

## Stabilization in the Volatility of Output: A Decline in Cross-industry Comovements

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Output volatility in Japan's manufacturing sector has been stabilizing from a long-term perspective and this tendency has become noticeable in recent years. In this current economic expansion, the volatility of overall production has been reduced, since cross-industry comovements have declined and thus fluctuations of individual industries have offset one another. This decline in cross-industry comovements has two driving factors: (1) diversification of the types of goods whose demand is expanding, reflecting the fact that global economic growth is now supported by a more diverse range of countries in response to the high growth of emerging economies such as BRICs, and (2) weakening interactions among domestic industries due to the progress in the international division of labor. As a consequence, a shock in an industry is unlikely to spillover to other domestic industries. These factors suggest that by and large, domestic production is unlikely to be affected by a single negative shock. It should be noted, however, that the volatility of Japan's production may increase with increased cross-industry comovements, when there is a significant shock that triggers global comovements.

### 1. Introduction

The current economic expansion—starting from early 2002—has continued for more than five and a half years, Japan's longest postwar expansion on record (Chart 1). The economy has indeed exhibited "sustained" growth, but it is also true that this expansion did not gather stronger momentum as observed in the "moderate" growth, marking only slightly above the potential growth rate. Real GDP has continued to grow at a constant pace of around 2 percent during this current economic expansion. Furthermore, industrial production—which usually fluctuates substantially over business cycles—has been on a gradual uptrend, with small fluctuations (Chart 2). The purpose of this *Review* is to examine why cyclical movements have stabilized in this current expansion, focusing on production in the manufacturing sector.

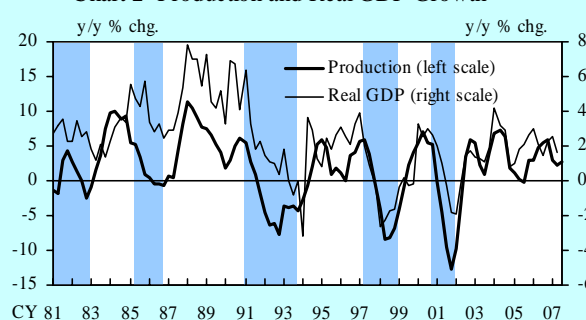
This *Review* is structured as follows. We first show that the stabilization of output volatility arose from the decline in cross-industry comovements in this current expansion. One central stylized fact of business cycles is that most industries in the economy move up and down together. Recent episodes, however, tell us

Chart 1 Economic Expansions in the Postwar Period

Boom	Expansion period	Duration	ann., % chg. Average growth of production
<i>Jinmu boom</i>	Nov.1954 - Jun.1957	31 months	20.2
<i>Iwato boom</i>	Jun.1958 - Dec.1961	42 months	22.1
<i>Olympic boom</i>	Oct.1962 - Oct.1964	24 months	16.3
<i>Izanagi boom</i>	Oct.1965 - Jul.1970	57 months	16.7
	Dec.1971 - Nov.1973	23 months	12.9
	Mar.1975 - Jan.1977	22 months	10.4
	Oct.1977 - Feb.1980	28 months	9.7
	Feb.1983 - Jun.1985	28 months	7.0
<i>Bubble boom</i>	Nov.1986 - Feb.1991	51 months	6.5
	Oct.1993 - May 1997	43 months	3.7
<i>IT-Bubble boom</i>	Jan.1999 - Nov.2000	22 months	4.7
Current expansion	Jan.2002 -	over 69 months	4.1

Note: Shaded areas indicate expansions lasting over 33.7 months (the average duration of past expansions).

Chart 2 Production and Real GDP Growth



Note: Shaded areas indicate recession periods (same hereafter).

Sources: Ministry of Economy, Trade and Industry, "Indices of Industrial Production"; Cabinet Office, "National Accounts."

that this is actually not the case.<sup>1</sup> In the next section, we shed light on several factors that affect the decline in cross-industry comovements and explore the mechanisms of the ongoing moderate expansion in production in light of shocks and propagation mechanism. Finally, we conclude with remarks on the outlook for production.

