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Changes in the Volatility of Economic Activity at the Macro and Micro Levels

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Abstract

We review evidence on the Great Moderation in conjunction with evidence about volatility trends at the micro level. We combine the two types of evidence to develop a tentative story for important components of the aggregate volatility decline and its consequences. The key ingredients of the story are declines in firm-level volatility and aggregate volatility – most dramatically in the durable goods sector – but the absence of a decline in the volatility of household consumption and individual earnings. Our explanation for volatility reduction stresses improved supply chain management, particularly in the durable goods sector, and a shift in production and employment from goods to services. We also provide some evidence for a specific mechanism, namely shorter lead times for materials orders. The tentative conclusion we draw is that, although better supply chain management involves potentially large efficiency gains with first-order effects on welfare, it does not imply (nor is there much evidence for) a reduction in uncertainty faced by individuals.

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The decline of volatility in real economic activity over the past 50 years in the advanced economies is striking. Volatility reductions are evident for output, employment and productivity at the aggregate level and across industrial sectors and expenditure categories. Previous studies advance several potential explanations for this “Great Moderation.” Some credit improved monetary policy for reductions in the volatility of both real activity and inflation (e.g. Clarida, et al., 2000). Others suggest that financial innovation and increased global integration play a role (Dynan et al., 2006). Still others, pointing to evidence that output volatility fell more than sales volatility, highlight the potential role of technological change in the form of better inventory control methods (e.g., Kahn et al. 2002). Another line of research (e.g., Stock and Watson, 2002) stresses “good luck” in the form of less volatility in exogenous driving forces.

These explanations are not mutually exclusive. As Bernanke (2004) remarks in his discussion of the Great Moderation: “Explanations of complicated phenomena are rarely clear cut and simple, and each … probably contains elements of truth.” The main elements can also interact in complicated ways. Perhaps, for example, the unsuccessful monetary policy of the 1970s or the more successful policy that followed facilitated the spread of volatility-reducing financial innovations. Or, perhaps sound monetary policy is easier when shocks are milder. Nonetheless, even if no single factor fully explains the phenomenon, it is useful to amass evidence for and against particular hypotheses.

We consider a variety of evidence related to The Great Moderation, drawing mainly on U.S. data, and work towards a story with a few key themes. Unlike most research on the topic, we consider volatility behavior at the micro level for clues about the sources and consequences of aggregate volatility changes. As it turns out, the micro story is complex. The average volatility of firm-level employment growth fell after the early 1980s but trended in opposite directions for publicly traded and privately held firms (Davis et al. 2006). In financial data, the variance in the idiosyncratic component of firm-level equity returns more than doubled from 1962 to 1997 (Campbell et al. 2001). However, this trend largely reflects an influx of increasingly risky new listings (Fama and French, 2004, Brown and Kapadia, 2007). At the individual level, several indicators point to a large decline in the risk of unwanted job loss since the early 1980s (Davis, 2007). However, when we consider household-level consumption changes, we find no evidence for a decline in volatility after the 1980s. The available evidence on individual earnings uncertainty points to a longer term rise, not a decline.

We begin with some facts about the Great Moderation and a review of the macroeconomics literature. We then turn to evidence from micro data. We review the short, and volatile, history of thought on the evolution of microeconomic volatility, and describe some new work on household consumption data. With that as background, we then return to the macroeconomic arena and try to piece together a coherent story. As partial explanations for the Great Moderation, our story stresses improved supply chain management, particularly in the durable goods sector, and a shift in production and employment activity from goods to services. We also provide some evidence for a specific mechanism, namely shorter lead times for materials orders. The last part of the paper describes a model of improved inventory control that is broadly consistent with the facts about reduced volatility in the durable goods sector, and also provides some evidence for a specific mechanism, namely shorter lead times for materials orders.

I. Reduced Volatility of Aggregates

An abrupt drop in the volatility of U.S. real GDP growth in the early 1980s (Figure 1) provided the initial impetus for research on The Great Moderation. Early findings of a discrete break in volatility around 1983 (McConnell and Perez-Quiros, 2000) encouraged a focus on comparisons before and after 1983. This approach conceals the fact that many economic series did not undergo an abrupt volatility drop around 1983. Some did so much earlier, some later. The “sudden drop” view also directs attention away from certain developments that perhaps play an important role in the long term decline of volatility. Structural shifts in the economy, e.g., a rising share of services in aggregate output, are unlikely to produce an abrupt drop in aggregate volatility.

We argue, echoing Blanchard and Simon (2001) somewhat, that the suddenness of the volatility drop is more apparent than real—that, in fact, large shocks in the 1970s and a deep contraction in the early 1980s obscure longer term developments that contributed to a downward drift in volatility even before the 1980s. Figure 2 provides some evidence on this issue, showing quarterly annualized growth rates for the four NIPA sectors that comprise GDP: nondurable goods, durable goods, services, and structures. Each is scaled by its nominal share of GDP so that the magnitudes (in terms of growth contributions) are comparable, and the scale of the charts is the same as in Figure 1. It is clear from these figures that only in the durable goods sector did volatility change in much the same way—both in terms of magnitude and timing—as GDP. Nondurables output volatility dropped, but it had also been lower in the 1960s before increasing in the 1970s, and in any case it was never anywhere nearly as volatile as durables. Thus the decline—such as it was—is unlikely to have been a major factor in the stabilization of the early 1980s. Service sector output was also never nearly as volatile as durable goods output, and moreover, its volatility dropped substantially in the early 1960s, and again in the 1970s, long before the break in GDP volatility. Structures output did experience a drop in volatility at the same time as overall GDP, but the size of the sector and the magnitude of the contribution is modest.[1]

Thus both in magnitude and timing, the drop in GDP volatility appears most closely related to developments in the durable goods sector. This is further illustrated in Figure 3, the top half of which plots rolling 5-year variances for the same four sectors and GDP, along with a "covariance" term reflecting the variance of GDP not accounted for by the variances of the sectors. This figure also makes clear that both for total GDP and especially for durables, the volatility decline in the early 1980s was an acceleration of a trend that dates back to World War II. Only the durables sector volatility exhibits a downward trend on the order of that followed by overall GDP volatility. The bottom half of Figure 3 shows the analogous chart for GDP volatility broken down by expenditure categories. Prominent in the evolution of volatility is the inventory investment term and the covariance term.

Figure 3 is just accounting, and does not prove cause and effect. It is possible that the decline in GDP volatility also caused the decline in durables sector volatility, or in inventory investment volatility, or that both had a common cause. Still, a challenge for any explanation of the overall decline in GDP volatility is to account for the specific patterns observed in this figure, as well as the more detailed facts regarding inventories and durable goods found below in Sections III and VI below.

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[1] Note that the volatility contributions depicted in the charts are also affected by trends in sector shares over time, but the effect is very slight. The pictures would look virtually identical if sector shares were held constant.

A question that frequently arises about the reduction in GDP volatility is the extent to which secular shifts in sector shares could account for declines in volatility. While it is true that the less volatile sectors such as services have grown over time relative to the more volatile goods sectors. It turns out, however, that at least as a far as these broad aggregates are concerned, the sectoral shift toward services plays only a modest role in the reduction of overall volatility. Specifically, if we reconstruct GDP growth fixing the sector shares at their values for a particular year, we get volatility reductions almost as large as in the raw data, and following similar patterns. Table 1 shows the results of this exercise using 1959 shares: The raw decline in GDP volatility using 1984Q1 as the break date is 1.97 percent, while with sector shares fixed at their 1959 values, the decline is 1.75 percent. Thus only about one-tenth of the decline is explained by sectoral shifts. Of course, this does not rule out shifts within the sectors we examine. **We will examine this issue in the next draft, exploiting more finely disaggregated data.**

II. Financial Markets

To be written.

III. Inventory Behavior

Another potentially important fact about the Great Moderation is that output volatility fell by substantially more than (and earlier than) final sales volatility, particularly in the durable goods sector.[2] Since the difference between output and final sales is the change in inventories, this fact implies a change in inventory behavior—either a reduction in the volatility of inventory investment, or a change in the covariance between inventory investment and sales. Note that by convention, the service and structures sector do not carry inventories (in structures this is because final output includes construction in progress), so the source of the change in inventory behavior must by definition lie in the goods sector.[3] Figure 4 shows the behavior of output and sales

[2] See McConnell and Perez-Quiros (2000), Kahn et al. (2002).
[3] There is, however, evidence of a change in inventory behavior in construction, even though it is not treated as such in the NIPAs. See Kahn (2000).

volatility over time in the durable goods sector. In contrast to the behavior of output volatility, sales volatility shows only a modest decline.[4]

Given our focus on the volatility of real growth rates (as opposed to levels), we can examine a similar relationship between output, inventories and sales in terms of growth contributions. Although inventory investment, because it can be negative, does not have a conventionally defined growth contribution, we can define it indirectly as the difference between the growth rate of output and the growth contribution of final sales (cf. Kahn et al, 2002). Following Whelan (2000) we can approximate the latter in terms of the real growth rate of sales and the nominal share of sales in output. Letting γ_{xy} denote the growth contribution of x to output y, where $x = s$ for sales and $x = i$ for inventories, we define the growth contribution of inventory investment as

$$\gamma_{iy} \equiv \gamma_{yy} - \gamma_{sy}$$

where $\gamma_{sy} = \gamma_{ss}\theta_{sy}$, θ_{sy} is the nominal share of s in y (measured as the average of current and lagged shares). The growth contribution of a variable to itself is just its real growth rate.

With these definitions in hand, we can track the contributions of sales and inventory investment to the variance of output growth over time:

$$\sigma_y^2 = \sigma_s^2 + \sigma_i^2 + 2\sigma_{si}$$

where the variances and covariance on the right-hand side refer to the growth contributions defined above. Figure 5 plots the three components for the durable goods sector. We see that both the inventory term and the covariance term exhibit a substantial downward trend, with the covariance term accounting in particular for the big drop in the early 1980s. Thus not only is the apparent break in 1984 associated with a change in inventory behavior, but the downward trend from the 1950s onward is as well.

IV. Inflation Moderation

In addition to the apparent break in volatility around 1983, that year is also often viewed as a turning point in monetary policy, the beginning of the Volcker-Greenspan era

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[4] McConnell and Perez-Quiros (2000) find evidence of a statistically significant break in the mid-1980s in durables output but not in final sales.

of low and stable inflation. A large literature, led by Clarida et al (2000), has debated the extent to which there was a change in monetary policy regime, one that had the effect of reducing both inflation and output volatility. For it to do both requires not just a more aggressively anti-inflationary policy, which according to traditional policy analysis would actually increase output volatility, but a superior policy that shifts the locus of the tradeoff.

