Do electricity supply constraints matter for comparative advantage? : a neoclassical approach

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Abstract

This paper examines the extent to which electricity supply constraints could affect sectoral specialization. For this purpose, an empirical trade model is estimated from 1990--2008 panel data on 15 OECD countries and 12 manufacturing sectors. We find that along with Ricardian technological differences and Heckscher-Ohlin factor-endowment differences, productivity-adjusted electricity capacity drives sectoral specialization in several sectors. Among them, electrical equipment, transport equipment, machinery, chemicals, and paper products will see lower output shares as a result of decreases in productivity-adjusted electricity capacity. Furthermore, our dynamic panel estimation reveals that the effects of Ricardian technological differences dominate in the short-run, and factor endowment differences and productivity-adjusted electricity capacity tend to have a significant effect in only the long-run.

Keywords: Technology, Factor endowments, GDP function, Comparative advantage, Electricity
JEL classification: F1, F11, Q40

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Do Electricity Supply Constraints Matter for Comparative Advantage?: A Neoclassical Approach*

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Abstract

Since the Fukushima accident in the aftermath of the Great East Japan Earthquake, the impact of electricity supply constraints on the Japanese economy has been a serious concern in public debate. This paper examines the extent to which electricity supply constraints could affect sectoral specialization. For this purpose, an empirical trade model is estimated from 1990–2008 panel data on 15 OECD countries and 12 manufacturing sectors. We find that along with Ricardian technological differences and Heckscher-Ohlin factor-endowment differences, productivity-adjusted electricity capacity drives sectoral specialization in several sectors. Among them, electrical equipment, transport equipment, machinery, chemicals, and paper products will see lower output shares as a result of decreases in productivity-adjusted electricity capacity. Furthermore, our dynamic panel estimation reveals that the effects of Ricardian technological differences dominate in the short-run, and factor endowment differences and productivity-adjusted electricity capacity tend to have a significant effect in only the long-run.

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1 Introduction

As a result of the Fukushima accident following the Great East Japan Earthquake, electricity supply in Japan has been constrained, raising serious concerns among businesses and policy makers about the negative impact on the country's economy. Since the nuclear accident, Japanese electricity companies have suspended nuclear power plants accounting for about 20% of the net installed electricity capacity in Japan as of 2010. Consequently, electricity companies have substituted thermal power for nuclear power, which has arguably led to increases in electricity prices.[1]

This paper examines the extent to which electricity supply constraints would affect sectoral specialization and sectoral outputs. Prior studies have examined the impact of electricity supply constraints caused by the nuclear accident. For example, Tachi and Ochiai (2011) use a static comutalbe general equilibrium model to calculate the impact of a hypothetical situation, in which all nuclear power plants are shut down, on regional economies and industries. Tokui, Arai, and Miyagawa (2012) estimate the impact of increases in electricity price on regional economies and industries by examining the input-output table. Although these studies provide valuable insight, their simulations rely on either a particular macro economic model or a short-run (and inflexible) industrial structure, and so they are not very informative from the perspective of a longer time horizon, during which firms may adjust their input composition and primary factors may be reallocated across industries. This paper takes a very different course from the previous studies. To obtain new insights (and I hope more general insights) about how sectoral output distribution is influenced by electricity capacity and other standard economic elements, such as sectoral total factor productivity (TFP) and factor endowments, I estimate an international trade model on the basis of data from 12 manufacturing sectors in 15 OECD countries during 1990–2008, following the gross domestic product (GDP) function approach of Harrigan (1997b).

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[1] Tokyo Electric Power Company, the largest electricity company in Japan and owner of the Fukushima plant that was seriously damaged by the Great East Japan Earthquake, raised electricity prices for industrial use in April 2012 and for consumer use in September 2012. Following Tokyo Electric Power Company's lead, other electricity companies have also raised electricity prices.

Harrigan (1997b) estimates the GDP function under the neoclassical trade model.[2] This paper also estimate a variation of the GDP function. To see the effect of electricity supply constraints, I slightly modify the embedded model by incorporating non-tradable intermediate goods as a proxy for the electricity supply sector, assuming that this sector uses a specific factor. Electric power plants usually run for rather long periods once they are installed. Hence, the specific factor assumption about this sector is reasonable.