## 2. Stabilization in output volatility and a decline in cross-industry comovements

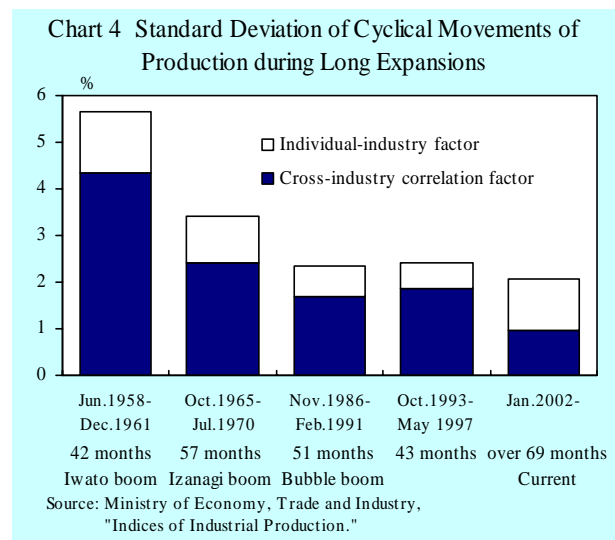
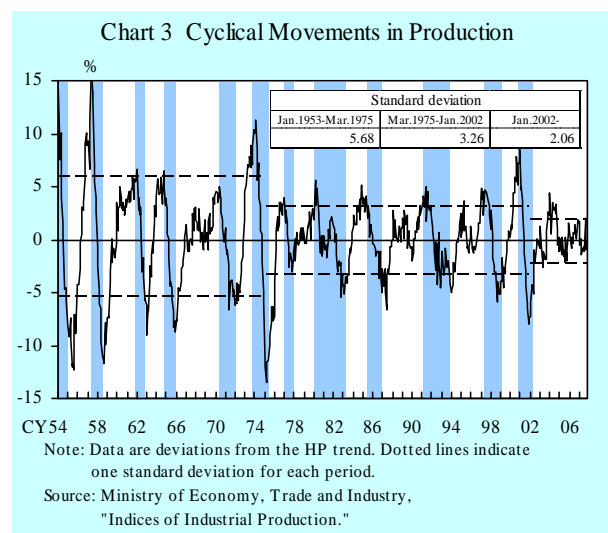
### (1) Stabilization in output volatility

Movements in Japan's industrial production have been stabilizing. Looking at the cyclical movements of production (deviations from the HP trend) from a long-term perspective, the amplitude of fluctuation has become smaller; this tendency has become evident in recent years (Chart 3).<sup>2</sup> The standard deviation of cyclical movements during 1953-1975 was 5.7 percent, whereas it was 3.3 percent in 1975-2001, and dropped further to 2.1 percent during this current economic expansion, which started from early 2002.

The stabilization of output volatility is attributed to various factors such as technological progress in inventory management.<sup>3</sup> Added to this, movements of individual industries and cross-industry comovements are also important.

Aggregate production is the share-weighted average of production of individual industries; hence (1) when the fluctuations of individual industries become small, aggregate production stabilizes. In addition, (2) even when the magnitude of fluctuations in individual industries remains unchanged, that of aggregate fluctuations becomes smaller when cross-industry comovements decline. To understand the latter, consider a hypothetical economy consisting of two industries, comparing a case in which the production of both industries is moving in the same direction (positive correlation) and a case in which they are moving in the opposite direction (negative correlation). Clearly, the overall fluctuation is smaller in the latter case than in the former, even when the output volatilities of individual industries are exactly the same in the two cases; a negative correlation makes fluctuations of each industry offset one another, leading to stabilization of aggregate output.

From this viewpoint, we decompose the fluctuations (standard deviation) of overall production in the long-lasting postwar economic expansion into two parts: (1) volatility driven by fluctuations in individual industries, and (2) volatility caused by cross-industry correlations (Chart 4).<sup>4</sup> In this current expansion, it was the decline in correlations that contributed to the stabilization of overall production. That is, output volatility of individual industries in this current expansion increased rather slightly compared to the Bubble period and the expansion in the mid-1990s. On the other hand, the decline in cross-industry correlations was large enough to offset these effects. In sum, output volatility shrank in recent years not because it contracted among individual industries, but as a result of a decline in cross-industry comovements that enabled fluctuations of each industry to offset one another.<sup>5</sup>