It is worth noting that low and stable inflation is not a post-1983 phenomenon. Inflation volatility in the period from 1955 to 1969 was almost as low as it was after 1983 (See Figure 6). Yet output volatility was relatively high. This does not necessarily refute the "better policy" hypothesis, but it requires a more complicated story. The low inflation volatility/high output volatility combination of the earlier period could be consistent with a more anti-inflation policy stance, but still with policy rules or responses that were inefficient relative to those of the post-1983 era. If one envisions a tradeoff between inflation and output volatility, this view would represent the 1950s and early 1960s as choosing a low-inflation point on that tradeoff, whereas the Greenspan-Volcker era policies actually shifted the terms of the tradeoff, allowing lower volatility of both output and inflation.

But while one can tell such a story, there is little evidence to support it. Romer and Romer (2002a, 2002b), in fact, argue that policy in the 1950s was similar to policy in the 1990s. Moreover, if one considers the more detailed breakdown of volatility declines discussed thus far, it becomes even more difficult to tell a story that gives a great deal of weight to improved monetary policy. As argued in Kahn et al (2002), such a story would have to explain why improved monetary policy would affect one sector more than another, and output volatility differently from sales volatility. No doubt it is possible to construct models that have these implications, given the greater interest sensitivity of durable goods demand, but a quantitative case for the ability of a monetary model to explain these facts has yet to be made.

One argument in favor of the "better policy" hypothesis is that it is potentially the one story most compatible with a discrete change such as researchers have found in the volatility data. Technical progress associated with improved inventory management is unlikely to have been implemented suddenly. Financial innovation was a gradual process, even if there were discrete events such as the development of new securities or the opening of a new type of market. Of course, one discrete event that undoubtedly contributed to reduced volatility in the structures sector was the phaseout of Regulation Q's interest rate ceilings in the early 1980's as part of the Monetary Control Act of 1980 (see, for example, Bernanke, 2007). The limits on interest on deposits made credit availability to the housing sector (which was especially dependent on this source of funds) highly sensitive to increases in market interest rates, and thus to contractionary monetary policy. As argued above, however, the structures sector, and residential construction in particular, was too small to make much of a dent in the overall volatility of GDP. Finally, the "good luck" hypothesis does not have a structural story behind it (it being really a sort of residual hypothesis that remains standing when more specific models fail to explain the data). To be compelling, the "good luck" hypothesis requires support in the form of reduced volatility in identifiable, measurable and arguably exogenous disturbances.

Monetary policy, on the other hand, can certainly be subject to sudden changes in "regime." In the last 20 years, for example, many central banks around the world have adopted "inflation targeting" regimes that represent a discrete departure from earlier policies. In October 1979 the Federal Reserve under Volcker shifted from targeting the Federal Funds rate to targeting non-borrowed reserves, a regime that lasted until 1983. A number of studies (e.g. Clarida et al, 2000) provide evidence that the interest rate targeting regimes pre-1979 and post-1983 were fundamentally different, the former resulting in both inflation and output instability.

Nonetheless, the evidence of the importance of such regime shifts is ambiguous. Sims and Zha (2006) argue that changes in monetary policy regimes were relatively inconsequential, and in any case do not line up very well with changes in volatility. In a series of papers, Athanasios (e.g. 2002) argues that the policy regime of the 1970's was not fundamentally different, but was hit with large structural changes (a higher "natural" unemployment rate, lower trend productivity growth) for which it had limited and imperfect information in real time.

There are, moreover, good reasons to doubt the hypothesis that a sudden regime shift in monetary policy is responsible for the discrete drop in volatility post-1983.

Modern research on monetary policy points to a variety of factors that influence the efficacy of monetary policy. These include the credibility of the policymaker, transparency, and the commitment to rules (as opposed to maintaining discretion). While with the benefit of hindsight, the Volcker-Greenspan era represents a discrete break with the immediate past (though as argued earlier, perhaps not with the policies of the 1950s and early 60s), nonetheless it is asking a lot to believe that enhanced credibility was achieved overnight. In addition, increased transparency has been an evolutionary process. The FOMC only began making public its interest rate target decisions in 1994. Only in 1998 did the committee begin releasing statements explaining its policy decisions, and the informational content of these statements has continued to evolve. Finally, the FOMC has yet to adopt an explicit inflation target, make its economic forecasts public, or move toward any semblance of an explicit policy rule.

At the same time, there is no question that in many important ways, monetary policy is more transparent. The statements released with the announcement of decisions are increasingly substantive and informative, the minutes of the FOMC meetings are now released sooner after the meeting than in the past, and public statements by the Chairman and committee members have undoubtedly reduced the opaqueness of policy. There is wealth of evidence that uncertainty about future inflation has been substantially reduced [citations]. In view of all this, there is little doubt that monetary policy has advanced considerably in the last 25 years. But the contention that there was a discrete and substantial break in 1983 that can explain a discrete drop in volatility beginning in the early 1980s is dubious at best.

On the other hand, the evidence described earlier indicates that to some extent the break in volatility in the early 1980s may be a red herring. A broader view suggests that aggregate volatility has both a trend and cyclical component, and that the trend has been downward (though, as argued by Blanchard and Simon, 2001, interrupted by the turbulent 1970's) throughout the postwar era, perhaps leveling out since the mid-1980s. Note that in Figure 3, the volatility troughs, which tended to occur toward the beginning of lengthy expansions, are successively lower until the 1990s. The peaks, which tended to occur at the ends of expansions, are also successively lower until the 1990s except for the 1975-83 period.

The volatility of the 1970's does support a role for monetary policy in the Great Moderation, but not the one emphasized by the adherents of that view. It suggests that policy mistakes during that decade may have contributed to increased volatility, and an interruption in the longer-term trend toward reduced volatility. The cessation of those mistakes (whether from a regime change or from the dissipation of the shocks of the early 1970s), and a return to policies more resembling those of the 1950's and early 1960's, may have allowed volatility simply to return to its previous trend. This gave the appearance of a large drop in volatility, but only because volatility's downward march had been temporarily suspended. Whatever factors were in motion over the postwar period to reduce volatility over time were continuing, and in time, after the disruptions of the 1970's, reasserted their dominance.

So to summarize, the case for an important role for monetary policy in the Great Moderation is not helped substantially by the apparent suddenness of the drop in volatility in the early 1980s. This is both because it is at least questionable whether monetary policy had a sudden break with its past, and because the drop in volatility was not as discrete or sudden as it appears, but in fact had been ongoing until interrupted in the 1970's. Monetary policy may have inadvertently contributed to the Great Moderation by adding to volatility in the 1970's before some combination of the economic environment and policy itself reverted to something resembling earlier times. A persuasive case for a more positive role for would require (a) distinguishing how policy in the post-1983 period was distinctive from both the policies of the 1970's and the 1950's; and (b) a model that predicts the changed monetary policy would have a disparate impact on sectoral volatility, and on inventory behavior.

V. Changes in Micro Volatility

A. Firm-Level Volatility in Sales and Employment Growth Rates

Several recent studies find a secular rise in volatility among publicly traded firms.[5] Prominent examples include Comin and Philippon (2005) and Comin and Mulani (2006).

[5] Here, "publicly traded" refers to firms with equity securities listed on a stock exchange or traded in over-the-counter markets. As a practical matter, given the heavy reliance on COMPUSTAT for research in this area, "publicly traded" means firms that are also in COMPUSTAT, which has reasonably comprehensive coverage of publicly traded firms since the addition of NASDAQ listings in 1973.

Figure 8 replicates a key finding from these two studies. It shows that the cross-sectional average of firm-level volatility in sales and employment growth rates roughly doubled from the early 1960s to the late 1990s.[6] This type of evidence persuaded many observers that business-level volatility rose sharply in recent decades, in glaring contrast to the big drop in aggregate volatility. Evidence of rising variability in firm-level equity returns, discussed below, seemed to provide independent support for this view.

It turns out, however, that the volatility trend among all firms displays a dramatically different pattern than the one in Figure 8. To develop evidence on this issue, Davis et al. (2006) exploit the Longitudinal Business Database (LBD), which covers all tax-paying businesses in the nonfarm private sector of the U.S. economy.[7] Using LBD employment data, they first confirm a strong rise in average volatility among publicly traded firms, broadly in line with results from COMPUSTAT data. They then repeat the same volatility calculations for all firms, publicly traded and privately held alike, and find a 40% *decline* in firm volatility from 1982 to 1996.

Figure 9 reproduces a key figure in Davis et al. (2006), showing the average volatility of employment growth rates for publicly traded, privately held, and all firms.[8] Volatility is high and declining for privately held firms, low and rising for publicly traded firms. In other words, there is strong move toward "volatility convergence" between publicly traded and privately held firms. The same pattern holds for the volatility of establishment growth rates, although the movements over time are smaller. The volatility convergence phenomenon also occurs within all major industry groups, as seen in Table 2. As this table indicates, the volatility convergence pattern in Figure 9 does not arise from different industry distributions for publicly traded and privately held firms.

So why does the volatility trend among publicly traded firms depart so much from the overall trend? At one level, the answer is simple: publicly traded firms account for less than one-third of private sector employment, so there is much room for the trend among

[6] Firm-level volatility is calculated from COMPUSTAT data as a moving ten-year window on the standard deviation of firm growth rates. The volatility measure is limited to firm-level observations for which a ten-year window is available. Thus, entry, exit and short-lived firms are excluded.
[7] Access to the LBD is available to non-Census personnel for approved projects through the Center for Economic Studies at Census Bureau facilities in Suitland, Maryland and through one of several Census Research Data Centers operating at various locations. See www.ces.census.gov for more information.
[8] Figure 9 shows results for a modified volatility measure that captures entry, exit and short-lived firms, and that does not require the deletion of observations near sample end points.

publicly traded firms to depart from the overall trend. Digging deeper reveals another, more interesting, answer: There was a pronounced shift in the economic selection process governing entry into the set of publicly traded firms, and this shift greatly affected volatility trends among publicly traded firms.

To see this, it is important to first recognize the large influx of newly listed firms in the 1980s and 1990s. Fama and French (2004) report that the number of new lists (mostly IPOs) on major U.S. stock markets jumped from 156 per year in 1973-1979 to 549 per year in 1980-2001. Remarkably, about 10% of listed firms are new each year from 1980 to 2001. Davis et al. (2006) report that firms newly listed in the 1980s and 1990s account for about 40% of employment among all publicly traded firms by the late 1990s. So the influx of new lists in the 1980s and 1990s is large in number and eventually accounts for a large share of activity.

Second, Fama and French (2004), among others, also provide evidence that new listings are riskier than seasoned public firms by a variety of measures, *and* that they become increasingly risky relative to seasoned firms after 1979. Likewise, Davis et al. (2006, Figure 11) find higher volatility of employment growth rates for publicly traded firms that first list in the 1980s and 1990s. Taken together, these results point to the influx of successively riskier and more volatile cohorts as an important source of the upward volatility trend among publicly traded firms.

