines somewhat from 1989 to

¹⁸In absolute value, sales is often larger than earnings, where the latter captures profits. The comparatively large absolute values of sales tend to imply comparatively small absolute values for the growth rate in equation (1), and therefore tend to imply low values for measured earnings volatility.

1997. In business years ending in 1998, there is a small increase in earnings volatility. From 1999 onwards, there is a large increase in earnings volatility. Earnings volatility reaches its peak in 2002, before a substantial decline.

Finally, firm-specific employment growth volatility increases from 1986 to 1989. It then decreases somewhat through 1996. From 1997 onwards, employment volatility rises, reaching its highest measured level in 2002. After that, employment volatility decreases.

Combining the above evidence, we find that firm-specific volatility declined for all three variables in the early and mid-1990s. The decline is most pronounced for sales growth volatility, and more moderate for employment and earnings volatility.

From business years ending in 1998 onwards, firm-specific volatility in all three variables increased, peaking in the early 2000s. The increase in volatility was most pronounced for earnings growth, but was still substantial for sales and employment growth.

4.2 Robustness

We consider robustness of our volatility estimates on two counts. First, we divide the balanced panel into firm size quartiles. Second, we report results for the unbalanced panel. Our main conclusions from the balanced panel continue to hold, which indicates that these conclusions are not driven by changes in the firm size distribution.

From now on, we always report volatility estimates without rescaling, so that the basis of comparison is Figure 4, not Figure 5.

Figure 6 reports results by firm size quartile based on threshold sales-to-GDP ratios, which we construct as explained in Section 3.1. The left column captures the quartile of smallest firm sizes. Firm size increases as we consider columns further to the right. As before, we estimate volatility from equations (2), (4) and (5), but with one difference: we drop the firm size dummies e_q and

their interaction terms be_{tq} from equation (2).

Irrespective of firm size, sales volatility declines after 1990, reaches its trough in about 1997, and increases substantially from 1998 onwards, reaching a peak in 2000. In each size category, earnings volatility declines somewhat through about 1997, increases substantially from 1999 onwards, but reaches a peak in the early 2000s. Therefore, our results for sales and earnings volatility from Section 4.1 apply across firm size quartiles.

For employment volatility, developments differ somewhat across size quartiles. We tend to see increasing volatility through 1989, and then declining or stable volatility through 1996. All size quartiles display a substantial increase in volatility in the late 1990s.

We now consider the unbalanced panel. In this case, we use equations (3), (4) and (6). The black lines in Figure 7 indicate estimated firm volatility, and the corresponding 95 percent confidence intervals, for the full unbalanced panel.

According to these estimates, the overall pattern of changes in volatility over time in the unbalanced panel is similar to that in the balanced panel. One difference is that earnings volatility increases somewhat in the early and mid-1990s, unlike in the balanced panel. Yet our main conclusions continue to hold in the unbalanced panel. Sales volatility declines from 1990 to 1997, and then increases, reaching its peak in 2000. Employment growth volatility declines somewhat from 1989 to 1997. Both earnings and employment volatility increase markedly from 1998 on, reaching their highest measured point in 2002.

4.3 Adjusting for Changes in Accounting Standards

In this subsection, we present evidence that our finding of increasing firm-level sales and earnings volatility in 1998-2002 is not driven by the change in accounting standards in 2000. We do so by estimating firm volatility for a subset of firms that is unlikely to be affected by the accounting

change.

Recall from Section 2.2 that the data indicate massive firm-level employment growth rates in 2000 and high mean employment growth in 2001, which plausibly reflects a broadening in the definition of subsidiaries that parent companies have to include in their consolidated accounts.

Because the change in accounting standards appears to have greatly affected recorded employment, our intuition is that firms that did not have very high recorded employment growth rates in 2000 and/or 2001 are unlikely to be affected by the change in accounting standards. For this reason, we also estimate firm volatility for a subset of firms that did not record very high employment growth in any of those years.¹⁹

For the unbalanced panel, the pink lines in Figure 7 present estimated firm-specific volatility, along with 95 percent confidence intervals, for that subset. Recall that the black line is firm volatility in the full unbalanced panel.

Focusing first on years other than 2000 and 2001, we see that sales and earnings volatility follow similar paths in the restricted and full samples. This similarity suggests that the subset is a reasonable proxy for the full sample.

In 2000 and 2001, estimated sales volatility is somewhat higher in the full sample than in the restricted sample. Because differences of this magnitude are rare in other years and do not occur at all in the years immediately preceding or immediately following the episode, it does appear that the change in accounting standards increased measured sales volatility in 2000 and 2001. However, the difference is small, and estimates for the subset still indicate an increase in sales

¹⁹We omit firms with measured employment increases in 2000 and/or 2001 above a threshold chosen to make the employment distribution in those years similar to years with comparable aggregate employment growth. In the unbalanced panel, the threshold is the 50th percentile of the distribution with accounting changes still in it (18.42 percent employment growth) in 2000, and the 95th percentile (44.18 percent employment growth) in 2001. In the balanced panel, the threshold is the 20th percentile (8.49 percent employment growth) in 2000, and the 95th percentile (34.25 percent employment growth) in 2001.

volatility from 1998 onwards.

For earnings volatility, the average firm in the restricted sample is somewhat more volatile than the average firm in the full sample from 1996 onwards. The accounting rules change should only have affected measured volatility in the full sample in 2000 and 2001, such that the difference between the restricted and full sample in other years should be fully due to the fact that the two samples are different. Since the differences in estimated volatility in 2000 and 2001 between the restricted and full sample are not markedly larger than in the surrounding years, it appears that the change in consolidation standards hardly affected measured earnings growth rates.

Figure 7 also graphs employment volatility estimates for the subset of firms that did not experience very high recorded employment growth rates. From the early 1990s through 2005, employment volatility for the subset is somewhat lower than that for the full sample. This suggests that the subset not only excludes firms affected by the change in consolidation standards, but also excludes some firms for which actual employment volatility was high around that time. This apparent sampling difference notwithstanding, employment volatility still follows a fairly similar pattern in the restricted sample. In particular, our finding that employment volatility rose substantially in the late 1990s and peaked in the early 2000s also applies to the restricted sample.

We conclude that the finding that sales, earnings and employment volatility rose from the late 1990s on and peaked in the early 2000s is not merely due to the change in accounting standards in 2000-2001.²⁰

²⁰An analogous comparison in the balanced panel yields similar implications. We do not focus on the balanced panel here because it involves taking a small subset from an already fairly small sample. In this case, that turns out to mean that sampling differences between the restricted and full balanced panel affect the volatility estimates in all years, such that we cannot draw equally strong conclusions either way about the impact of the accounting change.

5 Interpretation

We now delve deeper into our results on firm-specific volatility to find out whether and when weak firms were allowed to shrink relative to healthier firms.

5.1 Changes in the Extent to Which Weak Firms Were Protected?

First of all, in our sample period, patterns in firm volatility have changed when macroeconomic circumstances have. The gradual decline in firm volatility in 1991-1997 coincides with a period of slow but mostly positive aggregate growth. The pronounced increase in firm volatility during business years 1998-2002 coincides with the deepest economic slump in our sample period. Finally, the Japanese economy was recovering when firm volatility tended to decline in business years 2003-2005.

One of the reasons why the Japanese economy stagnated for so long arguably lies in the fact that weak firms were shielded from market forces in various ways. For instance, it is well-documented that while firms' balance sheets deteriorated after the 1990 stock market crash, Japanese banks continued lending to (mostly large) firms that were otherwise insolvent. This practice is known as evergreening, and this type of firms as zombie firms. To cite one other factor, weak firms were often protected by other firms with which they had close affiliations, for instance because they were in the same corporate group (keiretsu).²¹

By dampening the shrinking of weak firms and reducing their failure rate, these factors would also hamper growth and entry of more productive firms, and therefore harm aggregate productivity. In this way, protection of weak firms would prevent, or at least postpone, a large cyclical downturn, but it would also tend to prevent a vigorous recovery. This is consistent with the

²¹ See the introduction for references to relevant papers. Also see Fukuda, Kasuya, and Nakajima (2005), Uesugi (2008), and Fukuda, Kasuya, and Akashi (2009), who find that there was less evergreening for small firms.

economic stagnation in business years 1991-1997, as well as with our finding that firm turnover declined in business years 1991-1997.

On the other hand, the fact that in business years 1998-2002, the Japanese economy experienced its most severe downturn during our sample period is in itself consistent with the hypothesis that troubled firms were finally allowed to shrink or fail. Our finding that firm turnover increased at that time does reveal that some firms shrank substantially more than others during the downturn. In the following two subsections, we investigate whether this reflects the possibility that weak firms were allowed to shrink relative to healthier firms.

