

What drives the recent fluctuations of Japan's output? A structural factor analysis on Japan's industrial productions

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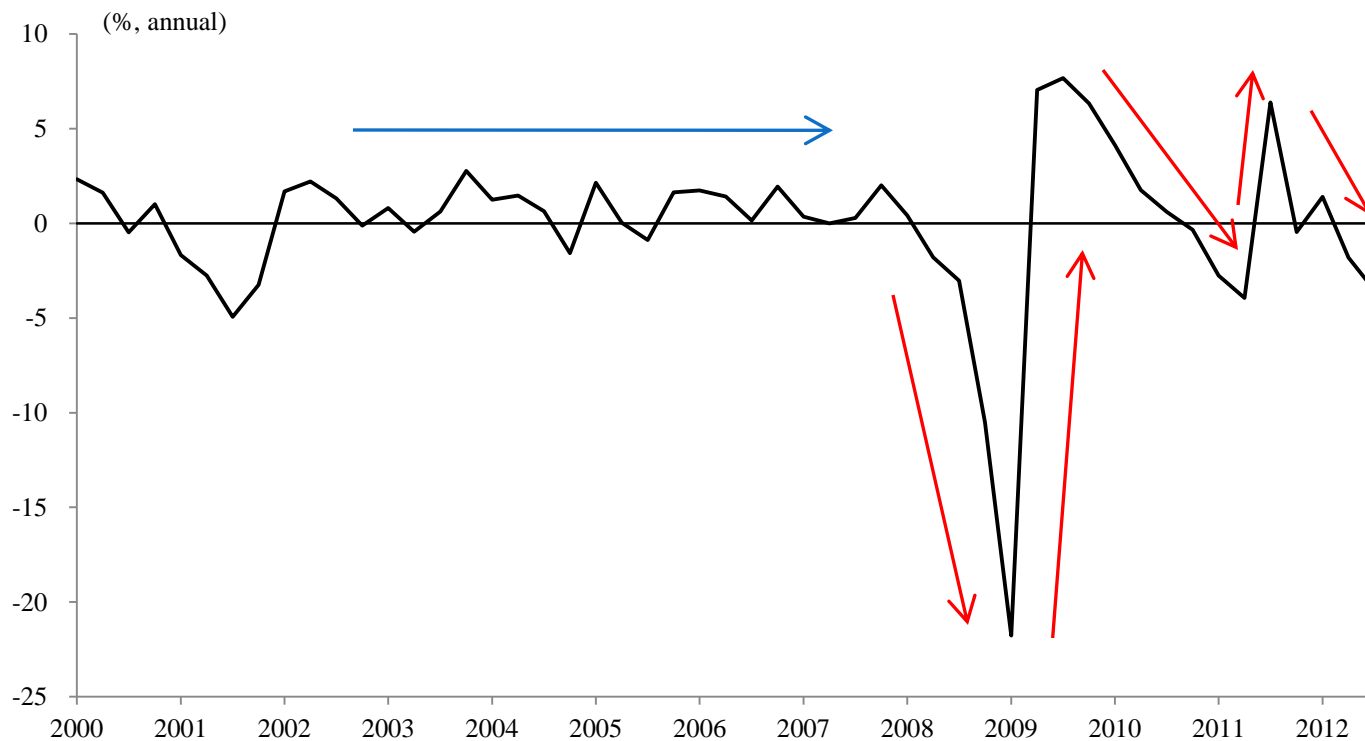
Bank of Japan, Macro-Modeling Group