Our estimates on productivity-adjusted electricity capacity are statistically significant and meaningful in many sectors, suggesting that decreases in productivity-adjusted electricity capacity will have different impacts, in terms of both size and direction, on output shares according to sector. Among the sectors, electrical equipment, transport equipment, machinery, chemicals, and paper products experience a relatively large negative impact. Furthermore, our dynamic panel estimation reveals that whereas the effects of Ricardian technological differences dominate in the short-run, differences in factor endowments and productivity-adjusted electricity capacity tend to have a significant effect in only the long-run.

The rest of the paper is organized as follows. In the next section, I lay out a theoretical framework for estimation. Section 3 describes an empirical strategy, deriving the estimated equation from the translog GDP function. Section 4 summarizes the data. Section 5 reports the results of the estimation, and Section 6 describes their implications. Section 7 concludes.

2 Theoretical Framework

The analysis employed here closely follows the GDP function approach of Kohli (1991) and Harrigan (1997b). However, I have slightly modified the standard neoclassical trade model embedded in the GDP function approach by explicitly considering the intermediate goods sector (which presumably corresponds to the electricity supply sector). Fully including the intermediate goods sector into the model may yield new insights (e.g. Caliendo and Parro (2009)). Unfortunately, this comes at the cost of complexity and needing to collect detailed

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[2] Other recent applications of Harrigan's approach include Ju, Zhu, Chen, and Crier (2011) and Kee, Nicita, and Olarreaga (2008).

data to make meaningful estimations. Taking account of limited data availability and the benefit of exploiting inter-country variations in the data, the modification I propose here remains quite simple.

Consider a perfectly competitive small open economy with N final goods ($i = 1, \ldots, N$) and one intermediate good. I assume that the intermediate good is non-tradable. There are M primary factors ($k = 1, \ldots, M$) for the production of the final goods. These factors are domestically, but not internationally, mobile. Each good is produced with HD 1 production technology. I assume that the production of the intermediate good requires only one specific factor, k_m.[3] The production functions of final good i and the intermediate good m are given by

$$x_i = \theta_i f_i(\mathbf{v}_i, m_i), \tag{1}$$

$$m = \theta_m k_m, \tag{2}$$

where θ_i is the productivity parameter of good i, $\mathbf{v}_i$ is the vector of primary inputs, and m_i is the input of the intermediate good. Likewise, θ_m is the productivity parameter of the intermediate good. I assume that the function f_i is shared among countries, but θ_i may vary by country.

As is standard, final good producers maximize the profits for given product prices p_i, factor prices w_k, and the intermediate good price p_m. Then, the usual equilibrium conditions are expressed as follows:

$$p_i \leq \frac{c_i(\mathbf{w}, p_m)}{\theta_i} \qquad \text{(zero profits)} \tag{3}$$

$$\mathbf{A}(\mathbf{w}, p_m)\mathbf{x} = \mathbf{v} \qquad \text{(factor market clearing)} \tag{4}$$

$$\sum_{i=1}^{N} m_i^d(\theta_i, p_i, p_m, x_i) = \theta_m k_m \qquad \text{(intermediate good market clearing)} \tag{5}$$

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[3] The model can be extended by incorporating primary energy input e into the production of the intermediate good m, such as by $m = g(\theta_m k_m, e)$. It is reasonable to regard the primary energy input (e.g., oil or gas) as a tradable good with its price is exogenously given by the international market. It is possible to show that the GDP function may contain the exogenous price of the primary energy input. However, in estimation, it is likely that time dummy and country dummy variables absorb the impact of the price of the primary energy input. Thus, I have omitted the primary energy input from the model to obtain the simple model presented in the main text.

where $\mathbf{w}$ is the vector of factor prices, $\mathbf{A}$ is the vector of unit requirements, $\mathbf{x}$ the output vector of final goods, and $\mathbf{v}$ is the vector of factor endowments. The derived demand for the intermediate good, m_i^d, comes from the first-order conditions for profit maximization.