To quantify the contribution of these cohort effects to the volatility trend for publicly traded firms, Davis et al. use a regression approach. They first fit a weighted least squares regression of firm-level volatility on year dummies in COMPUSTAT data, with weights proportional to firm size. The fitted year effects trace out the time path of firm-level volatility, and the difference between year effects $\left(\Delta\hat{y}\right)$ gives the change in volatility between two points in time. To quantify the percentage of the volatility change accounted for by cohort effects, they then expand the regression to include one-year cohort dummies (year of first listing) and consider the change in estimated year effects with cohort controls $\left(\Delta\hat{y}^{CC}\right)$. Lastly, they calculate the percentage of the volatility change accounted for by cohort effects as $100\left(\Delta\hat{y}-\Delta\hat{y}^{CC}\right)/\Delta\hat{y}$. According to this calculation, simple cohort effects alone account for 67% of the volatility rise among publicly traded firms from 1978 to 2001. In contrast, analogous calculations for size, age and industry effects – separately or in combination – account for little of the volatility rise among publicly traded firms.

B. Firm-Level Variability in Equity Returns

An influential paper by Campbell et al. (2001) documents a large upward trend in the volatility of firm-level equity returns for U.S. common stocks. Specifically, they find that the variance of firm-level returns in daily data more than doubles from 1962 to 1997. They also show that the trend increase in firm-level return volatility reflects a rise in the volatility of the idiosyncratic, firm-specific component. These findings stimulated several investigations into the reasons for the rise in the volatility of firm-level equity returns and its implications.[9]

As we discussed above, Fama and French (2004) document a large influx of newly listed firms, increasingly risky public firms in the 1980s and 1990s. Based on their review of the evidence, they conclude that this upsurge of new listings explains much of the trend increase in idiosyncratic stock return volatility documented by Campbell et al. (2001). They also suggest that there was a decline in the cost of equity that allowed weaker firms and those with more distant payoffs to issue public equity. A more recent study by Brown and Kapadia (2007) reaches even stronger conclusion. Using a regression methodology similar to the one described above, they find that "there is generally no significant trend in idiosyncratic risk after accounting for the year a firm lists." They also provide other evidence that firm-specific risks in the economy as a whole did not increase, even though the volatility of firm-level equity returns rose because of an influx of successively riskier cohorts. Hence, the evidence and conclusions in Brown and Kapadia mirror those in Davis et al. (2006).

C. The Risk of Job Loss

As discussed at length in Davis (2007), a wide variety of labor market indicators point to a secular decline in the risk of job loss. These indicators include unemployment inflows by experienced workers in the Current Population Survey (CPS), the three-year job-loss rate in the CPS Displaced Worker Survey, several measures for the gross rate of

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[9] Brandt, Brav and Graham (2005) find that the volatility in firm-level equity returns turned down after 2001. Our Figure 9 suggests that firm-level volatility in employment growth rates also turned down after the late 1990s.

job destruction, the number of workers involved in mass layoff events, and the number of new claims for unemployment insurance benefits. All of these indicators point to a secular decline in the risk of job loss, although the extent and timing of the decline differs among the indicators. Figure 10 provides an example, showing a dramatic decline in new claims for unemployment insurance benefits as a percent of covered employment.

CPS data also show a dramatic decline since the early 1980s in unemployment inflows as a percentage of employment. Both indicators point to a large decline in the incidence of unwanted job loss. Davis et al. (2007) provide evidence that about half of the long term decline in unemployment inflow rates is explained by the reduction in the gross job destruction rates and in the volatility of firm-level growth rates. Hence, their study provides evidence of a direct link between the secular declines in firm-level volatility in Figure 9 and the secular declines in the incidence of job loss.

D. Consumption and Earnings Uncertainty

Based on the evidence of large secular declines in firm-level volatility and the risk of unwanted job loss, one might expect to also see a decline in the volatility of individual earnings and household-level consumption changes. Indeed, many laid-off workers experience large and persistent earnings losses, apparently as a direct consequence of job loss (e.g., Jacobson, Lalonde and Sullivan, 1993). However, the large body of work on earnings inequality suggests otherwise. This line of research has clearly established a large rise in earnings inequality since the early 1980s. See Lemieux (2007) for a recent review. It seems highly likely that greater earnings uncertainty accounts for a nontrivial portion of the large rise in earnings inequality.

Cunha and Heckman (2007) estimate the contribution of earnings uncertainty to the rise in earnings inequality. Their method uses data on schooling choices in combination with data on earnings outcomes to decompose the realized variance of earnings into predictable and unpredictable components. They estimate that roughly a quarter of the rise in the present value of earnings uncertainty between ages 22 and 36 is due to components that are not forecastable.

Another approach to quantifying changes in individual and household uncertainty exploits data on consumption expenditures. Gobachev (2007) uses data from the Panel

Study of Income Dynamics on food expenditures to estimate the volatility of household consumption after controlling for predictable variation associated with movements in real interest rates and changes in family structure. **Discuss Gorbachev results here.**

We take a simple approach to consumption volatility using data from the interview segment of the Consumer Expenditure Survey. This survey contains up to four consecutive observations on quarterly household-level consumption expenditures. We measure consumption volatility in terms of absolute log changes in household consumption expenditures per adult equivalent on nondurables goods and services. Our measure of adult equivalents is 1.0 times the first adult plus 0.7 times each additional adult in the same consumer unit plus 0.5 times each child in the consumer unit.

We sort households each year into deciles of predicted consumption based on a regression of log expenditures per adult equivalent on sex of the household head, a quartic polynomial in the head's age, four educational attainment categories, marital status of the head, interview month, and employment status of the head and the head's spouse, if there is one. We perform this sort based on the first interview with consumption expenditures for the consumer unit. After sorting households into deciles, we then compute the mean value of the absolute log changes in each consumption decile for the 1980 to 1991 and 1992 to 2004 periods. Figure 11 shows the results for the 6-month absolute log changes. The results are similar for 3-month and 9-month absolute log changes.

Figure 11 shows two main results. First, consumption volatility rises with the level of (predicted) consumption beyond the first three or four deciles of the consumption distribution. Second, there is no evidence for a decline in consumption volatility after the 1980s. In fact, the evidence in Figure 11 points to a modest increase in household-level consumption volatility except at the lower end of the consumption distribution. Of course, with these data we cannot rule out the possibility that consumption volatility was greater before the 1980s.

E. Summary of Micro Volatility Evidence and Implications

Based on our discussion and review of the evidence for changes in micro-level volatility, we draw the following conclusions:

1. The volatility of firm-level employment growth rates fell after the early to mid 1980s. The decline in average firm-level volatility is similar in magnitude to the decline in aggregate volatility, but the timing differs. Although we did not discuss it here, the volatility of state-level employment growth rates also fell after the 1980s (Carlino et al., 2007).
2. Among publicly traded firms, the volatility in real activity and in equity returns rose sharply after the early 1980s. This volatility rise among publicly traded firms is a striking phenomenon, but it mainly or entirely reflects shifts in the selection process governing which firms become public. Volatility trended in opposite direction among publicly traded and privately held firms in every major industry group.
3. Hence, considerable care is required when drawing inferences about the sources and nature of The Great Moderation from data on equity returns, or on any data limited to publicly traded firms.
4. Declines in firm-level volatility and gross job destruction rates are closely linked to declines in the risk of unwanted job loss, as reflected in sharply lower unemployment inflows after the early 1980s. In this respect, data on aggregate volatility, average firm-level volatility, job destruction rates and the incidence of unemployment all point to a much more quiescent economic environment since the early 1980s.
5. However, data on labor earnings and household consumption do not conform to a story of greater tranquility and lower uncertainty at the individual level. Although there is much room for further research, the available evidence suggests a modest to large increase in individual and household uncertainty.
6. Assuming this assessment of volatility in consumption growth and earnings uncertainty holds up under further scrutiny, it highlights a puzzle that research on The Great Moderation has yet to confront. To wit: Why has the dramatic decline in the volatility of aggregate real activity, and the roughly coincident decline in firm-level volatility, not translated into sizable reductions in the degree of (pre-tax) earnings uncertainty and consumption volatility facing individuals and households?

VI. Improved Inventory Control

A. A Closer Look at Durable Goods and Inventories

As discussed above, since the early 1980's there have been a number of significant changes in the behavior of inventories in aggregate data. Here we focus on the durable goods sector, where, as we have seen, the most dramatic declines in output volatility have occurred, and where we have already seen evidence of a change in inventory behavior as discussed in Section III. The reader is referred to Kahn et al. (2002) for a discussion of inventory behavior in the nondurable goods sector. McCarthy and Zakrajsek (2007) examine the behavior of manufacturing sector inventories pre- and post-1983.

While the inventory literature has traditionally focused on more disaggregated data, and in particular on the 2-digit (SIC) level manufacturing data, for the questions examined in this paper aggregate data has some distinct advantages. Disaggregated data can be misleading because it is impossible to tell whether changes in inventory behavior are genuine or just the result of economically (relatively) meaningless relocation. For example, if manufacturers decide to shift final goods inventories downstream to wholesalers and retailers, or shift materials inventories upstream to their suppliers, manufacturing inventories would decline relative to their shipments. Yet that decline would be largely offset by an increase in inventories elsewhere in the economy, and a mere re-labeling would get misinterpreted as evidence of a structural change.

In addition to the indirect evidence of changing inventory behavior described in Section III, we can directly examine the inventory-sales ratio in the durable goods sector. Figure 12 shows that whether one looks at the ratio of real (in year 2000 dollars) inventories to real sales, or nominal to nominal, the ratio began a sharp declined in the early 1980s, at the same time that volatility in the sector declined. This is not by itself a proof of "progress;" it could just represent a shift along a fixed technological tradeoff in response to changing costs, or a compositional change within the sector. But the timing of the break in trend is striking.

Secondly, the inventory-sales ratio is clearly less volatile (relative to its varying trend), suggesting that businesses either make smaller mistakes or are able to correct their inventories more quickly. Again this is not definitive as it could be that the shocks are smaller or that the industry composition has shifted. Kahn et al. (2002) also describes results from a VAR with sales and inventories that indicates a change in the variance decomposition pre- and post-1983. Before 1983 sales accounted for much more of the variance of inventories than inventories did of sales (37.8 percent versus 5.4 percent); after 1983 they were almost even (18.2 versus 14.9), consistent with the idea that firms were better able to anticipate sales and adjust inventories in advance. Moreover, the residual variance of sales dropped precipitously, meaning that less of the variation in sales was unpredicted given prior sales and inventories.

B. A Model of Improved Inventory Control

One approach to assessing the role of improved inventory control is to be agnostic about the details, but look for changes in parameters and propagation in, for example, a structural VAR. This is the approached in McCarthy and Zakrajsek (2007). They do find evidence of structural change pre- and post-1983. They use conventional identifying restrictions in an effort sort out the role of, for example, monetary policy in altering the dynamics of the sales process.

A second approach is a more specific model of improved inventory control as in Kahn et al (2002), based on the approach in Kahn (1986) and Bils and Kahn (2000). Firms carry finished goods inventories to avoid stockouts in the face of uncertain demand, trading off the cost of foregone profits against the cost of carrying inventories. If demand is serially correlated, the mistakes will get magnified in production volatility, so that it will exceed the volatility of sales. If technology enables firms to have better information about demand disturbances, then they will make smaller errors in their production decisions, and the additional volatility induced by correcting those errors is reduced. Firms may also be able to hold fewer inventories.