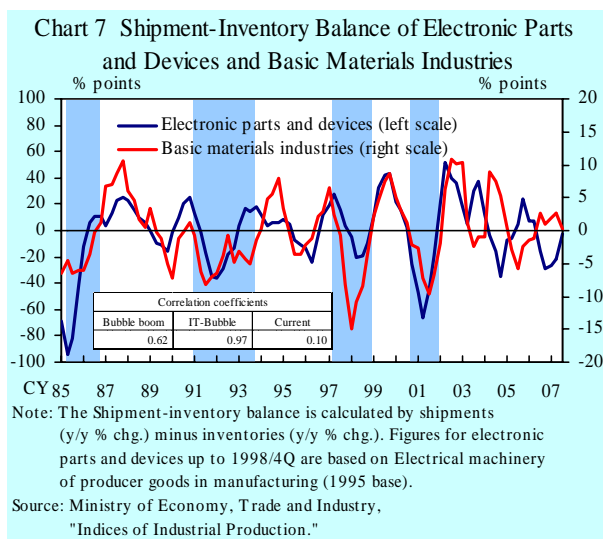
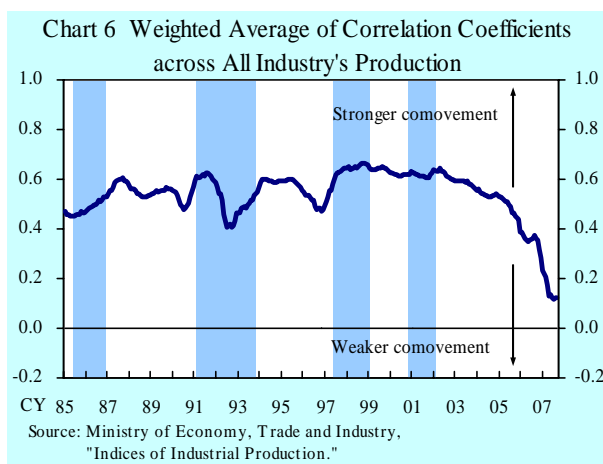
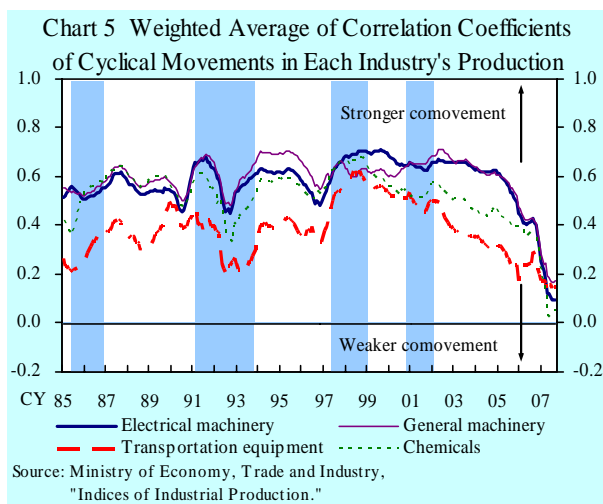
## (2) A decline in cross-industry comovements

Let us look closely at the decline in cross-industry comovements. Chart 5 shows the correlation coefficients between production of an industry and other industries (weighted average by weight of production).<sup>6</sup>

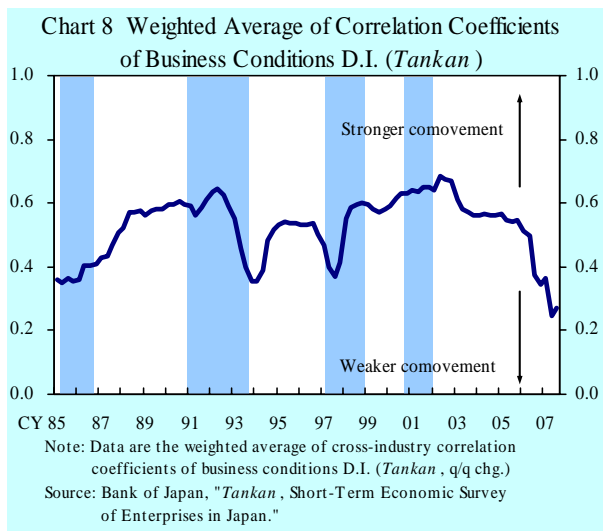
Here, in the correlation coefficients between four representative industries (electrical machinery, general machinery, transportation equipment, and chemicals)—which comprise a large weight—and other industries, we can see that the correlation coefficients have been falling markedly in recent years in all these industries. Aggregating the correlation coefficients over all manufacturing industries, we can still find a notable downtrend in this current economic expansion (Chart 6).<sup>7</sup> The aggregated cross-industry correlation coefficient used to be around 0.5, whereas it has currently dropped to slightly more than 0.1; it has hardly shown any correlation. Put differently, it seems as though cross-industry comovements as observed in the past are now lost. Positive comovements of production across sectors have long been identified as a stylized fact of business cycles. In this sense, the current economic expansion has been showing a cyclical pattern historically different from those observed in past business cycles.

