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The role of output composition in the stabilization of US output growth

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Abstract

US output growth became much more stable over the past half-century. This paper assesses the role of changes in the composition of output—the increasing importance of stable sectors and diminishing importance of volatile sectors—in this stabilization. Our decomposition of output growth volatility by one-digit industry indicates that a bit less than half of the drop in volatility between the pre- and post-1982 periods is accounted for by compositional shifts, most notably the decline of manufacturing.

JEL classification: E32; E23

Keywords: Economic fluctuations; Macroeconomic stabilization; Deindustrialization; Manufacturing

1. Introduction

The US economy has been growing progressively more stable over the past half-century and perhaps longer. Fig. 1 depicts the five-year rolling variance of GDP growth using real, quarterly output data starting in 1947. Economists have put forward various explanations for the recent US economic stability. Fewer exogenous shocks, better fiscal policy, better

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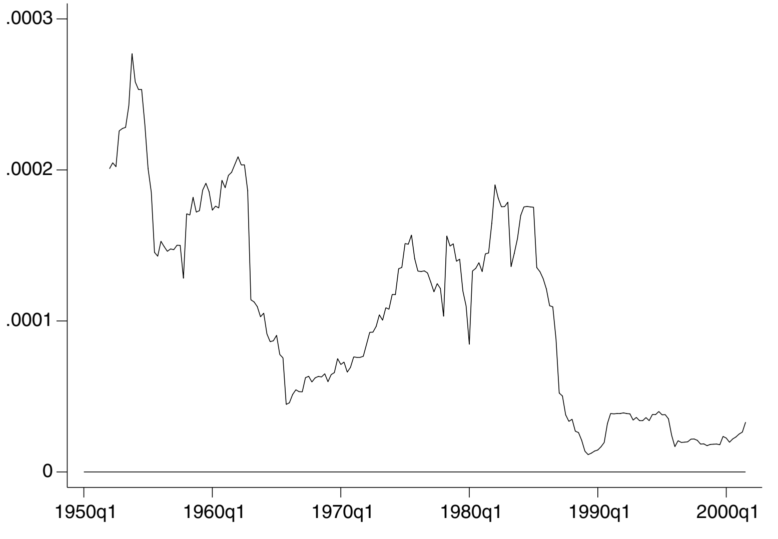

Fig. 1. Rolling variance of quality GDP growth.

monetary policy, changes in inventory management, and changes in the composition of output are among the explanations most often cited.[1] This paper focuses on the last of these factors.

The most striking changes in the composition of US GDP over the past half-century have been the relative decline of the manufacturing and agricultural sectors and the relative rise of the financial and services sectors. Because manufacturing and agriculture are particularly volatile sectors, and finance and services are particularly stable, it stands to reason that this restructuring of the economy would substantially stabilize overall US output growth. Our analysis confirms this intuition. We find that a bit less than half of the decline in US output growth variance between the periods before and after 1982 can be attributed to shifts in output composition. This finding challenges the conclusion of several recent studies which downplay the role of compositional changes. Not surprisingly, the role of compositional changes appears to depend greatly on how one divides GDP into components—by type of output, by type of expenditure, or by type of producer. Our growth volatility decomposition exercises show that composition was an important part of stabilization using the last of these series and less important for the others.

The paper proceeds as follows. Section 2 describes the relationship between composition and volatility and introduces some relevant recent findings. Section 3 highlights the decomposition by which we analyze the role of composition in output growth stabilization. Section 4 presents our results. Section 5 concludes.

[1] This list is based partly on John Simon's remarks at the conference "Structural Change and Monetary Policy" sponsored by the Federal Reserve Board of San Francisco and the Stanford Institute for Economic Policy Research, March 3–4, 2000.

2. Output composition and output volatility

It is well known that the 10 one-digit SIC sectors of the US economy have different levels of output volatility. In particular, sectors in which producers can postpone selling and consumers can postpone buying, sectors which are capital intensive, and sectors whose products are vulnerable to foreign demand and exchange rate fluctuations tend to have volatile output.[2] Manufacturing is a volatile sector for all three reasons; finance and services are relatively stable because none of the above really apply.