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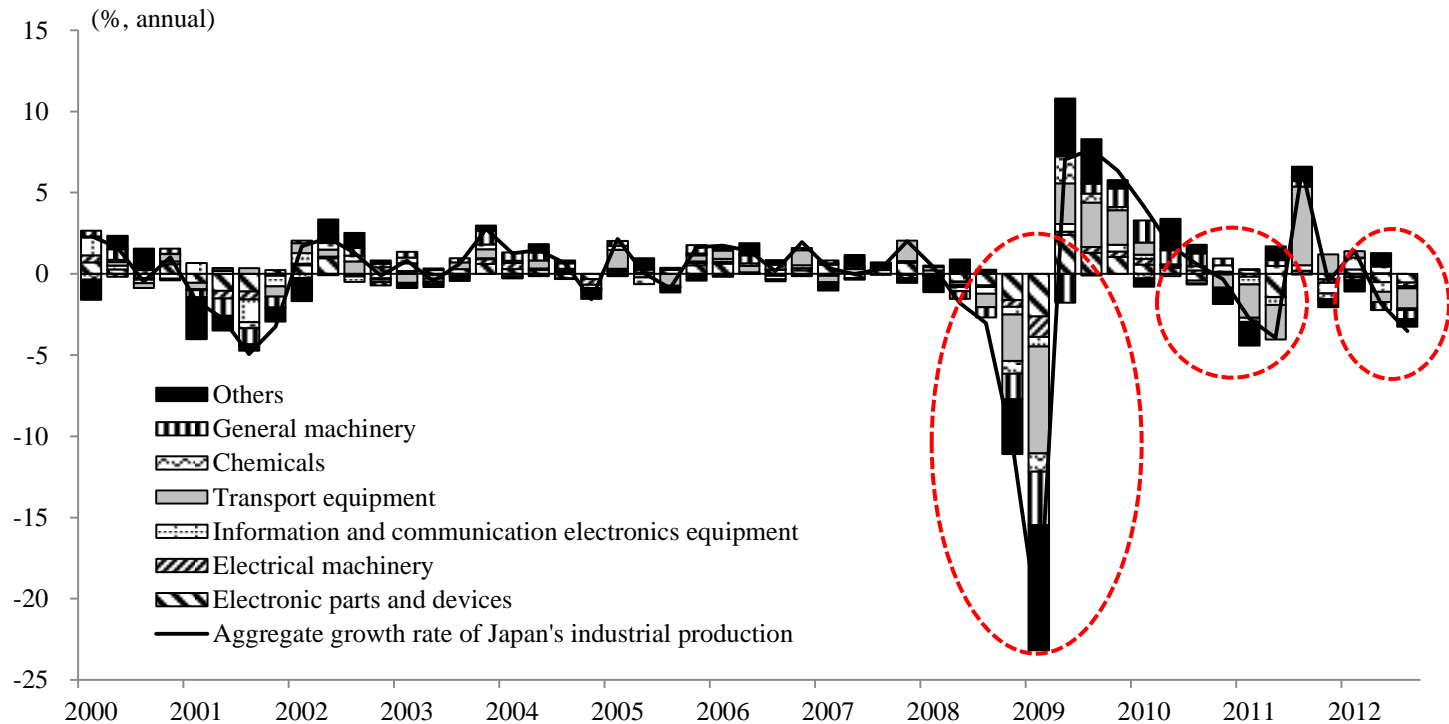
(Note) Views expressed in this paper are those of the authors and do not necessarily reflect the official views of the Bank of Japan.

Motivation

- ▶ Japan's industrial production (IP) had been relatively stable until the mid-2000s, but it became volatile afterwards.



- ▶ Output declines occurred simultaneously in various manufacturing sectors, rather than in particular sectors.



- ▶ Japan's IP seems to be driven by an aggregate shock or a sectoral shock influencing other sectors through production linkages.

What we do

- ▶ We investigate the sources of the fluctuations in Japan's IP, by taking into account the comovement across sectors.
- ▶ We apply a method of structural factor analysis developed by Foerster, Sarte, and Watson (2011, FSW) to Japan's IP.
 - In the framework of FSW, a time series model is presented as a reduced form of multi-sector DSGE model into which inter-sectoral production linkages are incorporated.
- ▶ Their framework enables us to decompose IP into aggregate shocks and sectoral shocks by properly taking into account the input-output relationships.

Related literature

(1) FSW (2011, JPE)

- ✓ Use the U.S. data prior to financial crisis
- ✓ Do not examine the sources of aggregate shocks

(2) Iyetomi et al. (2011, JJIE)

- ✓ Use Japan's IP data (but excluding the Great Earthquake)
- ✓ Use shipment & inventory data as well as IP
- ✓ Do not take into account the production linkages

(3) Kimura and Shiotani (2009, JJIE)

- ✓ Use Japan's IP data (but excluding financial crisis and earthquake)
- ✓ Use shipment & inventory data as well as IP
- ✓ Use only aggregate data.
- ✓ Do not take into account the production linkages

Model

Framework of FSW

- A multi-sector DSGE model (N distinct sectors)

$$\max E_t \sum_{t=0}^{\infty} \beta^t \sum_{j=1}^N \left(\frac{C_{jt}^{1-\sigma}}{1-\sigma} - \psi L_{jt} \right),$$

$$s.t. \quad C_{jt} + \sum_{i=1}^N M_{jit} + \sum_{i=1}^N Q_{jit} = Y_{jt},$$

$$Y_{jt} = A_{jt} K_{jt}^{\alpha_j} \left(\prod_{i=1}^N M_{jit}^{\gamma_{ij}} \right) L_{jt}^{1-\alpha_j - \sum_{i=1}^N \gamma_{ij}},$$

$$\ln A_t = \ln A_{t-1} + \varepsilon_t,$$

$$K_{jt+1} = Z_{jt} + (1 - \delta) K_{jt},$$

$$Z_{jt} = \prod_{i=1}^N Q_{ijt}^{\theta_{ij}}, \quad \sum_{i=1}^N \theta_{ij} = 1.$$

where C is consumption, M is intermediate goods, Q is investment goods, Y is output, K is capital, L is labor, Z is investment.