This type of mechanism can account for reduced production volatility (relative to the volatility of sales), but has several drawbacks. First, depending on the timing of the arrival of information, either the volatility of sales actually increases substantially, or the covariance of sales with inventory investment increases. As we have seen, the opposite is the case in the data. The reason sales volatility increases in this model is that the improved information essentially allows firms to accommodate demand shocks as opposed to damping them via stockouts. The covariance of sales and inventory investment only becomes more negative if the firm gets the information in time to adjust production sufficiently in advance (due to a desire to smooth production if costs are convex) that inventory movements anticipate the demand shock. Then when the shock occurs, inventory investment moves in the opposite direction, as anticipated by the firm. But this tends to exacerbate sales volatility.

The second problem with this approach is that it does not apply so obviously or directly to the durable goods sector, much of which is best characterized as production-to-order rather than production-to-stock. And as pointed out by Humphries et al (2001) and many others, most inventories, particularly in durable goods, are of materials or works in process, not final goods. Third, while there is much anecdotal evidence of technology that might provide better information about future sales, there is no direct evidence to assist in specifying a model. And as this discussion suggests, the details matter.

A variation on this approach that appears to address these problems is in Kahn (2007). Firms are production-to-order, and must order materials at least one period in advance. For simplicity (to avoid having to track three different stocks), materials are immediately converted into works-in-process inventories. Stockouts occur in these inventories if they are insufficient to allow the firm to meet its (stochastic) orders, in which case the order gets added to the stock of unfilled orders. The setup is illustrated in Figure 12 as a flowchart.

Details of the model are provided in an Appendix. It is obviously, as is any model, a vast oversimplification. In reality, production can involve many more stages, and many suppliers—both internal and external to the firm—at different stages. Of course, although it is modeled as a single firm, it could easily be applied to a vertically non-integrated supply chain where the two stages of production are done by different firms. Thus the model is consistent with the argument of Irvine and Schuh (2005) that attribute substantial reduced volatility reduced comovement between the manufacturing and trade sectors. In any case, the hope is that the model captures the essential features of reality while avoiding unnecessary complexity.

The intuition for how the model works is similar to that of the stockout-avoidance approach from Kahn (1986) described above. Orders for final goods are serially correlated, so errors in forecasting demand get magnified in production (sales plus inventory investment) volatility. The key difference is that final production is equal to sales, so if the firm is better able to forecast orders, the reduced volatility of production that comes from that may also reduce the volatility of sales. The other effect, that fewer stockouts means that the firm better accommodates demand shocks, is still present, but for reasonable parameters, as we shall see, the former effect dominates.

So this model immediately addresses all but one of the objections raised above. It is specifically tailored to characteristics of the durable goods sector in that it assumes production-to-order rather than production to stock. It features works-in-process rather than final goods inventories. It has the property that better information about final orders has the potential to reduce the volatility of both output and sales, the former more than the latter.

The remaining issue is evidence for specifying how the firm is better able to forecast orders. Here we rely on evidence obtained from the Institute of Supply Management on average lead times for orders of production materials. This is imperfect evidence, as it is not confined to the durable goods sector, but it is striking nonetheless. The series is depicted in Figure 13, plotted against the volatility (5-year rolling variance) of output volatility in durable goods. While the average lead time series does not exhibit the underlying downward trend of the volatility series, it does feature a clear drop in level post-1983 relative to earlier. It also shows some elevation in the 1970s.

What is the connection between shorter lead times and better information? In the model, the essential information for the firm on which it bases its forecast of future final goods orders is the history of observed final goods orders. So the longer it can delay materials orders, the better handle it has on how much to order. Consequently the mistakes are smaller, and the firm can carry lower average stocks.

Of course, what allows for shorter lead times is not modeled, but taken as direct evidence of technical progress. Given that the goal of the so-called “just-in-time” approach is greater flexibility to reduce the need to carry large stocks, this is reasonable, but may only be part of the story. For example, some of the increased lead times in the

1970s could have been the result of the Nixon-era price controls, which created shortages and frictions in materials. It would be natural for firms concerned about not being able to obtain materials in a given time frame to order farther in advance. This does not negate the mechanism in the model, it just says that something other than technical progress may be behind some sustained movements in average lead times. It may well be that price controls, or even the high inflation of the 1970s, could have disrupted market signals and caused some of the increased lead times, and hence the increased volatility, but this hypothesis awaits further research.

There is little doubt that vast resources have been devoted to improving what is generally referred to as “supply chain management.” How this translates into observable behavior and data is another question entirely. As Mentzer et al (2001) write:

> “Despite the popularity of the term Supply Chain Management, both in academia and practice, there remains considerable confusion as to its meaning. Some authors define SCM in operational terms involving the flow of materials and products, some view it as a management philosophy, and some view it in terms of a management process.”

They go on to define the term as “the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole.” While this definition is vague, it is clearly intended to encompass a number of specifics, notably what they refer to as a logistics system: “the total flow of materials, from the acquisition of raw materials to delivery of finished products, to the ultimate users, as well as the related counter-flows of information that both control and record material movement.

The strong prediction of the model is that a reduction in lead times, for any reasonable parameters, gives rise to a large reduction in output volatility and a somewhat smaller reduction in the volatility of final sales. While the magnitudes of these declines depend on specifics such as the average inventory-sales ratio (which is endogenous in the model and depends on price-cost markups and inventory holding costs) and the ratios of inputs to gross output at each stage of production, the qualitative results only require some degree of persistence in the final goods orders process. Table 3 gives the results of a representative simulation. The model easily matches the basic facts about reduced volatility in the durable goods sector: Initially production volatility exceeds sales volatility by a lot. Subsequently, both volatilities go down, but production volatility declines by much more than sales volatility.

VII. Conclusions

[to be added]

Appendix

The model's notation is contained in the following table:

Z_t	Orders of materials
D_t	Deliveries
O_t	Final goods orders
Y_{Mt}	Intermediate production
Y_{Ft}	Final production (= shipments)
M_t	Stock of works-in-process
U_t	Stock of unfilled orders
X_t	Inputs into final production (out of M)
b_M, b_F	Input requirements for intermediate and final output
N_M, N_F	Labor inputs to intermediate and final output

The technology is as follows:

Materials delivery lag $\tau : D_t = Z_{t-\tau}$
Production (Leontief): $Y_{Mt} = \min\left\{D_t / b_M, N_M\right\}, Y_{Ft} = \min\left\{X_t / b_F, N_F\right\}$
Resource constraints:

$$M_t = M_{t-1} + Y_{Mt} - X_t$$
$$U_t = U_{t-1} + O_t - Y_{Ft}$$
$$M_t \geq 0$$
$$U_t \geq Y_{Ft}$$

Assume a continuum of firms indexed by *i*

Stochastic orders (firm *i*):

$$O_{it} = \rho O_{t-1} + \eta_t + v_{it}$$
$$\text{where } \int v_{it} di = 0.$$

where v is an idiosyncratic shock and η an aggregate shock.

Firms maximize

$$E_t \left\{ \sum_{s=t}^{\infty} \beta^{s-t} \left[pY_{Fs} - qD_s - w\left(N_{Ms} + N_{Fs}\right)\right]\right\}$$

where we take β, *p*, *q*, and *w* as fixed and exogenous, with *p* sufficiently large that the markup is positive. Consequently, firms will always seek to fill all unfilled orders, so we have

$$Y_{Ft} = \min\left\{U_t, b_F^{-1}\left[M_{t-1} + b_M^{-1} D_t\right]\right\}$$
$$X_t = \min\left\{M_{t-1} + b_M^{-1} D_t, b_F U_t\right\}$$

The first condition says that the firm fills its unfilled orders if it can, otherwise it stocks out of works-in-process inventories. The second condition is the implication of the first for the usage of works-in-process inventories.

Beginning with the easier case of $\tau = 1$, we have

$$D_t = Z_{t-1} = b_M\left[b_F\left(E_{t-1}\left\{U_t\right\} + \kappa\right) - M_{t-1}\right]$$

where κ depends on the distribution of $\eta_t + v_{it}$, the markup, and the discount factor. Specifically, if we let *c* stand in for the cost of producing a unit of output, κ comes from the first-order condition

$$-c + p\frac{dY_{F,t+1}}{dZ_t} + \beta c\left(1 - \frac{dY_{F,t+1}}{dZ_t}\right) = 0$$

where

$$\frac{dY_{F,t+1}}{dZ_t} = \Pr\left(b_F U_{t+1} > M_t + b_M^{-1} D_{t+1}\right).$$

If *G* is the c.d.f for $\eta_t + v_{it}$, then one can show that

$$\kappa = b_F G^{-1}\left(\frac{p-c}{p-\beta c}\right).$$

The idea is that the firm takes into account what it already is carrying over in works-in-process, and orders what it expects to use, plus a factor κ that reflects uncertainty and the relative costs and benefits of stocking out versus carrying extra inventory.

If $\tau = 2$ we get something analogous:

$$D_t = Z_{t-2} = b_M\left[b_F\left(E_{t-2}\left\{U_t\right\} + \kappa'\right) - E_{t-2}\left\{M_{t-1}\right\}\right]$$

where $\kappa' \neq \kappa$ (typically it will be larger) and depends on the distribution of $\eta_t + v_{it}$ and $\eta_{t-1} + v_{it-1}$ in addition to the markup and discount rate. Again the firm orders what it expects, to need, but with less information than when $\tau = 1$.

With some straightforward and not so straightforward algebraic manipulations, and applications of the law of iterated expectations, we can show that shipments and total output (shipments plus the change in inventories) behave as follows:

$$\tau = 1:$$
$$Y_{Ft} = E_{t-1}\{O_t\} + \eta_{t-1} + \min\{\kappa, \eta_t + v_{it}\} - \min\{\kappa, \eta_{t-1} + v_{it-1}\}$$
$$Y_{Ft} + \Delta M_t = b_F^{-1} X_t = E_{t-1}\{O_t\} + \eta_{t-1} + v_{it-1} + (1 - b_F)\left[\min\{\kappa, \eta_t + v_{it}\} - \min\{\kappa, \eta_{t-1} + v_{it-1}\}\right]$$

and

$$\tau = 2:$$
$$Y_{Ft} = E_{t-2}\{O_t\} + (1+\rho)[\eta_{t-2} + v_{it-2}] + \Delta \min\{\kappa', \eta_t + v_{it} + (1+\rho)[\eta_{t-1} + v_{it-1}]\}$$
$$Y_{Ft} + \Delta M_t = b_F^{-1} X_t = E_{t-2}\{O_t\} + (1+\rho)[\eta_{t-2} + v_{it-2}] + (1 - b_F)\Delta \min\{\kappa', \eta_t + v_{it} + (1+\rho)[\eta_{t-1} + v_{it-1}]\}$$

Finally, we can aggregate by integrating over the firms' idiosyncratic risk *v*. Supposing *v* is normally distributed with mean zero and variance σ^2, we can define

$$\xi_t = \int_{-\infty}^{\infty} \min\{\kappa, \eta_t + \sigma u\}\phi(u)\,du$$
$$= \int_{-\infty}^{\frac{\kappa-\eta_t}{\sigma}} (\eta_t + \sigma u)\phi(u)\,du + \kappa\left[1 - \Phi\left(\frac{\kappa - \eta_t}{\sigma}\right)\right]$$

for the $\tau = 1$ case. Then aggregate *M* is just $b_F(\kappa - \xi_t)$ and

$$Y_{Ft} = \rho O_{t-1} + \eta_{t-1} + \xi_t - \xi_{t-1}$$
$$Y_{Ft} + \Delta M_t = \rho O_{t-1} + \eta_{t-1} + \xi_t - \xi_{t-1} + (1 - b_F)[\xi_t - \xi_{t-1}]$$

A similar exercise provides analogous results for the $\tau = 2$ case. These form the basis for the simulation results in Table 3.