Meanwhile, the relative size of these sectors in the US economy has changed markedly over the past half-century. In the period from 1947 to 1982,[3] manufacturing was by far the largest of the one-digit sectors, accounting for almost 26% of US output, more than twice the output of the service and finance sectors. In the period between 1982 and 2001, both finance and services eclipsed manufacturing, growing to around 18% of the US economy each, while manufacturing shrunk in relative size to just under 18% of US output. Agriculture, which had been in a steady decline for decades, shrank from over 4% of the US economy before 1982 to under 2% between 1982 and 2001. Given that these well-known structural changes in the US economy tended to increase the relative size of stable sectors compared to volatile ones, it seems reasonable to ask how much of the decline in overall US output growth volatility in this period can be attributed to these compositional changes.

The argument that changes in overall stability could arise from compositional shifts among GDP components of heterogeneous volatility is straightforward and intuitively compelling. Still, it has not been well received in recent efforts to analyze the long-term stabilization of the US economy. Blanchard and Simon (2001), observing that the rolling standard deviation of output growth using fixed 1947 shares of expenditures (consumption, investment, government spending, and net exports) looks identical to the actual series, conclude that composition was inconsequential. McConnell and Perez Quiros (2000) reject the role of composition by noting that an output series with shares of goods, services, and structures fixed at the sample-wide averages still experienced a volatility break in the second quarter of 1984. Reviewing the work of Warnock and Warnock (2000) and Stock and Watson (2002) use employment data to show that GDP growth volatility would have dropped by about the same amount if the share of employment by 1-digit sector had remained at 1965 levels. They also point out that the smooth shift from manufacturing to services could not explain the early 1980s break in volatility that several researchers have detected.

Because the intuition behind a role for composition in the long-term stabilization of US GDP is so strong, and because studies to date have approached different data (i.e., various decompositions of GDP based on expenditures by type, expenditures by purchaser, or employment) with disparate methods (i.e., breakpoint tests vs. holding shares fixed at average or starting values), we revisit the issue. Our results suggest that compositional changes have, indeed, played a strong role in the stabilization of US output growth, and that value-added by industry is the dimension along which the effects of compositional changes can be seen most clearly.

[2] See Filardo (1997) for a more complete discussion of the volatility of manufacturing output.

[3] Our choice of January 1982 as a cut-off is somewhat arbitrary, but is in line with conventions and findings in relevant literature. Those studies that identify changes in the dynamics of GDP growth through breakpoint testing all find breaks in the early 1980s. Kim and Nelson (1999) and McConnell and Perez Quiros (2000) both place the break at 1984:I, and Stock and Watson (2002) estimate a confidence interval of 1982:4–1985:3.

3. A decomposition of output growth volatility

In order to measure more precisely the relative importance of changes in the composition of GDP and of changes in the volatility of the components of GDP, we conduct the following simple decomposition. We express the growth rate of GDP as the sum of sector growth rates multiplied by their share of GDP (essentially, a weighted average growth rate). Simplifying notation, we denote the growth rate of sector i from period $t-1$ to t by $\widehat{X}_{it}$ and the share of sector i in GDP at $t-1$ by x_{it-1}. The rate of GDP growth is thus written as

$$\widehat{Y}_t = \sum_i x_{i,t-1} \cdot \widehat{X}_{it}. \tag{1}$$

Under the assumption that the sectoral shares are constant, $x_{i,t-1} \equiv x_i$, we can write the variance of the growth rate of an economy consisting of, say, sectors i and j as follows:

$$\mathrm{Var}(\widehat{Y}_t) = x_i^2 \cdot \mathrm{Var}(\widehat{X}_{it}) + x_j^2 \cdot \mathrm{Var}(\widehat{X}_{jt}) + 2x_i \cdot x_j \cdot \mathrm{Cov}(\widehat{X}_{it}, \widehat{X}_{jt}). \tag{2}$$

