Diverging Trends in Macro and Micro Volatility: Facts

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Abstract

In this paper we document the diverging trends in volatility of the growth rate of sales at the aggregate and firm level. The upward trend in micro volatility is not driven by a compositional bias in the sample studied. We also show that many other firm level variables display a similar upward trend in volatility. Finally, we argue that this new fact renders obsolete the proposed explanations for the decline in aggregate volatility and that, given the symmetry of the patterns at the micro and macro level, a common explanation is highly likely.

1 Introduction

The interest of macroeconomists in the volatility of macro variables has increased substantially in recent years. McConnell and Perez-Quiros [2000] have shown that since the mid 1980's the volatility of aggregate sales has declined significantly. Blanchard and Simon [2002] show that indeed there is a downward trend in volatility of GDP starting in the 50's with the exception of the 70's. Stock and Watson [2002] analyze the time series of 124 macro variables since 1960 and show that the decline in aggregate volatility, beginning in 1984, is pervasive. Reinforcing this evidence, the return on some aggregate index like the S&P 500 was less volatile in the 80's and 90's than in the 70's.

Intriguingly, this downward trend in volatility is not observed at the micro level. Comin [2000] finds that the volatility of individual stock returns has increased monotonically since the 1950's. Campbell et al. [1999] find the same upward trend in the firm-specific risk. Comin [2000] also finds that at the 2-digit manufacturing level, there is an upward trend in the excess job reallocation rate between 1973 and 1993 (a measure of the degree of turbulence in the labor market) despite the fact that Davis, Haltiwanger and Schuh [1996] find that at the aggregate level, the excess job reallocation rate is flat. Also in the labor markets, Gotshalk and Moffit [1994] find that the wages of the individuals in the PSID were more volatile in the 1980's than the 1970's.

This paper takes a careful look at the evolution of volatility of non-financial variables at the firm level, as opposed to the markets, in order to validate the fact that micro and macro volatility have followed diverging trends, at least, since the mid 1980's. To inspect this hypothesis, we analyze the volatility of the growth rate of nominal sales for the firms in the COMPUSTAT database. We find strong evidence of the diverging patterns of the volatility of the growth rate of sales at the macro and micro level. To show that this finding is robust, we conduct several checks in sections 3 and 4. First, we show that both cross-sectional and time series measures of micro volatility are upward trending. An important issue when using the COMPUSTAT database is the possibility of a bias due to the change in the composition of the sample. To establish that our results are not driven by a compositional change, we show that the pattern holds for all the quintiles in the distribution of sales, that it also holds once we remove the predictable effect of age and size on the firm-level volatility and, finally, that the increase in micro-volatility is also robust to controlling for firm-specific aspects.

Once we have proved the diverging macro and micro trends in the volatility of the growth rate of sales, we try to assess the pervasiveness of the pattern by turning our attention to other COMPUSTAT variables like the share in net sales of profits, the cost of goods sold, general expenses, interest expenses and labor costs. All of these variables display trends similar to the volatility of the growth rate of firm-level sales.

In section 5, we use our empirical findings to evaluate the explanations proposed to understand the decline in aggregate volatility. These can be divided in two groups. The first group attempts to explain the decline in macro volatility through mechanisms that lead to a decline of volatility at the firm level and then, trivially, aggregate up the micro behavior. The second group of explanations tries to explain directly the decline in macro volatility. Both of these approaches are unsatisfactory in the light of the facts presented in this paper. The first is clearly at odds with the increase in micro volatility. The second, though not completely inconsistent, is clearly insufficient to account per se for the upward trend in firm-specific uncertainty. To fill this gap, in section 5 we propose a simple explanation that can account simultaneously for the opposite trends observed in micro and macro volatility.

