THE RISE IN FIRM-LEVEL VOLATILITY: CAUSES AND CONSEQUENCES

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Abstract

We study the increase in firm level risk and how it relates to the decrease in aggregate risk [..]

Introduction

Over the past 30 years, there has been a decline in aggregate volatility (McConnell and Perez-Quiros (2000) and Stock and Watson (2002)). At the same time, there has been a large increase in the volatility of firms (Campbell, Lettau, Malkiel, and Xu (2001), Comin and Mulani (2003) and Chaney, Gabaix, and Philippon (2002)).

Our paper has two parts. First we want to explore whether the firm level trend towards more volatility and the aggregate trend towards more stability are related, or whether the two have moved in opposite directions by coincidence.

In the second part, we will explore the proximate reasons for the increase in firm volatility. We believe that the main suspects are:

1 The basic facts

The decline in aggregate volatility has been documented by McConnell and Perez-Quiros (2000), Blanchard and Simon (2001) and Stock and Watson (2002).

On the other hand, firm level volatility has increased. Firm level volatility can be measured using financial data or real data. Using financial data for the US, Comin (2000) and Campbell, Lettau, Malkiel, and Xu (2001) document an increase in volatility of idiosyncratic stock returns using time series and cross-sectional measures of volatility. The results in Campbell, Lettau, Malkiel, and Xu (2001) are important because they show an increase in risk, not just an increase in predictable heterogeneity. Using accounting data, Comin and Mulani (2003) and Chaney, Gabaix, and Philippon (2002) show an increase the idiosyncratic volatility of employment, sales, earnings and capital expenditures.

Figure 1 shows the evolution of idiosyncratic and aggregate volatility. Aggregate volatility (σ_t^a) is defined as the standard deviation of the annual growth rate (γ_t) of real GDP

$$\sigma_t^a = \left[\frac{1}{10} \sum_{\tau=-4}^{+5} \left(\gamma_{t+\tau} - \bar{\gamma}_t \right)^2 \right]^{\frac{1}{2}} \tag{1}$$

where $\bar{\gamma}_t$ is the average growth rate between $t-4$ and $t+5$. For each firm i, we compute the volatility of the growth rate of sales $(\gamma_{t,i})$ as

$$\sigma_t^i = \left[\frac{1}{10}\sum_{j=-4}^{+5}\left(\gamma_{t+\tau,i} - \bar{\gamma}_{t,i}\right)^2\right]^{\frac{1}{2}} \tag{2}$$

We then take the median across all firms present in the sample at time t as our measure of typical firm volatility

$$\sigma_t^f = med_i \left\{\sigma_t^i\right\}$$

Figure 1 shows the decline in σ_t^a and the increase in σ_t^f. Note also the difference of scale between the two measures. Idiosyncratic volatility is an order of magnitude larger than aggregate volatility.

Our first task is to show the robustness of these findings. The main issues are sample selection bias and measurement errors. Sample selection is an issue because more small firms have entered the COMPUSTAT database over time. Since small firms tend to be more volatile, the changing composition could explain the trend. We deal with this first issue by controlling for size and age, and showing that the increase in firm volatility holds within groups of comparable firms. Comin and Mulani (2003) also show that the results are robust to the inclusion of firms fixed effects.

The second issue is whether firm level results are economically meaningful. To take an extreme example, suppose that we live in a world of constant returns without financial frictions or incentive problems, in which boundaries of organizations do not matter. Plants could move among firms without any real consequences, yet firms would appear to be volatile. Firms would simply not be the right unit of observation. One could argue that M&As fall partly into the category or irrelevant ownership changes. Thus, as a robustness check, we are going to show that our results are not driven by M&As.