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Table 1: Impact of Sectoral Shifts on Volatility Declines

	GDP Growth	GDP Growth (1959 sector shares)
1947Q1-1983Q4	4.07	4.28
1984Q1-2007Q2	2.10	2.53

*Standard deviations of annualized growth rates

Table 2. Firm Volatility Trends by Major Industry Group and Ownership Status

	All Firms			**Publicly Traded Firms**			**Privately Held Firms**			**Volatility Ratio: Privately Held to Publicly Traded**		
Industry	1978	2001	Percent Change	1978	2001	Percent Change	1978	2001	Percent Change	1978	2001	Change
Minerals	0.54	0.41	-24.2	0.25	0.28	10.9	0.74	0.52	-29.8	3.0	1.9	-1.1
Construction	0.78	0.51	-34.5	0.33	0.34	1.3	0.82	0.52	-36.6	2.5	1.5	-0.9
Manufacturing	0.34	0.30	-12.9	0.16	0.21	28.7	0.53	0.35	-33.5	3.2	1.7	-1.5
TPU	0.37	0.34	-6.7	0.11	0.25	129.4	0.67	0.45	-32.8	6.3	1.8	-4.4
Wholesale	0.53	0.33	-36.5	0.16	0.24	45.6	0.58	0.36	-38.3	3.6	1.5	-2.1
Retail	0.56	0.36	-36.1	0.17	0.20	16.8	0.70	0.44	-37.5	4.2	2.2	-1.9
FIRE	0.44	0.39	-13.1	0.17	0.33	96.4	0.54	0.42	-22.6	3.3	1.3	-2.0
Services	0.59	0.41	-30.7	0.27	0.38	38.5	0.61	0.41	-32.4	2.3	1.1	-1.2
All	0.49	0.38	-22.9	0.17	0.26	55.5	0.63	0.42	-33.4	3.7	1.6	-2.1

Notes: Firm-level volatility calculated per equation (6) in Davis et al. (2006). Average volatility across firms computed on an employment-weighted basis.

Source: Calculations on the Longitudinal Business Database by Davis et al. (2006).

Table 3: Simulation Results

	Standard deviations of			
	Output	Sales	Output growth	Sales growth
$\tau = 2$	3.38	2.59	7.43	3.39
$\tau = 1$	2.54	2.32	3.65	1.93

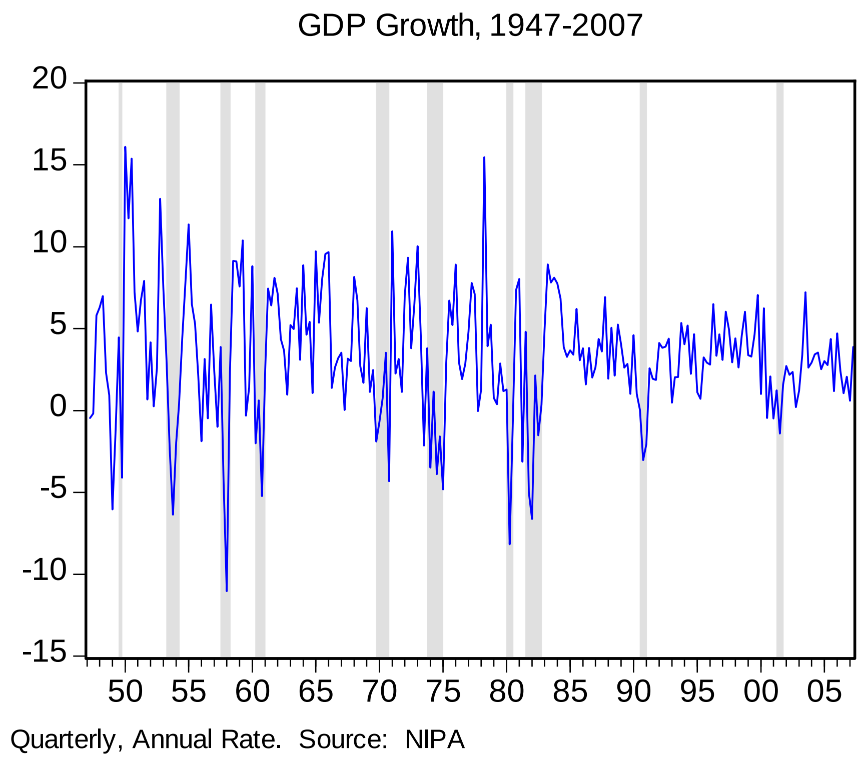

GDP Growth, 1947-2007
20
15
10
5
0
-5
-10
-15
50
55
60
65
70
75
80
85
90
95
00
05
Quarterly, Annual Rate. Source: NIPA

Figure 1

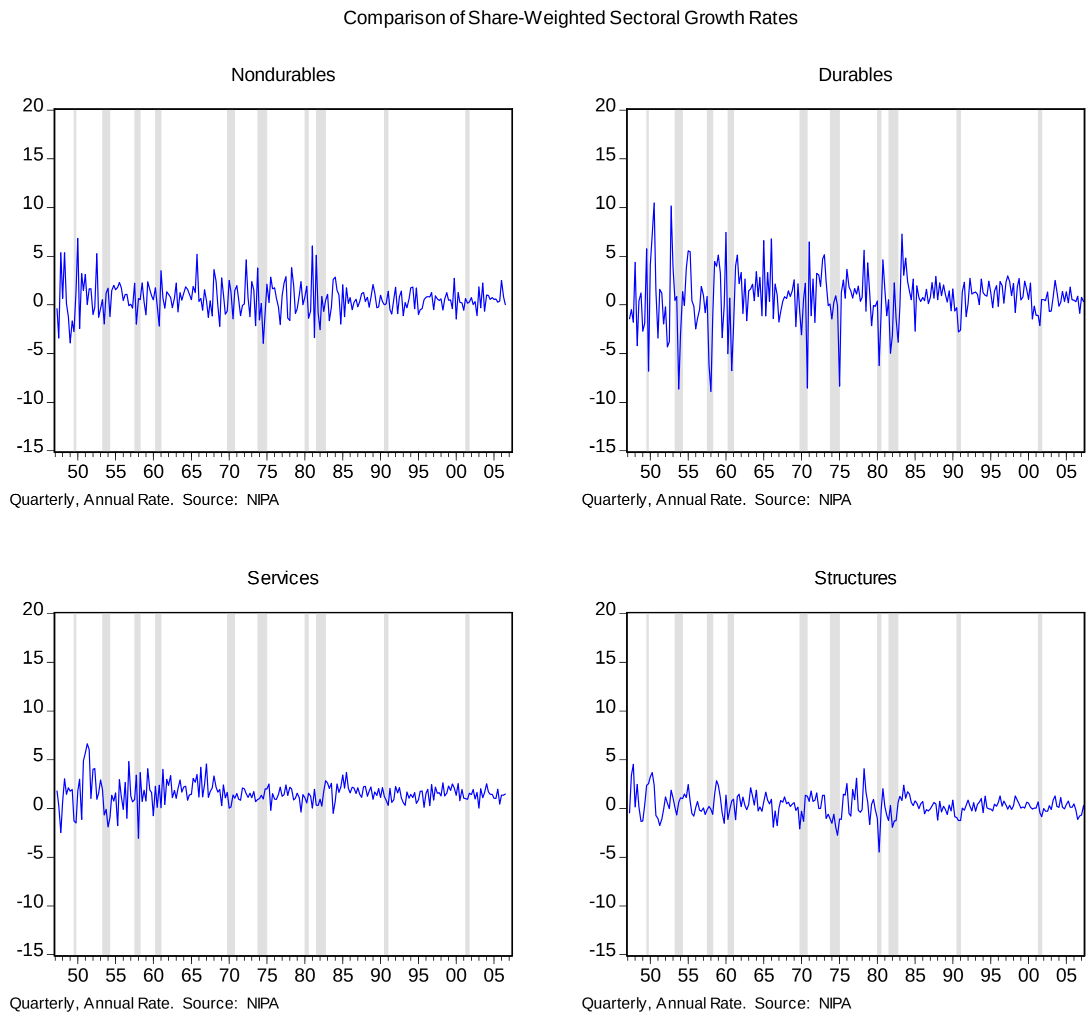
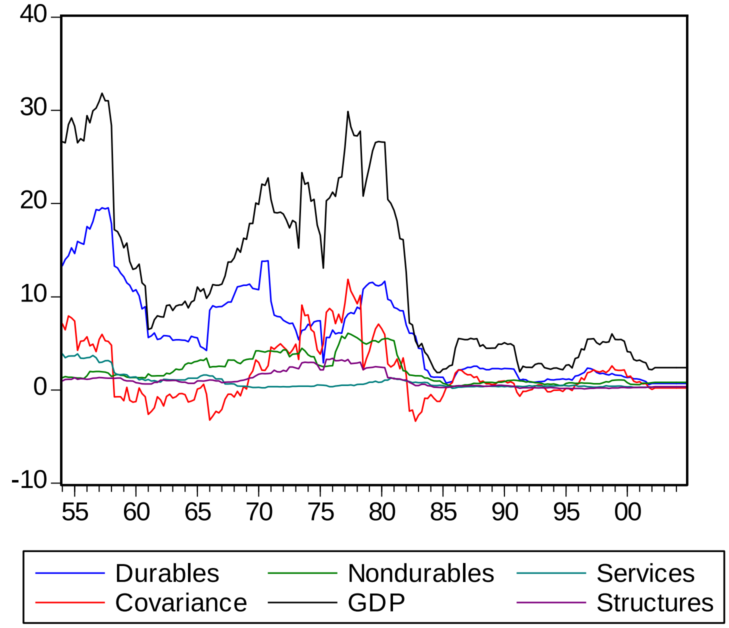
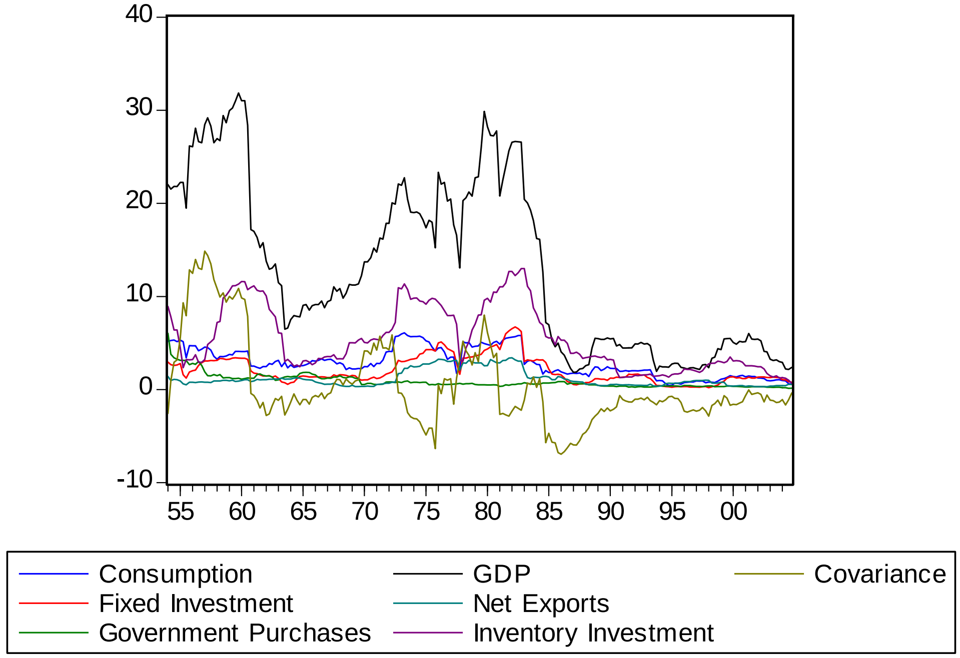