Looking at the inventory cycle by industry gives us another way to see how the decline in cross-industry comovements stabilizes output volatility. Empirically, in electronic parts and devices as well as basic materials industries (such as iron/steel and chemicals), fluctuations in the inventory cycles, furthermore, and output volatility tend to become large. In the past, the inventory cycles of these two sectors showed synchronized movements, but there has been a lag between the two cycles in this current expansion. When comparing the shipment-inventory balance of the two sectors (year-on-year shipments minus year-on-year inventories; Chart 7), they showed similar movements until around 2002, but from then onward have been moving in opposite directions. Specifically, during (1) the second half of 2004 to the first half of 2005, and (2) the end of 2006 up until present, the shipment-inventory balance of electronic parts and devices marked a negative that entailed inventory adjustments, whereas it registered a positive

for basic materials in both of these periods. As a result of these two sectors offsetting each other, inventory adjustment pressures for industrial production overall did not rise. This is in stark contrast to deep inventory adjustments observed around 2001, when the shipment-inventory balance of both sectors showed synchronized deterioration since the burst of the IT bubble.



A decline in cross-industry comovements is also observed in the business sentiment of firms. The correlation coefficients of the business conditions DI of large manufacturing firms in the *Tankan* (changes from the previous quarter)—calculated using the same method as that of production above (Chart 8)—suggest that there has been a precipitous decline in recent years as with the case of production.



### 3. Factors affecting the decline in cross-industry comovements

Why did cross-industry comovements of production decline in this current economic expansion? There are several possible reasons, but here we focus on the following two explanations.<sup>8</sup>

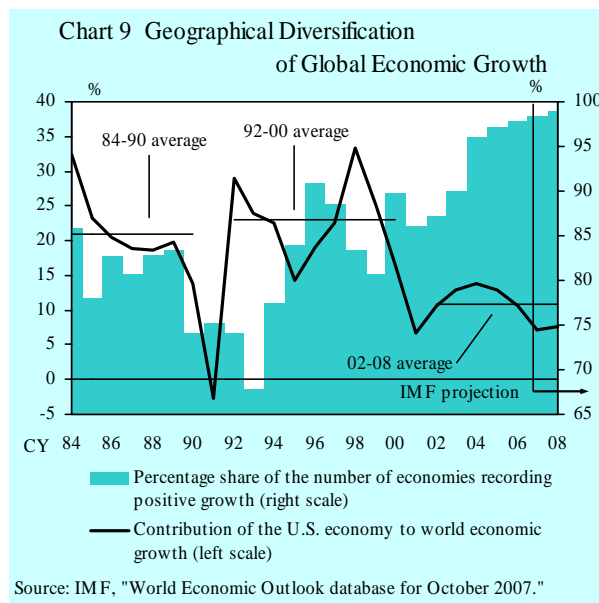
The first explanation is a qualitative change on the demand side: diversification of the types of goods demanded, which reflects the geographical diversification of global economic growth. The second explanation is a structural change on the supply side: domestic industries have become less interactive due to progress in the international division of labor.

#### (1) Diversification of global demand

Diversified foreign demand—which has been the driving force for the increase in production in this current expansion—has facilitated the decline in cross-industry comovements.

Recently, emerging economies such as BRICs have been growing remarkably. High growth has been observed not only in some emerging economies, but

also in an increasing number of other emerging economies in a wider range of regions. This is evident from the smaller contribution by the U.S. economy to global economic growth and from the increasing number of countries exhibiting positive growth (Chart 9). With such geographical diversification of global economic growth, the types of goods demanded will tend to become more diverse, reflecting the growth in various economies with demand for different types of goods.



As for developments in Japan's exports, the composition—not only in terms of destination but also goods—has diversified in response to this situation. By share of export destination, the weight of exports to the United States—which had been approximately 30 percent around 2000—has currently edged lower, dropping to about 20 percent. Instead, exports to countries such as China have increased their share. By goods, the weight of exports of IT-related goods—which had comprised a little under 20 percent—dropped to slightly more than 10 percent. On the other hand, exports of capital goods, intermediate goods, and automobile-related goods have increased their share.<sup>9</sup> This diversification of exports both in terms of destination and goods has diversified the risks that Japan's economy faces, and in turn has led to the stabilization of exports and production. Calculating the correlation coefficients of export movements by destination and goods (Chart 10), we can see that they have declined substantially in this current expansion compared to the past.