Figure 2 shows that the trend increase in firm volatility is not driven by the entry of young and small firms, or by an upsurge in M&A activities[1]. An even better way to show that our results are economically meaningful is to show that they relate to results obtained in other data sets. Guvenen and Philippon (2005) show that firm volatility measured across industries in COMPUSTAT is a good predictor of both unemployment risk and wage

[1]This is not to say that M&As are not important. They do not matter much here because we use the median to aggregate across firms. If we had used the mean as our benchmark for figure 1, then some large mergers would have affected our measure, and removing these mergers would have made a difference.

inequality measured across the same industries in PSID. Comin, Groshen, and Rabin (2005) relate firm-level volatility to wage volatility at the occupation level by taking advantage of a unique data set that contains firm-level and worker-level information for a sample of firms in Ohio. They document a positive relationship between firm level volatility and the volatility and dispersion of wages at the occupation level.

If firms have really become more risky, then this should be reflected in corporate bond spreads and corporate bond ratings. For the spread, we use Moody's seasoned Aaa corporate bond yield minus the 5-year treasury rate. For bond ratings, we use S&P long term domestic issuer credit rating from COMPUSTAT, coded from 2 for AAA to 27 for D (default). We first regress the rating on firm level characteristics (age, assets, sales, SIC code), and we then average the residuals across firms. **Figure 3** shows that Aaa spread over treasury has increased overtime, and also that the average credit rating of firms in COMPUSTAT has deteriorated. Both trend clearly suggest an significant increase in risk, consistent with the increase in cash flow volatility. For more on this topic, see Campbell and Taksler (2003).

We conclude that the evidence clearly shows that U.S. firms have become more risky over the past 30 years, and that this increase in risk in at least partly passed on to their workers.

2 Sectoral Evidence

We have established that the aggregate stabilization of the US economy has coincided with a large increase in firm level risk. However, in a statistical sense, this is only one observation. Our goal in this section is to explore sectoral dynamics and see how they relate to firm volatility. We are first going to show that the decline in aggregate volatility is accounted for by a decrease in the co-movement of the different sectors, and not by a decrease in the average volatility of each sector. Second, we are going to show that sectors in which firms have become more volatile have typically become less correlated with the aggregate.

2.1 Decomposition of Aggregate Volatility

We now perform a decomposition of the aggregate variance of the growth rate of real value added, TFP and real value added per worker into sector variances and correlations. Let $\gamma_{s,t}$ be the growth rate of the particular variable in sector s at time t, and let ω_{st}^{sec} be the share of sales for sector s in the aggregate sales in the economy. Also, let $V([Z_\tau]_{t-4}^{t+5})$ denote the variance of $\{Z_{t-4},\ Z_{t-3},\ ...\ \ Z_t, ...\ Z_{t+4},\ Z_{t+5}\}$ for any generic variable Z and $Cov([Z_\tau]_{t-4}^{t+5}, [Y_\tau]_{t-4}^{t+5})$ be the covariance between $\{Z_{t-4},\ Z_{t-3},\ ...\ \ Z_t, ...\ Z_{t+4},\ Z_{t+5}\}$ and $\{Y_{t-4},\ Y_{t-3},\ ...\ Y_t, ...\ Y_{t+4},\ Y_{t+5}\}$. By definition, the aggregate growth rate is

$$\gamma_t = \sum_i \gamma_{s,t}\omega_{s,t}^{\text{sec}}\ .$$

Then, using the definition of the variance,

$$V([\gamma_\tau]_{t-4}^{t+5}) \equiv \frac{1}{10}\sum_{\tau=t-4}^{t+5}\left(\sum_i \gamma_{s,\tau}\omega_{s,\tau}^{\text{sec}} - \frac{1}{10}\sum_{\tau=t-4}^{t+5}\sum_i \gamma_{s,\tau}\omega_{s,\tau}^{\text{sec}}\right)^2\ .$$