The zero-profit conditions in (3) imply that factor prices w_k can be expressed in terms of the vector of final goods prices $\mathbf{p}$, the price of the intermediate good p_m, and the N-dimensional diagonal productivity matrix Θ. Noting this, factor market clearing in (4) implies that the output of each final good x_i can be expressed in terms of $\mathbf{p}, p_m, \Theta$, and $\mathbf{v}$. Finally, market clearing of the intermediate good in (5) determines the equilibrium price of the intermediate good $\tilde{p}_m$ in terms of $\mathbf{p}, \Theta, \theta_m, \mathbf{v}$ and k_m. For example, declines in θ_m or k_m will lower the output level of final goods and also alter the composition of final goods output (e.g., $x_i / \sum_{j=1}^{N} x_j$).

We now turn to the GDP function. Increases in θ_i are exactly equivalent to proportional increases in production value for a given vector of factor inputs. Hence, along with the above discussions about the small open economy with N final goods and one (non-tradable) intermediate good, the GDP function is given by

$$r(\Theta\mathbf{p}, \mathbf{v}, \theta_m k_m) = \max_{\mathbf{x}} \{\mathbf{p}'\mathbf{x} : (\mathbf{x}, \mathbf{v}, \theta_m k_m) \in \mathbf{T}\} \tag{6}$$

where $\mathbf{T}^t \subset \mathbf{R}^{N+M+1}$ is the convex production set.[4]

It is assumed that the GDP function is well-defined; namely, it is homogenous of degree one in output prices, twice differentiable, convex on $\Theta\mathbf{p}$, and concave on $\mathbf{v}$ and $\theta_m k_m$.[5] Thus, the vector of output supplies $\mathbf{x}$ is given by the gradients of the GDP function with respect to $\mathbf{p}$.

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[4] See Dixit and Norman (1980) Ch.5 for more detail. As is standard, positive elements of x represent outputs, which includes exports, and negative elements of x are imports.

[5] For the GDP function to be a continuous and twice-differentiabile function requires smooth substitutability among factors and at least as many factors as goods, so $M \geq N$. See Harrigan (1997b) for more on this point.

3 Empirical Strategy

Following the convention of providing the GDP function in a translog functional form (Kohli (1991)), the GDP function discussed above is specified as follows:

$$\begin{aligned}\ln r(\Theta\mathbf{p},\mathbf{v},\theta_m k_m) = a_0 &+ \sum_{i=1}^{N} a_i \ln\theta_i p_i + \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} a_{ij}\ln\theta_i p_i \ln\theta_j p_j \\ &+ \sum_{k=1}^{M} b_k \ln v_k + b_m \ln\theta_m k_m + \frac{1}{2}\sum_{k=1}^{M}\sum_{l=1}^{M} b_{kl}\ln v_k \ln v_l \\ &+ \frac{1}{2} b_{mm}(\ln\theta_m k_m)^2 + \frac{1}{2}\sum_{k=1}^{M} b_{km}\ln v_k \ln\theta_m k_m \\ &+ \sum_{i=1}^{N}\sum_{k=1}^{M} c_{ik}\ln\theta_i p_i \ln v_k + \sum_{i=1}^{N} c_{im}\ln\theta_i p_i \ln\theta_m k_m. \qquad (7)\end{aligned}$$

To ensure that the translog GDP function is homogenous of degree one in prices, we adopt the following restrictions:

$$\sum_{i=1}^{N} a_i = 1, \quad \sum_{i=1}^{N} a_{ij} = \sum_{i=1}^{N} c_{ik} = 0, \quad a_{ij} = a_{ji} \qquad (8)$$
$$\forall i = 1,\ldots,N, \quad \text{and} \quad \forall j = 1,\ldots,N.$$

Likewise, to ensure that the translog GDP function is homogenous of degree one in factors, the following restrictions are adopted:

$$\sum_{k=1}^{M+1} b_k = 1, \quad \sum_{k=1}^{M+1} b_{kl} = \sum_{k=1}^{M+1} c_{ik} = 0, \quad b_{kl} = b_{lk} \qquad (9)$$
$$\forall k = 1,\ldots,M+1, \quad \text{and} \quad \forall l = 1,\ldots,M+1.$$

where I slightly abuse notations and include $\theta_m k_m$ into the primary factors v_k.