Given that global economic growth is supported by a more diverse range of countries than in the past, the growth rate of the overall world economy itself has stabilized in recent years. For instance, the OECD composite leading indicators show that the fluctuations have become substantially smaller in the past few years (Chart 11). In addition to the geographical diversification of global economic growth, we should bear in mind that the following three essential factors are attributable to this stabilization of the world economy: (1) generally favorable macro-economic conditions in which inflationary pressures have been restrained overall; (2) the smooth flow of risk money due to financial innovation; and (3) the fact that a common shock large enough to trigger cross-regional comovements of growth—such as those observed in the Asian financial crisis in the latter half of the 1990s and in the IT bubble and its burst around 2000—did not occur.

Chart 10 Weighted Average of Correlation Coefficients of Real Exports

Destination	US	EU	China	NIEs	ASEAN4	Others	Average
1996 - 2001	0.48	0.39	0.36	0.44	0.31	0.21	0.39
2002 onward	-0.00	0.31	0.21	0.35	0.29	0.30	0.23

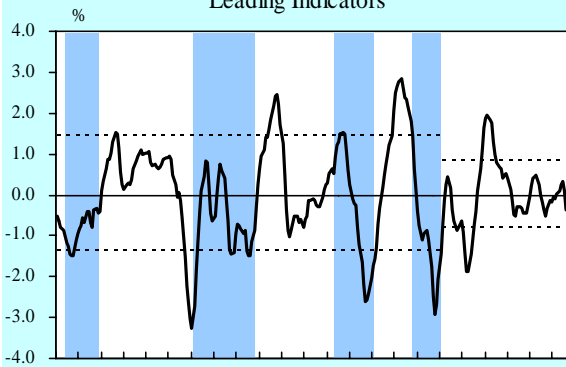
  

Goods	Intermediate goods	Automobile-related goods	Consumer goods	IT-related goods	Capital goods and parts	Others	Average
1996 - 2001	0.55	0.46	0.59	0.65	0.64	0.56	0.58
2002 onward	0.31	0.00	0.38	0.40	0.37	0.31	0.28

Note: Data are the weighted average of correlation coefficients of real export's deviation from the HP trend calculated by destination and goods.

Sources: Ministry of Finance, "The Summary Report on Trade of Japan"; Bank of Japan, "Corporate Goods Price Index."

Chart 11 Cyclical Movement of OECD Composite Leading Indicators

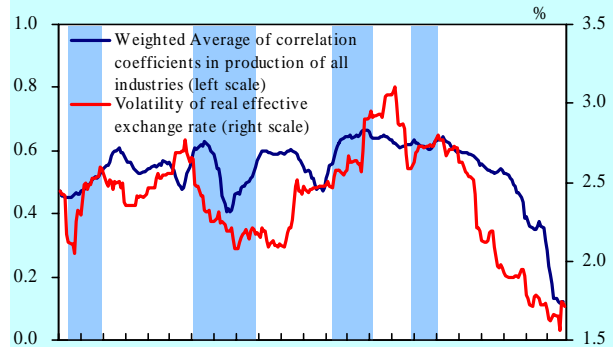


Note: Dotted lines indicate one standard deviation for each period. Data are deviations from the HP trend. They are calculated by excluding Japan from OECD and Non Member Economies (BRICs, Indonesia). Source: OECD, "OECD Composite Leading Indicators."

The stable movement of the exchange rate in recent years is one of the reasons why Japan's exports and

production have been able to reap the benefits of the diversification of global demand mentioned above. Since a sharp fluctuation in the exchange rate commonly affects the external price-competitiveness of many industries, exports and production tend to comove largely across industries. In this current expansion, however, the yen depreciated mildly, with smaller fluctuation of the exchange rate; this has created an environment in which the diversification of global demand has tended to lead to a decline in cross-industry comovements (Chart 12).

Chart 12 Volatility of Exchange Rate and Cross-Industry Comovements in Production



Note: Volatility of the real effective exchange rate is based on a 60-month rolling standard deviation of month-to-month percent changes.

Sources: Bank of Japan, "Effective Exchange Rate," etc.