5.2 Firm Volatility and Zombie Lending

First, we assess whether in 1998-2002, firm volatility increased the most in sectors where zombie lending declined the most during that period.

Figure 8 presents our estimates for firm volatility by sector in the balanced panel. Recall that our sectors are meant to match those of Caballero, Hoshi, and Kashyap (2008).²² We use equations (2), (4) and (5), but we now omit sector effects d_s and sector interaction terms bd_{ts} from equation (2).

Caballero e.a. (2008) find that across sectors, the fraction of zombie firms increased in the first half of the 1990s. From the mid-1990s onwards however, the patterns differ across sectors. They find that in services, the fraction of zombies virtually declined by half from 1998 to 2002. In the same timeframe, the fraction of zombies declined somewhat in manufacturing, while it increased somewhat in trade. Over that same period, the fraction of zombies increased substantially in the construction sector.

²²In the balanced panel, there are 52 firms in construction; 49 in trade; 382 in manufacturing; 21 in services; and 73 in the “other” sector. The “other” sector includes five real estate companies, a number so small that we do not provide separate estimates for the real estate sector.

To the extent that the fraction of zombie firms reflects banks' propensity to lend to intrinsically insolvent borrowers, and under the hypothesis that rising firm volatility reflected a decline in the protection of weak firms, we would expect to see firm volatility rising the most in sectors where the fraction of zombie firms declined most in 1998-2002.

The evidence on this is mixed. In manufacturing, firm volatility increased in 1998-2002 while the fraction of zombie firms declined somewhat. Firm volatility increased less strongly in the trade sector, while the fraction of zombie firms increased somewhat in 1998-2002. In services, volatility increased more than in manufacturing, while the fraction of zombies declined substantially.²³ The evidence from these three sectors is roughly in line with the hypothesis in the sense that sectors with more pronounced volatility increases tended to see a (more pronounced) decline in zombie lending.

However, this pattern is broken by the construction sector, where firm volatility as well as the fraction of zombie firms increased the most among the reported sectors.

5.3 Firm Volatility and Health Status

Second, we assess whether the volatility increase from 1998 on is due to the possibility that weak firms were worse affected by the two recessions in business years 1998-2002. We use two alternative criteria to classify firms into weak and healthy firms. One is based on earnings growth in business years 1991-1997, while the other is based on leverage growth over the same period.

The idea behind the earnings growth criterion is that while weak firms' market and employment shares may not have declined as much as they would have without protection, their underlying difficulties likely did show up as a comparatively weak performance in terms of profitability.

The second criterion identifies firms as weak if they experienced a comparatively large rise

²³The services sector has the smallest number of firms in our sample, which may explain the choppiness of the sales (and employment) volatility estimates for that sector.

in leverage in 1991-1997. If a firm's debt-equity ratio increased much during the period from the peak of the asset boom to shortly before the financial crisis of November 1997, this is likely because the value of its assets declined while its borrowing did not decline to the same extent. This is reminiscent of the sources of weakness in firm balance sheets that we mentioned when we spoke about zombie firms in Subsection 5.1.

Firstly, we report results when classifying firms in the balanced panel based on average earnings growth in 1991-1997. We construct this variable as follows:

$$\gamma_{i,9197} = \frac{EBIT_{i,1997} - EBIT_{i,1990}}{\frac{1}{7} \sum_{\tau=1991}^{1997} SALES_{i,\tau}} * 100 \quad (8)$$

For any firm i , the number $\gamma_{i,9197}$ indicates its profitability in business year 1997 as compared with its earnings level at the peak of the bubble, scaled by its average level of sales over business years 1991-1997. According to this criterion, we classify firms as weak if they fall in the bottom 25 percent of earnings growth $\gamma_{i,9197}$ among the 577 firms in the balanced panel, and as healthy otherwise.²⁴

For each of these categories, Figure 9 graphs means and medians of the residuals ε_{it} from equation (2), based on which we computed firm-specific volatility. Recall from Section 3 that the residuals capture firm growth rates after controlling for aggregate developments, as well for sector and firm size.

In Figure 9, red lines indicate weak firms, green lines healthy firms, and the black lines indicate the combination of these two groups, i.e. all firms in the balanced panel. Dashed lines indicate means and diamonds indicate medians. Note that the mean residuals for the all-firms category

²⁴Below we will also distinguish firms according to average leverage growth in 1991-1997. Whether we use average earnings growth or leverage growth, we report results for a classification based on the distribution for all firms in the balanced panel. In every case, the results are not materially different when we classify firms based on the distribution within their sector.

are essentially zero at all times.

The findings we are about to discuss apply to both means and medians. According to the sales growth graph, firms with low profit growth in business years 1991-1997 did lose market share in 1999 and especially in 2000. However, this loss is roughly offset by a gain in other years, implying only small sales growth differentials on average during the downturn in business years 1998-2002 and during the period of business years 1998-2005 which also includes the subsequent recovery.

For earnings and employment growth, we also find that there are only small growth differentials between healthy and unhealthy firms, on average over the same two periods. If anything, unhealthy firms actually gained market, profit and employment share from 1998 onwards.

Still, there are particular years in which previously weak firms lost market or employment share. To check how significant any of these situations are for firm volatility, we compute a measure for the contribution of the growth differential between weak and healthy firms to firm volatility.

For this purpose, we denote estimated average firm-specific volatility in year t as $\hat{\sigma}_t = (1/N) \sum_{i=1}^N \hat{\sigma}_{\varepsilon,it}$, and substitute our definition for firm-specific volatility $\hat{\sigma}_{\varepsilon,it}$ from equation (4):

$$\hat{\sigma}_t = \frac{1}{N} \sqrt{\frac{\pi}{2}} \sum_{i=1}^N |\hat{\varepsilon}_{it}| \quad (9)$$

To capture the part of average firm volatility $\hat{\sigma}_t$ explained by differences between weak and healthy firms, we compute the extent of firm volatility that would arise if all healthy firms were at the estimated mean residual for healthy firms $\hat{\varepsilon}_{H,t}$ while all unhealthy firms were at the estimated mean residual for unhealthy firms $\hat{\varepsilon}_{U,t}$. This measure accounts for differences in growth rates between healthy and weak firms, but it sets the dispersion within each of those two categories to zero.

Since in this case 144 of the 577 firms are classified as unhealthy and the remaining 433 as healthy, we compute the contribution to firm volatility of the gap between healthy and unhealthy firms based on the following equation:

$$\hat{\sigma}_{cont,t} = \frac{1}{577} \sqrt{\frac{\pi}{2}} (144 |\hat{\varepsilon}_{U,t}| + 433 |\hat{\varepsilon}_{H,t}|) \quad (10)$$

In order to only capture the contribution of years where previously weak firms shrink relative to healthy firms, we use equation (10) in years where $\hat{\varepsilon}_{U,t} < \hat{\varepsilon}_{H,t}$, and set the contribution to zero otherwise.

For the years 1996-2005, Figure 10 graphs mean total firm volatility $\hat{\sigma}_t$ (in dashed lines) and the contribution to firm volatility (in solid lines) of previously unhealthy firms shrinking relative to other firms.

For sales, earnings and employment growth alike, health status makes a negligible contribution to firm volatility at most times. The only time when there is a non-trivial contribution occurs in 1999-2000 for sales growth volatility. In this respect, recall our finding that previously weak firms lost market share in particular during those two years. The largest contribution occurs in 2000, when $\hat{\sigma}_{cont,t} = 2.00$. This is a small part of estimated mean sales volatility of 11.19.

To sum up the evidence so far, we find that previously unhealthy firms, as measured by profit growth in 1991-1997, do not perform systematically worse than previously healthy firms after 1998. In years where they do perform worse, the gap accounts for a small part of total volatility.

Now, we use leverage growth as the criterion to separate healthy from weak firms. We use long-term debt as a percent of common equity as our definition of leverage.²⁵

²⁵For observations with negative debt-equity ratios, we set the ratio equal to the highest positive debt-equity ratio in the sample. Firms that actually have negative debt-equity ratios have negative equity, such that they are in fact more highly indebted relative to their equity than any firm with a positive debt-equity ratio could be. At any rate, we also windorize the top 2.5 percent of the level of leverage to reduce the effect of outliers.

In the right column of Figure 11, we characterize a firm as unhealthy if its average percentage change in leverage in business years 1991-1997 exceeds the 75th percentile of all firms in the balanced panel.

We find that firms that experienced the largest increases in leverage in business years 1991-1997 (in red) grew at similar rates as other firms (in green), on average over business years 1998-2002 as well as in 1998-2005 which includes the subsequent recovery. This finding applies to sales, earnings, as well as employment growth, and to means as well as medians.