We extend such a framework to three alternative GDP series: expenditures (consumption, investment, government, and net exports), products (durable goods, nondurable goods, services, and structures), and production (value-added by 10 1-digit SIC sectors). The Appendix provides detail about each data series. In each case we use the nominal GDP series corrected for inflation using a GDP deflator.[4] For each sector and each period (pre- and post-1982), we calculate the output growth variance and average GDP share, as well as covariance terms for every 2-sector combination.

Dividing output growth volatility in the early and late periods into sector volatility components and (fixed) sector shares allows us to decompose the observed change in output growth volatility into three parts: a part explained by changes in the sectoral output shares, a part explained by changes in the variances and covariances of sector growth rates, and a part explained by interactions between sector composition and volatility. First, write the change in volatility for the two sector economy using $t = 2$ to denote the late period and $t = 1$ to denote the early period:

$$\Delta\mathrm{Var}(\widehat{Y}) = \mathrm{Var}(\widehat{Y}_2) - \mathrm{Var}(\widehat{Y}_1). \tag{3}$$

Now, observing that it is possible to express any change in a two-term product $A_2 \cdot B_2 - A_1 \cdot B_1$ as $(A_1 + \Delta A) \cdot (B_1 + \Delta\ B) - A_1 \cdot B_1$, and deleting $\Delta A \cdot \Delta B$ as negligible we get $\Delta A \cdot B_1 + \Delta B \cdot A_1$. We can rewrite the RHS of Eq. (3), using Eq. (2), as the sum of three separate terms:

$$\Delta x_i^2 \cdot \mathrm{Var}(\widehat{X}_{i1}) + \Delta x_j^2 \cdot \mathrm{Var}(\widehat{X}_{j1}) + 2\Delta(x_i \cdot x_j) \cdot \mathrm{Cov}(\widehat{X}_{i1}, \widehat{X}_{j1}) \tag{4}$$

$$+ x_{i1}^2 \cdot \Delta\mathrm{Var}(\widehat{X}_i) + x_{j1}^2 \cdot \Delta\mathrm{Var}(\widehat{X}_j) + 2x_i \cdot x_j \cdot \Delta\mathrm{Cov}(\widehat{X}_i, \widehat{X}_j) \tag{5}$$

$$+ \Delta x_i^2 \cdot \Delta\mathrm{Var}(\widehat{X}_i) + \Delta x_j^2 \cdot \Delta\mathrm{Var}(\widehat{X}_j) + 2\Delta(x_i \cdot x_j) \cdot \Delta\mathrm{Cov}(\widehat{X}_i, \widehat{X}_j). \tag{6}$$

[4] In using nominal shares, we follow McConnell and Perez Quiros (2000). If we were to correct for relative price changes among sectors in this analysis, our results would probably indicate a smaller role for composition: the price of services has risen relative to the price of goods, which contributes to the fact that services have become a larger part of the nominal economy. Unfortunately, the BEAs construction of GDP does not allow us to employ "real sector shares" and to test the role of price-adjusted composition in output growth stabilization.

Table 1
Annual output growth volatility, fixed shares and actual shares

Series	Expenditures	Product	Producer	Expenditures	Producer	Producer (no manufacturing)
Frequency	Quarterly	Quarterly	Annual	Annual	Annual	Annual
Sector shares fixed within periods						
Early	1.02E−03	9.35E−04	7.95E−04	7.86E−04	7.25E−04	3.70E−04
Late	4.22E−04	4.15E−04	4.36E−04	3.73E−04	3.69E−04	3.34E−04
% Change	−58.6	−55.6	−45.2	−52.5	−49.2	−9.7
Actual shares						
Early	9.42E−04	9.42E−04	7.36E−04	7.36E−04	7.36E−04	3.28E−04
Late	4.40E−04	4.40E−04	3.99E−04	3.97E−04	3.97E−04	3.03E−04
% Change	−53.4	−53.4	−45.8	−46.1	−46.1	−7.7

Data series: GDP by expenditures, product, and producer (see Appendix for details).