## (2) Progress in international division of labor and the decline in interactions between domestic industries

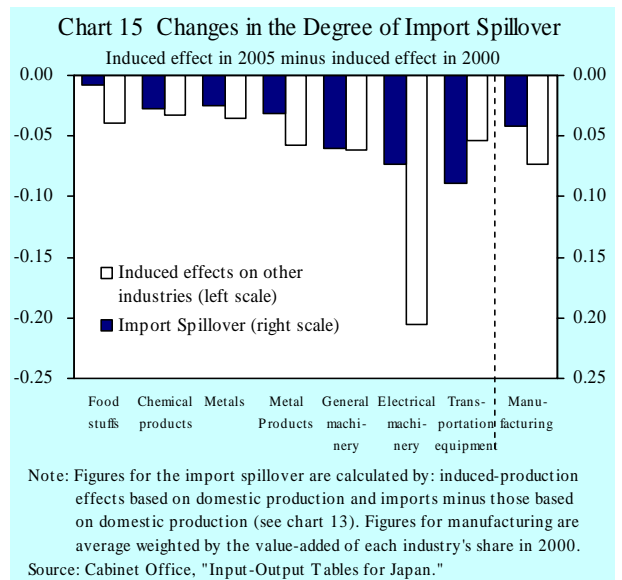
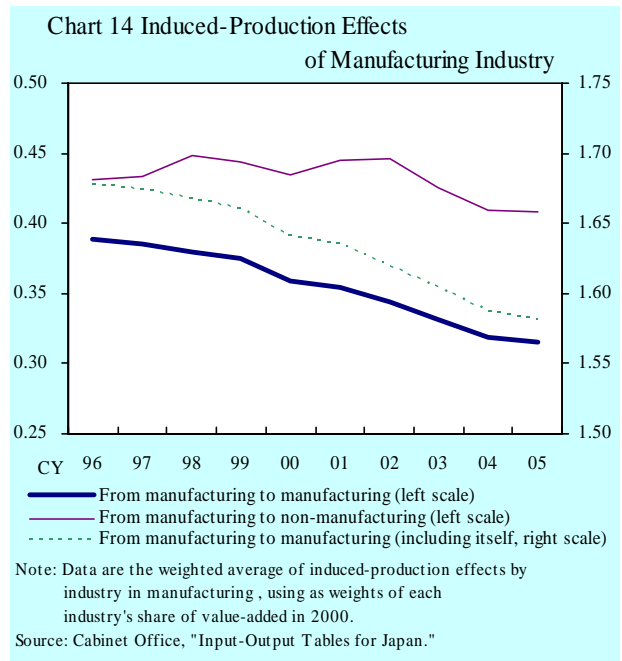
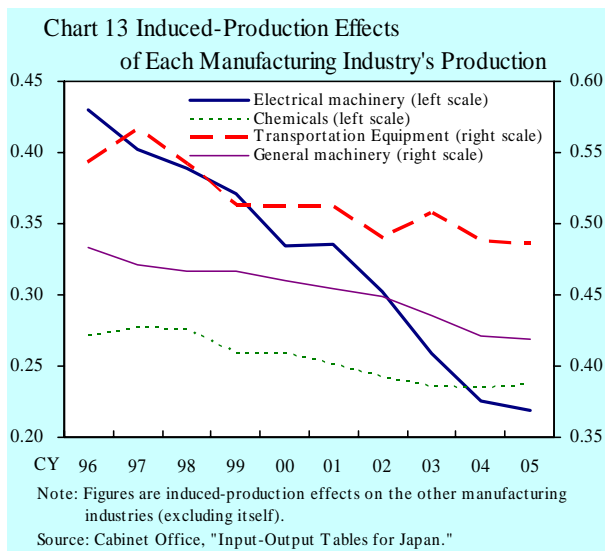
The increase in the trade volume due to the progress in the international division of labor enables demand shocks to spread overseas, which in turn weakens the interaction between domestic industries. For example, consider a certain product that is mostly made from imported materials and parts. If domestic demand for that product plunges for some reason, then the effects of that negative shock on other domestic industries will be minimal.

To confirm these changes in interactions between domestic industries, we look at the induced-production effects calculated from the *Input-Output Tables for Japan*, a coefficient indicating the total units of induced production of other manufacturing industries, when final demand of a certain industry increases per unit (Chart 13).<sup>10</sup> This reveals that a decline in the coefficient was observed



in all four representative manufacturing industries since the latter half of the 1990s. Particularly in electrical machinery—which is one of Japan's leading manufacturing industries as well as an industry in which a global supply-chain network has been firmly established—the induced effects declined significantly. To be specific, in electrical machinery, an increase of one unit in final demand induced production of other industries by slightly more than 0.4 units in 1996, but the induced effects dropped to slightly more than 0.2 units in 2005. This implies that one mechanism driving the aggregate fluctuations—a mechanism in which a shock hitting a leading industry propagates to other industries through input-output linkages—has weakened compared to the past.

