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Declining output growth volatility: A sectoral decomposition

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ABSTRACT

A decomposition of the U.S. aggregate output growth volatility using two-digit industry-level data shows that more than 60% of the post-1983 reduction in aggregate output growth volatility is attributed to the lowered comovement in total factor productivity (TFP) growth between industries. In contrast, stabilized input and TFP growths within an industry contribute little.

1. Introduction

During the past decades, the volatility of the U.S. GDP growth rate fell significantly, so-called the Great Moderation.[1] The potential explanations for the increased stability of GDP growth are improved monetary policy (Clarida et al., 2000), improved business practice including inventory management (Kahn et al., 2002), financial innovation (Dynan et al., 2006), and good luck in the form of less variable shocks (Stock and Watson, 2002). However, as Bernanke (2004) pointed out, each hypothesis may convey a partial explanation to the complicated phenomena such as the Great Moderation.

In this paper, instead of adding another possible explanation, we investigate the source of the Great Moderation by performing volatility accounting using two-digit industry-level data.

First, we decompose each industry's output growth into input and total factor productivity (TFP) growths and quantify the contributions of changes in variances and covariances of industry-level input and TFP growths to reduction in aggregate output growth volatility. We find that the lowered between-industry covariance of TFP growth accounts for more than 60% of the post-1983 reduction in aggregate output volatility and that of input growth for about 28%. In contrast, stabilized input and TFP growths within an industry contribute little to the declining aggregate output volatility. Our findings extend Irvine and Schuh (2005) and Stiroh (2006) who report declined comovement in output growth rate among U.S. industries.[2]

Second, we examine whether declined between-industry comovements of input or TFP growth reflect changes in labor and capital input compositions and/or sectoral and foreign input diversification. Even though we find limited explanatory powers for these variables, a lot of cross-industry variation is left unexplained. This invites future research in identifying the source of the Great Moderation at the disaggregated level.

2. Variance decomposition

To decompose aggregate output growth into industry-level output growth and further into industry-level input and TFP growths, we construct output (value-added), labor, capital, and TFP growth rates for 55 private industries (20 manufacturing and 35 non-manufacturing). We obtain both nominal and real value-added, and labor input from the *Gross Product Originating* (GPO) published by the Bureau of Economic Analysis (BEA). Before 1977, value-added deflators are unavailable, so we use gross output and intermediate input prices from the *Bureau of Labor Statistics* (BLS) *Multifactor Productivity Database* to construct substitutes.[3] For labor and capital quantities, we

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[1] McConnell and Perez-Quiros (2000) find a structural break in the U.S. GDP volatility around 1984. Volatilities of other macroeconomic variables, such as inflation and unemployment rates, exhibit similar patterns of stabilization (Stock and Watson, 2002).

[2] These studies argue that the declining GDP volatility is attributed to structural changes in the U.S. economy such as better inventory management (Irvine and Schuh, 2005) and increased labor market flexibility (Stiroh, 2006).

[3] Our sample ends in 2000, the last year BEA and BLS report most SIC-based industry-level data. Newly introduced NAICS-based data are only available from 1987.

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Table 1
Variance decomposition of aggregate output growth.

	(1)	(2)	(3)	(3)−(2)
	1971–2000	1971–1983	1984–2000	
Variance of aggregate output	8.24	15.05	3.98	−11.07
	(100)	(100)	(100)	(100)
Within-industry				
Variance of input	0.32	0.45	0.24	−0.21
	(3.87)	(2.98)	(5.93)	(1.92)
Variance of TFP	1.02	1.57	0.72	−0.86
	(12.38)	(10.47)	(18.01)	(7.76)
Covariance of input and TFP	−0.06	−0.04	−0.06	−0.02
	(−0.78)	(−0.25)	(−1.45)	(0.18)
Between-industry				
Covariance of input	2.78	4.83	1.75	−3.08
	(33.74)	(32.07)	(43.97)	(27.80)
Covariance of TFP	3.09	7.06	0.30	−6.76
	(37.51)	(46.91)	(7.59)	(61.04)
Covariance of input and TFP	1.03	1.14	0.97	−0.16
	(12.49)	(7.57)	(24.50)	(1.49)

Notes: Contributions to variance of aggregate output growth are in parentheses. Shares of contributions do not add to 100 because of rounding. Weights used in columns (1), (2), and (3) are industry value-added averages over 1971–2000, 1971–1983, and 1984–2000 periods, respectively.

use full-time equivalent employees from the GPO and real capital stock from the *Fixed Reproducible Tangible Wealth* (FRTW) published by the BEA, respectively.