Framework of FSW

- Reduced form of FOCs and resource constraints: a vector ARMA(1,1)

$$(I - \Phi L) X_t = (\Pi_0 + \Pi_1 L) \varepsilon_t, \quad \text{where } X_t = (\Delta \ln Y_{1t}, \dots, \Delta \ln Y_{Nt})' \text{ and } L \text{ is lag operator.}$$

— Φ , Π_0 , and Π_1 depend on structural parameters ($\alpha_j, \gamma_{ij}, \theta_{ij}, \beta, \sigma, \psi$, and δ).

Based on the structural parameters and X_t , we can obtain the values of ε_t .

- Process of structural shocks

$$\varepsilon_t = \Lambda_s S_t + v_t,$$

↑ ↙
Common factor (aggregate shocks) Idiosyncratic factor (sectoral shocks)

— S_t and v_t are serially and mutually uncorrelated. $E v_t v_t'$ is diagonal.

— Λ_s, S_t and v_t are estimated by taking the principal components of ε_t .

Values for model parameters

- Values based on Japan's production structure

γ_{ij} : input coefficient for output production }
 α_j : capital share } Japan's input-output matrix (2005 year)

θ_{ij} : input coefficient for capital production } Japan's fixed capital matrix (2005 year)

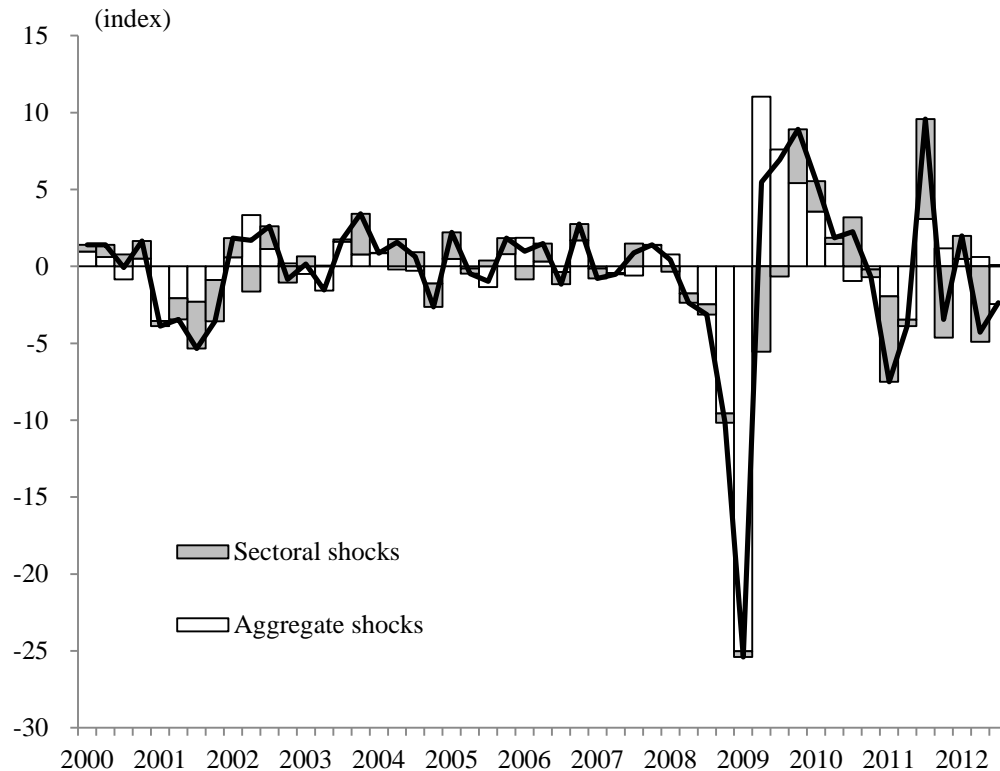
- Other structural parameters (based on FSW)

$\beta = 0.99, \sigma = 1.0, \psi = 1.0,$ and $\delta = 0.025.$

Results of structural factor analysis

Decomposition of average structural shocks

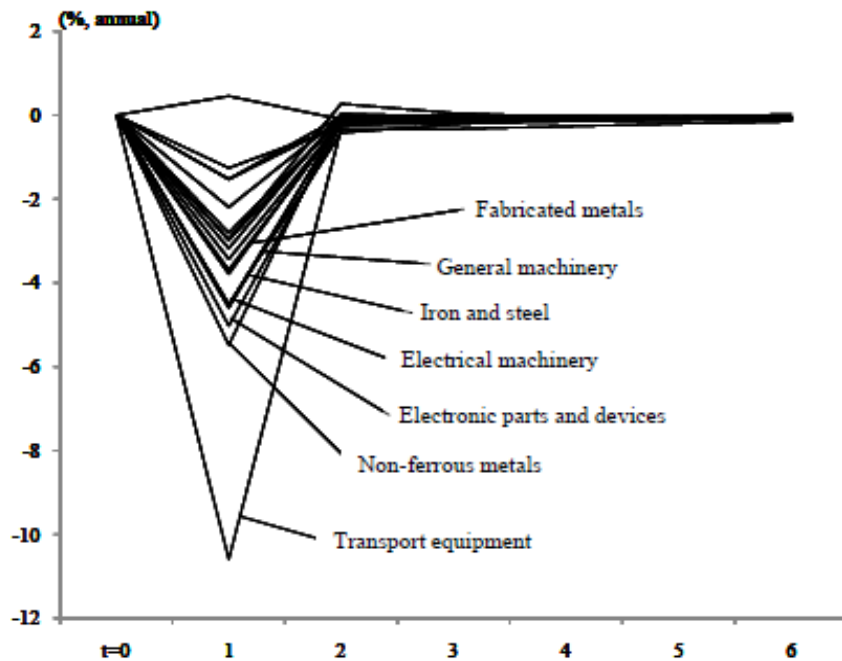
Average structural shocks: $\bar{\varepsilon}_t = \sum_{i=1}^N \omega_{it} \varepsilon_{it}$, where ω_{it} is share weight of sector i .