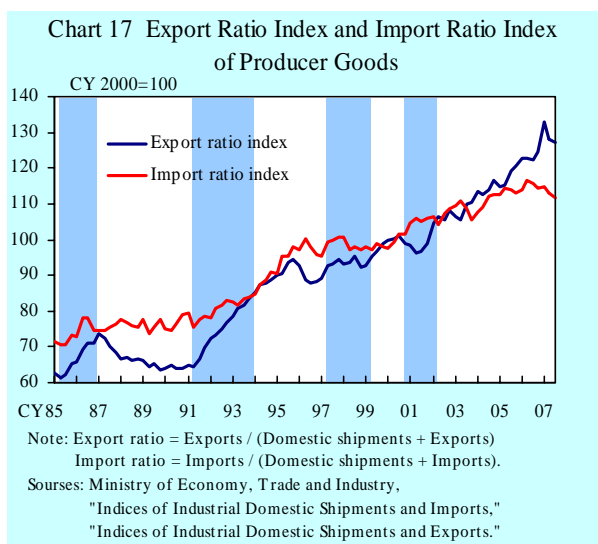
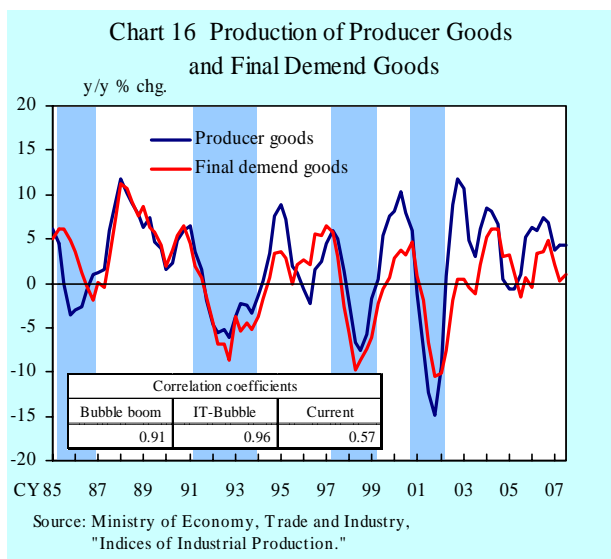
Aggregating the industry-level induced effects over the manufacturing sector as a whole, we can also see that it has been declining consistently since the second half of the 1990s, dropping by roughly 20 percent for the ten years until 2005 (Chart 14). Meanwhile, the induced effects of manufacturing on non-manufacturing have not decreased as much compared to those between manufacturing industries, since the non-manufacturing sector entails many nontradable goods that cannot be easily substituted for imports. Comparing the changes in induced-production effects with those in the degree of import spillover at an industry level for manufacturing, the induced effect tended to drop in industries with a higher degree of import spillover (Chart 15). This means that the decline in the induced effects has been affected by the progress in the international division of labor.



The weakening interactions of domestic industries can also be found in the decline in comovements between final demand goods and producer goods (Chart 16). These two goods have shown synchronized fluctuations until around 2000, but their correlation has decreased in this current expansion. This is possibly due to the rise in the export/import ratios of producer goods—which weakens domestic input-output linkage—(Chart 17).

On the other hand, it should be noted that the progress in the international division of labor has allowed overseas shocks to affect domestic production through the global supply-chain network. For instance, the impact on Japan's economy of the burst of the IT bubble around 2000 was massive, mainly

because (1) the demand fluctuation itself was larger than most expected, as well as because (2) domestic production was susceptible to adjustment pressures from overseas as a result of the progress in the global supply-chain network.<sup>11</sup>



#### 4. Conclusion

We can summarize this discussion as follows.

- (1) In this current economic expansion, overall output volatility has decreased, since cross-industry comovements of output have declined and thus the fluctuations of industries have offset one another.
- (2) The decline in cross-industry comovements is due to a qualitative change on the demand side: diversification of the types of goods whose demand is expanding, a response to the fact that

global economic growth is supported by a more diverse range of countries in response to emerging economies such as BRICs.

- (3) The decline is also due to the structural change on the supply side: in line with the progress in the international division of labor, interactions of domestic industries have weakened. As a result, a shock hitting a certain industry is less likely to propagate to other domestic industries.

The above changes indicate that by and large, Japan's production is unlikely to be influenced by a single negative shock.

As mentioned earlier on, the decline in cross-industry comovements in this current expansion have been affected not only by geographical diversification of global economic growth, but also by the fact that a common shock large enough to bring about a global comovement did not occur. Hence, when such a shock occurs, Japan's output volatility is likely to rise as the cross-industry comovements increase again through the global linkage between production bases.

<sup>1</sup> For instance, Lucas—in his famous paper on business cycles—said that the most important "regularity" of business cycles is not the duration or the amplitude of fluctuation, but the comovements of output across sectors.