For simplicity, suppose that $\omega_{s,t}^{\text{sec}} = \omega_s^{\text{sec}}$ for all the sectors i and all years t. Then, $V([\gamma_\tau]_{t-4}^{t+5})$ can be written as follows:

$$\begin{aligned}
V([\gamma_\tau]_{t-4}^{t+5}) &= \frac{1}{10}\sum_{\tau=t-4}^{t+5}\left(\sum_s \gamma_{s,\tau}\omega_s^{\text{sec}} - \frac{1}{10}\sum_{\tau=t-4}^{t+5}\sum_s \gamma_{s,\tau}\omega_s^{\text{sec}}\right)^2 \\
&= \frac{1}{10}\sum_{\tau=t-4}^{t+5}\left(\sum_s \omega_s^{\text{sec}}\left(\gamma_{s,\tau} - \frac{1}{10}\sum_{\tau=t-4}^{t+5}\gamma_{s,\tau}\right)\right)^2 \\
&= \frac{1}{10}\sum_{\tau=t-4}^{t+5}\left(\sum_s\sum_j \omega_s^{\text{sec}}\omega_j^{\text{sec}}\left(\gamma_{s,\tau} - \frac{1}{10}\sum_{\tau=t-4}^{t+5}\gamma_{s,\tau}\right)\left(\gamma_{j,\tau} - \frac{1}{10}\sum_{\tau=t-4}^{t+5}\gamma_{j,\tau}\right)\right) \\
&= \sum_s\sum_j \omega_s^{\text{sec}}\omega_j^{\text{sec}}\left(\frac{1}{10}\sum_{\tau=t-4}^{t+5}\left(\gamma_{s,\tau} - \frac{1}{10}\sum_{\tau=t-4}^{t+5}\gamma_{s,\tau}\right)\left(\gamma_{j,\tau} - \frac{1}{10}\sum_{\tau=t-4}^{t+5}\gamma_{j,\tau}\right)\right) \\
&= \underbrace{\sum_s (\omega_s^{\text{sec}})^2\, V([\gamma_{s,\tau}]_{t-4}^{t+5})}_{\text{Variance Component}} + \underbrace{\sum_s\sum_{j\neq s}\omega_s^{\text{sec}}\omega_j^{\text{sec}} Cov([\gamma_{s,\tau}]_{t-4}^{t+5}, [\gamma_{j,\tau}]_{t-4}^{t+5})}_{\text{Covariance Component}}
\end{aligned}$$

Hence, the variance of the growth rate of aggregate sales is decomposed into two terms - the first is related to the sector level variance of sales (variance component) and the second reflects the covariances between the growth rates of sales at different sectors (covariance component).[2]

The covariance component is affected by the sectoral variance and by the correlation of a sector with the others. To increase further our understanding we also compute the

[2] The small discrepancy between the total variance and the sum of these two components is due to the time variation of the shares.

correlation component. Specifically, we define first the correlation of each sector with the other sectors:

$$Corr^{\text{sec}}_{s,t} = \sum_{j \neq s} \frac{\omega^{\text{sec}}_j}{\sum_{h \neq s} \omega^{\text{sec}}_h} Corr([\gamma_{s,\tau}]^{t+5}_{t-4}, [\gamma_{j,\tau}]^{t+5}_{t-4}) \ , \tag{3}$$

Then we define aggregate correlation as a weighted average of the sectoral correlations:

$$Corr^a_t = \sum_s \omega^{\text{sec}}_s Corr^{\text{sec}}_{s,t}.$$

Figure 4 shows the decline in aggregate correlation for value added, TFP and value added per worker. Sectoral variances display an hump-shaped pattern over time, with no obvious decline over our sample period, 1959 to 1996. On the other hand, there is a clear decline in correlations over time, for all three variables of interest.

Hence, we conclude that, in order to understand the decline in aggregate volatility, we should try to understand what drives this decline in the correlation between sectors.