Expression (4) represents the part of $\Delta\text{Var}(\widehat{Y})$ due to changes in the share terms, which we will refer to as the ‘‘composition effect’’. Expression (5) represents the part of $\Delta\text{Var}(\widehat{Y})$ due to changes in the variance and covariance terms, which we will refer to as the ‘‘volatility effect’’. Expression (6) represents the part of $\Delta\text{Var}(\widehat{Y})$ due to the interaction of changes in variance and covariance terms with changes in the share terms, which we will refer to as the ‘‘interaction effect’’. It may also be useful to notice that the composition effect is the sum of sector share changes, weighted by their early period variances and covariances; the volatility effect is the sum of changes in sector variances and covariances, weighted by their early period shares.

Before assessing the relative importance of changes in composition and volatility on output growth volatility, it is straightforward to demonstrate that fixing sectoral shares within periods has little effect on the dynamics of GDP growth. (This is not so surprising since shares should be far less variable than growth rates.) Table 1 shows the output growth variance for our three GDP series (expenditures,[5] products, and production) both with fixed early and late period shares and with the actual shares. In each case the variance calculated with fixed shares is quite close to the observed variance, and the percentage drop from the early period to the late period is nearly the same using fixed and actual shares. Since GDP by production sector is only available at annual frequency, we also work with annual versions of the other two series to show that the results are comparable. Not surprisingly, the variance figures for the annual series are lower than those for the quarterly series. But here and elsewhere the analysis is the same regardless of the data frequency.

4. Results

Table 2 presents the results of our decomposition of total change in variance into composition, volatility, and interaction effects for each of our GDP series. The results

[5] Reconstructing an output series using fixed sector shares is awkward for GDP by expenditures, since net exports changed signs some 17 times between 1947 and 1980 (the last year for which they were positive) and it is thus not possible to calculate a growth rate for that component. Instead we separately include imports and exports, with imports being assigned a negative share of GDP.

Table 2
Decomposition of change in output growth volatility

Series	Expenditures	Product	Producer	Expenditures	Product	Producer (no manufacturing)
Frequency	Quarterly	Quarterly	Annual	Annual	Annual	Annual
Composition effect (%)	17.4	31.0	59.8	23.4	32.4	13.9
Volatility effect (%)	86.2	77.9	64.1	82.3	73.4	−14.1
Interaction effect (%)	−3.5	−8.9	−23.8	−5.6	−5.9	100.2

Data series: GDP by expenditures, product, and producer (see Appendix for details).

demonstrate that the importance of compositional changes in the stabilization of output growth depends on how GDP is decomposed. Changes in the mix of expenditures (consumption, investment, government spending, net exports) and in the mix of products (durable and nondurable goods, services, and structures) seem to have had a modest effect on output volatility. This result echoes findings of Blanchard and Simon (2001) and Stock and Watson (2002), respectively. Changes in the mix of production sectors (manufacturing, services, finance, etc.), by contrast, are of decisive importance. Our volatility decomposition by production sector suggests that a little less than half of the variance drop can be attributed to changes in the relative size of the 10 sectors of the US economy. Changes in variance and covariance terms accounted for the rest. In all cases, but especially in the case of production, the interaction effect was negative, meaning that on balance sectors that shrank (grew) in relative size also became less (more) volatile.