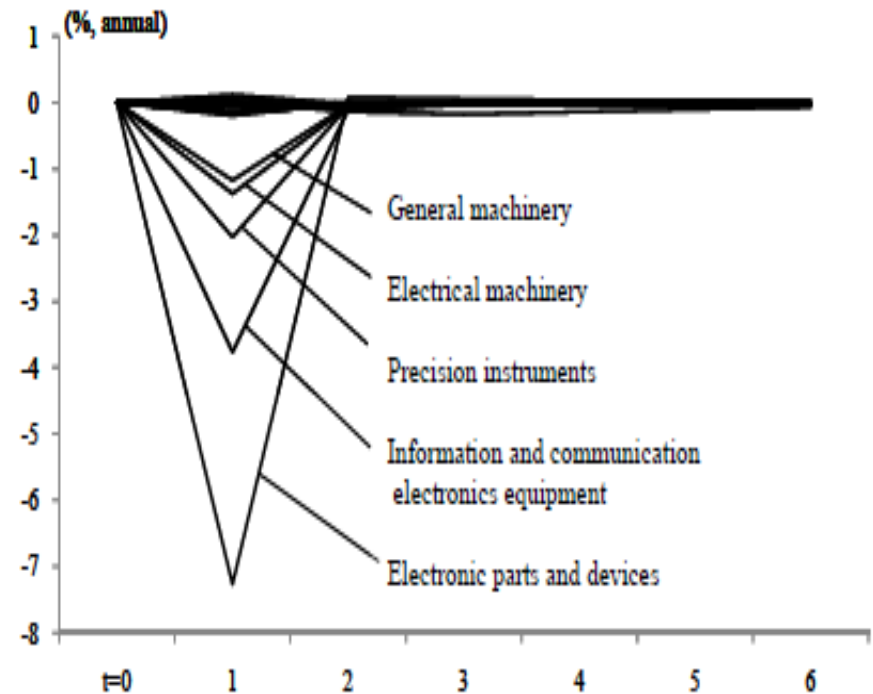
Variance / Period	Whole shocks	Aggregate shocks	Sectoral shocks
	Full sample (1978Q1-2012Q3)	11.9	9.1
		76.6%	23.4%
Pre-crisis (1978Q1-2007Q4)	3.9	2.2	1.7
		57.4%	42.6%

