Spatially Uneven Pace of Deindustrialization within A Country

Kozo Kiyota

Keio University, University of Hawai'i, and RIETI

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Summary

Research question

- How and why the patterns of deindustrialization are uneven across regions within a country?
  - Deindustrialization: the declining share of manufacturing in value-added

Methodology

- The analysis of this paper builds upon the neoclassical theory of trade and production that allows us to identify the determinants of deindustrialization in the general equilibrium framework.
- The theory translates the fall in manufacturing and the rise in services sectors into the contribution of prices (p), productivity (φ), and factor endowments (v):

$$s_{zjt} = \beta_{0j} + \sum_k \beta_{jk} \ln \varphi_{zkt} p_{zkt} + \sum_i \gamma_{ij} \ln v_{zit} + \varepsilon_{zjt},$$

where $\sum_j s_{zjt} = 1$. (j, k: industry; z: region; t: year; i: factor)

Contribution

- This paper takes into account the spatial interdependence across regions, based on spatial econometric techniques.

Summary

Data

- Source: Regional-Level Japan Industrial Productivity (R-JIP) Database 2017
  - Similar to the National Bureau of Economic Research manufacturing database.
  - But the R-JIP data cover not only manufacturing but also non-manufacturing, and are available at the region level from 1972 to 2012.

Major findings

1. Deindustrialization is mainly attributable to the decline in the relative price of manufactured goods.
2. In some prefectures, its negative effects are too large to be offset by the positive effects of productivity growth and capital accumulation, which results in the regional unevenness of deindustrialization.
3. Although the effect of spatial interdependence is statistically significant, its economic magnitude turns out to be relatively small in explaining deindustrialization.

Deindustrialization is becoming a concern

- The declining share of manufacturing in value-added, which is often called "deindustrialization," is becoming one of the main concerns for policy makers as well as academic researchers (e.g., Rodrik, 2016, JEG; Bernard, Smeets, and Warzynski, 2017, EP).
- In this context, several studies examined the specialization dynamics of manufacturing production across countries:
  - Factor endowments: Redding (2002, JIE)
  - Productivity: Nickell, Redding, and Swaffield (2008, WE)
  - Relative prices: Nickell, Redding, and Swaffield (2008, WE)

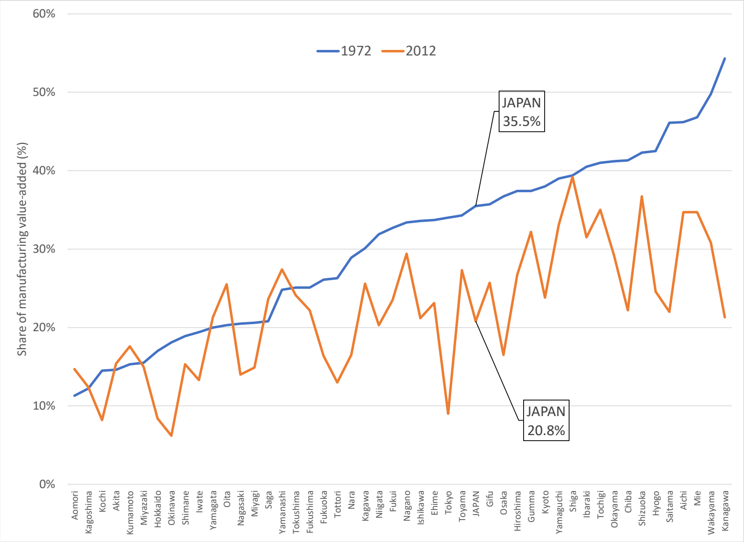
Deindustrialization is becoming a concern

- It is also an issue that manufacturing in some regions within a country declines more rapidly than in other regions.
  - This issue is essential because such regional heterogeneity could lead to unintended distributional consequences of various policies such as trade liberalization.
- However, compared with the country-level analysis, the region-level analysis of deindustrialization (i.e., declining share of manufacturing in value-added) within a country is still limited.
  - One reason for this is that, in order to investigate deindustrialization (i.e., the declining share of manufacturing value-added), one needs not only the information on manufacturing but also that on non-manufacturing (to compute share).
  - In other words, the analysis on manufacturing specialization patterns across regions within a country is not necessarily able to address the issue of deindustrialization within a country directly.
  - Migration: Murakami (2015, JAPE)
  - Trade: Dauth and Sudekum (2016, JEG)
  - ...Transportation cost?: Theory/simulation – Murata (2008, JDE) and Desmet and Rossi-Hansberg (2014, AER)