Fig. 2a–c, which depict the GDP share and standard deviation of output growth by sector for each of our three GDP series, provide a graphical sense of how composition and volatility effects play different roles in different decompositions of GDP. These figures plot sectoral share on the horizontal axis and the standard deviation of sectoral output growth on the vertical axis. The early and late period points are plotted for each sector and are connected by a line, with the sector label closest to the late period point. A line pointing toward the origin thus indicates a drop in both output growth volatility and share of GDP between the early and late periods. Fig. 2a, which depicts the expenditure series, shows clearly that compositional changes were small relative to volatility drops in imports, exports, investment, and government. (The remaining sector, consumption, experienced a modest increase in volatility and drop in GDP share.) Compositional changes were more significant for product sectors (Fig. 2b), with the growth of the relatively stable services sector being the most significant change. Sector stabilizations clearly play a large role here, with the large services sector and both goods sectors dropping significantly in volatility (although the effect was counteracted by rising volatility in the smaller structures sector). Fig. 2c makes clear why the composition effect was largest for the producer series. While there are significant volatility drops in some sectors (particularly government, manufacturing, and transportation), the horizontal movement of the stable finance and service sectors to the right and the more volatile manufacturing sector to the left signify a major reweighting of the economy towards stability.

Clearly, differences in the extent of compositional changes and the volatility of the sectors in which these changes took place account for differences in the relative importance of the composition effect in our three GDP series. It is less straightforward to determine the implications of this finding. In theory, it would be possible to group the same

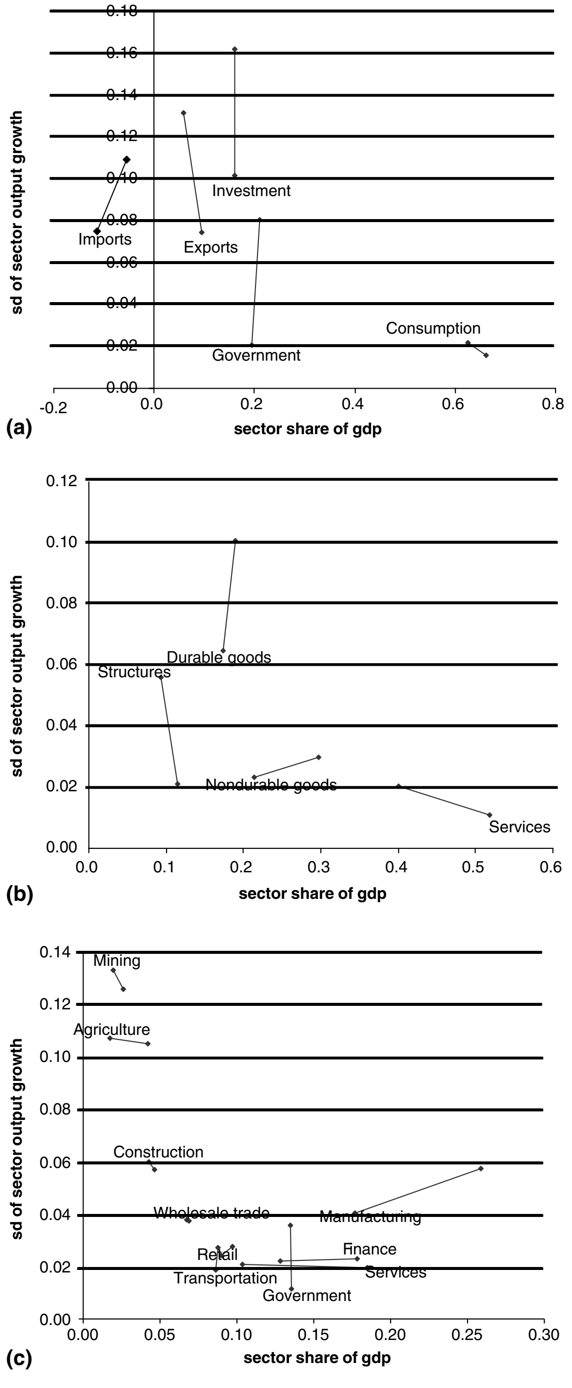

Fig. 2. Sectoral shares of GDP and standard deviation of sectoral output growth, 1947–1981 and 1982–2001 (sector labels at later point): (a) GDP by type of expenditures (see Appendix for details on data series); (b) GDP by type of product (see Appendix for details on data series); and (c) GDP by type of producer (see Appendix for details on data series).