As Figure 12 shows, in years where the mean growth residual for high-leverage growth firms exceeds that of other firms, the growth gap always accounts for a small part of total dispersion in firm growth rates, and by no means explains the rise in firm volatility in 1998-2002.

Finally, we investigate whether firms that reduced leverage the most in 1991-1997 actually did better during the recovery in business years 2003-2005. Reducing leverage is one aspect of the restructuring that was necessary, yet often postponed, in Japan during the 1990s.

For this purpose, we separate firms that fall below the 25th percentile of the distribution of average leverage growth in 1991-1997 from other firms. The left column of Figure 11 performs this separation. Green lines mark firms with lowest leverage growth, red lines other firms, and black lines the combination of these two categories.

We find that firms that reduced leverage the most grew at similar rates as other firms, on average, in the recovery years 2003-2005. This applies to sales, earnings as well as employment growth, and to means as well as medians.

In years where low-leverage growth firms grew faster, the difference in growth rates accounts for a trivial part of firm volatility at all points in 1998-2005, such that changes in the growth differential between delevering firms and other firms do not explain either the volatility increase

during the downturn or the volatility decline in the subsequent recovery.

6 Conclusion

We have provided a year-by-year estimate for firm-specific volatility in sales, earnings, and employment growth in Japan. In so doing, we have also estimated how different firm growth rates were in each year, and therefore have gauged the evolution of turnover in market, profit, and employment shares.

We find that patterns in firm volatility changed as macroeconomic circumstances did. Firm turnover tended to decline during the period of economic stagnation which followed the 1990 stock market crash but preceded the 1997 financial crisis. Turnover increased substantially during the deep downturn in 1998-2002. Firm-specific volatility decreased again during the post-2002 recovery.

Factors implying protection of weak firms such as zombie lending, the main bank system and the keiretsu system plausibly prolonged the economic downturn and contributed to the decline in firm turnover that we observe in business years 1991-1997.

The widening in the firm growth distribution in business years 1998-2002 indicates that within each sector and within classes of firms of similar size, some firms were much more affected by the downturn than others. However, our findings suggest that neither this increase in turnover nor the fact that the economy experienced a deep downturn actually reflect any decline in the extent of protection of weak firms.

We find that firms that experienced low earnings growth or high leverage growth in business years 1991-1997 did not systematically shrink relative to healthier firms in business years 1998-2002. In years where these firms did grow more slowly, the gap in growth rates is too small to be an important factor in the firm volatility patterns.

Therefore, our evidence suggests that the two recessions in fiscal years 1998-2002 were not cleansing, in the sense that this episode does not seem to have caused a shift towards healthier and plausibly more productive firms.

Our finding that firm health does not explain the rise in firm volatility in 1998-2002 raises the question what caused this stir-up in the firm growth distribution. In the remainder of this conclusion, we briefly assess a number of candidate explanations. Finding out what does explain the rise in volatility during the 1998-2002 downturn is a topic on which more research is warranted.

Before we start discussing candidate explanations, note that our finding that firm-specific volatility rose in 1998-2002 cannot reflect differences in growth rates across sectors. By construction, our measure of firm-specific volatility is not affected by any such growth differentials across sectors.

Our measure of firm-specific volatility is meant to capture a broad range of firm-specific supply and demand shocks. We discuss three such possible explanations.

Firstly, the volatility in the Japanese Yen after the 1997 Asian crisis could have induced volatility in firm-specific shocks, at least in the beginning of the period 1998-2002. Note that exchange rate variation does not affect our measure of firm-specific volatility to the extent that it only induces differences between sectors. It does induce firm-specific volatility to the extent that it affects firms within the same sector differently, for instance because even within the same sector, firms vary in terms of their export and import orientation.

Secondly, if firms that downsized or restructured more at any time after the 1990 stock market crash subsequently grew faster than other firms, differences across firms in terms of the degree of restructuring could explain some or all of the dispersion in subsequent firm growth rates. In principle, this applies whether the restructuring occurred in the form of leverage reduction, the

selling of capital equipment, the reduction of employment, or more in general through any form of cost reduction.

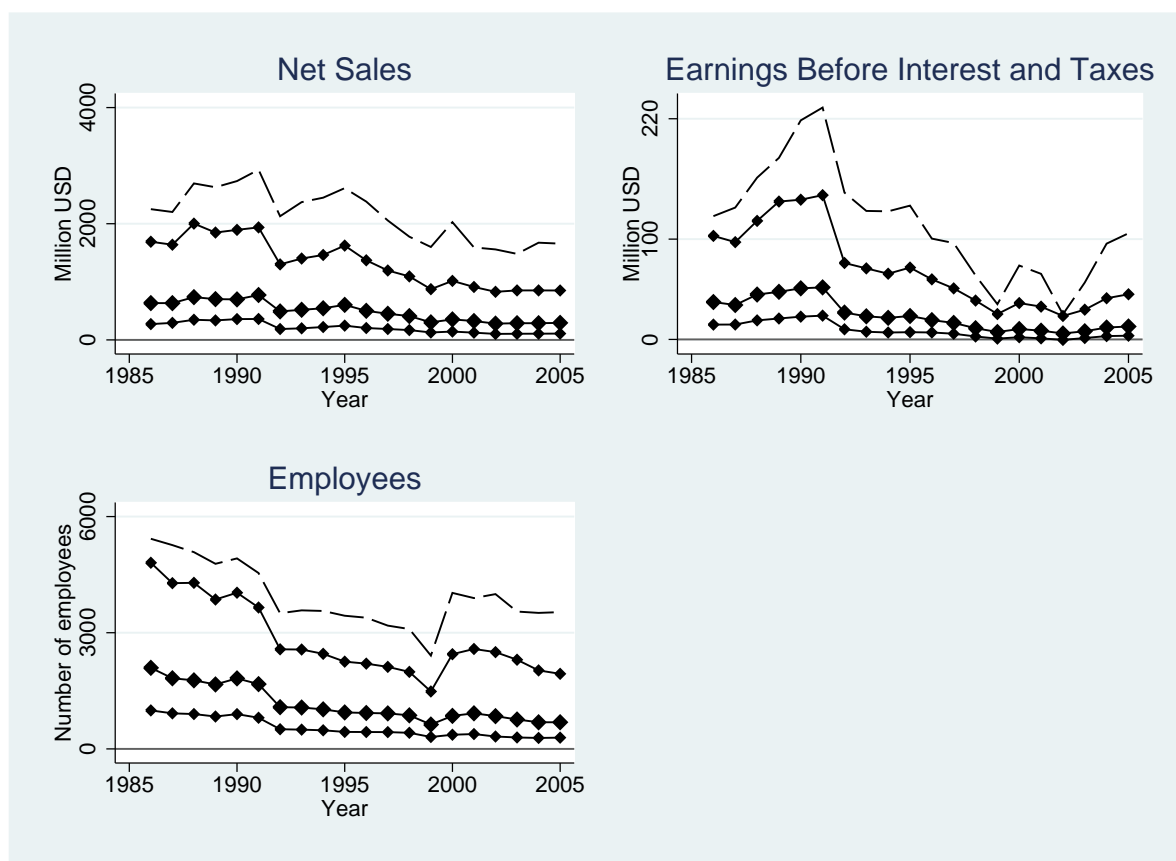
On this point, note that in Section 5.3 we found that firms which decreased leverage the most in 1991-1997 did actually not grow faster than other firms in the recovery years 2003-2005. This provides evidence against the importance of leverage reduction for explaining differences in growth rates during the recovery, but does not necessarily carry over to other forms of restructuring.

Finally, differences in access to finance could in principle explain why the firm growth distribution widened after the financial crises of 1997 and 1998. In this paper, we find that differences in firm health do not appear to explain differences in firm growth. This suggests that access to finance did not become systematically more restricted for weak firms. However, firms may have become more different in terms of their access to finance for other reasons. For instance, if some banks fared worse than others during the 1998-2002 downturn, this could have resulted in bank-level “credit crunches” in the sense that access to finance became problematic for the firms that had close lending ties with those particular banks, irrespective of these firms’ own profitability and balance sheet position.

Figures and Tables

Figure 1

Unbalanced 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 over the period 1986-2005 for all 4,507 Japanese firms in the Worldscope database. Large diamonds indicate medians while small diamonds indicate the 25th and 75th percentiles. Dashed lines are means. Net sales and Earnings Before Interest and Taxes (EBIT), both in nominal terms, are in million USD. Employees stands for the number of employees.