Differentiating $\ln r(\Theta\mathbf{p},\mathbf{v},\theta_m k_m)$ with respect to $\ln p_i$ and using the homogeneity restrictions, we obtain the share of sector i's output in GDP, $s_i = p_i x_i / r(\Theta\mathbf{p},\mathbf{v},\theta_m k_m)$ in the following simple form:

$$s_i = a_i + \sum_{j=1}^{N} a_{ij}\ln\theta_j p_j + \sum_{k=1}^{M} c_{ik}\ln v_k + c_{im}\ln\theta_m k_m, \qquad (10)$$

which implies that output distribution depends on the productivities of final goods Θ, the factor endowment $\mathbf{v}$, the productivity of the intermediate good θ_m, and the specific factor for the intermediate good k_m. This output share in (10) will be estimated instead of estimating the GDP function itself. The coefficient c_{ik} is the response of output i's share to changes in the factor endowment v_k, so that it is a quasi-Rybczynski elasticity. It is well known that the Rybczynski elasticity is easily recovered from there. Noting that $\ln x_i = \ln(s_i r/p_i)$ and using s_i in (10), the Rybczynski elasticity is expressed by

$$\frac{\partial \ln x_i}{\partial \ln v_k} = \frac{c_{ik}}{s_i} + s_k, \tag{11}$$

where s_k is the reward share of factor k in GDP.[6] Likewise, we can construct the output elasticity of own TFP such that

$$\frac{\partial \ln x_i}{\partial \ln \theta_i} = \frac{a_{ij}}{s_i} + s_i, \tag{12}$$

Using restrictions in (8) and (9), the share equations for country c can be rewritten in a relative manner, such that

$$s_i^c = a_i + \sum_{j=2}^{N} a_{ij} \ln \widetilde{\theta_j^c p_j^c} + \sum_{k=2}^{M} c_{ik} \ln \tilde{v}_k^c + c_{im} \ln \widetilde{\theta_m^c k_m^c}, \tag{13}$$

where $\widetilde{\theta_j^c p_j^c} = \theta_j^c p_j^c/(\theta_1^c p_i^c)$, $\tilde{v}_k^c = v_k^c/v_1^c$ and $\widetilde{\theta_m^c k_m^c} = \theta_m^c k_m^c/v_1^c$. The treatment of productivity-inclusive prices in (13) is not easy since internationally comparable price data are, in general, difficult to obtain for a broad range of goods and services. One method is estimating productivity coefficients θ_j^c and applying a simple stochastic model for productivity-exclusive prices p_j^c. Harrigan (1997b) takes this course. More specifically, dividing N goods into tradable goods ($i = 1, 2, \ldots, N_T$) and non-tradable goods ($i = N_{T+1}, \ldots, N$), collecting productivity-exclusive price terms for tradable goods and productivity-inclusive price terms for non-tradable goods leads to

$$\eta_i^c = \sum_{j=2}^{N_T} a_{ij} \ln \tilde{p}_j^c + \sum_{j=N_T+1}^{N} a_{ij} \ln \tilde{\theta}_j^c \tilde{p}_j^c. \tag{14}$$

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[6] Similarly, differentiating the GDP function with respect to $\ln v_k$ and using the homogeneity restrictions generates the share of factor k's input in GDP, $s_k = w_k v_k/r$. Again, using the estimated coefficient c_{ik}^t, the Stolper-Samuelson elasticity also can be recovered.

Productivity terms for tradable goods are not included in η_j^c because they will be estimated separately (this is discussed later). We specify η_i^c as a random variable with fixed effects d_i^c by country and fixed effects e_{it} by time as follows:

$$\eta_i^c = d_i^c + e_{it} + \mu_i, \tag{15}$$

where μ_i is normally distributed with mean 0 and variance σ_i^2. By modeling nontradable goods as shown above, we focus on estimating s_i^c for only tradable goods, which means that the restriction of homogeneity on a_{ij}^c can be dropped. Substituting (15) into (13), the main estimated equation is expressed by

$$s_{it}^c = a_{it} + \sum_{j=1}^{N_T} a_{ij} \ln \theta_{jt}^c + \sum_{k=2}^{M} c_{ik} \ln \tilde{v}_{kt}^c + c_{im} \ln \widetilde{\theta_{mt}^c k_{mt}^c} + d_{ic} + e_{it} + \mu_i. \tag{16}$$

It should be noted that the specification in (14) is appropriate only when the productivity-inclusive prices of non-tradable goods tend to grow at a common rate across countries (it is assumed that international trade makes productivity-exclusive prices of tradable goods synchronized). Further, the exogeneity of the price of tradable goods relies on the assumption that the world consists of many small countries. Noting these issues, I will proceed with the estimation of (16).