Comparison of Share-Weighted Sectoral Growth Rates
Nondurables
Durables
Services
Structures
20
15
10
5
0
-5
-10
-15
50 55 60 65 70 75 80 85 90 95 00 05
Quarterly, Annual Rate. Source: NIPA

Figure 2

Volatility over Time by Sector and Expenditure Category





5-year rolling variances

Figure 3

Figure 4

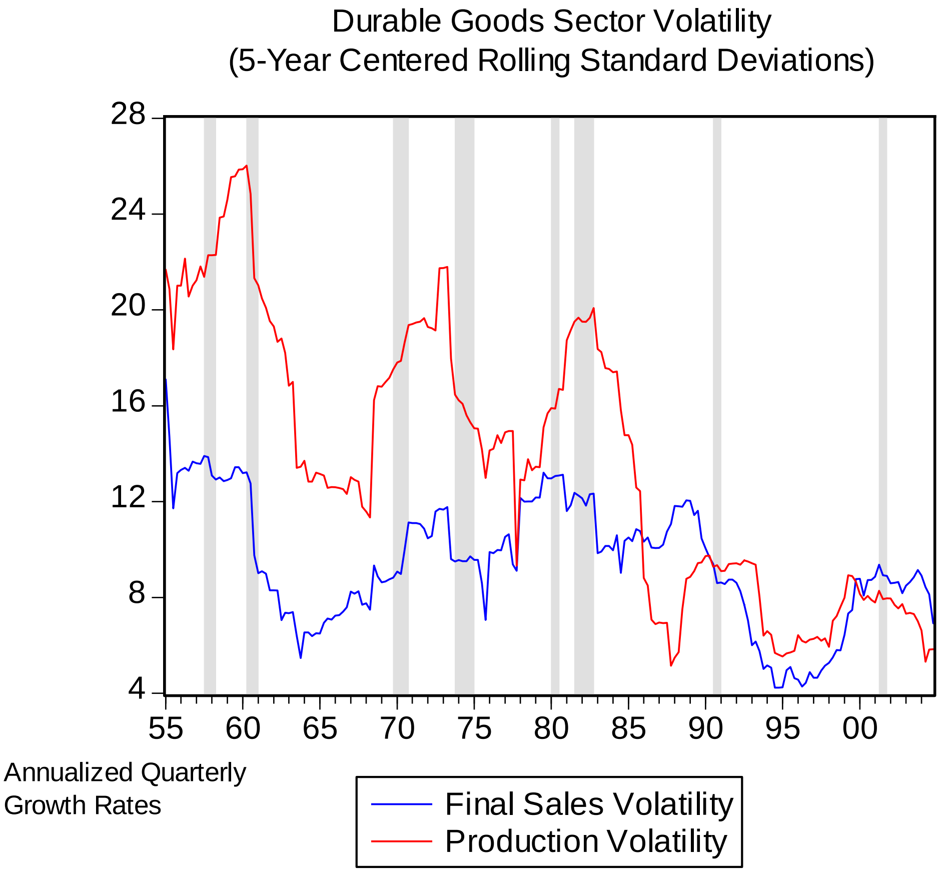


Figure 4

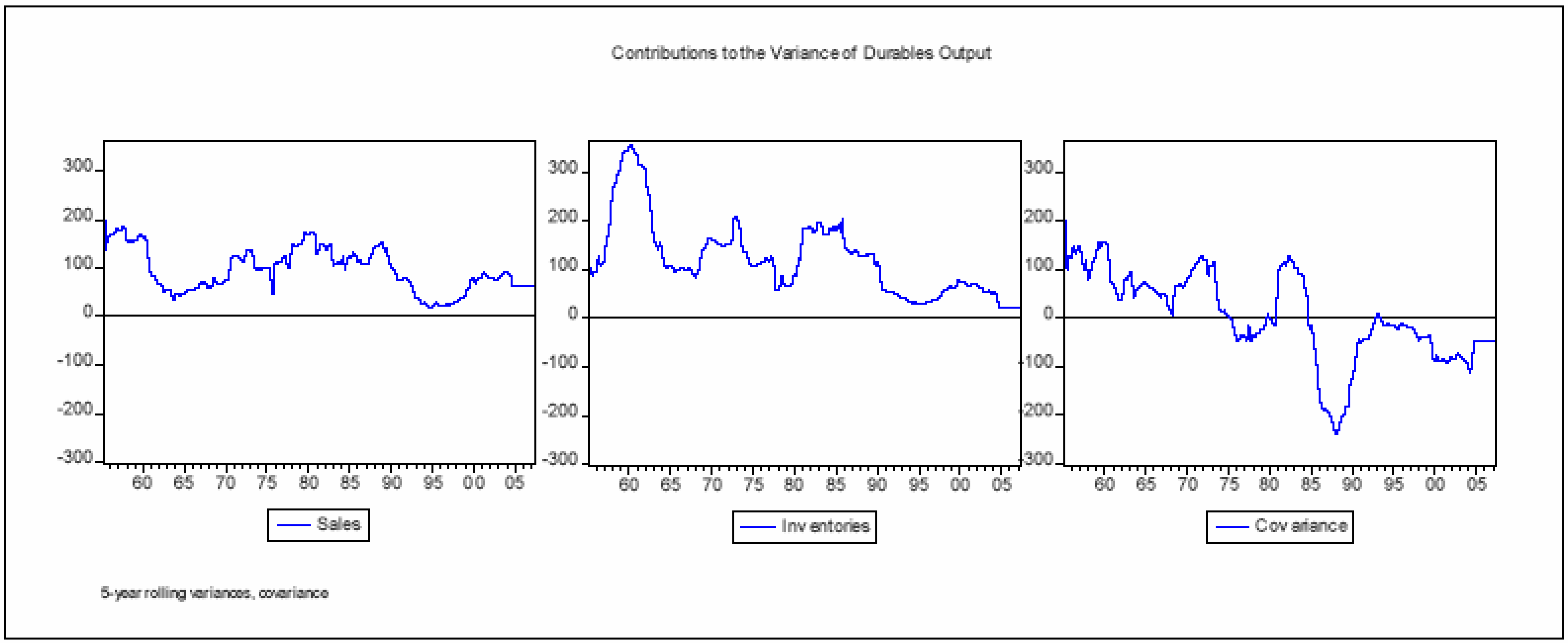

Contributions to the Variance of Durables Output
Sales
Inv entories
Cov ariance
5-year rolling variances, covariance

Figure 5

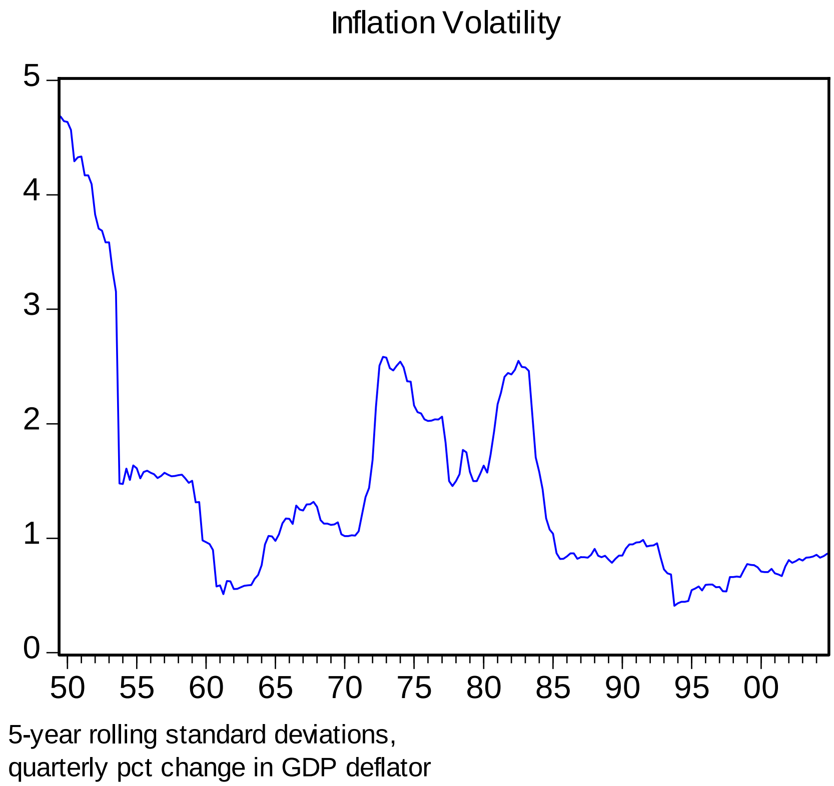
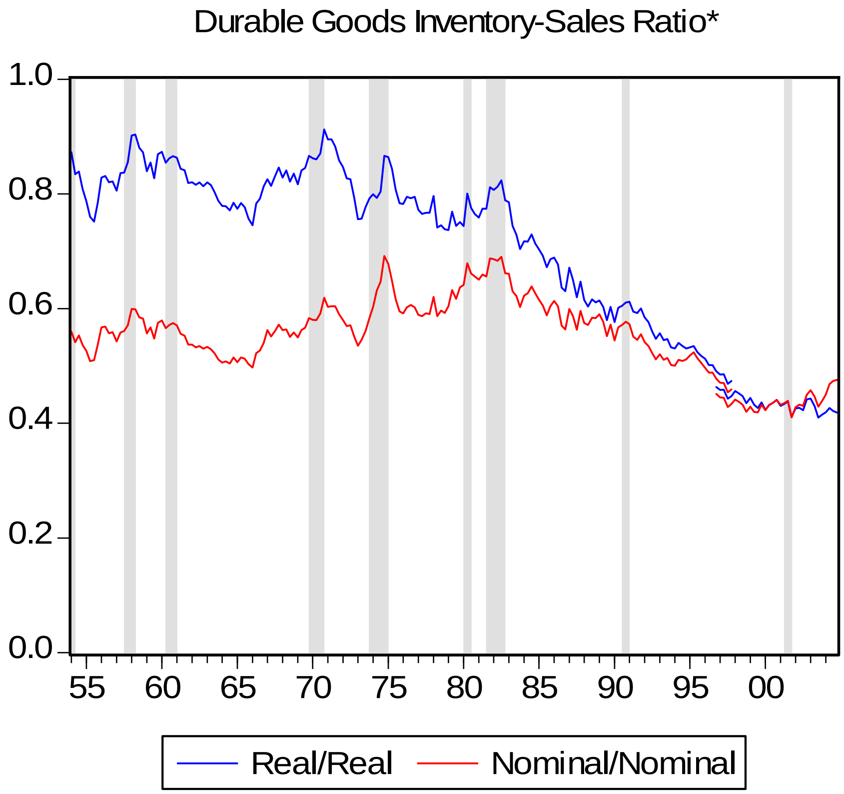