macroeconomic data into sectors whose composition does not change between periods (thus attributing 100% of the stabilization to the volatility effect) or into sectors whose volatility does not change between periods (thus attributing 100% of the stabilization to the composition effect). Performing this exercise would undoubtedly require creating groupings of economic activity that completely lack economic coherence, and the results would tell us nothing about what caused the US economy to become more stable. To the extent that compositional changes among economically meaningful categories (such as the ones we use) can be tied to stabilization, though, we can draw conclusions about the reasons for past stabilization and the prospects for future volatility. In our view, our findings on the role of composition place an upper limit on the role of policy or luck in the stabilization of US output growth in the period 1947–2001, and suggest that continued structural shifts toward more services and finance and less manufacturing will lead to continued stabilization.

4.1. The role of manufacturing

As depicted in Fig. 2c and discussed earlier, the manufacturing sector is both a large and volatile sector in the US economy, but both its size and volatility have declined significantly in the last half-century. It is worth taking a closer look at the consequences that these changes have had on the stability of output growth.

One way to assess the role that manufacturing has played in the decline in US output growth volatility is to divide the economy-wide change in volatility into a part explained by manufacturing, which involves 3 out of 30 variance terms and 30 out of 300 covariance terms from the total decomposition by producer, and another part that is not explained by manufacturing, which involves all the remaining variance and covariance terms. We report this decomposition in Table 3.

It is striking that, both in the total effect and in each decomposed effect category (that is, the composition effect, volatility effect, and interaction effect), manufacturing alone accounts for the entire change from the early to late period, while the rest of the economy generates a small effect in the opposite direction. (Around half of manufacturing's total effect is due to covariance terms with other sectors which, of course, cannot be attributed solely to changes in the size and stability of manufacturing.) The figures in Table 3 show that, at least in an accounting sense, a reduction in the size of manufacturing and in its volatility were both important in stabilizing the US economy, and the magnitude of the two effects was roughly the same.

Table 3
Proportion of stabilization associated with manufacturing

	Δ variance	Δ in manufacturing variance terms	Δ in all manufacturing terms	% of total Δ due to manufacturing terms	
				Variance terms	All terms
Total	−3.59E−04	−1.92E−04	−3.96E−04	53.5	110.3
Composition effect	−2.15E−04	−1.28E−04	−2.31E−04	59.6	107.8
Volatility effect	−2.30E−04	−1.47E−04	−2.80E−04	64.1	121.6
Interaction effect	8.56E−05	8.76E−05	1.18E−04	102.4	138.2

Data series: GDP by producer (see Appendix for details).

The last column of Table 1 shows that a hypothetical economy without manufacturing would have had much more stable growth over the whole period and would have exhibited a much smaller drop in output growth volatility.[6] The variance of the non-manufacturing economy's growth rate is less than half the variance of the full economy's growth rate in the early period and about 25% lower in the late period. The observed drop in growth volatility without manufacturing is under 10%.

Still focussing on the US economy excluding manufacturing, we again decompose the change in variance into three parts. The results in the last column of Table 2 show that, when weighted by their pre-1982 shares of GDP, sectors other than manufacturing were somewhat *more* volatile after 1982 than they were before, a result which is surprising considering the overall decline in output growth volatility. It appears that stabilization of the government and transportation sectors were counteracted by increased volatility in mining, agriculture, construction, and finance (see Fig. 2c). On the other hand, compositional shifts and interactions between compositional changes and sectoral volatility changes tended to reduce volatility. These results suggest that very little if any of the observed decline in output volatility is explained by changes in the output dynamics of non-manufacturing sectors, and that only a small part is related to shifts in composition among non-manufacturing sectors.