We define TFP growth rate of industry i in year t as:

$$\begin{aligned}\Delta T_{it} &= \Delta Y_{it} - (S_{L,it}\Delta L_{it} + S_{K,it}\Delta K_{it}) \\ &= \Delta Y_{it} - \Delta I_{it}\end{aligned} \quad (1)$$

where ΔT_{it}, ΔY_{it}, ΔL_{it}, and ΔK_{it} denote growth rates of TFP, real value-added, labor, and capital inputs, respectively. $S_{L,it}$ and $S_{K,it}$ are average labor and capital cost shares over the two adjacent years and input growth (ΔI_{it}) is the cost share weighted average of labor and capital growths. To measure capital cost, we construct the rental price of capital as in the formula of BLS (1997). We use the asset composition of the FRTW for each industry to aggregate the BLS asset-specific rental prices of capital using the Törnqvist method.

For the whole sample period of 1971–2000 and two sub-periods 1971–1983 and 1984–2000, we decompose the variance of aggregate output growth into six components:

$$\begin{aligned}\mathrm{Var}(\Delta Y) &= \mathrm{Var}(\sum_i w_i \Delta Y_i) \\ &= \underbrace{\sum_i w_i^2 \mathrm{Var}(\Delta I_i)}_{\text{Within Input}} + \underbrace{\sum_i w_i^2 \mathrm{Var}(\Delta T_i)}_{\text{Within TFP}} + \underbrace{2\sum_i w_i^2 \mathrm{Cov}(\Delta I_i, \Delta T_i)}_{\text{Within Input and TFP}} \\ &\quad + \underbrace{2\sum_{i<j} w_i w_j \mathrm{Cov}(\Delta I_i, \Delta I_j)}_{\text{Between Input}} + \underbrace{2\sum_{i<j} w_i w_j \mathrm{Cov}(\Delta T_i, \Delta T_j)}_{\text{Between TFP}} + \underbrace{\sum_{i\neq j} w_i w_j \mathrm{Cov}(\Delta I_i, \Delta T_j)}_{\text{Between Input and TFP}}\end{aligned} \quad (2)$$

where the weight (w_i) is the average of industry i's nominal value-added over aggregate nominal value-added for each sample period.

The first row in Table 1 confirms that the volatility of aggregate output growth significantly declined from 1971–1983 to 1984–2000 periods.[4] The last column presents the contributions of six decompositions in Eq. (2) to the reduction in the variance of aggregate output growth. Most of the aggregate reduction is attributed to lowered between-industry covariance terms rather than to stabilized within-industry variances of input or TFP growth. Especially, the contribution of lowered between-industry covariance of TFP growth accounts for about 60% of the aggregate reduction, which is also more than twice larger than the contribution of lowered between-industry covariance of input growth.[5] The findings show that the Great Moderation can be characterized by the declining sectoral comovement in productivity growth.

[4] When we extend the sample period to start from 1959, volatility accounting results in Table 1 change little.

Table 2
Correlation coefficients.

	(1)	(2)	(3)	(3)/(2)
	1971–2000	1971–1983	1984–2000	
Within-industry				
Correlation of input and TFP	−0.09	−0.05	−0.05	1.07
Between-industry				
Correlation of input	0.27	0.38	0.18	0.47
Correlation of TFP	0.09	0.14	0.02	0.17
Correlation of input and TFP	0.04	0.05	0.04	0.85

In the following section, we examine cross-sectional determinants of between-industry comovement. Thus, in Table 2, we calculate between-industry correlations of TFP growth to normalize the comovement pattern. Declining correlations confirm results reported in Table 1 in that decreases in covariances (numerator) are faster than decreases in standard deviations (denominator) of underlying growth rates used in calculating correlations. All these indicate that productivity growth which became more industry-specific (thus reducing comovements) over past decades plays more important role for the reduced aggregate volatility than the increased stability of industry's TFP or input growth rate.

3. Between-industry correlations of input versus TFP growths

In the previous section we have shown that the falling aggregate output growth volatility is mainly attributable to declining correlations between industries rather than declining variances within industries. In this section we examine underlying factors explaining changes in between-industry correlations of input or TFP growth.

Dependent variables in regressions are changes in pairwise correlation of input growth or TFP growth between industries from 1971–1983 to 1984–2000 periods. Since we have 55 industries, the total number of observations for the dependent variables is $1485 = 0.5\times(55\times54)$. Since correlation coefficients are bounded between −1 and 1, we apply the Fisher's z-transformation, $\rho_{ij}^z = 0.5\times\ln\,[(1+\rho_{ij})/(1-\rho_{ij})]$, to make the variable $\in \mathfrak{R}^1$, and then we take the differences over the two sub-periods.[6]

We consider three sets of independent variables. First, we examine whether the declining correlations are concentrated in a particular cluster such as manufacturing or non-manufacturing sector. A dummy variable DM_{ij} is equal to 1 if both industries i and j are in the manufacturing sector and zero otherwise. DN_{ij} is similarly defined for the non-manufacturing sector.