Inflation Volatility
5
4
3
2
1
0
50
55
60
65
70
75
80
85
90
95
00
5-year rolling standard deviations,
quarterly pct change in GDP deflator

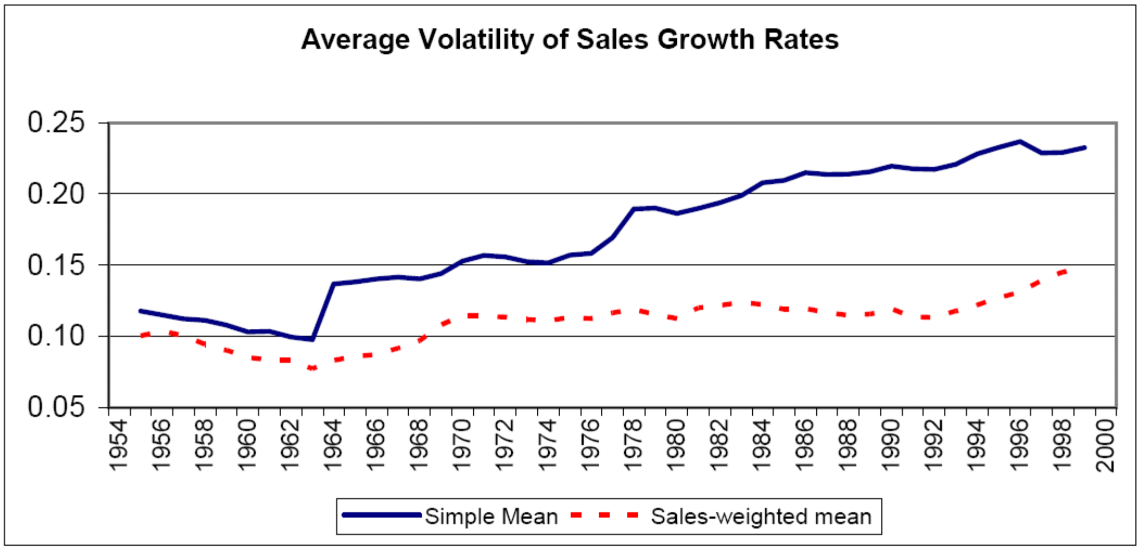
Figure 6

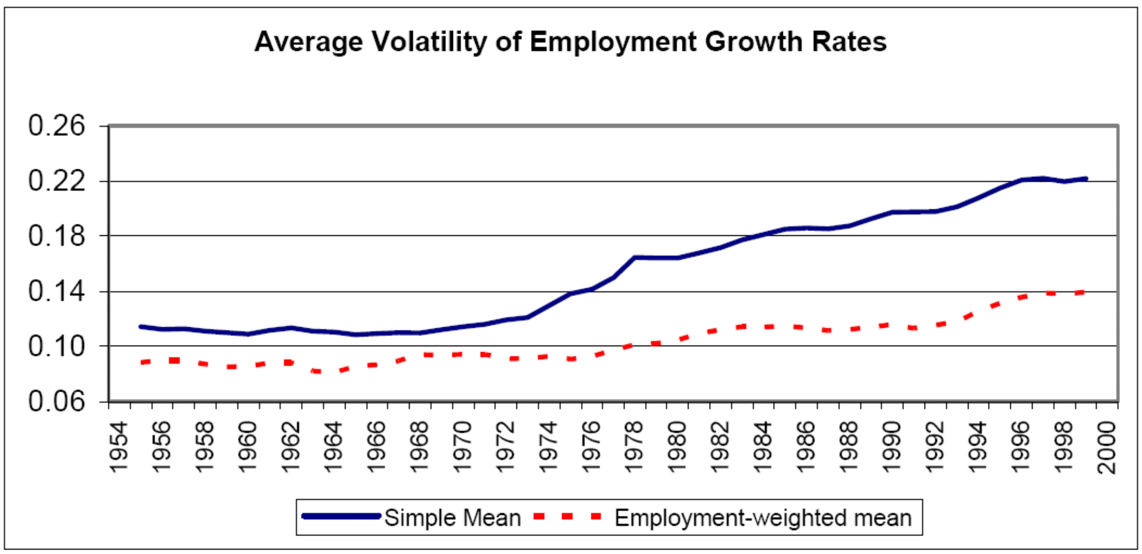


*The series is discontinuous (and overlapping for one year) due the change from SIC to NAICS industry definitions

Figure 7

Figure 8: Firm-Level Volatility among Publicly Traded Firms, COMPUSTAT Data

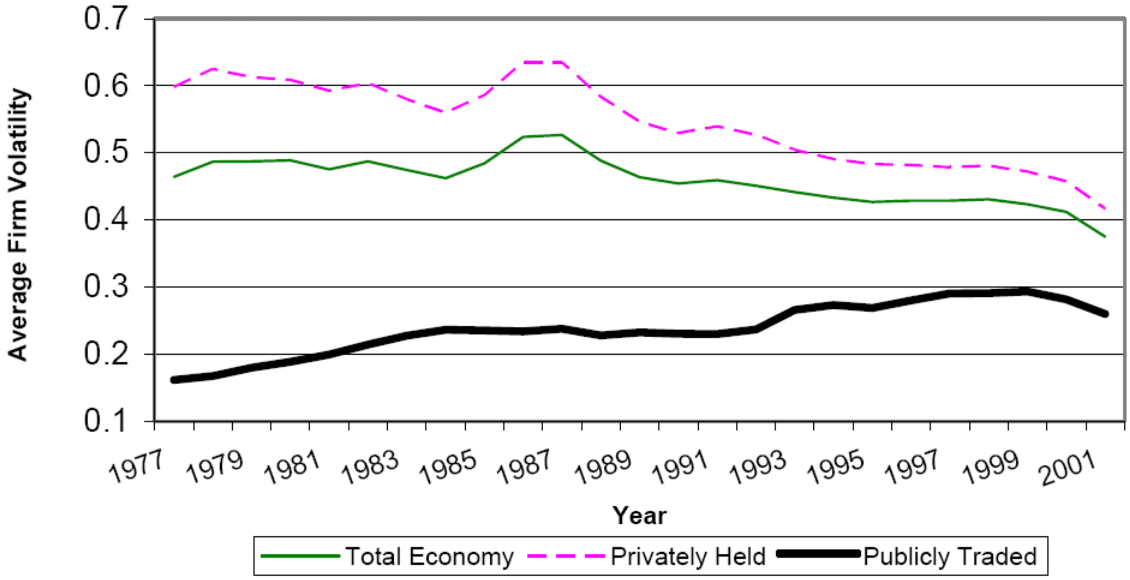




Notes: Firm-level volatility computed as a moving ten-year window on the standard deviation of firm-level growth rates. Average volatility across firms computed on an unweighted or weight basis, as indicated.

Source: Calculations on COMPUSTAT data by Davis et al. (2006).

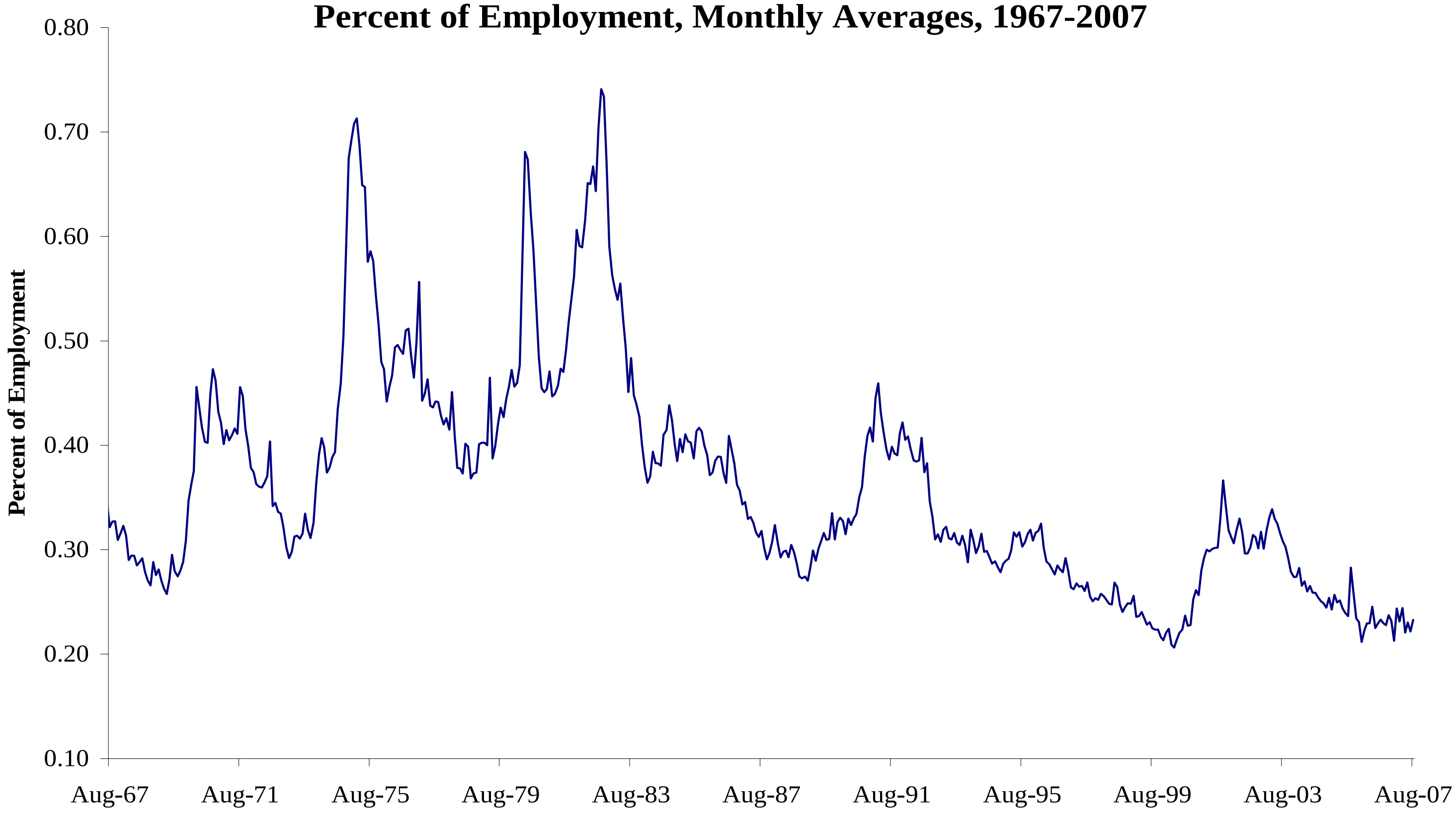
Figure 9: Volatility in Firm-Level Employment Growth Rates,
Overall and by Ownership Status, 1978 to 2001