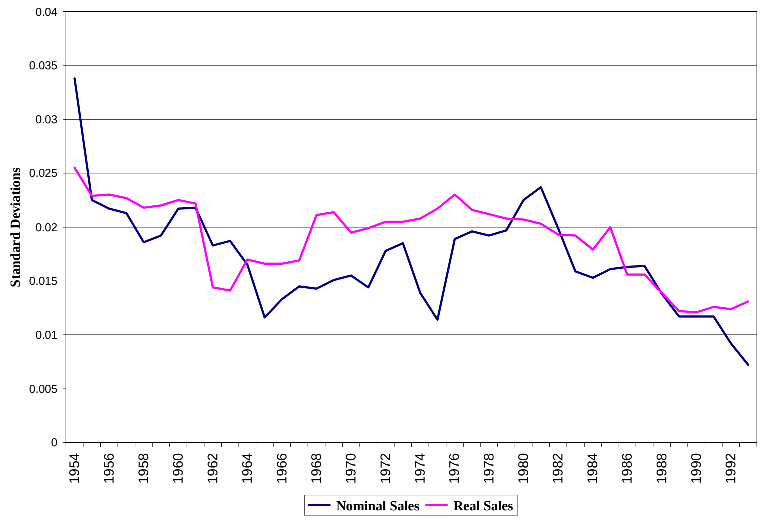

Figure 1: Aggregate time series, rolling windows of standard deviations of growth rate of nominal and real sales.

2 Macro Facts

We illustrate here the decline in volatility at the aggregate level. We start by examining annual data on aggregate sales expressed in nominal and real terms. Growth rates for these variables, as for all variables examined are calculated as follows:

$$X_t = \frac{X_{t+1} - X_t}{(X_{t+1} + X_t)/2} \tag{1}$$

Then we compute a series of the standard deviations of 10-year rolling windows for both the growth rate of nominal and real aggregate sales (i.e $\sigma_t = \sigma(X_{t-4} : X_{t+5})$). These series are plotted in figure 1.

Rolling window results for both the real and nominal aggregate sales variables show significant declines in volatility beginning in the 1980's. As emphasized by Blanchard and Simon [2002] for GDP, the time series for aggregate volatility can be better characterized by a secular decline that started in the 1950's and was interrupted from the mid 60s through the 70s. Given the similar downward trends in both nominal and real sales, inflation adjustment does not seem to be a significant issue.

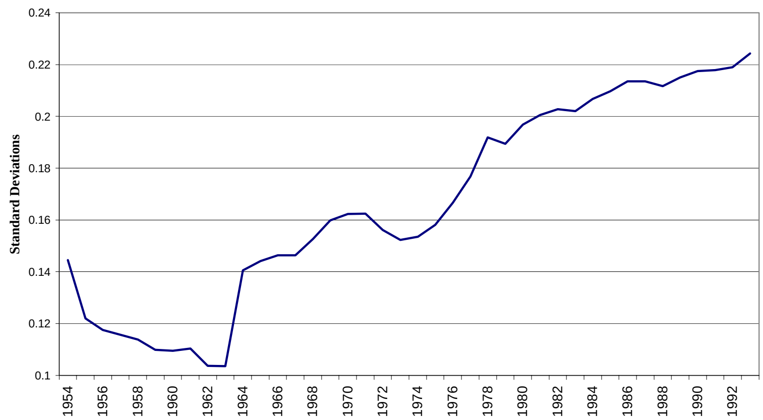

Figure 2: Micro time series, rolling windows of average standard deviations of growth rate of nominal sales.

3 Micro Facts

To investigate the evolution of the volatility at the micro level, we use the merged COMPUSTAT-COMPUSTAT annual data base. We extract data on net nominal sales at the firm level dropping the firms for which we do not have 11 consecutive observations. These represent a mere 3 percent of the total sample. We then compute the rolling windows in a similar manner at the micro level. After deriving the series of standard deviations across 10 year intervals for every firm, these standard deviations are averaged across firms to arrive at the standard deviation for every year. Volatility at the firm level clearly exhibits a significant upward trend as illustrated by figure 2. When examined along with the data at the aggregate level, the diverging trends are quite evident (figure 3).

In order to acquire a more representative measure of volatility, we weight the standard deviations. While averaging across firms for a given year, the standard deviation of every firm is weighted using its sales as a share of total sales. As can be seen in figure 4, the upward trend in volatility persists.

Another way to measure the volatility inherent in the firm's environment is by focusing on the cross-section instead of the time series. This involves computing standard deviations of growth rates across all the firms in a given year. Figure 5 reflects the steady increase in volatility at the firm level.