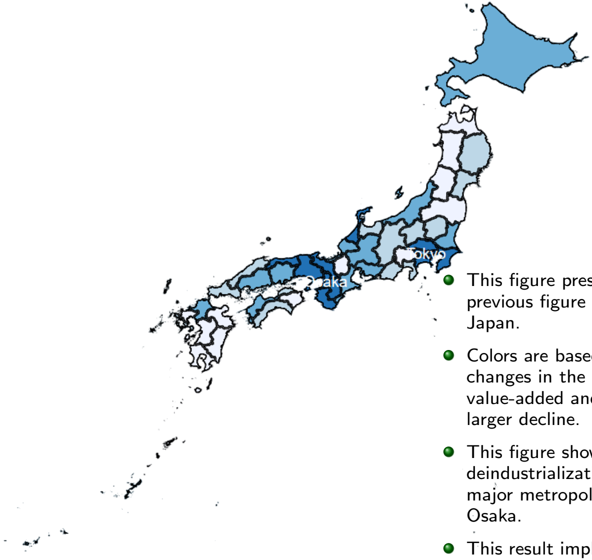
About this paper

- This paper focuses on Japan where both output and input data are available at detailed region and industry level for both manufacturing and non-manufacturing industries between 1972 and 2012.
- Like other high-income countries, Japan has been faced with shrinking manufacturing employment and value-added as a share of the total for the last four decades.
- Such deindustrialization is, however, not common across prefectures within Japan.
    - Japan consists of 47 administrative regions.
    - Each region is officially called "prefecture".
    - Hereafter, this paper freely interchanges the terms "region" and "prefecture".

Share of manufacturing value-added, by prefecture



Changes in the share of manufacturing value-added



- This figure presents the changes in the previous figure pattern on the map of Japan.
- Colors are based on the quartile of the changes in the share of manufacturing value-added and a darker color indicates a larger decline.
- This figure shows that the rapid deindustrialization is concentrated in two major metropolitan areas: Tokyo and Osaka.
- This result implies that deindustrialization may be spatially interdependent.

Related literature

- Based on this background, this paper empirically examines how and why deindustrialization patterns are diversified across regions within a country.
- My theoretical and empirical approach is based on a series of works by Stephen Redding (Princeton) and his colleagues, which builds upon neoclassical trade theory.
  - Redding (2002, JIE): factor endowments play an important role in the long-run patterns of specialization in OECD countries.
  - Nickel, Redding, and Swaffield (2008, WE): more rapid decline in the manufacturing share of GDP in the United Kingdom and the United States than in Germany and Japan is largely explained by patterns of total factor productivity and changes in the relative price of manufactured and non-manufactured goods.
- A contribution of this paper is to extend their framework to the analysis of regional heterogeneity within a single country, based on regional data and spatial econometric techniques.
- An advantage of the model is that it enables us to analyze the changes in the GDP share of different sectors simultaneously in a simple manner.

Can we apply trade model to regional data? (*)

- As does this paper, several empirical tests of the Heckscher–Ohlin model, such as Davis, Weinstein, Bradford, and Shimpo (1997, AER) and Kiyota (2012, JIE), utilized prefectural data within a country.
    - Both measurement error and technology differences are likely to be much smaller across prefectures within a country than for a cross-section of countries
- One may be concerned that the standard assumption that factor endowments are exogenous and perfectly immobile across locations is unlikely to apply.
- Fortunately, however, at least labor mobility is relatively low in Japan.
    - Annual migration across prefectures is about one percent, which is almost the same as the migration rates of some OECD countries, such as Switzerland (Kiyota, 2012, JIE).
- Nonetheless, my econometric analysis takes into account the spatial aspects that are not considered in this line of the literature, such that the analysis addresses some concerns about the use of regional data.

Neoclassical theory of trade

- My theoretical framework follows Redding (2002, JIE), which is based on the neoclassical theory of trade and production (Dixit and Norman, 1980, Cambridge U Press).
- Revenue function for an industry in region z at time t:

$$r(\varphi_{zt} p_{zt}, v_{zt})$$

  where y_{zt} = output; v_{zt} = factor input; φ_{zt} = productivity; p_{zt}= relative prices
- Key assumptions:
  - Perfect competition
  - Constant returns to scale
  - Hicks-neutral technology
  - Trans-log functional form
  - Firms maximize profits, taking producer prices (= foreign producer prices + tariffs + transportation costs) as given.

Revenue function

- Differentiating the revenue function with respect to p_{zjt} ($j =$ industry) and adding error term ε_{zjt}:

$$\frac{\partial r(\varphi_{zt} \mathbf{p}_{zt}, \mathbf{v}_{zt})}{\partial p_{zjt}} = s_{zjt} \equiv \frac{p_{zjt} y_{zjt}}{r(\varphi_{zt} \mathbf{p}_{zt}, \mathbf{v}_{zt})} + \varepsilon_{zjt}$$
$$= \beta_{0j} + \sum_k \beta_{jk} \ln \varphi_{zkt} p_{zkt} + \sum_i \gamma_{ij} \ln v_{zit} + \varepsilon_{zjt},$$

where $\sum_j s_{zjt} = 1$.