2.2 Firm Volatility and Sector Co-movements

We now ask if the decline in co-movement across sectors is linked to the increase in volatility within each sector. We start from our measure of idiosyncratic firm volatility σ^i_t defined in equation (2). We aggregate this measure within each sector to obtain a sector specific measure of firm volatility

$$\sigma^{\text{sec}}_{s,t} = \sum_{i \in s} \omega_{it} \sigma^i_t$$

where we use the share of sales of firm i in the sector as our weight

$$\omega_{it} = \frac{Sales_{it}}{\sum_{j \in s} Sales_{jt}}$$

On the other hand, we have the sector specific correlation measure, $Corr^{\text{sec}}_{s,t}$, defined in equation (3). We run the following regressions

$$Corr^{\text{sec}}_{s,t} - Corr^{\text{sec}}_{s,t-10} = \alpha + \beta \left(\sigma^{\text{sec}}_{s,t} - \sigma^{\text{sec}}_{s,t-10} \right) + \varepsilon_{s,t}$$

Table 2 shows the results when the dependent variable is the change in the correlation of value added, employment, labor productivity and TFP. We estimate a negative β in all specifications, and it is significant for the last three. **Figure 5** shows the change in the correlation of output per worker between 1975 and 1990 against the change in the volatility of firms, across the 34 sectors in our sample. In various robustness checks, we have found that the results for productivity (either value added per worker, or TFP) are robust, while the results for quantities (either employment or value added) are not always significant.

3 International Evidence

Should we be surprised to see an increase in firm riskiness over time? Looking around the world, the answer is: probably not. Morck, Yeung, and Yu (2000), Durnev, Morck, and Yeung (2004) and Li, Morck, Yang, and Yeung (2004) show that developing countries are characterized by large aggregate and low idiosyncratic volatility, while developed countries display the opposite pattern. If we extrapolate from the cross-section to the time series, we would expect to see a decline in aggregate volatility and an increase in firm level risk as countries grow. In this sense, the U.S. experience may not be surprising.

Some research has been done on non-US data. Frazzini and Marsh (2002) do not find the same increase in the UK. Thesmar and Thoenig (2004) show an increase in France, especially for listed firms.

4 Theoretical Discussion

We are now going to discuss a few possible explanations for the facts that we have uncovered so far. In the last part of the paper, we will try to test these explanations

The first potential explanation is that aggregate stabilization led to more risk taking by firms. The cause of the aggregate stabilization could be luck, or better monetary policy. The link with individual risk taking could be the following. Suppose that reallocation is inefficiently low in recessions. Then entrepreneurs may be reluctant to start risky ventures because of the eventuality that they fail at a time where the economy is in a bust. This applies equally to human capital (unemployment risk) or physical capital (fire sales). A decline in aggregate volatility can therefore lead to more individual risk taking.

Other explanations assume that there is a change at the firm level that drives the increase in firm volatility and leads, directly or indirectly, to a decrease in aggregate volatility.

The second and third explanations start from an increase in competition in the goods market. In both cases, it is easy to see how competition can drive up firm level risk (Comin and Mullani (2005) document a threefold increase in the turnover of market shares during the postwar period). The explanations differ in how they link competition to aggregate volatility. The second explanation, formalized in Philippon (2003) is that more competition leads firms to adjust their prices faster, which reduces the impact of aggregate demand shocks. While intuitively appealing, the simple sticky price explanation cannot be complete because it also implies more volatile prices, contrary to the evidence.[3]

The third explanation, formalized in Comin and Mullani (2005), is that more competition leads to a decline in the variance of aggregate TFP shocks. To see why this could be the case, assume that each firm can choose to invest in the development of two kinds of innovations. Idiosyncratic, embodied innovations are patentable and benefit mostly the innovator. GPT-style innovations can potentially affect all the firms in the economy. With a large number of firms, if all the research effort is devoted to embodied innovations, we would expect smooth aggregate TFP growth. On the contrary, GPT-style innovations can create fluctuations in aggregate TFP growth. To the extent that competition can lead firms to favor embodied innovations, it could explain the decline in aggregate volatility. Comin and Mullani (2005) present a model where the willingness to spend resources on the development of GPT-style innovations increases with the stability of the market share of the industry leader. As competition increases and market shares become more volatile, firms endogenously decide to focus more on embodied innovations, and less on GPT innovations.

Finally, financial innovation could explain our facts, either directly, or indirectly through the competition channels just described, since financial development favors entry of new competitors. The direct link could be that financial innovation prevents credit crunches at the same time at it encourages individual risk taking (see Thesmar and Thoenig (2004) for instance).