Impulse responses

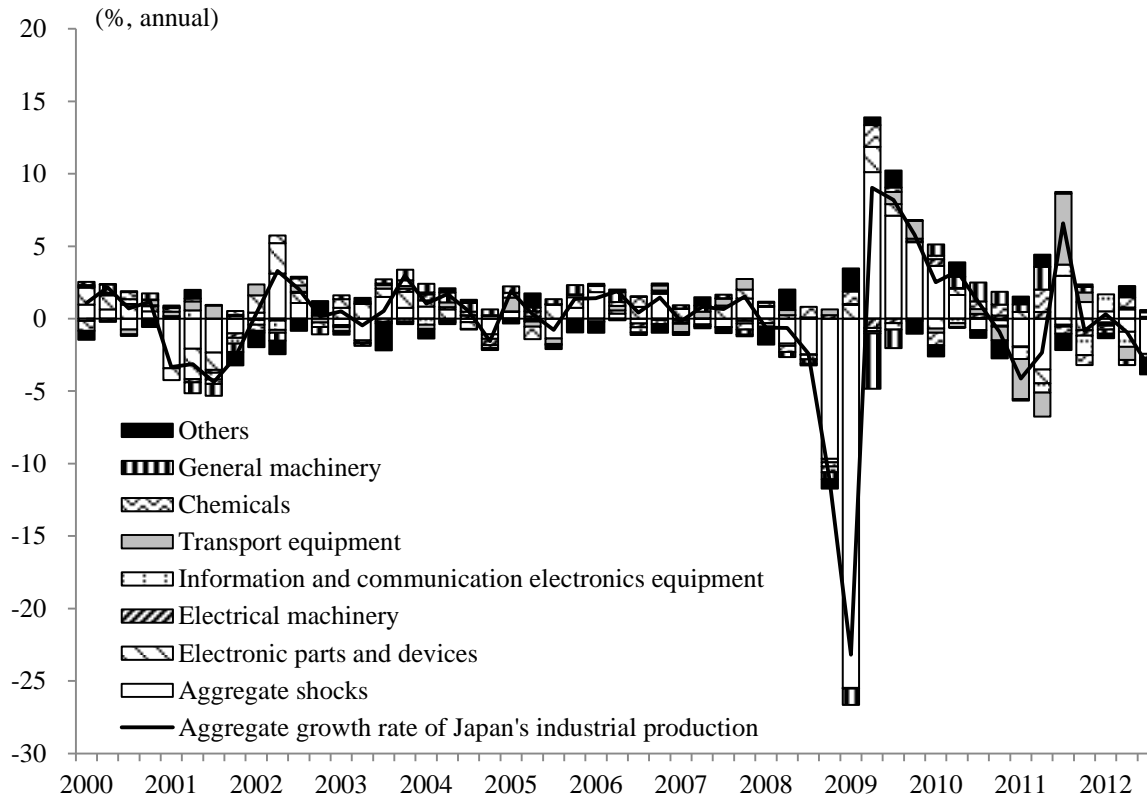
<Negative Aggregate Shock>



<Negative Sectoral Shock to Electronic Parts and Devices>



Decomposition of Japan's total IP



Variance / Period	Total	Aggregate shocks	Sectoral shocks
Full sample (1978Q1-2012Q3)	10.0	8.8	1.1
		89.1%	10.9%
Pre-crisis (1978Q1-2007Q4)	2.6	1.9	0.8
		71.8%	28.2%

Importance of aggregate shocks

- ▶ In the case of the U.S. economy, FSW report that aggregate shocks explain 76% in 1972-83 and 53% in 1984-2007, if they use two-digit level industrial classification (26 sectors).
 - Although a direct comparison is difficult, it could be seen that the importance of aggregate shocks is at least not smaller in Japan than that in the U.S.
- ▶ This indicates that, as is similar to the U.S., aggregate shocks explain a major part of the variations in Japan's IP, even if we take into account the presence of inter-sectoral production linkages.

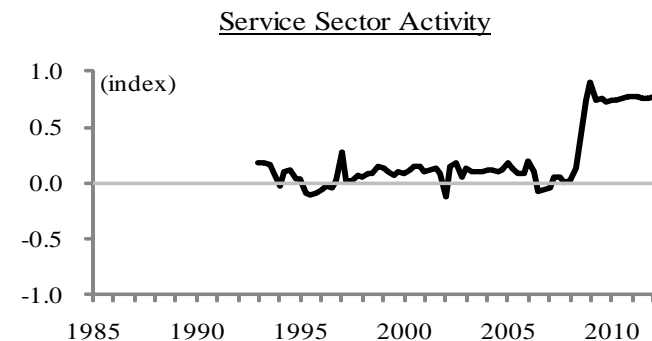
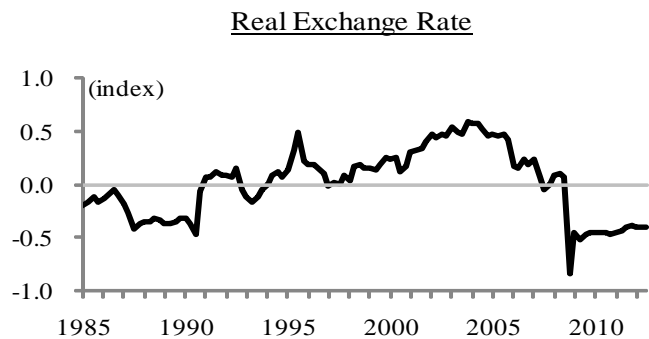
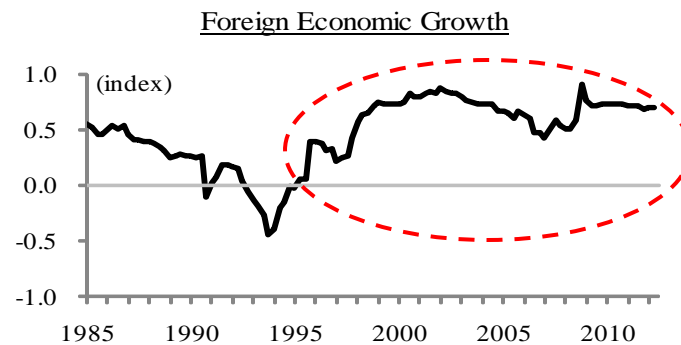
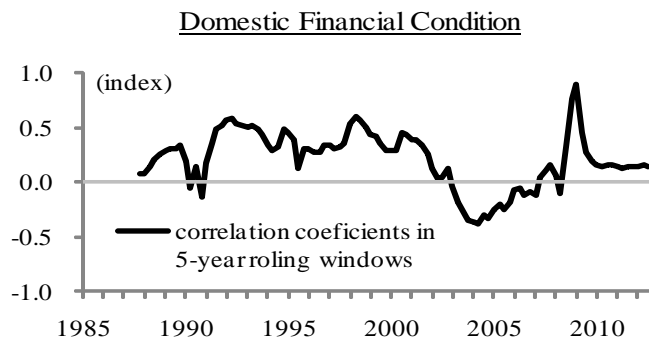
What explains aggregate shocks?