Notes: Firm-level volatility calculated as a ten-year weighted moving average of growth rates, inclusive of entry and exit and with a degrees-of-freedom correction. See equation (6) in Davis et al. (2006). Average volatility across firms computed on an employment-weighted basis.

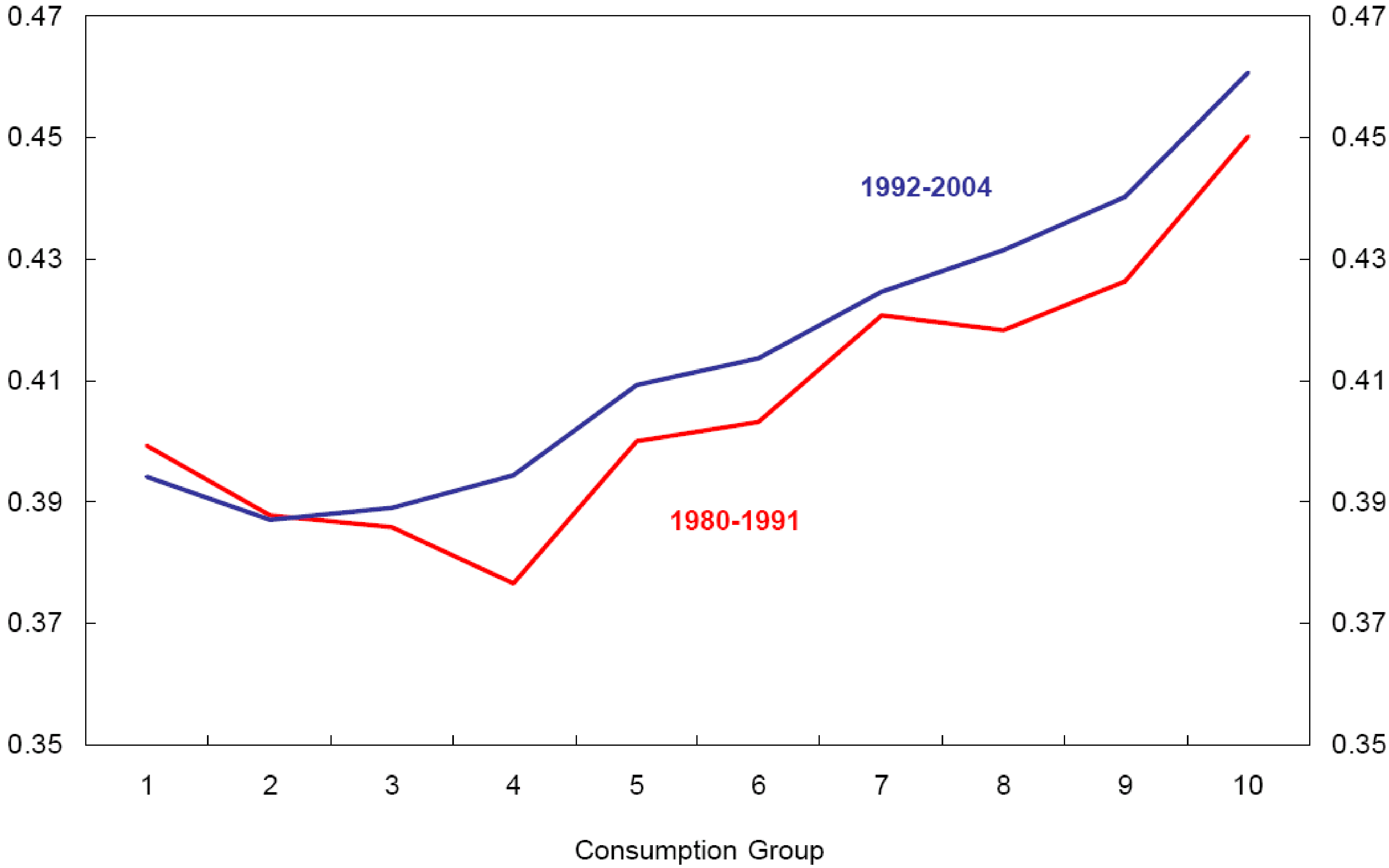
Source: Calculations on the Longitudinal Business Database by Davis et al. (2006).

Figure 10. Weekly New Claims for Unemployment Insurance as a Percent of Employment, Monthly Averages, 1967-2007



Source: Calculations by Davis (2007) using seasonally adjusted data on unemployment insurance weekly claims and total nonfarm emplyment data in the Current Employment Survey.

Figure 11: Household Consumption Volatility by Decile of Predicted Consumption,
Mean Absolute Log 6-Month Change in Consumption Per Adult Equivalent



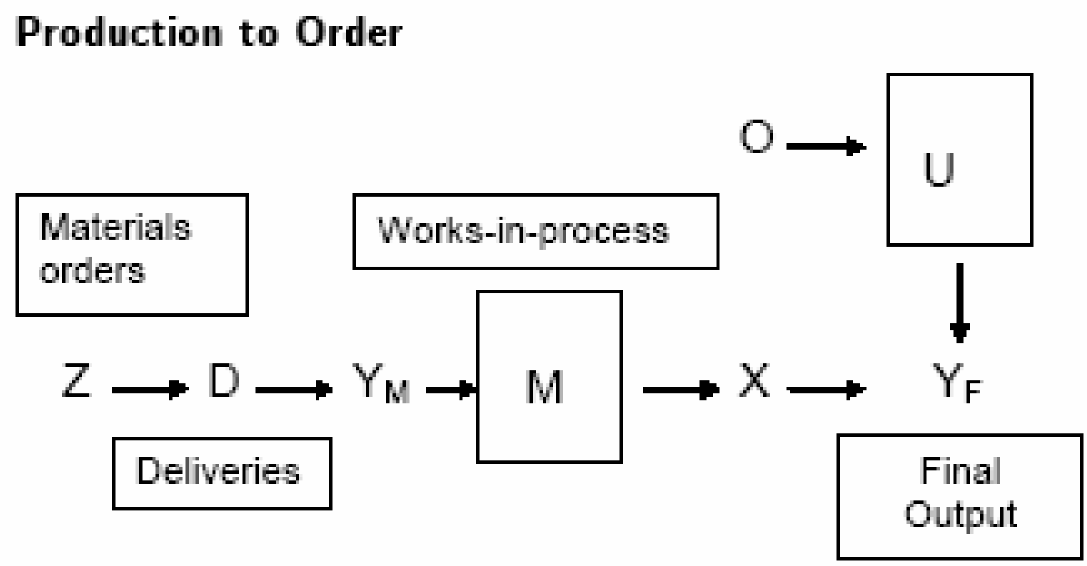
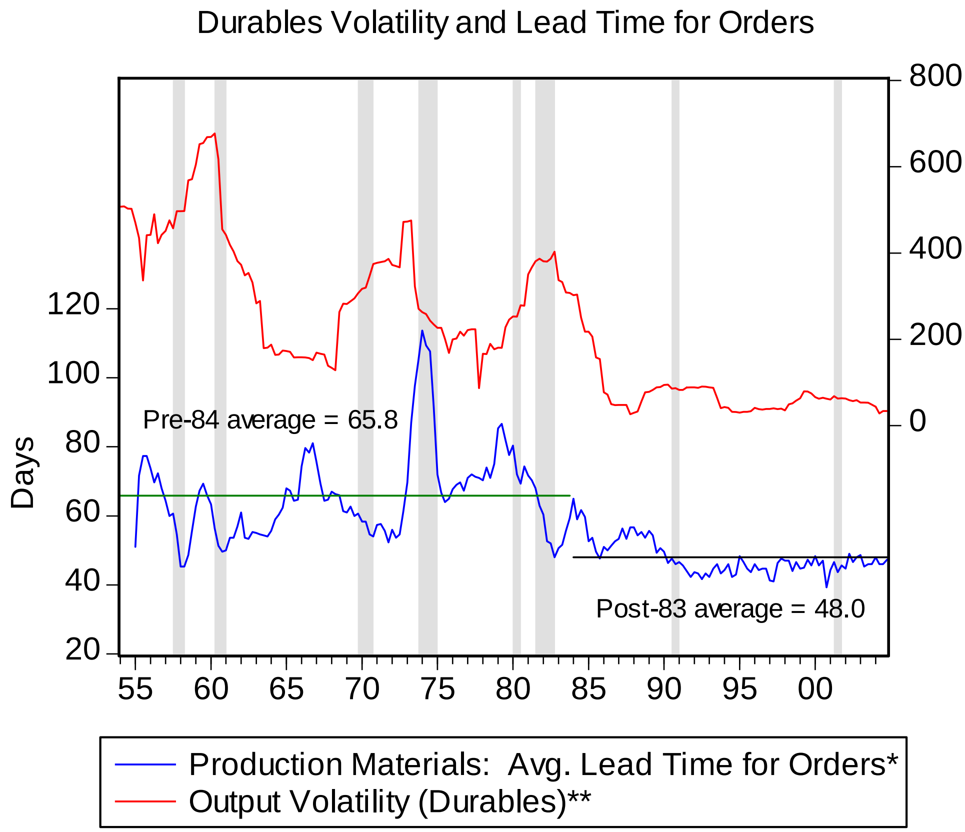

Production to Order
O
U
Materials orders
Works-in-process
Z
D
Y_M
M
X
Y_F
Deliveries
Final Output

Figure 12



* Source: ISM survey
**5-year centered rolling variance

Figure 13