Output Composition and the US Output Volatility Decline

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Abstract: We argue that the role played by output-composition changes on the decline in US output volatility has been incorrectly assessed in the recent literature. We obtain that shifts across broad sectors in the economy account for about thirty-percent of the volatility decline since the 1950's. (JEL: E32)

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1. INTRODUCTION

US output volatility has experienced a remarkable reduction over the last decades. For instance, output volatility (measured as the variance of quarterly real GDP growth) in the first quarter of 2002 was 37 percent of that in the first quarter of 1970 and 20 percent of that in the first quarter of 1957 (see the solid line in Figure 1). The possible causes pointed by the literature for the output volatility decline include improvements in inventory management (McConnell and Pérez-Quirós, 2000, and Kahn, McConnell and Pérez-Quirós, 2002), improvements in monetary policy (Clarida, Gali and Gertler, 2000), innovations in financial markets and changes in the dynamics of inflation (Blanchard and Simon, 2001), and good luck in the form of less intense exogenous shocks (Ahmed, Levin and Wilson, 2001). Still, according to Stock and Watson's (2002) calculations, about half of the decline in volatility is still unaccounted for.[1]

The shifts in output composition have been dismissed, however, as a significant cause of the output volatility reduction (McConnel and Pérez-Quirós, 2000, Blanchard and Simon, 2001, and Stock and Watson, 2002), contradicting so far the old prediction made by Arthur F. Burns in his presidential address to the American Economic Association (Burns, 1960).[2] This is rather surprising since output composition has experienced dramatic structural changes; for instance, the services sector which is by far the most stable sector, has increased its GDP share by more than 60% between 1947 and 2002 at the expense of the much more volatile goods sector. In this paper we reassess the issue. We argue that the output composition effect on volatility has been incorrectly assessed in the previous literature. We obtain that the shifts across broad sectors in the economy account for about thirty-percent of the decline in output volatility observed since the fifties, and that the contribution of this factor to the trend volatility decline is likely to have been increasing over time.

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[1] Besides its own empirical work, this paper also reviews the large, recent and growing literature on the output volatility decline.

[2] Arthur F. Burns predicted that the increasing importance of white collar jobs with respect to blue collar ones will bring about a more stable aggregate production.

2. IDENTIFYING THE OUTPUT-COMPOSITION EFFECT

Blanchard and Simon (2001) define volatility as the standard deviation of quarterly real output growth, where real output is chain-weighted GDP. Their preferred method to compute this standard deviation is using a rolling window of twenty quarters, so that the statistic reported for quarter *t* is the estimated standard deviation over quarters *t*-19 to *t*. We follow Blanchard and Simon (2001) in the definition of volatility except that we use the variance instead of the standard deviation[3] and that we extend to forty quarters the window used to compute the variance of GDP growth to better focus on medium and long run changes in volatility. Still, results are almost identical using the twenty quarter window. The output volatility path is plotted in Figure 1. Other measures of volatility such as the variance of an output gap (using the Hodrick-Prescott filter or a quadratic trend), computing annual rather than quarterly rates or computing volatility as the conditional variance obtained from the same series of the quarterly growth rates assuming a GARCH(1,1) process, yield similar outcomes.

Identifying the output-composition effect involves an index-like problem. GDP-volatility dynamics is the combined result of sectors' volatility dynamics and of changes in GDP composition. Hence, roughly speaking, sectors' GDP shares are to be somewhat fixed to identify the contribution of sectors' volatility changes to the change in GDP volatility; and sectors' volatilities are to be somewhat fixed to identify the contribution of output composition changes to the change in GDP volatility. The simple procedure followed in the literature to separate these two effects has been to compute a counterfactual series for GDP growth obtained by holding each sector's share constant, and then compare the output-volatility path obtained using this counterfactual series with the one obtained using the original series. Specifically, McConnel and Pérez-Quirós (2000) compute their counterfactual series holding each sector's share constant at its sample-wide average, Blanchard and Simon (2001) use the 1947 shares and Stock and Watson use the 1965 shares. Since the actual and the counterfactual series look very

[3] In this way, GDP volatility equals the weighted sum of the GDP-components' variances and covariances and we can easily perform additive decompositions.

similar to each other, they conclude that composition effects have been of little importance -if any- for the output volatility decline.

This methodology is unsatisfactory for the same reasons that using fixed-weight indexes has been abandoned to compute aggregate "real" series in the National Income and Product Accounts, and has been substituted by chain-weighted Fisher indexes (see Landefeld and Parker, 1997, and Whelan, 2000). Essentially, the problem is that taking an arbitrary base year to fix the weights to be used all over a large period of time may produce important distortions and involve systematic biases. In the particular case of output volatility, results are strongly dependent on the specific base year we choose since sector shares have experienced extremely important changes over the last fifty years. Specifically, since the share of goods and structures have substantially decreased from 1947 and the volatility in these sectors have decreased much more than in the services sector, using an early base year to fix sector shares overestimates the aggregate effect of the reduction in sectors' growth variances and covariances, and underestimates the importance of the composition effect.