5 Testing the Proposed Explanations

[...]

[3] This is because the standard sticky price model assumes a constant velocity, hence $y = m - p$ and , for given volatility of m, the only way to decrease the volatility of y is to increase the volatility of p. Sticky price models are one example in the class of models with counter-cyclical markups. Models with real counter-cyclical markups would not make the counter-factual prediction.

6 Conclusion

[...]

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Table 2: Increment in sectoral correlation vs. increment in average firm level volatility at the sector level

Dependent Variable	Δ sectoral correlation of growth in value added	Δ sectoral correlation of growth in employment	Δ sectoral correlation of growth in productivity	Δ sectoral correlation of growth in TFP
Increment in average firm-level volatility	-0.08	-0.35	-0.45	-0.4
	(0.098)	(.1)	(.1)	(.075)
Constant	-0.076	-0.044	0.01	-0.028
	(0.009)	(0.009)	(0.009)	(.007)
N	665	661	661	661
R2	0%	1.76%	3.13%	4.18%

standard errors in parenthesis

Fig 1: Aggregate versus Firm Level Volatility

Standard Deviation of Growth Rate, 10-Year Centered Rolling Window

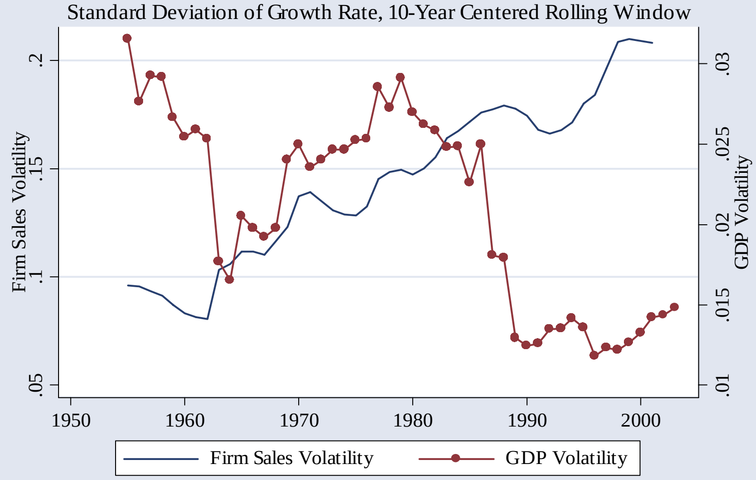


Fig 2: Firm Volatility, Alternative Measures

Standard Deviation of Growth Rate, 10-Year Centered Rolling Window

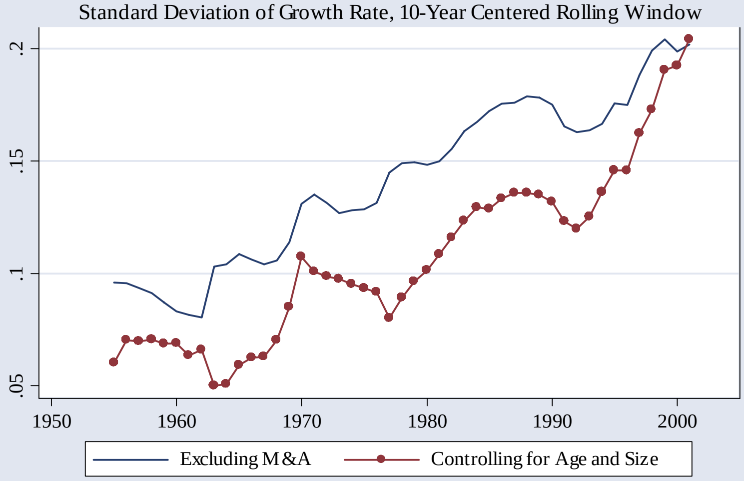
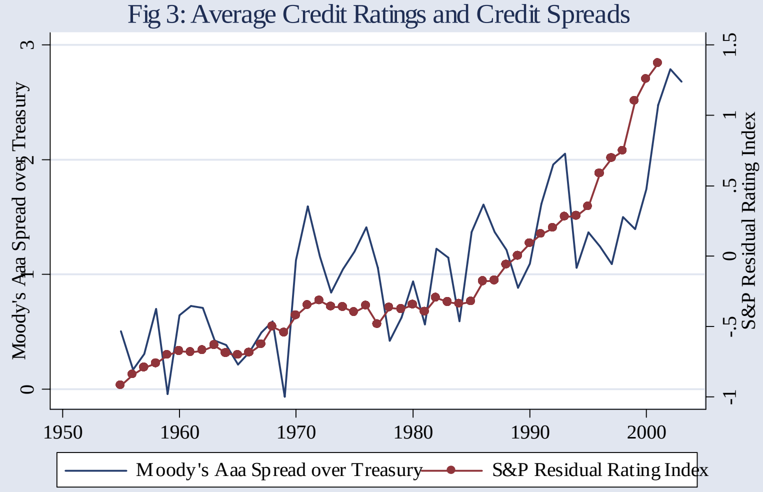
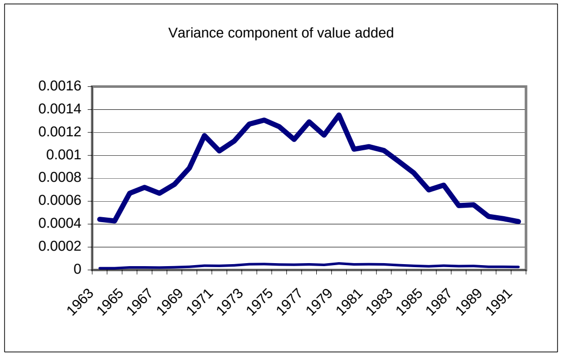


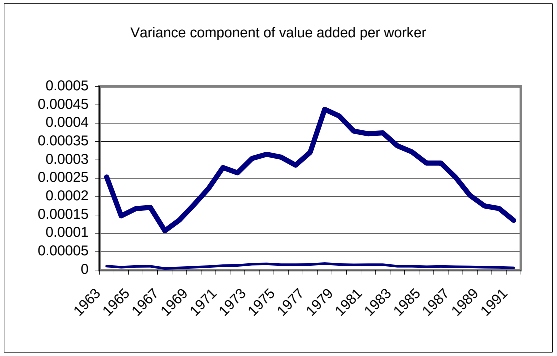
Fig 3: Average Credit Ratings and Credit Spreads

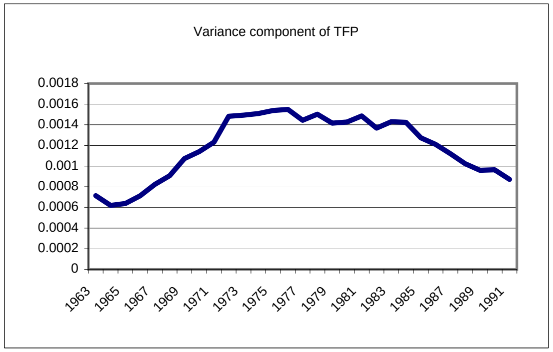


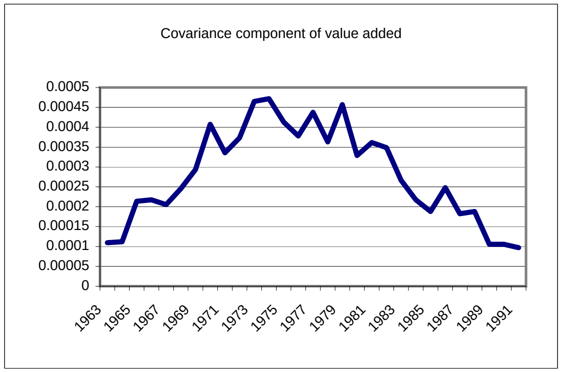
S&P Rating index ranges from2 for AAA to 20 for CCC. Residual obtained after controlling for age, size and industry.