The source of this increase in volatility is subject to question. While the upward trend may,

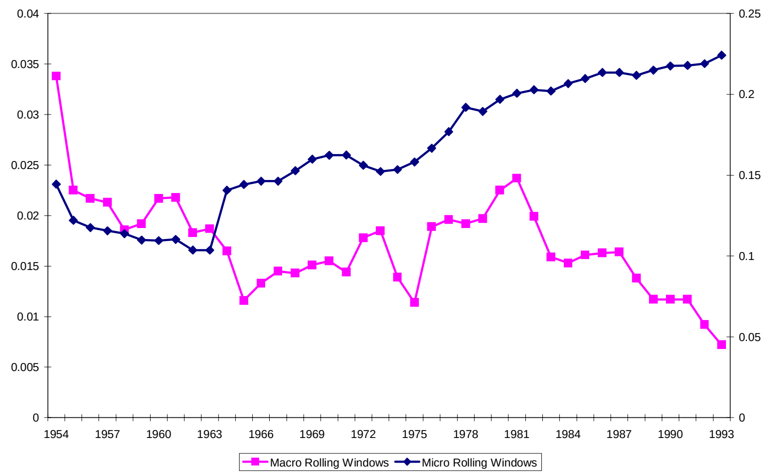

Figure 3: Micro and macro volatility.

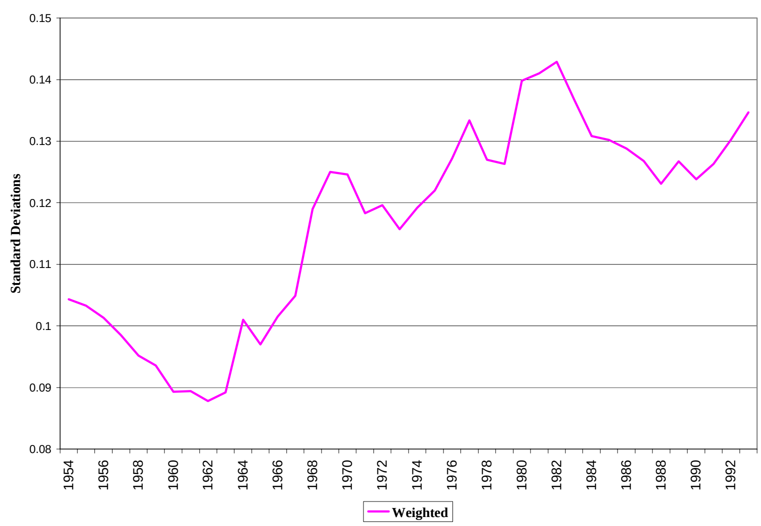

Figure 4: Micro time series, rolling windows of weighted average standard deviations.

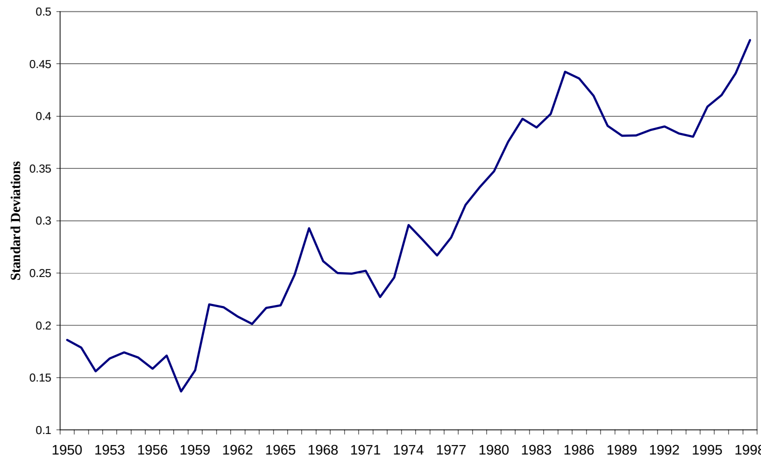

Figure 5: Cross section, average standard deviation of firm level growth rate of sales.

as we claim, accurately reflect changes in the economy, the increased volatility may be a feature specific only to the sample in use. Our claims neccessitate discrediting the latter possibility.

The data set used was extracted from the COPMPUSTAT database for years 1950 through to 2000. The size of the sample increases drastically in the 70's raising some concerns regarding the possibility that the upward trend in the firm-level volatility is the consequence of compositional bias. This may arise because the firms that are incorporated in the data set in the post 70s period, are more volatile than those that existed throughout either because the sector where they operate is more volatile, or on account of some firm specific attribute like being younger or smaller. The following section checks the robustness of the claimed upward trend in firm level volatility by controlling for compositional changes.

4 Robustness to test for composition

In order to show that the upward trend in micro volatility is not due to a compositional bias in the sample studied, we conduct three exercises. First, we divide up the sample at any point in time in five quintiles according to the level of sales and investigate whether the increase in volatility is driven by any specific quintile or holds across the board.