  - The model yields predictions for the share of the current price value-added of each sector in current price GDP.

- In the matrix form, the above equation is written as:

$$\mathbf{s}_{jt} = \beta_j \mathbf{X}_{jt} + \boldsymbol{\epsilon}_{jt},$$

where $\mathbf{s}_{jt}$ is GDP share; $\mathbf{X}_{jt}$ is a matrix of regressors including factor endowments.

Revenue function (*)

$$s_{zjt} = \beta_{0j} + \sum_k \beta_{jk} \ln \varphi_{zkt} p_{zkt} + \sum_i \gamma_{ij} \ln v_{zit} + \varepsilon_{zjt}, \tag{1}$$

where $\sum_j s_{zjt} = 1$.

- Equation (1) holds irrespective of factor mobility (Redding and Vera-Martin, 2006, RWE).
- However, factor mobility changes the interpretation of these relationships.
  - When factors are geographically immobile, exogenous changes in factor endowments lead to endogenous changes in production structure: supply-side interpretation.
  - When factors are geographically mobile, exogenous change in demand and therefore production causes factors to move endogenously across regions: demand-side interpretation.
- The equation could reflect both demand- and supply-side effects, although the demand-side effect does not seem to be so serious in the case of Japan because labor mobility across regions is relatively low.

Data

Regression equation:

$$s_{zjt} = \beta_{0j} + \sum_k \beta_{jk} \ln \varphi_{zkt} p_{zkt} + \sum_i \gamma_{ij} \ln v_{zit} + \varepsilon_{zjt},$$

where $\sum_j s_{zjt} = 1$.

- Value-added share (s_{zjt})
  - current price shares of sector j's GDP
- Productivity (φ_{zkt})
  - Computed from the data, using a superlative index number measure of total factor productivity (**TFP**)
- Prices (p_{zkt})
  - Value-added deflators (2000 = 1)
- Endowment (v_{zit})
  - Capital (K) and Labor (worker-hour) L
- Source: Regional-Level Japan Industrial Productivity (R-JIP) Database 2017
  - Period: 1972–2012

Industry aggregation

- Following Nickell, Redding, and Swaffield (2008), industries are aggregated into five sectors:

1. Agriculture
2. Manufacturing
   - Given that deindustrialization is concerned with the decline in the share of aggregate manufacturing in GDP, the manufacturing sector is considered as a whole.
3. Other production
   - The Other production sector comprises mining, utilities, and construction.
4. Business services
   - Financial and business services are likely to be more tradable than other services, which may lead to different patterns of price movements between prefectures.
5. Other services

Regression equation

$$
\begin{aligned}
s_{z1t} &= \beta_{01} + \sum_{k=1}^{4} \beta_{1k} \ln \frac{\varphi_{zkt} p_{zkt}}{\varphi_{zkt} p_{z5t}} + \gamma_1 \ln \frac{K_{zt}}{L_{zt}} + \lambda_1 W s_{z1t} + \alpha_{z1} + \alpha_{1\tau} + u_{z1t} \\
s_{z2t} &= \beta_{02} + \sum_{k=1}^{4} \beta_{2k} \ln \frac{\varphi_{zkt} p_{zkt}}{\varphi_{zkt} p_{z5t}} + \gamma_2 \ln \frac{K_{zt}}{L_{zt}} + \lambda_2 W s_{z2t} + \alpha_{z2} + \alpha_{2\tau} + u_{z2t} \\
s_{z3t} &= \beta_{03} + \sum_{k=1}^{4} \beta_{3k} \ln \frac{\varphi_{zkt} p_{zkt}}{\varphi_{zkt} p_{z5t}} + \gamma_3 \ln \frac{K_{zt}}{L_{zt}} + \lambda_3 W s_{z3t} + \alpha_{z3} + \alpha_{3\tau} + u_{z3t} \\
s_{z4t} &= \beta_{04} + \sum_{k=1}^{4} \beta_{4k} \ln \frac{\varphi_{zkt} p_{zkt}}{\varphi_{zkt} p_{z5t}} + \gamma_4 \ln \frac{K_{zt}}{L_{zt}} + \lambda_4 W s_{z4t} + \alpha_{z4} + \alpha_{4\tau} + u_{z4t},
\end{aligned}
$$

where $\beta_{jk} = \beta_{kj}$; $u_{zjt} = \rho_j W u_{zjt} + \varepsilon_{zjt}$.