4.2. Compositional changes within manufacturing

The decline in manufacturing's role in the US economy can be linked to a number of factors, some of which have been discussed in the popular press, including the increasing concentration of manufacturing facilities in lower-wage countries. We will not attempt to further analyze this phenomenon, other than to reemphasize that it is one of the primary explanations for the stabilization of US output growth.

There remains, though, the problem of explaining why manufacturing output has become more stable. One plausible explanation is that composition effects are again at work. That is, particularly volatile manufacturing industries may have grown more slowly than more stable manufacturing industries. GDP data are not available by two-digit SIC industry, but monthly data on gross output, which measures production rather than final sales, are available from the US Census Bureau for 14 manufacturing industries starting in 1958. Because production data involve double counting, working with such data is not equivalent to working with GDP data, but we expect that large changes in the dynamics or composition of output would affect both series in roughly the same way. Using the same method as in the previous section, we find that very little of the decline in gross output volatility is explained by changes in the composition of manufacturing output. See Table 4. Changes in the volatility of manufacturing output growth at the two-digit level, then,

[6] There may appear to be a contradiction between the last column of Table 3, which suggests that the change in manufacturing terms was larger than the change for the whole economy, and the last column of Table 1, which shows that a hypothetical economy without manufacturing would have become slightly more stable from the early to the late period. The reason for this apparent contradiction is that, in order to use the above decomposition to infer the volatility change in an economy without manufacturing, we must first adjust the share terms to account for the absence of manufacturing. Because manufacturing was larger in the early period than in the later period, the early period shares for the rest of the economy should be boosted by more than the late period shares, which magnifies the early period volatility and restores evidence of a volatility drop (although quite small).

Table 4
Decomposition of change in volatility of manufacturing gross output growth

Percent change in total variance (%)	−59.50
Percent due to each component effect (%)	
Composition effect	−10.63
Volatility effect	−58.06
Interaction effect	9.19

Data series: Manufacturing gross output (see Appendix for details).

seem to lie behind the dramatic decline in manufacturing output growth volatility. The next section will assess one possible explanation for this phenomenon.

5. Conclusion

Any discussion of the long-run stabilization of US output must consider changes in the composition of US output. Our decomposition of output growth volatility by one-digit industry indicates that a bit less than half of the drop in volatility between the pre- and post-1982 periods is accounted for by compositional shifts, most notably the decline of manufacturing and the rise of services and finance.

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Appendix

Details on data series

Series name	Components	Source	Prices
GDP by expenditures	Consumption, investment, government, spending, net exports	BEA National Income and Product Accounts, Table 1.1, "Gross Domestic Product"	Current dollars, adjusted for inflation with price index from BEA National Income and Product Accounts Table 7.1, "Quantity and Price Indexes for Gross Domestic Product"
GDP by products	Durable goods, non-durable goods, services, and structures	BEA National Income and Product Accounts, Table 1.3, "Gross Domestic Product By Major Type of Product"	Current dollars, adjusted for inflation with price index from BEA National Income and Product Accounts Table 7.1, "Quantity and Price Indexes for Gross Domestic Product"

Appendix (*continued*)

Series name	Components	Source	Prices
GDP by producer	Agriculture, forestry, and fishing; mining; construction; durable goods manufacturing; nondurable goods manufacturing; transportation; wholesale trade; retail trade; finance, insurance, and real estate; services; government (SIC 1-dight industries)	BEA Gross Domestic Product by Industry (value-added by 1-digit SIC sector)	Current dollars, adjusted for inflation with price index from BEA National Income and Product Accounts Table 7.1, "Quantity and Price Indexes for Gross Domestic Product"
Manufacturing gross output (shipments and inventories)	Food; tobacco; textiles; paper; chemicals; petroleum and coal products; rubber and I miscellaneous plastic products; stone, clay, land glass products; metals; metal products; machinery; electronics; transportation equipment; instruments	Census Bureau "Manufacturers' Shipments, Inventories, and Orders" (M3)	Current dollars, adjusted for inflation with BEA monthly price deflator

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