Figure 2

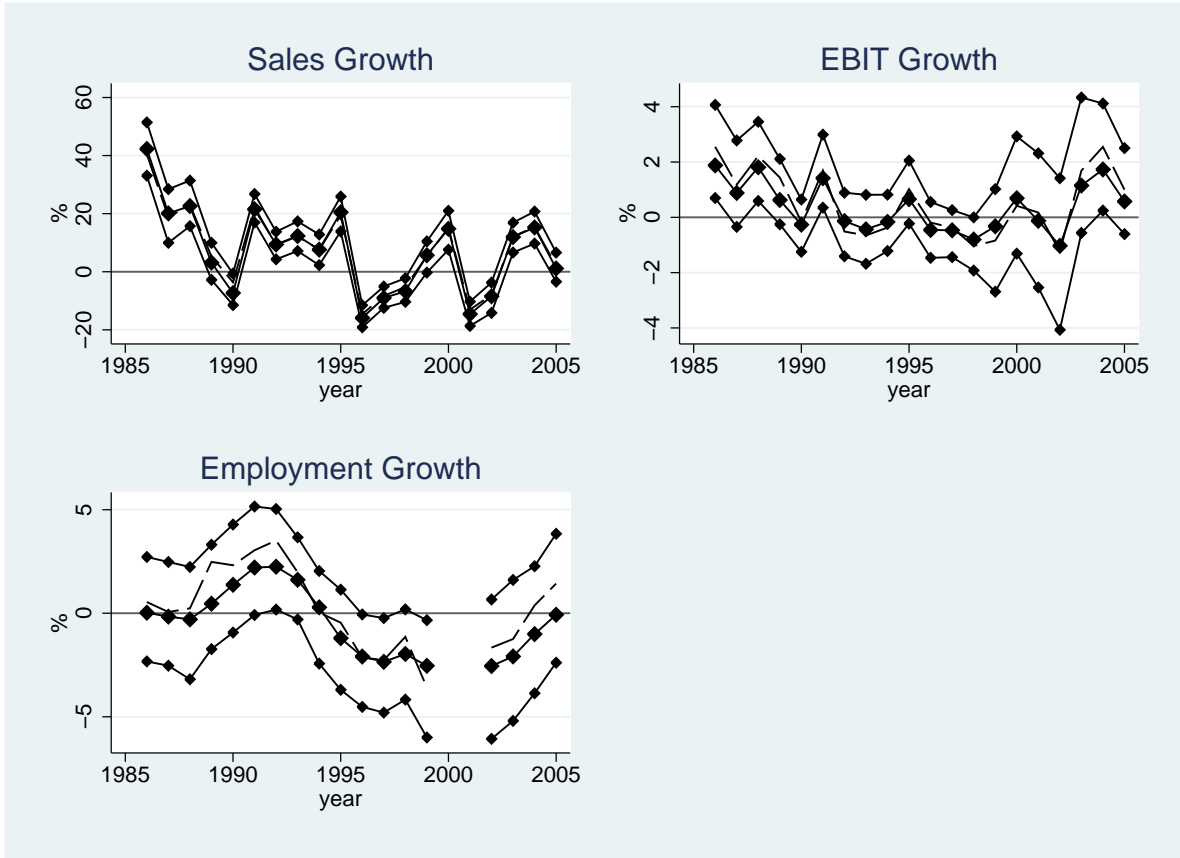
Balanced Panel: Mean and Quartiles of Levels Data



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

Figure 3

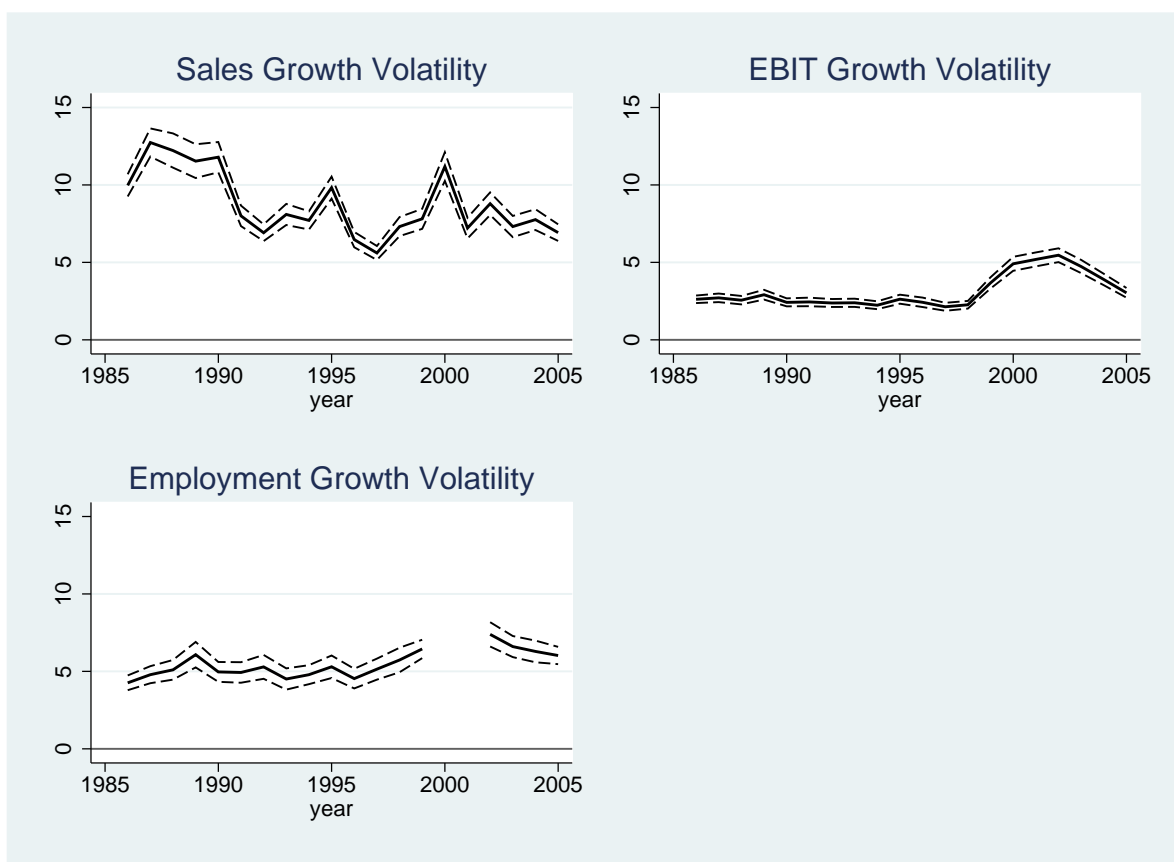
Balanced Panel: Mean and Quartiles of Growth Rates



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 Worldscoop for which data are continuously available over the period 1986-2005. Large diamonds indicate medians while small diamonds indicate the 25th and 75th percentiles. Dashed lines are means. Sales and EBIT are in nominal terms. All growth rates are in percentage terms. EBIT growth is as defined in equation (1).

Figure 4

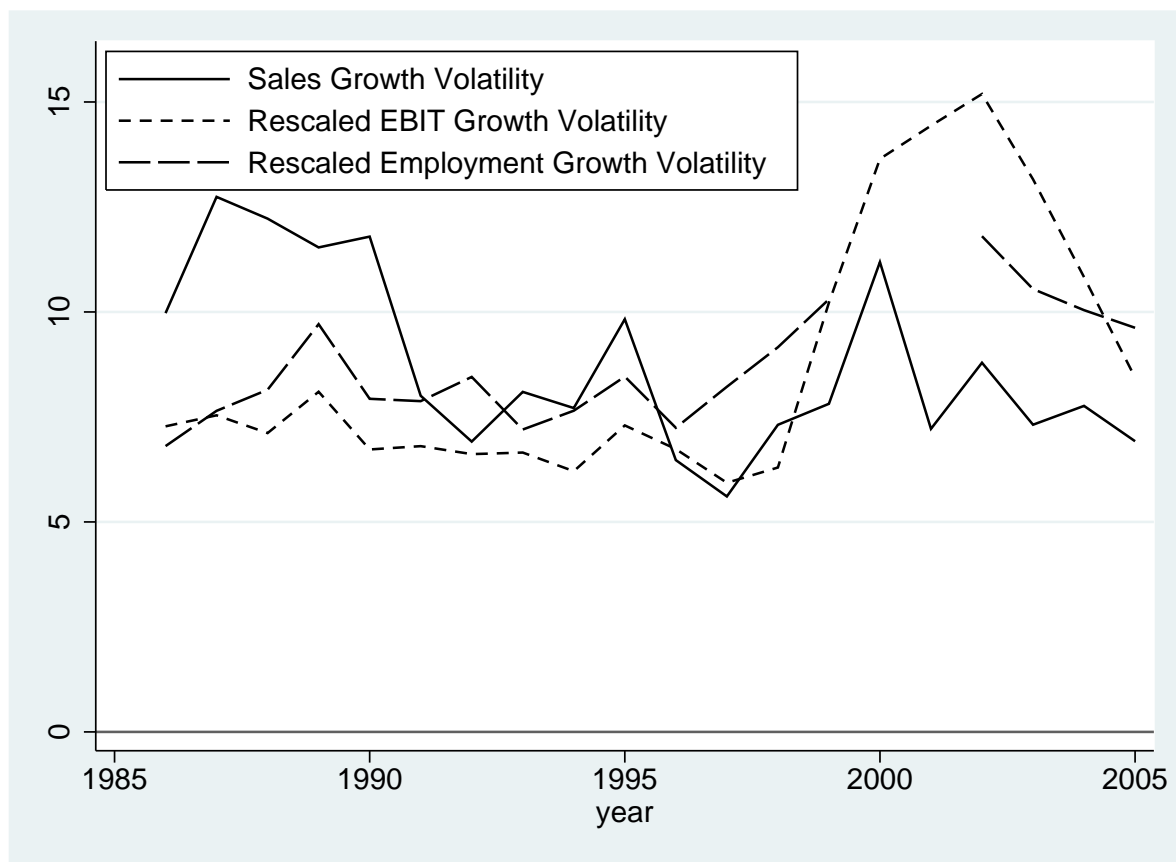
Balanced Panel: Firm-Specific Volatility