1. Note that, $\sum_j s_{zjt} = 1$ and parameter restrictions, only $N - 1$ equations can be estimated.

→ The system of equations is estimated, dropping one sector: Other services.

Regression equation

$$
\begin{aligned}
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\end{aligned}
$$

where $\beta_{jk} = \beta_{kj}$; $u_{zjt} = \rho_j W u_{zjt} + \varepsilon_{zjt}$.

2. Because regression equation forms the system that consists of 4 equations with cross-equation symmetry constraints (i.e., $\beta_{jk} = \beta_{kj}$), the error terms across equations would be contemporaneously correlated.

→ This paper employs Zellner's method for seemingly unrelated regression (SUR) equations.

Regression equation

$$
\begin{aligned}
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\end{aligned}
$$

where $\beta_{jk} = \beta_{kj}$; $u_{zjt} = \rho_j W u_{zjt} + \varepsilon_{zjt}$.

3. Deindustrialization may also be spatially interdependent.
   - Positive: Through the vertical linkage of manufacturing firms between neighboring regions, the decline in the production in a particular region may cause the decline in the production of firms in neighboring regions (e.g., automobile and parts).
   - Negative: Some manufacturing activities in one prefecture may move to another neighboring prefecture in order to avoid high land prices.

Regression equation

$$
\begin{aligned}
s_{z1t} &= \beta_{01} + \sum_{k=1}^{4} \beta_{1k} \ln \frac{\varphi_{zkt} p_{zkt}}{\varphi_{zkt} p_{z5t}} + \gamma_1 \ln \frac{K_{zt}}{L_{zt}} + \lambda_1 W s_{z1t} + \alpha_{z1} + \alpha_{1\tau} + u_{z1t} \\
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\end{aligned}
$$

where $\beta_{jk} = \beta_{kj}$; $u_{zjt} = \rho_j W u_{zjt} + \varepsilon_{zjt}$.

→ Such spatial interdependence is not captured in our theoretical model.

→ To address the issue of spatial interdependence while simplifying the theoretical framework, this paper employs **spatial econometric techniques** (W: spatial weighting matrix).

Regression equation

$$
\begin{aligned}
s_{z1t} &= \beta_{01} + \sum_{k=1}^{4} \beta_{1k} \ln \frac{\varphi_{zkt} p_{zkt}}{\varphi_{zkt} p_{z5t}} + \gamma_1 \ln \frac{K_{zt}}{L_{zt}} + \lambda_1 W s_{z1t} + \alpha_{z1} + \alpha_{1\tau} + u_{z1t} \\
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\end{aligned}
$$

where $\beta_{jk} = \beta_{kj}$; $u_{zjt} = \rho_j W u_{zjt} + \varepsilon_{zjt}$.

4. Both prices and TFP are potentially endogenous because they may be correlated with unobserved demand and/or supply shocks.

→ It is not easy to combine the instrumental variable approach with SUR because the above SUR itself is "structural" in the sense that it forms a system of equations that reflect the general equilibrium relationship between variables.

→ As a short cut, therefore, I control for unobserved demand and/or supply shocks by introducing prefecture–sector and sector–period fixed effects **(Olney, 2013, JIE)**.

Main results

	Agriculture	Manufacturing	Other production	Business services
$\ln(\varphi_1 p_1/\varphi_5 p_5)$	0.012***	-0.019***	0.006***	-0.003***
	(0.002)	(0.001)	(0.001)	(0.001)
$\ln(\varphi_2 p_2/\varphi_5 p_5)$	-0.019***	0.172***	-0.028***	-0.013***
	(0.001)	(0.003)	(0.001)	(0.001)
$\ln(\varphi_3 p_3/\varphi_5 p_5)$	0.006***	-0.028***	0.089***	-0.009***
	(0.001)	(0.001)	(0.001)	(0.001)
$\ln(\varphi_4 p_4/\varphi_5 p_5)$	-0.003***	-0.013***	-0.009***	0.056***
	(0.001)	(0.001)	(0.001)	(0.001)
$\ln(K/L)$	-0.078***	0.067***	0.013***	0.007***
	(0.002)	(0.004)	(0.002)	(0.001)
λ	-0.266***	-0.017	0.022	-0.235***
(**Ws**)	(0.025)	(0.018)	(0.024)	(0.022)
ρ	0.315***	0.321***	0.042	0.404***
(**Wu**)	(0.031)	(0.027)	(0.037)	(0.028)
Number of observations	7708			
R-squared	0.943	0.976	0.950	0.966
Log-likelihood	27431.9			
Breusch-Pagan statistic	837.4***			