In figure 6 we can appreciate that the firm-level volatility has increased in all five quintiles as one would expect if the firm's environment had become more uncertain. This finding, though, does not

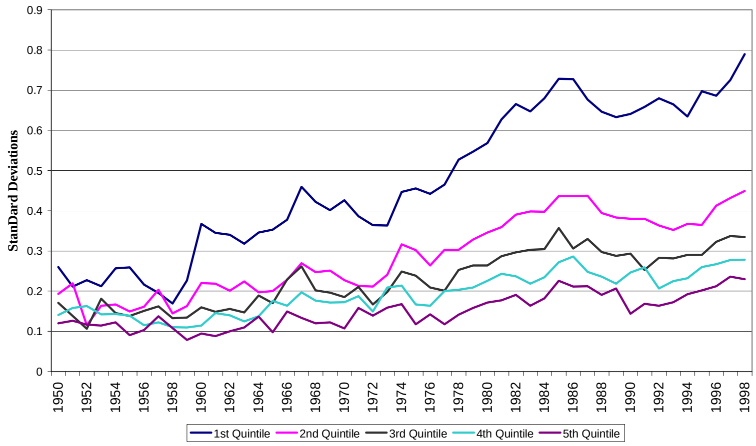

Figure 6: Micro cross section, standard deviations of growth rates by quintiles

not neccessarily negate the compositional bias argument. In theory, given the higher probability of sampling smaller firms in the post 1970 period, all the quintiles may be composed to a larger extent of smaller, more volatile firms.

To further control for changes in composition, we focus our analysis on the volatility component that is not predictable by the firm-level characteristics that have changed in the sample. Specifically, we run a pooled regression of the firm-level standard deviations on a vector of the firms characteristics (X_{it}) as in equation (2).

$$\sigma_{it} = \alpha_0 + \alpha_1 \; X_{it} + \epsilon_{it}^{\sigma} \tag{2}$$

Then, we aggregate up the unpredictable component of volatility to come out with an equivalent time series for the firm-level volatility. As in the previous section, we consider both weighted and unweighted measures of residual volatility, where the weights are given by the firm's share in total sales in the year. The first set of firm characteristics we control for is composed of age and age squared. With this we control for the fact that over time, the share of young (more volatile) firms in sample has increased presumably faster than in the US economy. In figure 7 we can see that removing the volatility attributable to changes in age does not diminish the upward trend in volatility.

Size is also an important determinant of firm-level volatility. To control for the effect of changes in the size distribution of the sample on our measure of firm-level volatility, we consider two addi-

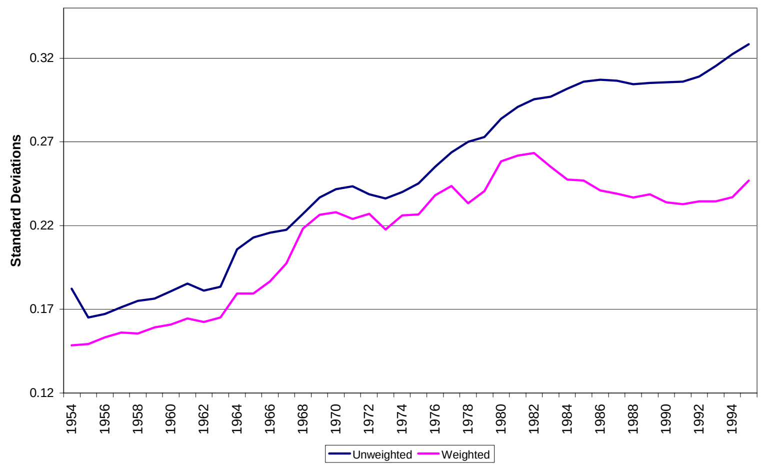

Figure 7: Controls; residuals from $\sigma_{it} = \alpha_0 + \alpha_1 \ age_{it} + \alpha_2 age_{it}^2 + \epsilon_{it}^{\sigma}$

tional variables in X_t. In figure 8, we report the series of the residual volatility after having included in X_t the firm share of sales in GDP in addition to age and age squared. In figure 9, we report the evolution of residual volatility when we control for the share of firm sales in the nominal value added of the sector apart from age and age squared. In both figures we can appreciate a prominent upward trend in volatility, though in the weighted measures there is a flattening of the trend in the 80's and 90's.