Notes: This figure graphs firm-specific sales, earnings, and employment growth volatility in every year for the balanced panel of 577 Japanese firms for which data are continuously available over the period 1986-2005, along with a regression-based 95 percent confidence interval. Volatility is estimated from equations (2), (4) and (5).

Figure 5

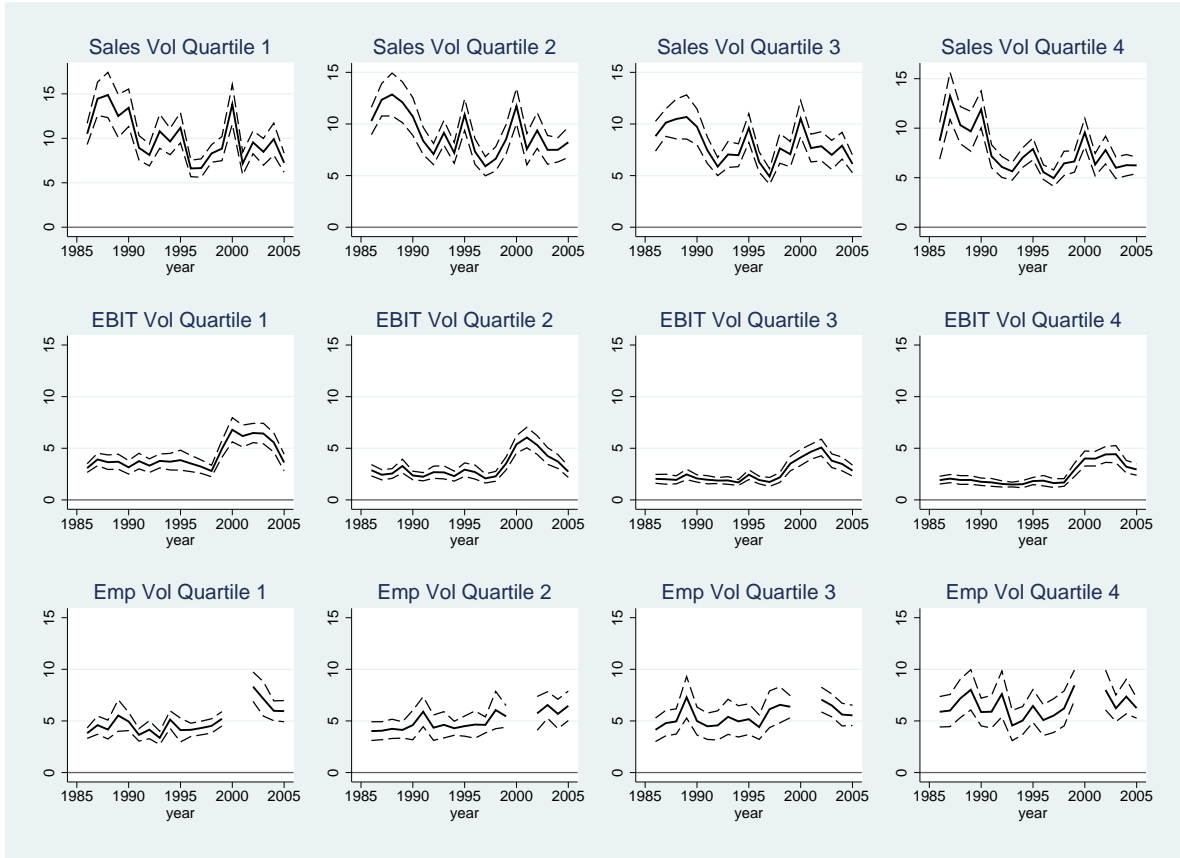
Balanced Panel: Re-Scaled Firm-Specific Volatility



Notes: This figure graphs the point estimates for firm-specific volatility from Figure 5 after rescaling the estimates for earnings and employment growth volatility so that their sample average equals the sample average of sales growth volatility.

Figure 6

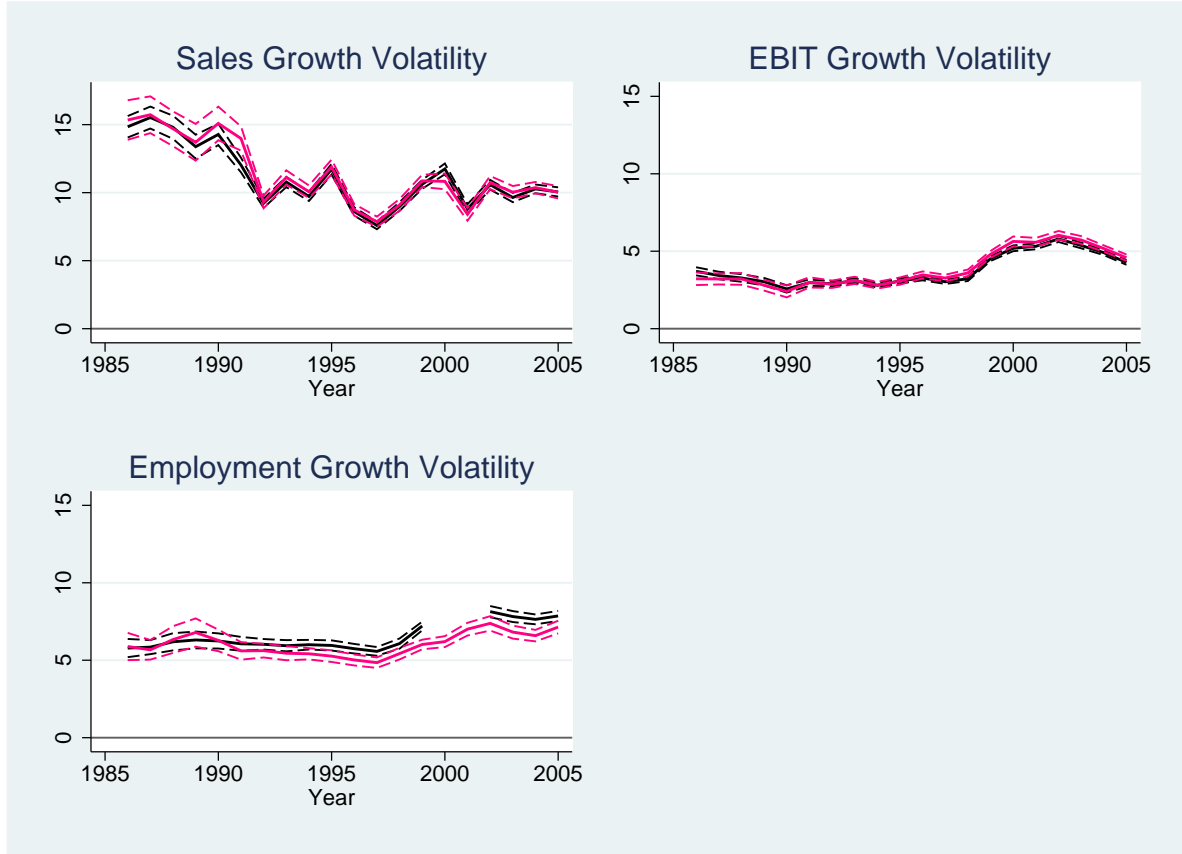
Balanced Panel: Firm-Specific Volatility by Firm Size Quartile



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), (4) and (5), with the only difference that we omitted firm size dummies and size interaction terms from equation (2).