Second, two industries can become less correlated as the composition of inputs of the two industries becomes dissimilar. We consider the dissimilarity of labor and capital input uses. We divide the labor input into four types by education-level (middle school or below, high school, some college, and 4-year college or above), which are obtained from the *Current Population Survey March Supplement* (CPS). We also divide capital input into three types, equipment, structures, and information technology and software obtained from the FRTW. We define the labor input dissimilarity between two industries i and j as $\sum_k |LC_{ik} - LC_{jk}|$

[5] To control changes in sectoral composition between the first and second sub-periods, we recalculate the post-1983 variance using weights of the first sub-period. Results change little.

[6] Regression results with or without z-transformation are qualitatively similar.

Table 3
Regressions explaining falling between-industry correlations.

	Input correlation				TFP correlation			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intercept	−0.268**	−0.286**	−0.272**	−0.270**	−0.150**	−0.140**	−0.127**	−0.141**
	(0.018)	(0.013)	(0.014)	(0.018)	(0.017)	(0.012)	(0.012)	(0.017)
Within MFG or NMFG								
DM	−0.319**			−0.301**	−0.041			−0.026
	(0.033)			(0.033)	(0.040)			(0.040)
DN	0.083**			0.069*	0.051*			0.032
	(0.028)			(0.028)	(0.026)			(0.025)
Dissimilarity of input use								
Labor		−0.526**		−0.354**		−0.267*		−0.258*
		(0.110)		(0.109)		(0.111)		(0.112)
Capital		−0.313**		−0.272**		−0.028		−0.079
		(0.072)		(0.072)		(0.063)		(0.064)
Diversification								
Input–output coefficient			−1.081*	−0.681			0.872	0.951*
			(0.538)	(0.506)			(0.458)	(0.455)
Share of foreign input			−0.077	0.020			−1.820**	−1.854**
			(0.361)	(0.376)			(0.402)	(0.412)
Adjusted R^2	0.060	0.025	0.002	0.075	0.003	0.002	0.015	0.020
Sample size	1485	1485	1485	1485	1485	1485	1485	1485

Notes: The dependent variables in columns (1)–(4) are Fisher's z-transformed between-industry input growth correlation coefficients of industry i and j over 1984–2000 less the same quantity over 1971–1983. The dependent variables in columns (5)–(8) are similarly defined for TFP growth. DM (DN) is a dummy variable which is equal to 1 if both industries i and j are in the manufacturing (non-manufacturing) sector and zero otherwise. Numbers in parentheses are heteroskedasticity-consistent standard errors. * and ** denote significance at the 5% and 1% levels, respectively.

where LC_{ik} is the labor cost share of type k in industry i. Capital input dissimilarity is analogously defined. Since both are annually measured, we average them over the two sub-periods.

Third, if an industry uses more intermediate inputs produced by another domestic industry (i.e., lower input diversification), the correlation of the two industries' input or productivity growths would rise. In contrast, an industry with a higher foreign input share relative to domestic input share is less likely correlated with other domestic industries. We construct two measures of diversification: sectoral and foreign diversification. To measure sectoral diversification, we construct coefficients of inter-industry transaction of intermediate inputs obtained from 85-sector input–output tables for years 1972, 1977, 1982, 1987, 1992, and 1997. Foreign diversification is measured by the ratio of foreign over domestic intermediate inputs. For a pair of industries i and j, we use the average of foreign diversification measures for the two industries. The 1972, 1977, and 1982 years are averaged for the 1971–1983 period and the 1987, 1992, and 1997 years for the 1984–2000 period.

Except for dummy variables, all independent variables are calculated as changes in averages between two sub-periods.

Table 3 presents regression results on determinants of changes in between-industry correlations of input or TFP growth. Even though some variables have significant coefficients in explaining correlation patterns, explanatory powers of these variables are limited, especially for TFP correlations. First, input correlations declined within the manufacturing sector but rose within the non-manufacturing sector, while changes in TFP correlations do not seem to be concentrated in a particular sector. Second, input dissimilarity measures have negative and significant coefficients for input correlations. Even though we still obtain negative coefficients, significance becomes weaker or disappear for TFP correlations. Third, diversification measures sometimes have wrong sign and sporadic significance. They tend to be more significant for TFP correlations unlike other variables. However, their explanatory powers are pretty small at 0.2% (1.5%) for input (TFP) correlations. Fourth, when all 6 variables are included together (columns 4 and 8), adjusted R^2 for input correlation is 7.5%, but the number for TFP correlation is much smaller at 2.0%. This suggests that changes in input dissimilarity or diversification have a limited role in explaining uncoupled productivity growth at the industry-level.

4. Conclusion

Throughout the paper, we have shown that the declining sectoral comovement in productivity growth is a main source of the Great Moderation. Neither the falling variances of input and TFP growths nor the declining between-industry covariance of input growth is a main contributor to the Great Moderation. Changes in dissimilarity of labor and capital input use or sectoral and foreign diversification have limited explanatory power in explaining lowered between-industry correlations of TFP and input growths. Our findings suggest that the full explanation for the Great Moderation should include the pattern of comovement in TFP growth at the disaggregate level and invite further empirical research on this topic.

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