To solve these problems we use a chain-weighting method to decompose the two effects on volatility. This method updates, for every quarter, the weight of each sector according to its current share in GDP, and provides consistent direct computations for both the sectors' variances-covariances effect and the output-composition effect. Specifically, our approach is the following. First, we can approximate the real growth rate of GDP by a weighted average of the growth rates of its components:

$$y_t = \sum_i \alpha_{i,t} x_{i,t}, \tag{1}$$

where $\alpha_{i,t}$ is the average of sector i's nominal share of GDP in the current and previous period, and $x_{i,t}$ is the real growth rate of sector i in the current period (see Whelan, 2000). From this, we can write the variance of GDP as the sum of its components' variances and covariances:

$$Var(y_t) = \sum_i \sum_j \alpha_{i,t} \alpha_{j,t} Cov(x_{i,t}, x_{j,t}). \tag{2}$$

Using this expression for t and t-1 we can obtain:

$$Var(y_t) = \sum_i \sum_j \left[Cov(x_{i,t}, x_{j,t}) - Cov(x_{i,t-1}, x_{j,t-1})\right](\alpha_{i,t}\alpha_{j,t} + \alpha_{i,t-1}\alpha_{j,t-1})/2$$
$$+\sum_i \sum_j (\alpha_{i,t}\alpha_{j,t} - \alpha_{i,t-1}\alpha_{j,t-1})\left[Cov(x_{i,t}, x_{j,t}) + Cov(x_{i,t-1}, x_{j,t-1})\right]/2 + Var(y_{t-1}). \quad (3)$$

Now, substituting $Var(y_{t-1})$ with the corresponding expression of (3) and iterating backwards we can express the change in output variance between period t and any initial period as:

$$Var(y_t) - Var(y_0) = \sum_{s=1}^{t} \sum_i \sum_j \left[Cov(x_{i,s}, x_{j,s}) - Cov(x_{i,s-1}, x_{j,s-1})\right](\alpha_{i,s}\alpha_{j,s} + \alpha_{i,s-1}\alpha_{j,s-1})/2$$
$$+\sum_{s=1}^{t} \sum_i \sum_j (\alpha_{i,s}\alpha_{j,s} - \alpha_{i,s-1}\alpha_{j,s-1})\left[Cov(x_{i,t}, x_{j,t}) + Cov(x_{i,t-1}, x_{j,t-1})\right]/2. \quad (4)$$

The first term in this expression is the *variances-covariances effect* and the second is the *output-composition effect*. Equation (4) may be seen as an (additive) parallel to the chain-weighted Fisher method to decompose nominal series changes into price and quantity shifts.

4. RESULTS

We now compute the contribution of each factor in equation (4), considering the same four broad sectors used in McConnel and Pérez-Quirós (2000) and Stock and Watson (2002); namely, durable goods, non-durable goods, services and structures. As already mentioned, each sector's growth variances and covariances for each quarter are estimated using a forty-quarter rolling window.[4] Our calculations are based on the data from the National Income and Product Accounts (NIPA) of the Bureau of Economic Analysis. Quarterly real growth rates are computed using the NIPA chain-type quantity indexes for GDP and its components (Table

[4] We use the same window to compute sector shares. It may be noted that using the average share of only the two quarters in the middle of the forty-quarter window used to calculate each period variances and covariances, yields a larger value for the output-composition effect.

7.17), and sector shares are computed using NIPA nominal data (Table 1.3). Since the first available observation for chain-weighted GDP is 1947:1, the first observation for the variance of the growth rate is 1957:1.

The solid line in the bottom panel of Figure 1 plots the contribution of the composition effect and the variances-covariances effect to the volatility decline between 1957:1 and 2002:2. Output volatility went down by 1.37 points (from 1.65 to 0.28) between 1957:1 and 2002:2. The contribution of the output-composition effect throughout this period was 0.38 points, and the contribution of the variances-covariances effect was 0.99. Hence the output-composition effect accounts for 28 percent of the output volatility reduction experienced in the last 45 years.[5]

Since volatility has gone through large fluctuations, computation of this contribution may strongly depend on the particular points used as benchmarks. A more appropriate calibration may be obtained by either comparing peaks or troughs in the series. If we now compare the two peaks in our series (which correspond to 1958:4 and 1984:2) volatility dropped by 0.64 points, of which 0.23 points (i.e., the 36 percent) corresponded to the composition effect. On the other hand, volatility declined by 0.45 points between the lowest point in the sixties (1970:4) and the lowest point since then (2001:1). The output-composition effect was then responsible for 0.24 points of the drop; i.e., 53 percent.[6]

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[5] Note also that, as pointed out by Stock and Watson (2002), this type of calculations still ignores general equilibrium effects that could amplify the impact of the shift in sector shares. For instance, higher stability of aggregate income due to a higher share of services may moderate fluctuations of demand for all sectors.