Figure 7

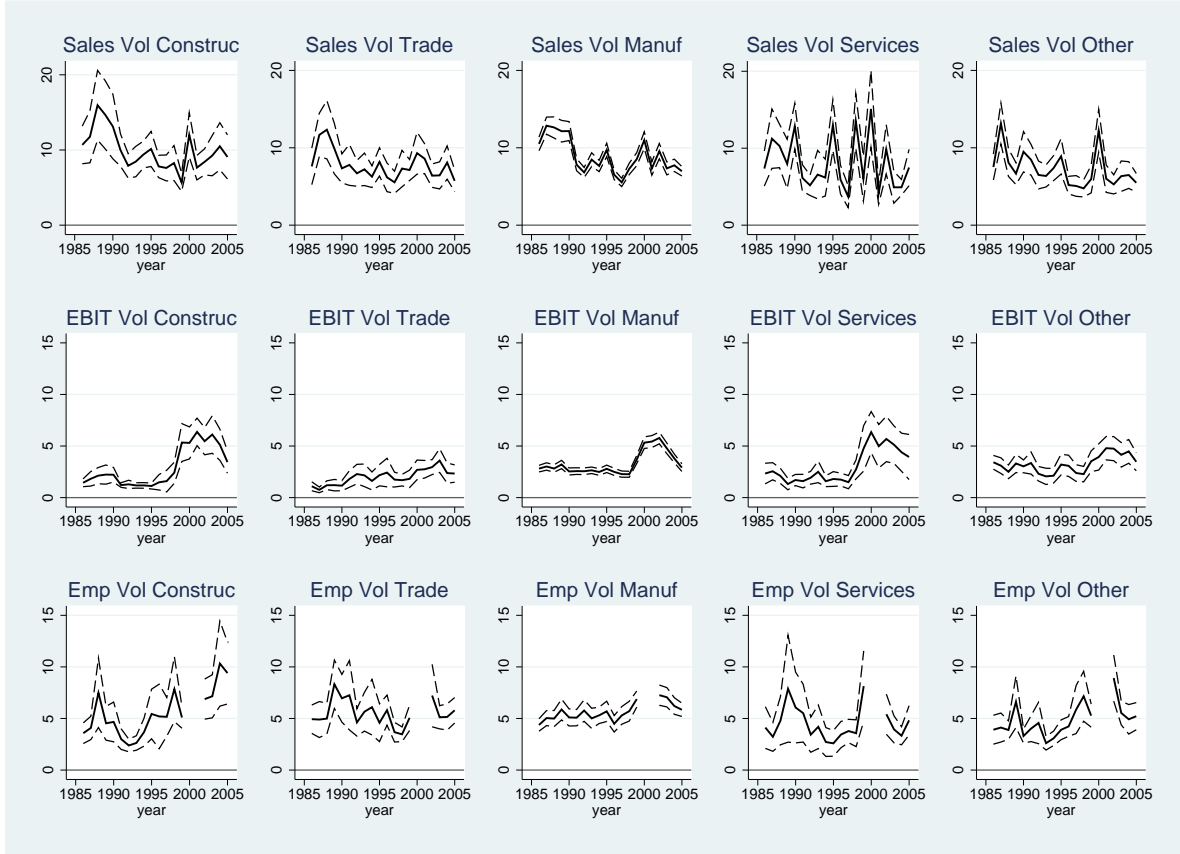
Unbalanced Panel: Firm Volatility. Adjusting for Changes in Accounting Standards



Notes: The black lines graph firm-specific sales, earnings, and employment growth volatility in every year for the unbalanced panel of the 4,507 Japanese firms in Worldscoop, along with a regression-based 95 percent confidence interval. The pink lines graph the same firm volatility measure for a subset of firms that did not record massive increases in employment in 2000 and/or 2001, and therefore is less likely to be affected by the change in consolidation practices at that time. In both cases, we estimate volatility from equations (3), (4) and (6).

Figure 8

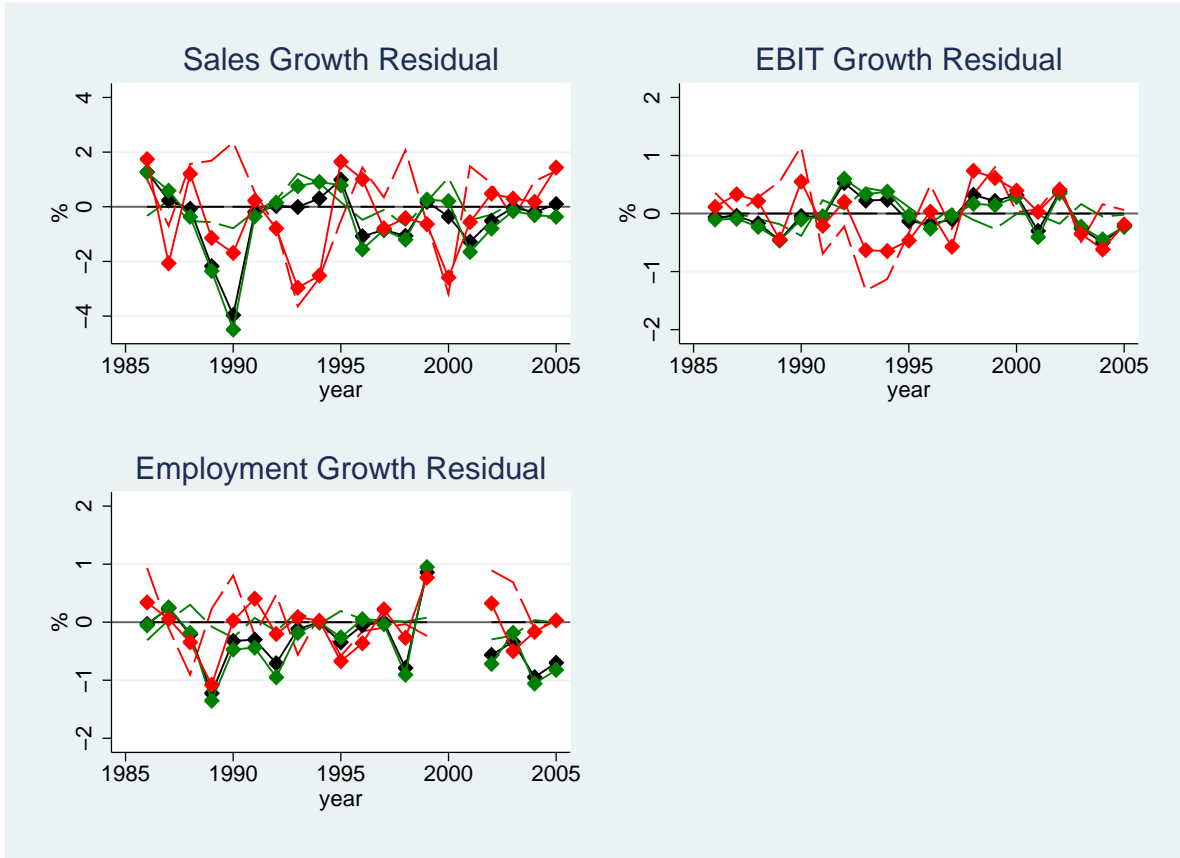
Balanced Panel: Firm-Specific Volatility by Sector



Notes: This figure graphs firm-level sales, earnings, and employment volatility when subdividing the 577 Japanese firms in the balanced panel into five sectors. From left to right, the sectors are: construction, trade, manufacturing, services, and other firms. The “other” sector includes firms in activities such as education, financials, real estate, utilities, health, transport, agriculture, and mining. Volatility for every sector is estimated using equations (2), (4) and (5), with the only difference that we omitted sector dummies and sector interaction terms from equation (2).