Robert E. Lucas Jr. (1981) "Understanding Business Cycles," in R.E. Lucas Jr. ed., *Studies in Business-Cycle Theory*, Boston: MIT Press.

<sup>2</sup> Here, unless noted, we use the deviation from the trend to focus on the cyclical movements of production. The Hodrick=Prescott (HP) filter is used for calculation (the parameter is set to 14,400 on a monthly basis).

<sup>3</sup> For details, see Kimura, T. and K. Shiotani (2007) "Nihon no seisan hendou, mittsu no jijitsu to sono haikai" ("Japan's output volatility—three facts and their background"; available in Japanese only), Bank of Japan Review Series, 2007-J-3, March 2007.

<sup>4</sup> A detailed calculation method is as follows. When  $X_i$  indicates production of each industry and  $w_i$  indicates weights, aggregate production is expressed as  $X = \sum_{i=1}^n w_i X_i$ . Then, the variance of aggregate production can be written as,

$$\text{Var}(X) = \sum_{i=1}^n w_i^2 \text{Var}(X_i) + \sum_{i \neq j} w_i w_j \text{Cov}(X_i, X_j)$$

The first term on the right-hand side is the weighted average of individual industries variances, whereas the second term is the weighted average of pairwise covariance between two industries. First, for variance, we calculate the contribution rates of the first and second terms in accordance with the above equation. Then we multiply these contribution rates with the standard deviation of  $X$ , identifying the former as the

"individual-industry factor" and the latter as "cross-industry correlation factor."

<sup>5</sup> This fact has also been pointed out by Kiyohiko G. Nishimura, member of the Policy Board (excerpts of a speech given at a meeting with business leaders in Hakodate on May 31, 2007 as well as those of a speech entitled "The current situation of Japan's economy and a new framework for the conduct of monetary policy" given at a meeting with business leaders in Nagasaki on June 22, 2006; both available in Japanese only).

<sup>6</sup> We calculated the weighted average correlation coefficients of industry  $i$  with other industries using the following equation.

$$\text{Corr}(i) = \frac{\sum_{j \neq i} w_j}{\sum_{k \neq i} w_k} \text{Corr}(X_i, X_j)$$

Here,  $w_j$  indicates the weight of industry  $j$  and  $\text{Corr}(X_i, X_j)$  indicates the 5-year (60 months) rolling correlation coefficients for production of industry  $i$  and industry  $j$ . The same method is used in the following paper as well.

Diego Comin and Thomas Philippon (2005) "The Rise in Firm-Level Volatility: Causes and Consequences," in M. Gertler and K. Rogoff, eds., *NBER Macroeconomics Annual 2005*, Boston: MIT Press.

<sup>7</sup> We aggregated the weighted average correlation coefficients by industry obtained in note 6, using the following equation.

$$\text{Corr} = \sum_i w_i \text{Corr}(i)$$

<sup>8</sup> Cross-industry comovements have decreased in recent years in the United States as well. See the paper mentioned below for the details. As for Japan, this *Review* mainly focuses on changes in foreign demand and the international division of labor as reasons for the decline in comovements. In addition to these factors, in this current expansion, the comovements may have decreased since (1) exports and fiscal expenditure, which comprise "exogenous" demand, have been moving in opposite directions, and (2) the impact of common cost shocks such as high crude oil prices have weakened as a result of decreases in raw materials needed for unit of production.

Kevin J. Stiroh (2006) "Volatility Accounting: A Production Perspective on Increased Economic Stability," Federal Reserve Bank of New York Staff Report no. 245.

<sup>9</sup> For details, see "Recent Developments of Japan's External Trade and Corporate Behavior," *BOJ Reports & Research Papers*, October 2007, Research and Statistics Department, Bank of Japan.

<sup>10</sup> More technically, the induced-production effect in chart 13 is the "column sum" (total sum of coefficients in each vertical column for Leontief-type inverse matrix) from the *Input-Output Tables*. Here, however, the induced-production of one's own industry is excluded from the total sum.

<sup>11</sup> Progress in the international division of labor has added considerable uncertainty to the ultimate effect of demand shocks from overseas on domestic production. This is because while domestic production has become susceptible to overseas shocks, these shocks can also be spread back overseas to some extent. In addition, the progress in the international division of labor will increase uncertainty about information on sales and procurement compared to when the overall production process was conducted domestically. When a large demand shock hits the economy, fluctuations in international trade are amplified by such information uncertainty, and this in

turn is likely to increase fluctuations in domestic production.

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