What explains aggregate shocks?

- ▶ We examine the correlations between aggregate shocks and some economic variables that can be viewed as exogenous to domestic IP and are broadly influential on various sectors.
- ▶ We choose 4 types of candidate variables.
 - (i) domestic financial conditions
 - (ii) foreign economic growth
 - (iii) real exchange rate
 - (iv) service sector activities

Correlations between aggregate shocks and economic variables

	Domestic Financial Condition	Foreign Economic Growth	Real Exchange Rate	Service Sector Activity
Period	1985:Q1~2012:Q3	1985:Q1~2012:Q3	1985:Q1~2012:Q3	1988:Q2~2012:Q3
Correlation coefficient	0.16	0.59	-0.14	0.36



Source of aggregate shocks

- ▶ Source of aggregate shocks has shifted over time.
- ▶ In the 1990s, aggregate shocks were largely driven by domestic financial problems.
- ▶ However, after the beginning of the 2000s, they were more influenced by world economic conditions.
- ▶ The importance of aggregate shocks to the recent fluctuations in Japan's IP could be explained by the increased connections between the global economy and Japan's manufacturing activities.

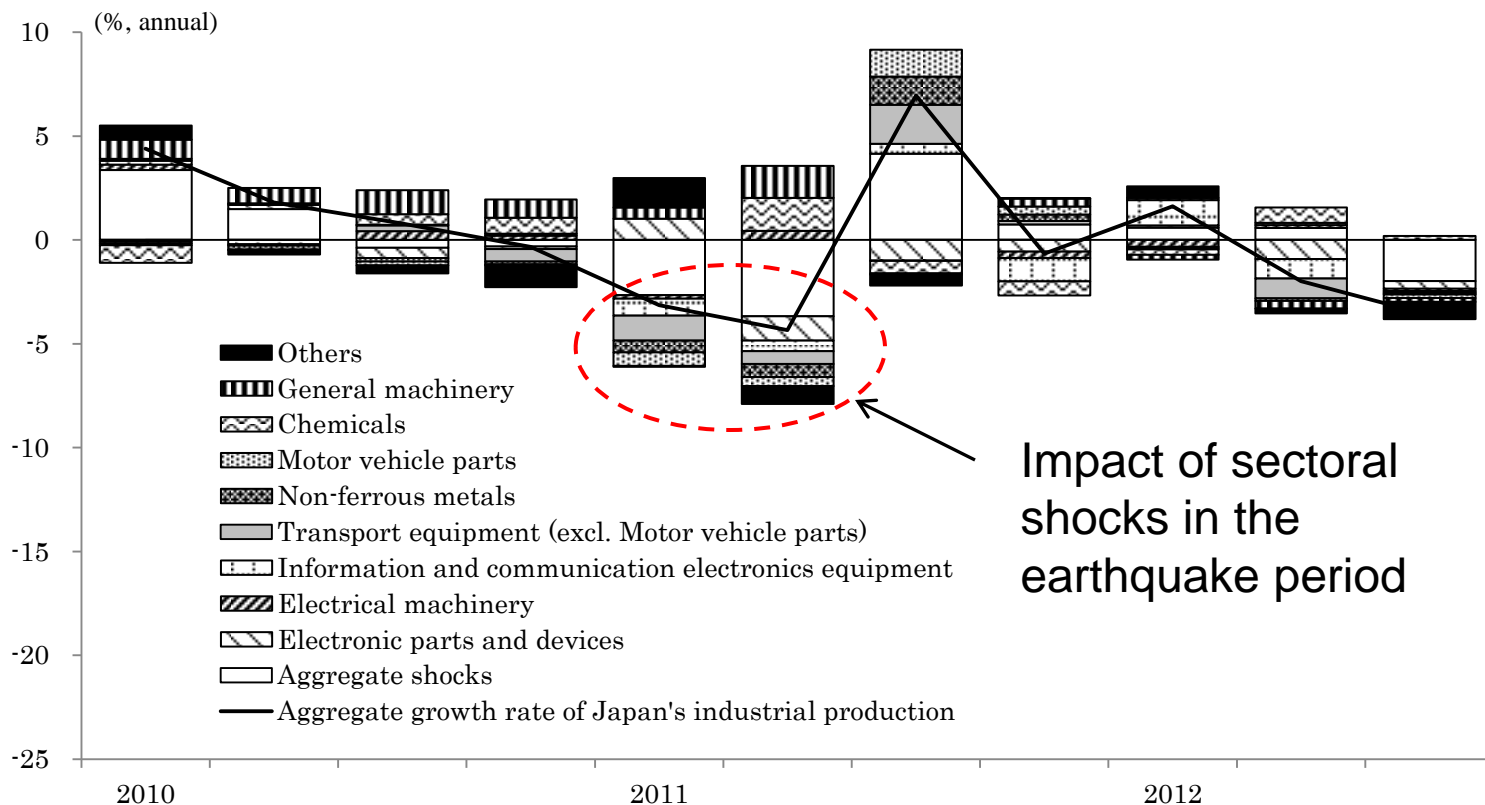
Are sectoral shocks and production linkages unimportant?