Figure 9

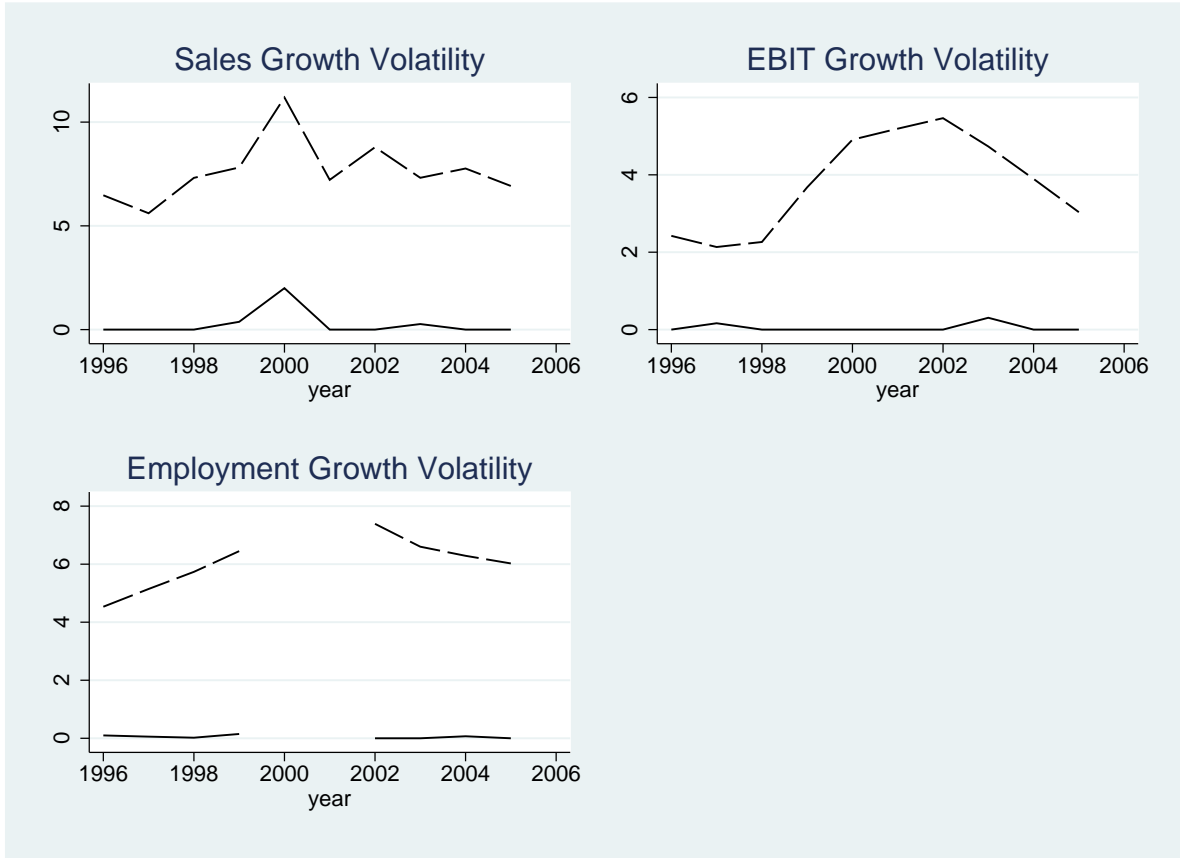
Comparing Weak and Healthy Firms: Earnings Growth Criterion



Notes: This figure graphs mean and median growth rate residuals from equation (2) for different categories of firms in the balanced panel. Dashed lines indicate means and diamonds indicate medians. Red lines indicate means and medians for firms that fall in the bottom 25 percent of average earnings growth in business years 1991-1997, where average earnings growth is defined in equation (8). Green lines indicate means and medians for all other firms in the balanced panel. Black lines indicate means and medians for the combination of the two foregoing groups, i.e. for the overall balanced panel.

Figure 10

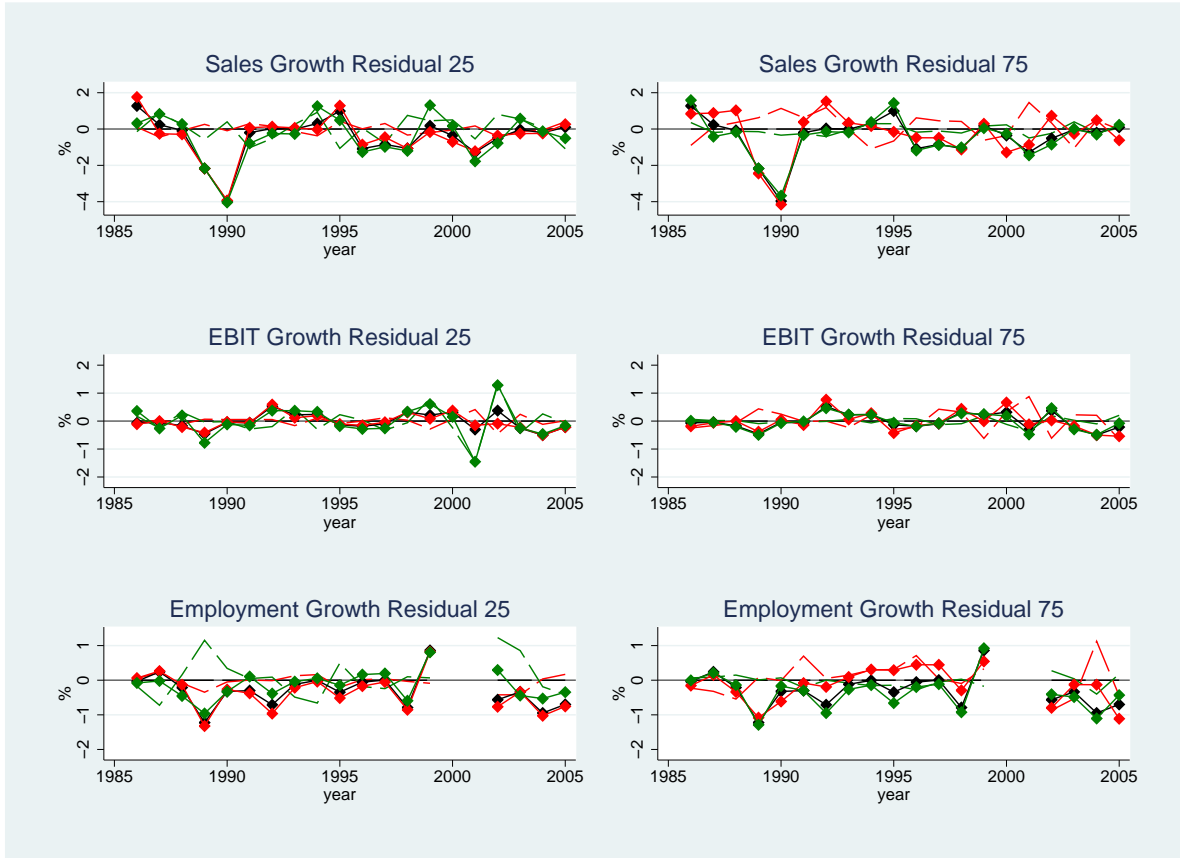
Contribution of Health Status to Firm Volatility: Earnings Growth Criterion



Notes: For the years 1996-2005, the dashed lines indicate total firm volatility which we reported above in Figure 4. The black lines indicate the contribution to firm volatility of the growth differential between weak and healthy firms for years where previously weak firms shrink relative to healthy firms. Like for Figure 9, we classify firms as weak if they fall in the bottom 25 percent of average earnings growth in business years 1991-1997. We compute the volatility contribution using equation (10) when weak firms shrink relative to healthy firms, and set the contribution to zero otherwise.

Figure 11

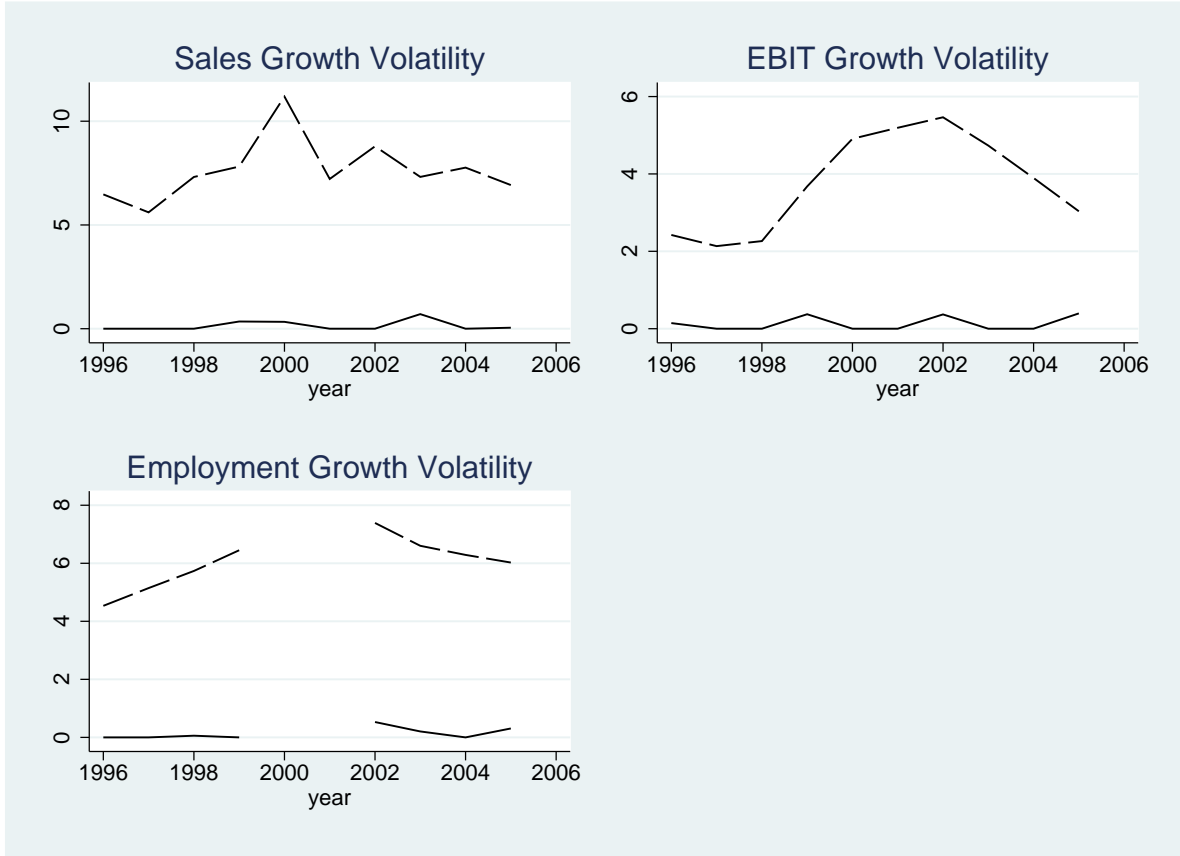
Comparing Weak and Healthy Firms: Leverage Growth Criterion