4 Data

4.1 Data construction

Productivity index To obtain internationally comparable productivity levels, a productivity index based on Caves, Chiritensen, and Diewert (1982) and Harrigan (1997b, 1999) is calculated. Assuming that value added Y is a function of capital K and labor L, the productivity index for sector i in country c relative to country b (the reference country) is measured by

$$TFP_i^c = \frac{Y^c}{Y^b} \left[\frac{\bar{L}}{L^c}\right]^{\frac{\alpha^c+\bar{\alpha}}{2}} \left[\frac{\bar{K}}{K^c}\right]^{\frac{\beta^c+\bar{\beta}}{2}} \left[\frac{L^b}{\bar{L}}\right]^{\frac{\alpha^b+\bar{\alpha}}{2}} \left[\frac{K^b}{\bar{K}}\right]^{\frac{\beta^b+\bar{\beta}}{2}}, \tag{17}$$

where $\bar{L}$ and $\bar{K}$ are geometric means of labor and capital over all samples (here, countries). While α and β represent labor's share and capital's share, respectively, in total cost, the bar indicates the arithmetic mean operation. This TFP index is superlative and transitive, and used as θ_j^c in (16).[7]

For calculating the TFP index in (17), data for real value added, labor input, capital input, and the expenditure shares of labor and capital in total cost are needed. The OECD STAN database reports value added at the 2-digit ISIC Rev. 3 (equivalent to 3-digit ISIC Rev. 2). The number of industries is limited to 12 to match the data availability of the database. To convert vale added to internationally comparable units, I use PPP exchange rates for machinery and equipments as reported in the OECD statistics, and then deflate value added by the U.S. value added deflators given in the OECD STAN database. For labor input, I use total hours worked while controlling for the quality of labor by human capital. For capital input, I estimate capital stock in each sector from the data on gross fixed capital formation. Details about the calculations of these variables are shown in the appendix.

Other data I construct three primary factors: capital stock and two types of labor with different levels of educational attainment. The data on educational attainment are from Barro and Lee (2010).

For the electricity supply sector, the productivity level is calculated by (17). It is important to note that the OECD STAN database reports at a more aggregated level (namely, electricity, gas, and water supply) for variables such as gross fixed capital in many countries. Hence, for computing TFP, I compromise by using capital stock in this broadly defined sector. Although electricity itself can be regarded as a typical homogeneous good, it is not easy to find an appropriate PPP for this product. I use PPP in total services in 2005 from OECD statistics.

For the specific factor k_m, I use the net installed capacity of electric power plants as a

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[7] Since this TFP index is superlative and transitive, time-series and cross-section comparisons are possible. To obtain this TFP index, it is necessary to assume that each country's value added function in good i has constant returns to scale and takes the form of a translog permitting the first-order translog parameters to differer by country. In addition, it is assumed that producers are cost-minimizers and price takers in input markets, which are standard assumptions in the neoclassical model. The construction of the country c's relative TFP in good i follows by finding the minimum proportional decreases θ_i^c in value added for good i such that the resulting value added is producible with the input levels of c and the productivity level of b. See Caves, Chiritensen, and Diewert (1982) for a detailed discussion.

proxy. The data on electricity capacity come from the United Nations Statistics Division's Energy Statistics Database. Although a natural alternative is capital stock in the electricity supply sector, such data are not available for many countries. Thus, the net installed capacity of electricity seems more appropriate. One problem with using the net installed capacity is that this capacity is typically not fully utilized. It is almost impossible to collect data on actual operation of power plants over such long periods and in so many countries. The TFP index of this sector is used to mitigate this problem because it generally measures the efficiency of the sector. Multiplying the net installed capacity by the TFP yields a proxy for $\theta_m k_m$, and this proxy will be referred to as the effective capacity of electricity (productivity-adjusted electricity capacity).