→ Not necessarily.

1. Importance of production linkages in the Great East Japan Earthquake period
2. Importance of sectoral shocks for the recent decline in Japan's production level

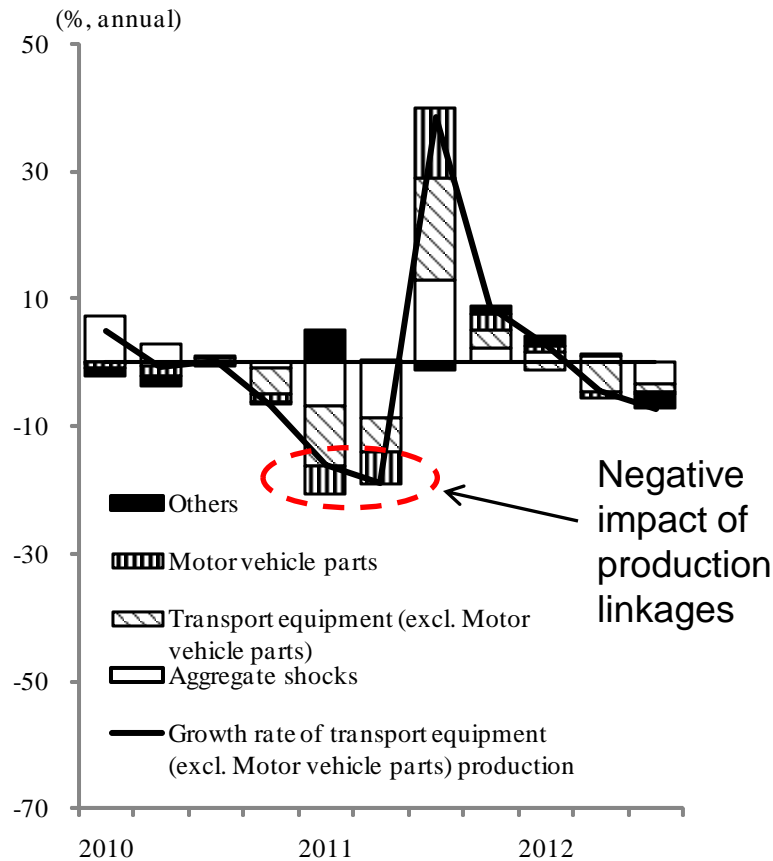
Importance of sectoral shocks in the Great East Japan Earthquake period

- ▶ We carry out structural factor analysis again by separating motor vehicle parts from transport equipment industry.

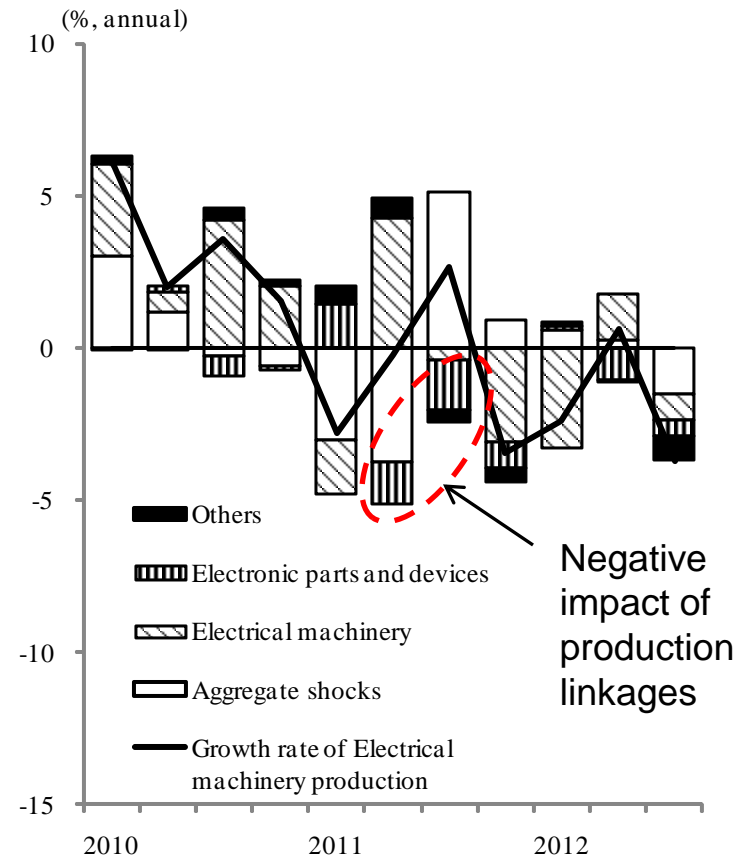


Importance of production linkages in the Great East Japan Earthquake period

Transport equipment (excl. Motor vehicle parts)