The evidence presented so far speaks against the hypothesis that the observed upward trend in firm specific uncertainty is just the result of the inclusion in sample of a larger share of small or young more volatile firms since 1970. However, it can still be argued that factors other than size or age induce higher volatility in the new population of firms sampled leading to a compositional bias. To rule out this possibility, we use firm specific dummies to eliminate the effect of firm specific variables (both observable and unobservable) on volatility. After removing this firm specific component of volatility, we are left with the component that is orthogonal to any firm characteristic and, therefore, immune to any compositional bias in the sample. Note that, this exercise constitutes a stringent test of the upward trend in micro volatility hypothesis. To illustrate this point, suppose that the trend is due to the fact that new firms in the economy are just more volatile. By removing the firm specific component of all the firms in sample, we would be eliminating the component that is more volatile for new firms and therefore denying a true fact. Nevertheless, throwing a firm fixed

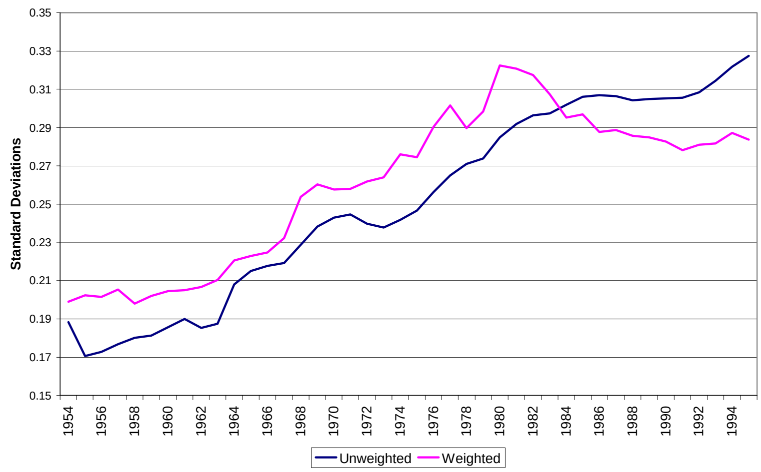

Figure 8: Controls; residuals from $\sigma_{it} = \alpha_0 + \alpha_1\ age_{it} + \alpha_2 age_{it}^2 + +\alpha_3 sales_{it}/GDP_t + \epsilon_{it}^{\sigma}$

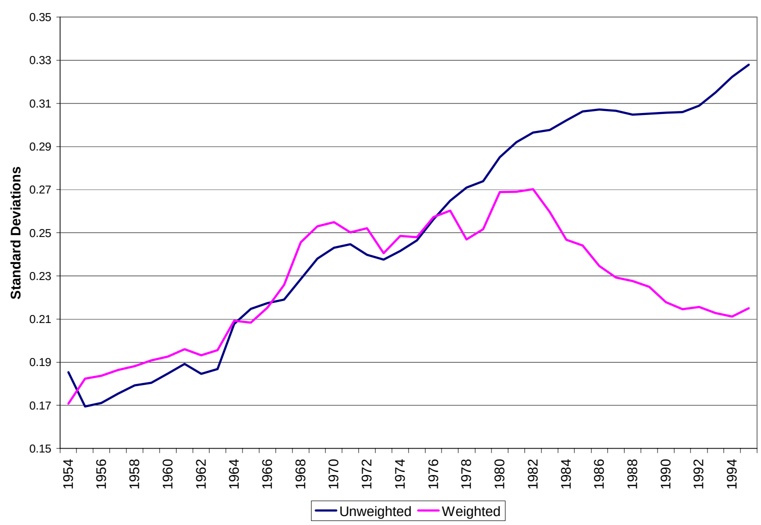

Figure 9: Controls; residuals from $\sigma_{it} = \alpha_0 + \alpha_1\ age_{it} + \alpha_2 age_{it}^2 + \alpha_3 sales_{it}/Total\ sales_{st} + \epsilon_{it}^{\sigma}$