Decomposition of the effects

- Regression equation:

$$s_{zjt} = \hat{\beta}_{0j} + \sum_k \hat{\beta}_{jk} \ln \frac{\varphi_{zkt} p_{zkt}}{\varphi_{5kt} p_{z5t}} + \hat{\gamma}_j \ln \frac{K_{zt}}{L_{zt}} + \hat{\alpha}_{zj} + \hat{\alpha}_{j\tau} + \hat{\lambda}_j W s_{zjt} + \hat{\rho} u_{zjt}.$$

- From the estimated coefficients, it is possible to decompose the changes into the share of manufacturing GDP to the effects of prices, productivity, and endowments as well as the spatial effect:

$$\begin{aligned} \overline{\Delta s_{jT}} &= \underbrace{\sum_k \hat{\beta}_{jk} \overline{\Delta \ln \frac{\varphi_{kT}/\varphi_{kT}}{\varphi_{5T}/\varphi_{5T}}}}_{\text{Productivity effect}} + \underbrace{\sum_k \hat{\beta}_{jk} \overline{\Delta \ln \frac{p_{kT}/p_{kT}}{p_{5T}/p_{5T}}}}_{\text{Price effect}} \\ &\quad + \underbrace{\hat{\gamma}_j \overline{\Delta \ln(K_T/L_T)}}_{\text{Endowment effect}} + \underbrace{\Delta \hat{\alpha}_{j\tau}}_{\text{Period effect}} + \underbrace{\hat{\lambda} \overline{\Delta W s_{jT}} + \hat{\rho} \overline{\Delta u_{jT}}}_{\text{Spatial effect}}, \end{aligned}$$

  where Δ is the difference between $t = 0$ and $t = T$.
- This paper focuses on the changes between 1972 and 2012.

Decomposition of the effects

	Coefficient × growth	Decomposition (%)	S.D.
Actual Δs, 1972–2012	-0.083	-100.0	
Productivity effect	0.149	179.4	(2,860.7)
Price effect	-0.167	-201.2	(2,484.0)
Endowment effect	0.108	130.2	(1,243.3)
Period effect	-0.155	-186.4	(1,675.4)
Spatial effect	-0.018	-22.1	(526.9)

1. The negative price and period effects outweigh the positive effect of productivity and endowment.

Decomposition of the Effects: Contribution

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1. The negative price and period effects outweigh the positive effect of productivity and endowment.
2. The effect of spatial interdependence is relatively small.
3. Both the price and productivity effects show larger standard deviations than other effects.

Conclusion

Research question

- How and why the patterns of deindustrialization are uneven across regions within a country?
  - Deindustrialization: the declining share of manufacturing in value-added