Electrical machinery



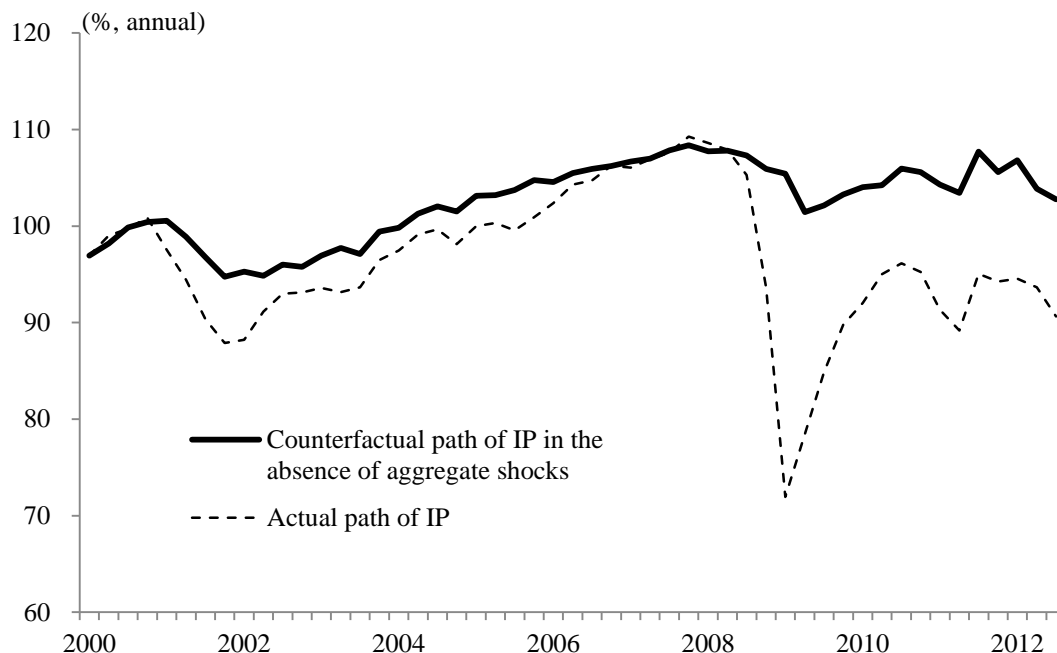
Importance of sectoral shocks and production linkages in the Great East Japan Earthquake period

(%)

	2011		
	1Q	2Q	3Q
Aggregate IP	-3.1	-4.3	7.0
Aggregate shocks	-2.7	-3.7	4.1
Sectoral shocks	-0.5	-0.7	2.8
Sectoral shock to Motor vehicle parts	-1.2	-1.1	2.6
Direct effect to Motor vehicle parts	-0.4	-0.4	0.9
Spillover effect to other industries	-0.9	-0.7	1.8
Sectoral shock to Electronic parts and devices	1.0	-1.2	-1.0
Direct effect to Electronic parts and devices	0.6	-0.6	-0.7
Spillover effect to other industries	0.4	-0.5	-0.3
Total spillover effects from sectoral shocks to Motor vehicle parts and Electronic parts and devices	-0.5	-1.2	1.5

Importance of sectoral shocks for the recent decline in Japan's production level

- ▶ Our counterfactual simulation indicates that aggregate shocks have largely contributed to the recent decline of Japan's IP.
- ▶ However, it also suggests that Japan's output would have declined after the financial crisis even if aggregate shocks were absent.



Importance of sectoral shocks for the recent decline in Japan's production level

- ▶ Sectoral shocks explain approximately 30% of the decline of Japan's IP after the financial crisis.

	Decomposition	Share
Aggregate shocks	-16.3	70.9
Sectoral shocks	-6.7	29.1
General machinery	-2.2	-
Information and communication electronics equipment	-2.0	-
Electronic parts and devices	-0.8	-
Transport equipment	-0.8	-
Electrical machinery	-0.3	-
Others	-0.6	-

- ▶ If some sectors have lost competitiveness in global markets, Japan's IP will not recover to the pre-crisis level even if world economy attain a full recovery.

Conclusion

- ▶ Aggregate shock explains a major part of the variations in Japan's IP as a whole, even if we take into account the presence of inter-sectoral production linkages.
- ▶ Aggregate shock was highly correlated to domestic financial conditions in the 1990s, but become even more closely correlated to foreign economic growth since the beginning of the 2000s.
-- This may reflect increased connections between the global economy and Japan's manufacturing activities.
- ▶ This does not necessarily mean that production linkages and sectoral shocks are unimportant.
- ▶ These two elements largely contributed to the declines of output growth in the Great East Japan Earthquake period and the recent output decline is partly attributable to negative sectoral shocks.