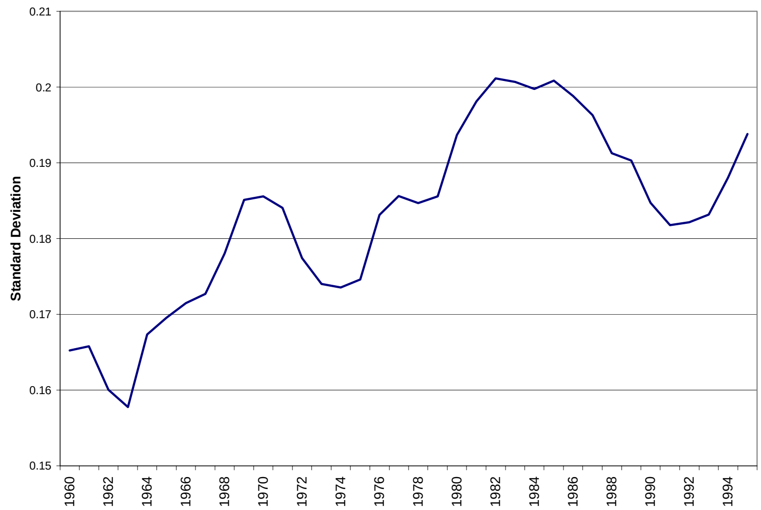

Figure 10: α_t from the regression: $\sigma_{it} = \alpha_i + \alpha_t + \epsilon^{\sigma}_{it}$

effect in the regression is an informative exercise because if the upward trend still holds we can claim that it is not due to a compositional bias in the sample studied.

Formally, we run the following regression where α_i is a set of firm specific dummies and α_t is a set of time dummies. Figure 10 plots the series of α_t.

$$\sigma_{it} = \alpha_i + \alpha_t + \epsilon^{\sigma}_{it}$$

It is clear from this picture that even after removing the firm specific component in volatility, the upward trend persists. In the next section we investigate whether this pattern is common to the volatility of other micro variables.

5 Other Series

Building non-overlapping measures of the volatility of monthly and annual stock returns over 10 year windows for the firms in the COMPUSTAT data set, Comin [2000] observed an important upward trend in micro volatility. Table 1 reproduces his results. Column 1 illustrates a large increase in the average volatility of individual stock returns, dated somewhere between the mid 60s and the mid 70s, without any sign of decline through the 80s and 90s. This pattern is in stark contrast to the evolution of the volatility of the returns on some aggregate index like the S&P500 described in column 2. There we can see that the increase in aggregate volatility experienced in the 70s was followed by an important decline in the 80s and 90s.

As shown in the rest of the columns, the upward trend in micro volatility is robust to many variations. Column 3 only considers those stocks with more than two years of data. Column 4 computes the median of the standard deviation of individual stock returns. Column 5 computes the average across stocks of the standard deviation of the deviations from a stock and decade specific time trend. Column 6 computes the average standard deviation of yearly individual stock returns. This measure is more immune to fads, bubbles and other non-fundamentals sources of return variability. Reassuringly, its pattern is the same as in the other columns. One can, therefore, conclude that the measured increase in the volatility of asset returns mostly reflects an increase in the uncertainty of fundamentals.[1]

Again, this upward trend in firm level volatility could be ascribed to an increase in the sample in the share of small more volatile firms. To control for this composition effect, columns 6 and 7 compute the average standard deviation of individual stock returns for the firms in sample in the 50's and 60's respectively. Note that this approach could a priori bias the results against the increase in volatility because of a selection effect. Finally, column 8 reports standard deviations of the individual stock returns weighted by the share in total capitalization over the decade.

Campbell, Lettau, Malkiel and Xu [1999] have observed a similar upward trend in firm-level risk computed as the cross-sectional volatility of the component in firm specific returns that is orthogonal to the return in the sector and in the whole market.

Comin [2000] has also observed micro turmoil and macro stability in manufacturing labor markets as measured by the excess job reallocation rate in the LRD. Davis, Haltiwanger and Schuh [1996] report no trend in the annual aggregate excess job reallocation rate for the LRD. However, at the 2-digit manufacturing level, Comin finds that there is a significant upward trend in the excess job reallocation rate.

COMPUSTAT also gives us a larger number of variables to investigate the prevalence of the upward trends in micro volatility. In this section, we report results for the share in sales of profits, of the costs of goods sold, of general expenses, of labor costs and of the cost of borrowing. For each variable x and firm i we compute the standard deviation of variable x in a ten year rolling window

[1] One could also argue that the increase in short term volatility is due to the faster trading methods available since the 1970's. However, the increase in volatility is robust to the length of the periods over which the returns are computed and this limits very much any potential concern about changes in the trading technology.