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1 Summary

2 Background

3 Theoretical Background

4 Data

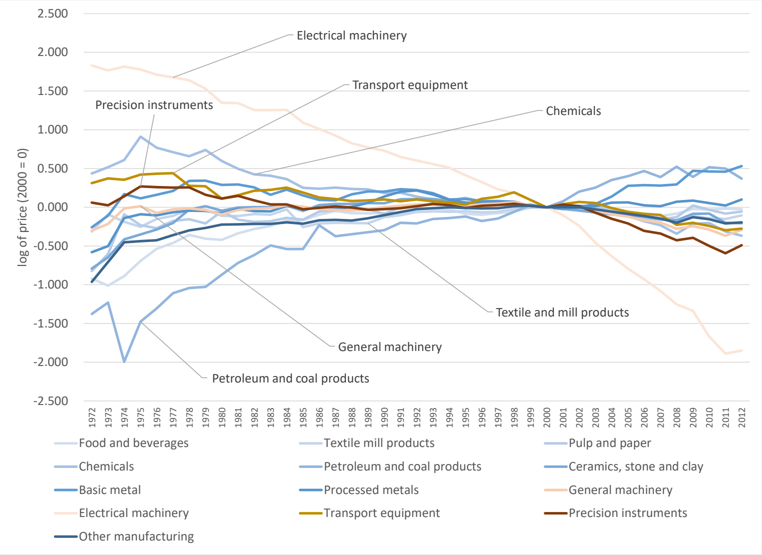
5 Econometric Issues

6 Results

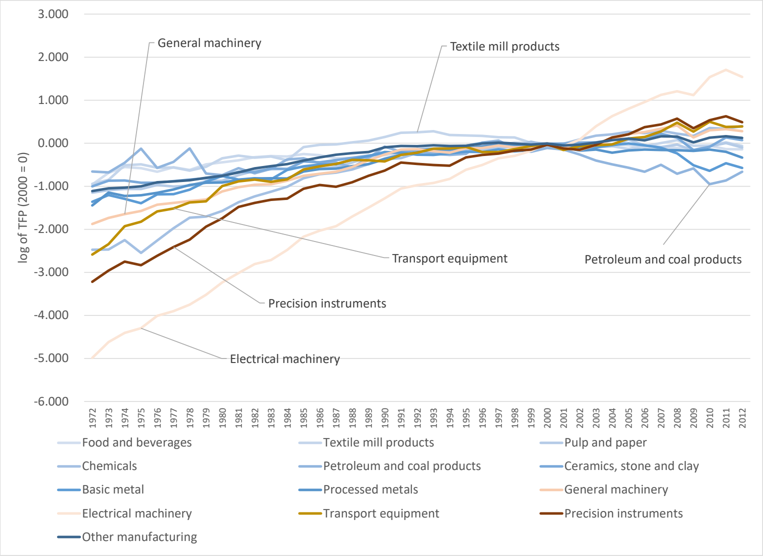
7 Conclusion

8 Appendix

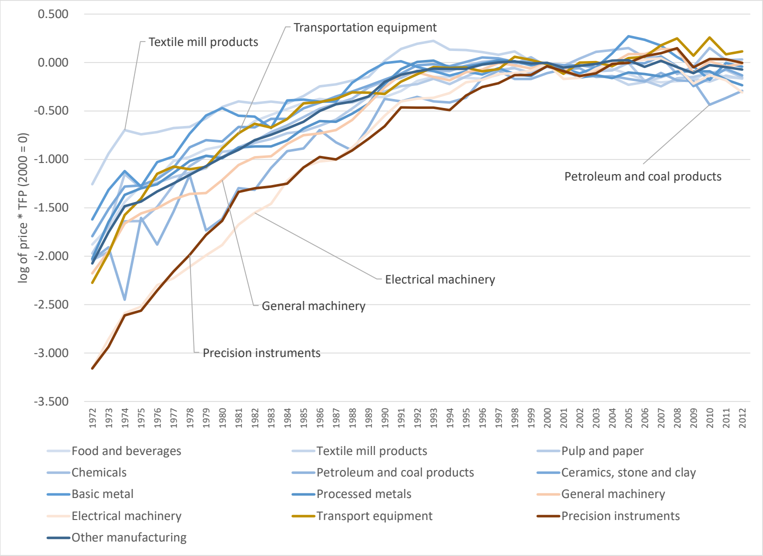
Changes in the price within manufacturing



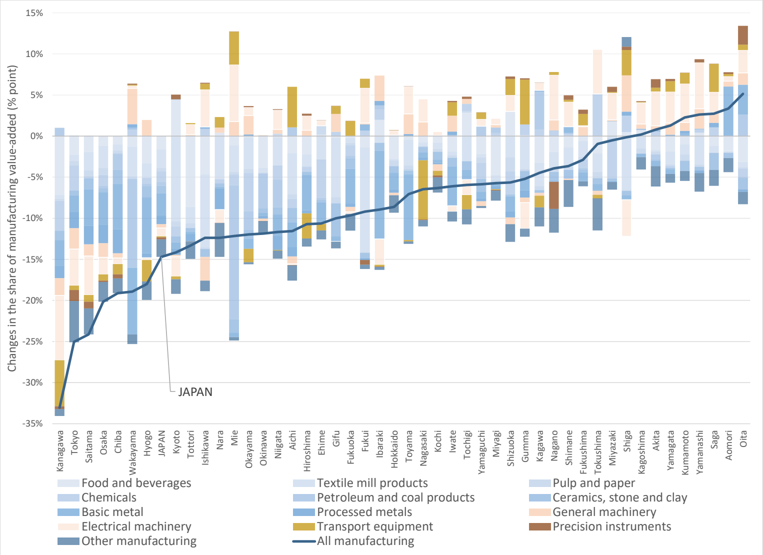
Changes in TFP within manufacturing



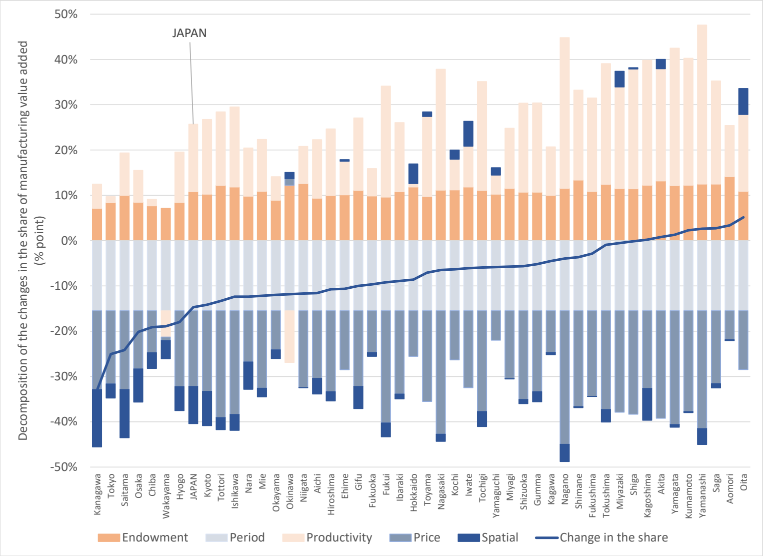
Changes in Price × TFP within manufacturing