Notes: This figure graphs mean and median growth rate residuals from equation (2) for different categories of firms in the balanced panel. Dashed lines indicate means and diamonds indicate medians. In the left column, green lines indicate means and medians for firms that fall in the bottom 25 percent of average leverage growth in business years 1991-1997, where we define leverage as the ratio of long-term debt to common equity. Red lines indicate means and medians for other firms, and black lines for all firms in the balanced panel. In the right column, red lines indicate firms for which average leverage growth in 1991-1997 is above the 75th percentile; green lines indicate other firms; and black lines indicate all firms in the balanced panel.

Figure 12

Contribution of Health Status to Firm Volatility: Leverage Growth Criterion



Notes: For the years 1996-2005, the dashed lines indicate total firm volatility which we reported above in Figure 4. The black lines indicate the contribution to firm volatility of the growth differential between weak and healthy firms for years where previously weak firms shrink relative to healthy firms. Like for the right column of Figure 11, we classify firms as weak if they fall above the 75th percentile of leverage growth in business years 1991-1997. We compute the volatility contribution from an equation like (10) when weak firms shrink relative to healthy firms, and set the contribution to zero otherwise.

Table 1

Convergence of Estimator for Firm-Specific Volatility

N =Number of firms	2.5th percentile	median	97.5th percentile
100	8.32	9.98	11.78
577	9.30	10.00	10.71
765	9.39	10.00	10.62
1,000	9.47	10.00	10.54
3,652	9.72	10.00	10.28
10,000	9.83	10.00	10.17

Note: This table documents convergence of our estimator for firm-specific volatility based on equation (4). For different sample sizes N , this table shows the median of the estimator $(1/N) \sum_{i=1}^N \hat{\sigma}_{\varepsilon,it}$ for the cross-sectional average of firm-specific volatility, along with the 2.5th and 97.5th percentiles. The simulated sample sizes are chosen to match our empirical sample sizes. $N = 577$ in the balanced panel of firms. In the unbalanced panel of firms, sample size varies between $N = 765$ in 1986 and $N = 3,652$ in 2005.

Appendix: Unbiasedness Proof

This appendix proves unbiasedness of our estimator $(1/N) \sum_{i=1}^N \hat{\sigma}_{\varepsilon,it}$ for the true cross-sectional average of firm-specific volatility $(1/N) \sum_{i=1}^N \sigma_{\varepsilon,it}$. We first prove that $E(\hat{\sigma}_{\varepsilon,it}) = \sigma_{\varepsilon,it}$. At the end of this appendix, we show that this implies that $E \left[(1/N) \sum_{i=1}^N \hat{\sigma}_{\varepsilon,it} \right] = (1/N) \sum_{i=1}^N \sigma_{\varepsilon,it}$.

Taking expectations of equation (4), but assuming that we know the true error term ε_{it} , we obtain:

$$E(\hat{\sigma}_{\varepsilon,it}) = \sqrt{\frac{\pi}{2}} E(|\varepsilon_{it}|) \quad (\text{A1})$$

Writing the expectation $E(|\varepsilon_{it}|)$ out as a function of the probability density function $f(\varepsilon_{it})$ yields:

$$E(\hat{\sigma}_{\varepsilon,it}) = \sqrt{\frac{\pi}{2}} \int_{-\infty}^{+\infty} |\varepsilon_{it}| f(\varepsilon_{it}) d\varepsilon_{it} \quad (\text{A2})$$

Assuming that the error term is normally distributed with mean zero, i.e. $\varepsilon_{it} \sim N(0, \sigma_{\varepsilon,it}^2)$, this implies:

$$E(\hat{\sigma}_{\varepsilon,it}) = \sqrt{\frac{\pi}{2}} \int_{-\infty}^{+\infty} |\varepsilon_{it}| \frac{1}{\sigma_{\varepsilon,it} \sqrt{2\pi}} e^{-\frac{1}{2} \left(\frac{\varepsilon_{it}}{\sigma_{\varepsilon,it}} \right)^2} d\varepsilon_{it} \quad (\text{A3})$$

Since $|\varepsilon_{it}| = |-\varepsilon_{it}|$, i.e. the absolute value is a function that is symmetric around the vertical axis, equation (A3) is equivalent to:

$$E(\hat{\sigma}_{\varepsilon,it}) = \sqrt{\frac{\pi}{2}} 2 \int_0^{+\infty} |\varepsilon_{it}| \frac{1}{\sigma_{\varepsilon,it} \sqrt{2\pi}} e^{-\frac{1}{2} \left(\frac{\varepsilon_{it}}{\sigma_{\varepsilon,it}} \right)^2} d\varepsilon_{it} \quad (\text{A4})$$

Since we can rewrite $|\varepsilon_{it}| = \varepsilon_{it}$ for $\varepsilon_{it} \geq 0$, and after bringing the term $1/(\sigma_{\varepsilon,it} \sqrt{2\pi})$ outside

the integral, we obtain:

$$E(\hat{\sigma}_{\varepsilon,it}) = \frac{1}{\sigma_{\varepsilon,it}} \int_0^{+\infty} \varepsilon_{it} e^{-\frac{1}{2}\left(\frac{\varepsilon_{it}}{\sigma_{\varepsilon,it}}\right)^2} d\varepsilon_{it} \quad (\text{A5})$$

Since the antiderivative of $\varepsilon_{it} e^{-\frac{1}{2}\left(\frac{\varepsilon_{it}}{\sigma_{\varepsilon,it}}\right)^2}$ is $-\sigma_{\varepsilon,it}^2 e^{-\frac{1}{2}\left(\frac{\varepsilon_{it}}{\sigma_{\varepsilon,it}}\right)^2}$, the fundamental theorem of calculus implies:

$$E(\hat{\sigma}_{\varepsilon,it}) = \frac{1}{\sigma_{\varepsilon,it}} \left[-\sigma_{\varepsilon,it}^2 e^{-\frac{1}{2}\left(\frac{\varepsilon_{it}}{\sigma_{\varepsilon,it}}\right)^2} \right]_0^{+\infty} \quad (\text{A6})$$

Solving the right-hand side yields $(1/\sigma_{\varepsilon,it}) \left[0 - (-\sigma_{\varepsilon,it}^2) \right]$, which in turn equals $\sigma_{\varepsilon,it}$. Therefore,

$$E(\hat{\sigma}_{\varepsilon,it}) = \sigma_{\varepsilon,it} \quad (\text{A7})$$

which proves unbiasedness of $\hat{\sigma}_{\varepsilon,it}$.

Since the foregoing equation holds for every firm i , it implies:

$$\sum_{i=1}^N E(\hat{\sigma}_{\varepsilon,it}) = \sum_{i=1}^N \sigma_{\varepsilon,it} \quad (\text{A8})$$

Multiplying by $1/N$, and using the property that the expectations operator is linear, we obtain:

$$E \left[\frac{1}{N} \sum_{i=1}^N \hat{\sigma}_{\varepsilon,it} \right] = \frac{1}{N} \sum_{i=1}^N \sigma_{\varepsilon,it} \quad (\text{A9})$$

This proves unbiasedness of our estimator $(1/N) \sum_{i=1}^N \hat{\sigma}_{\varepsilon,it}$.

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