[6] Since many researchers have focused on the large decline in volatility that occurred since 1984, it may be of interest to compute the fraction of the post 1983 decline that is associated with changes in output composition. This computation yields a fraction of 12.4 percent. However taking a peak (1984:1) and a trough (2002:2) in the volatility path as reference points to assess the relative importance of the long run impact of the composition effect, may give a misleading picture. The reason is that the composition effect has a fairly monotonic path whereas the variance-covariance effect exhibits large fluctuations. As a result, the assessment of

Still, a more accurate calibration of the composition effect's contribution can be obtained by estimating the trends over the period for output volatility and the composition effect. Hence we estimate:

$$\log(Var(y_t)) = a_y + b_y t + \varepsilon_y,$$
$$\text{and} \tag{5}$$
$$\log(C_t + Var(y_0)) = a_c + b_c t + \varepsilon_c;$$

where C_t is the output composition effect defined in equation (4), $Var(y_0)$ is output volatility at the beginning of the sample period, a_i and b_i (i=y,c) are the parameters to be estimated, and ε_i are the error terms. Estimating these equations for period 1957:1-2002:2 we obtain a_v=0.69, b_v=-0.0095, a_c=0.50, b_c=-0.0015.

The contribution of the output-composition effect can then be measured by the derivative of the composition-effect trend with respect to time, relative to the derivative of the GDP-volatility trend. According to this measure, the average contribution of the output-composition effect over the period (i.e., the mean of the derivatives ratio) in percentage terms was 30.2. This percentage is at least as large as Stock and Watson's (2002) estimates for the effect of improved policy on aggregate volatility and for the effect of good luck in the form of productivity and commodity price shocks. Moreover, the slopes ratio is increasing over time, going from 14 percent at the end of the 1950's to 52 percent at the end of the 1990's. Hence our results suggest that shifts in output-composition have played an important and increasing role in the long run reduction of US output volatility.

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the relative importance of the composition effect tends to be negatively biased if we use a volatility peak as the initial point and a volatility trough as the final point to fix the computation period, and it tends to be positively biased if we do the opposite.

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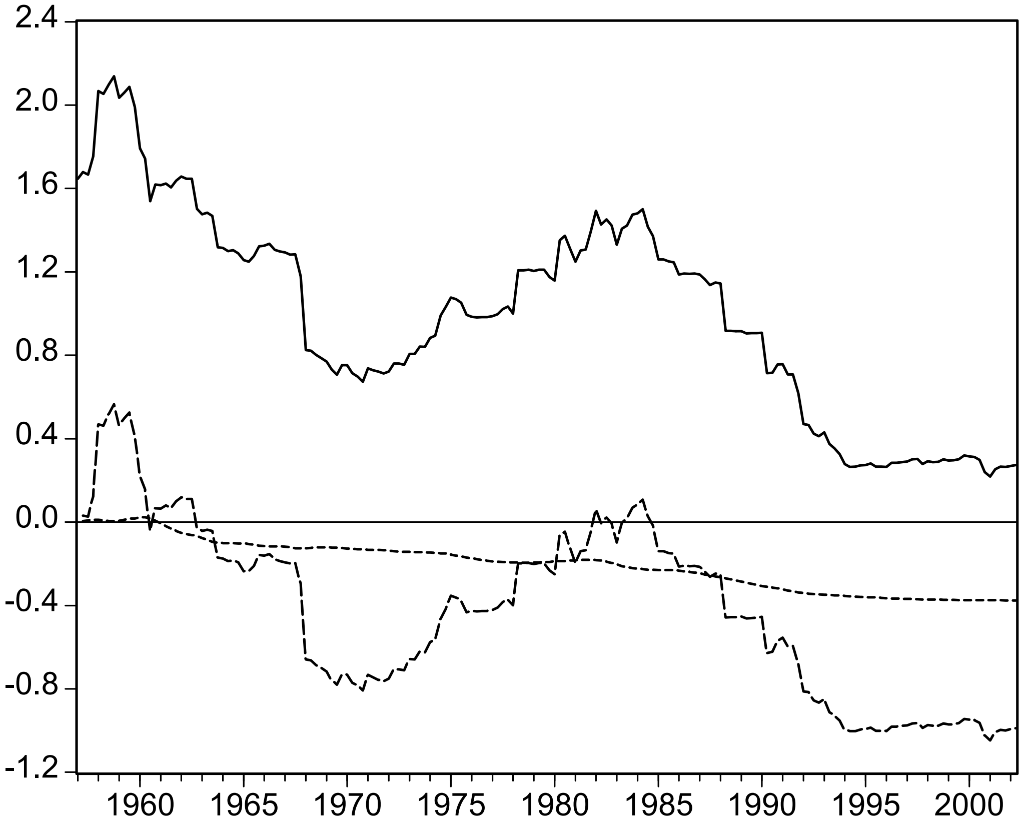
Figure 1
US Output Volatility Decline



——— GDP Volatility (Forty-quarter rolling variance of quarterly real GDP growth)
------ Contribution of the Composition effect to the volatility decline
– – – Contribution of the Variances-Covariances effect to the volatility decline

GDP Volatility(t) = GDP Volatility(1957:1) + Composition Effect(t) + Variances-Covariances Effect(t)