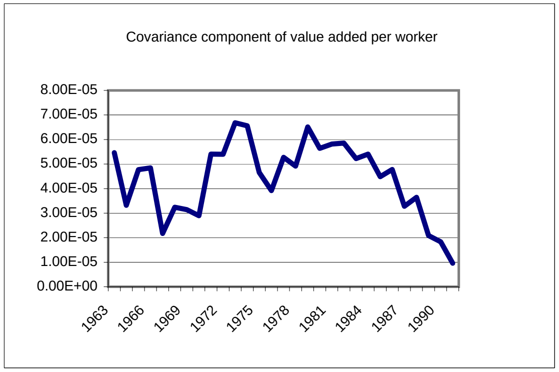
Table 4: Variance-Covariance-Correlation

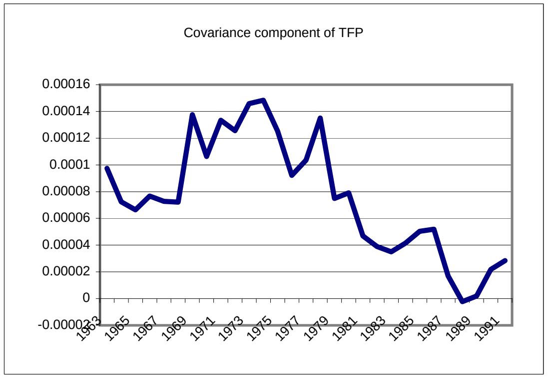


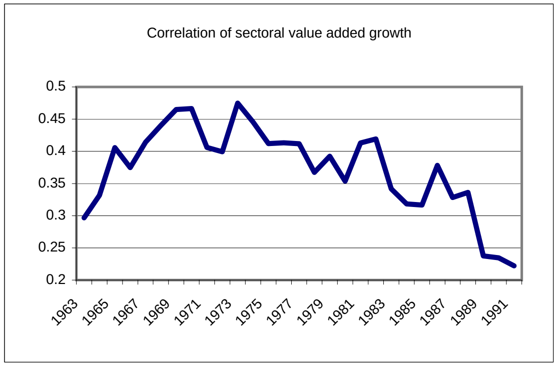


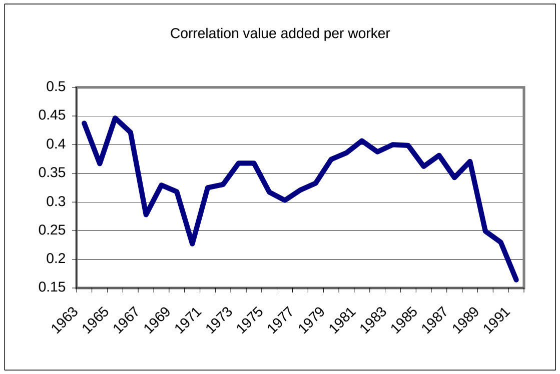


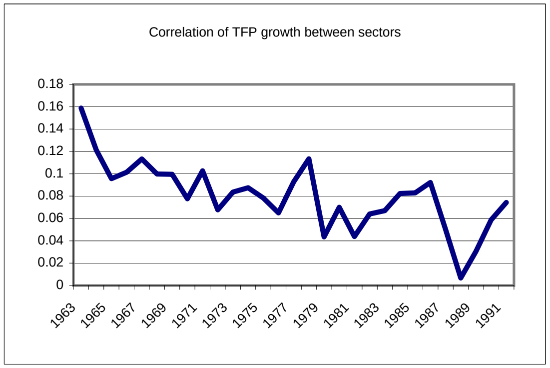












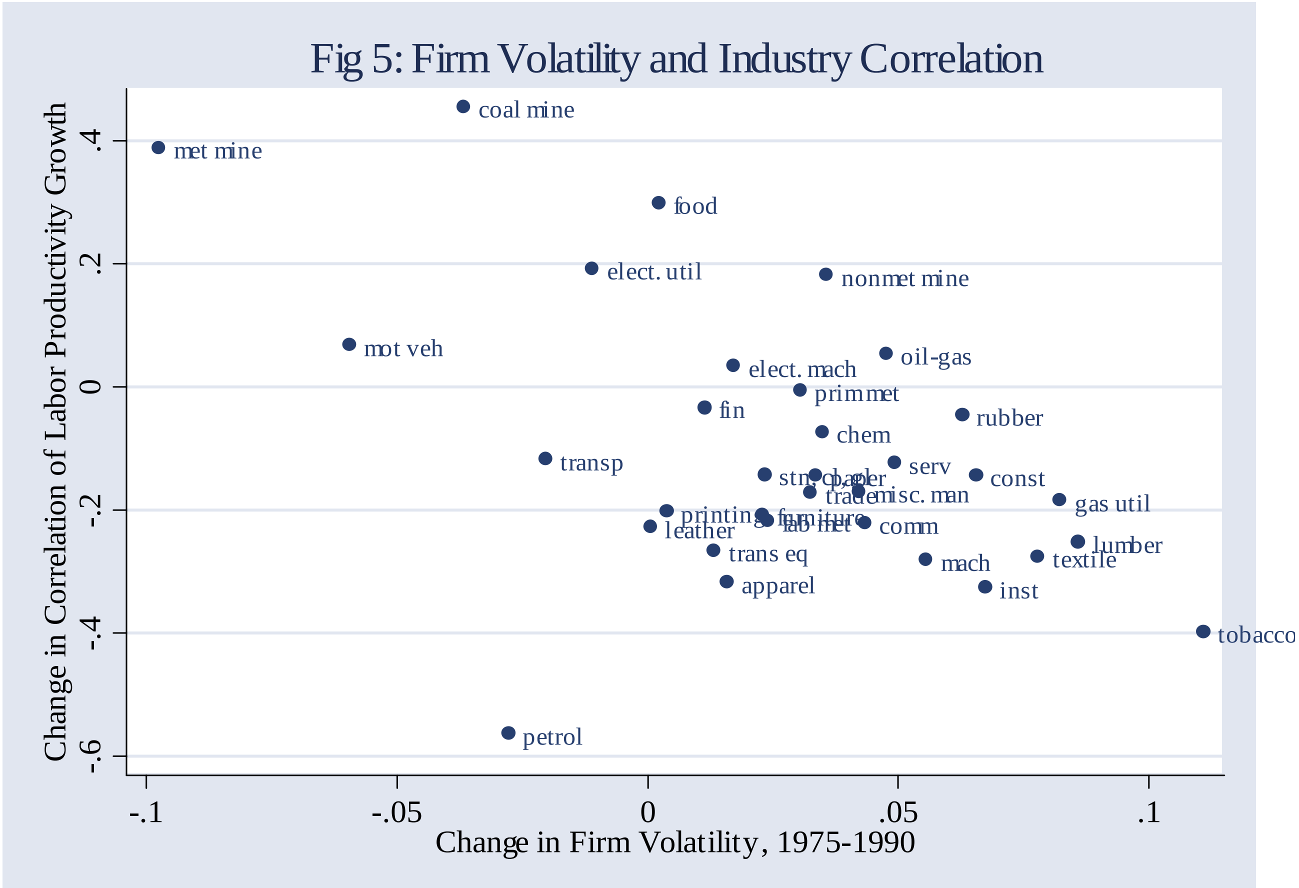


Fig 5: Firm Volatility and Industry Correlation
Change in Correlation of Labor Productivity Growth
Change in Firm Volatility, 1975-1990
-.6
-.4
-.2
0
.2
.4
-.1
-.05
0
.05
.1
coal mine
met mine
food
elect. util
nonmet mine
mot veh
oil-gas
elect. mach
prim met
fin
rubber
chem
transp
serv
const
paper
trade
misc. man
gas util
printing
furniture
fab met
leather
comm
lumber
trans eq
mach
textile
apparel
inst
tobacco
petrol