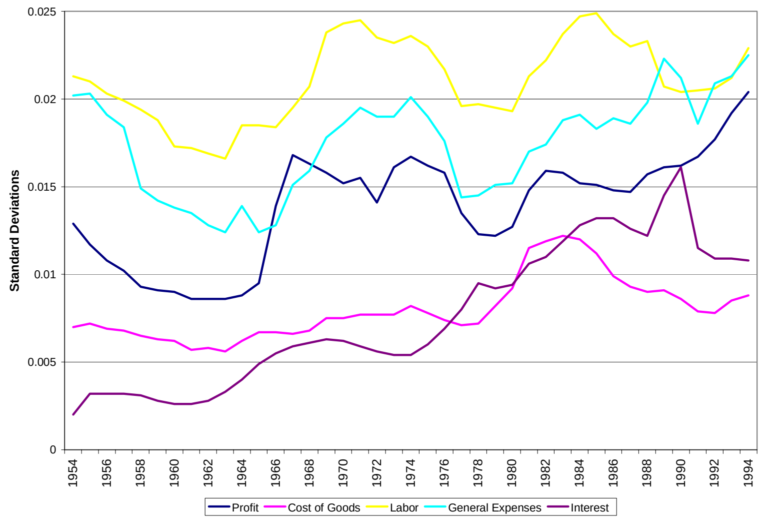

Figure 11: Rolling windows for the standard deviation of the share of variable X on net sales

and then we weight these firm specific time series by the share of sales in total sales.

The examination of the evolution of these variables reinforces our claim of increase in firm level volatility as can be appreciated in figure 11.

6 Conclusions

The US economy has experienced two opposite trends in several variables. At the macro level, these variables have become less volatile, with an interruption of this trend during the 70s and early 80s. At the micro level, however, the trend has been upwards, indicating that firm level volatility has increased. As we shall see next, this second fact has interesting implications for the evaluation of the proposed explanations for the decline in aggregate volatility. Moreover, the striking symmetry of the diverging trends makes it very tempting to pursue a common explanation (or set of explanations).

McConnell and Perez-Quiros [2000] proposed that new inventory management methods, such as just-in-time inventory management, are the source of the reduction in volatility in GDP. This mechanism operates at the firm level and, therefore implies that the volatility of net sales at the firm level should decline too. This contradicts the evidence presented in this paper.

Another line of research argues that part of the decline in aggregate volatility is due either to a reduction of the volatility of the shocks that hit the US economy or to an increase in the effectiveness of monetary policy to stabilize these shocks (Boivin and Gianonni [2002], Clarida, Gali and Gertler [2000], Congley and Sargent [2001], Gali, Lopez-Salido and Valles [2002], Primiceri [2002] and Sims and Zha [2002]. Though interesting and possibly true, these approaches cannot constitute the primary mechanism to explain the decline in aggregate volatility since, in principle, there is no reason to think that a decline in the aggregate volatility of shocks (or of their effect on the economy) is going to increase the uncertainty faced by individual firms. This consequence is, at the very least, not obvious.

This argument is consistent with Stock and Watson [2002]'s conclusion about the fraction of the decline that different candidate explanations can account for. They claim that after considering the reduction in the volatility of shocks and the increase in the effectiveness of monetary policy, at least half of the decline in volatility remains unexplained.

Since we are skeptical of theories attempting to explain any one of the two symmetric trends in isolation, we are going to devote the last paragraphs of the paper to sketch a new explanation to the decline in aggregate volatility. One that very naturally explains at the same time the increase in firm level volatility.

The simplest way to understand our explanation is in the context of the Dornbush, Fisher, Samuelson [1977] Ricardian trade model with trade costs (i.e. transport costs) and country specific productivity shocks. The force that drives the two divergent trends in volatility is a decline in the trade costs.[2] When this happens, the fraction of goods exported to the other countries rises and therefore, the demand faced by the national firms depends to a larger extent on the foreign productivity shocks. If the national and foreign productivity shocks are not perfectly correlated, the decline in trade costs is accompanied by a reduction in the volatility of GDP.

At the firm level, a decline in the trade costs increases the possibilities faced the firms: a larger fraction of firms can export their goods and capture international markets, but also a larger fraction is susceptible of being driven out of the market by international competitors. This leads to a higher volatility of the demand faced by the firms and therefore to an increase in the volatility of sales. In this way, a unique shock (namely, a decline in trade costs) can account simultaneously for the decline in aggregate volatility and the increase in firm level volatility.

[2] This same model can be relabeled to represent the integration of the US regions.

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