Changes in the share of value-added within manufacturing
Decomposition by industry



Changes in the share of value-added within manufacturing Decomposition by effect



Appendix Measurement of TFP

- This paper measures productivity using a superlative index number measure of TFP (Caves, Christensen, and Diewert, 1982, ECTA) because of the following two reasons:

1. It is derived under the neoclassical model's assumptions of constant returns to scale and perfect competition.
    - It thus is consistent with the theoretical framework of this paper.
2. Although much progress has been made on estimating production functions over the past decade (e.g., Ackerberg, Caves, and Frazer, 2015, ECTA), their framework requires large cross-sectional variations (i.e., large sample size for a given time) and thus is usually unable to apply sector-level data (i.e., relatively small sample).

Appendix Measurement of TFP

- Approximating constant returns to scale production technology with a translog functional form, this superlative index number evaluates productivity in each prefecture and year relative to a hypothetical average prefecture in the sector.
- Let Y, L, K denote the real value-added, labor input (hours worked), and real capital stock, respectively.
- Denoting the geometric mean of the variables as an upper bar, this relative TFP is written as follows:

$$\begin{aligned} \ln \varphi_{zjt} &= \ln \frac{Y_{zjt}}{\bar{Y}_{jt}} - \sigma_{zjt} \ln \frac{L_{zjt}}{\bar{L}_{jt}} - (1 - \sigma_{zjt}) \ln \frac{K_{zjt}}{\bar{K}_{jt}} \\ &\quad + \ln \frac{\bar{Y}_{jt}}{\bar{Y}_{j0}} - \bar{\sigma}_{jt} \ln \frac{\bar{L}_{jt}}{\bar{L}_{j0}} - (1 - \bar{\sigma}_{jt}) \ln \frac{\bar{K}_{jt}}{\bar{K}_{j0}}, \end{aligned} \tag{2}$$

where $\sigma_{zjt} = 1/2 \cdot (c_{zjt} + \bar{c}_{jt})$ is the average of labor share in total cost in prefecture z (c_{zjt}) and the arithmetic mean labor share ($\bar{c}_{jt}$); $\bar{\sigma}_{jt} = 1/2 \cdot (\bar{c}_{jt} + \bar{c}_{j0})$.

Appendix Spatial Econometric Techniques

1. SUR model without spatial effects:

$$\mathbf{s}_{jt} = \beta_j \mathbf{X}_{jt} + \boldsymbol{\epsilon}_{jt},$$

where $\mathbf{s}_{jt}$ is GDP share; $\mathbf{X}_{jt}$ is a matrix of regressors including factor endowments; j is sector; and t is time

2. SUR model with spatial autoregressive term:

$$\mathbf{s}_{jt} = \lambda_j \mathbf{W}\mathbf{s}_{jt} + \beta_j \mathbf{X}_{jt} + \boldsymbol{\epsilon}_{jt},$$

where $\mathbf{W}$ is the spatial weighting matrix.

3. SUR model with spatial errors:

$$\mathbf{s}_{jt} = \beta_j \mathbf{X}_{jt} + \mathbf{u}_{jt} \quad \text{and} \quad \mathbf{u}_{jt} = \rho_j \mathbf{W}\mathbf{u}_{jt} + \boldsymbol{\epsilon}_{jt}$$

4. **SUR model with spatial autoregressive term and spatial errors**:

$$\mathbf{s}_{jt} = \lambda_j \mathbf{W}\mathbf{s}_{jt} + \beta_j \mathbf{X}_{jt} + \mathbf{u}_{jt} \quad \text{and} \quad \mathbf{u}_{jt} = \rho_j \mathbf{W}\mathbf{u}_{jt} + \boldsymbol{\epsilon}_{jt}$$

Appendix Spatial Weighting Matrix (W)

- $\mathbf{W}\mathbf{s}_{jt}$ is a spatial analog of $\mathbf{s}_{j,t-1}$: while $\mathbf{s}_{j,t-1}$ measures the potential spillover from time $t-1$ to t, elements $\mathbf{W}(1,2)$ specify how much potential spillover there from region 2 to 1.
- The weighting matrix is constructed, based on whether regions are contiguous or not (including by tunnels or bridges, as of year 2000).
- An example:

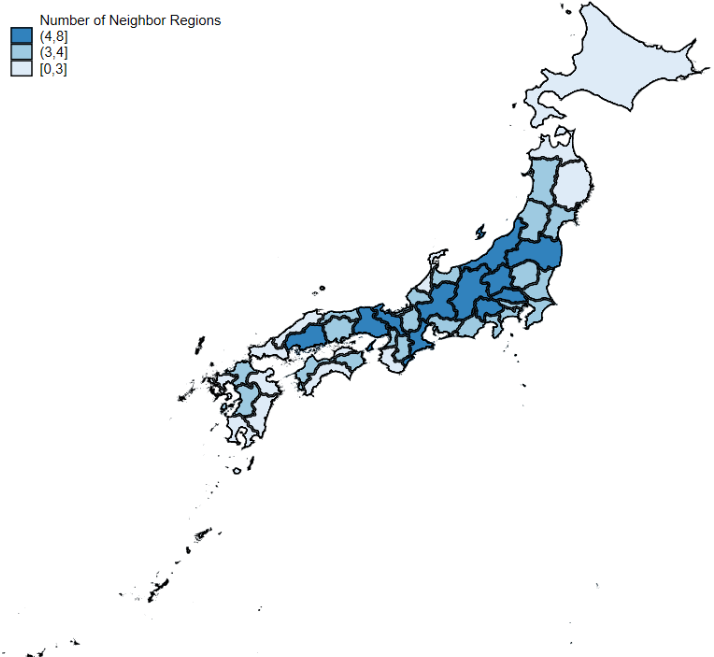
	Canada	US	Mexico
Canada	0	1	0
US	1	0	1
Mexico	0	1	0

- As is common, I use a row-standardized weighting matrix where it is normalized so that each row sums to unity:

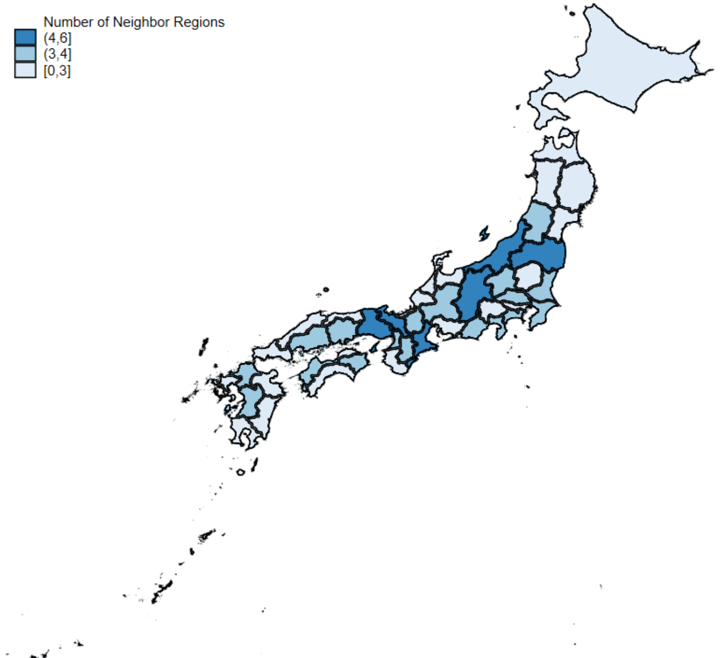
	Canada	US	Mexico
Canada	0	0.5	0
US	1	0	1
Mexico	0	0.5	0

- Multiplied by the vector of dependent variables, the spatially-weighted variable, $\mathbf{W} \cdot \mathbf{s}_{jt}$, then has the simple interpretation of row-sums being a proximity-weighted average of the sector j's GDP to other regions.

Number of Regions with Common Borders



Number of Regions with Common Borders: Alternative Definition



Appendix Year Fixed Effect

- Even though the use of year dummies is ideal, it is equivalent to including the simple average GDP share of sector j of all regions.

$$\mathbf{s}_{jt} = \lambda_j \mathbf{W}\mathbf{s}_{jt} + \bar{\mathbf{s}}_{jt} + \beta_j \mathbf{X}_{jt} + \boldsymbol{\epsilon}_{jt},$$

- If the regression equation includes both year dummies (i.e., simple average GDP share: $\bar{\mathbf{s}}_{jt}$) and spatial autoregressive term (i.e., weighted average GDP share: $\mathbf{W}\mathbf{s}_{jt}$) simultaneously, they will be highly correlated (Klemm and Van Parys, 2012, ITAX):
- It thus would be difficult to identify the true impact of each variable.
- To address this issue, I follow the approach taken by Olney (2013, JIE) that utilized 5-year fixed effects to control for trends in the data while avoiding the issues associated with including year fixed effects.