Following the empirical specification discussed in the previous section, all factors including the effective electricity capacity are divided by one factor, arable land, using data from the World Bank's World Development Indicators (WDI) database. After constructing the data for estimation in the manner explained above, I eventually obtain the data that cover 12 manufacturing sectors in 15 OECD countries for the period 1990–2008 (the ending year varies by country. See the Appendix for precise details).

4.2 Data preview

Industrial specialization Table 1 reports the share of each sector's value added in manufacturing total for all sample countries in 1990 and 2008, along with the share of GDP accounted for by manufacturing. With respect to the share of GDP accounted for by manufacturing, the data show a mixed tendency during the sample period. Finland and Korea show apparent increases; Australia, Spain, the United Kingdom, and Norway show rather obvious declines. The remaining countries, including the United States, Germany, and Japan, exhibit only small changes (slight increases or slight declines, see also Figure 1).

Within the manufacturing sector, the importance of individual sectors notably changes between 1990 and 2008. The share of value added in electrical equipment rises in all countries. Some countries, particularly the United States and Finland, exhibit rapid increases in the share of value added in electrical equipment. In contrast, the share of value added in textiles declines in all countries. Other sectors in which the relative importance declines in many countries are paper products (declining in 13 of 15 countries) and mineral products (declining in 12 countries). For the remaining sectors, the directions of changes are more mixed. For example, in transport equipment, 10 countries increase the share of value added while 6 countries reduce the share.

We can also observe different specialization patterns across countries even though the sample is limited to OECD economies. For example, although Japan and Germany have similar specialization patterns (in both countries in 2008, the top three sectors are electrical, transport, and machinery), their specialization patterns differ from that of Italy (metals, machinery, and textiles) and that of Australia (metals, food, and paper). In sum, while the sample data reveal common changes in industrial specialization—rises in electrical equipment and declines in textiles—they still capture inter-country differences in specialization to a certain degree.

Productivities Table 2 reports relative TFP indices. The U.S. TFP level in 2005 is normalized to 1 for all sectors. TFP indices grow over time in most sectors. In particular, the growth in the electrical equipment sector is remarkable. For example, in the case of the United States, the TFP level in 2005 is about 14-fold that in 1990. Finland also shows a rapid growth, with a TFP level in 2005 is about 6-fold that in 1990.[8] In contrast, the food sector exhibits relatively sluggish TFP growth: most countries have lower growth rates in the food sector than in total manufacturing.

Unsurprisingly, most countries see TFP growth in many sectors during the sample period. The exceptions are Japan and Spain. Japan has positive TFP growth in only two sectors, electrical equipment and transport equipment; Spain has positive TFP growth in three sectors, electrical equipment, machinery, and mineral. Japan's relatively poor performance in TFP growth in the sample period coincides with the long recessionary period after the Japanese financial crises of the 1990s.

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[8] Although these high growth rates in electrical equipment seem anomalous, the raw data suggest that rapid price declines in this sector can be attributable to rapid growth in TFP.

Factor endowments Table 3 summarizes each country's factor endowments, showing the levels in 2005 and the average annual growth rates from 1990 to 2005. In most countries, the number of workers increases except for in Finland and Japan which record slightly negative average growth rates.[9] Not surprisingly, the number of skilled (high-educated) workers as a share of total workers increases while the number of unskilled (low- and middle-educated) workers declines as a share of total workers in many countries. All countries except for the United States have higher growth rates in skilled labor than in unskilled labor, which implies that the share of skilled labor in total labor increases in most countries.

As pointed out by Harrigan (1997b), a flaw of using schooling years as a proxy for labor skill can be observed in the data. The share of skilled labor tends to be lower in some European countries than in countries of other regions. For example, although Japan's ratio of skilled workers is about 40% and Germany's is less than 20%, it is not credible to claim that Japan is much more abundant in skilled workers than Germany. The difference might reflect differences in the education systems of the two countries. Fixed effects by country mitigate such problems, so that these types of measurement errors do not cause serious trouble for regression.

Capital per worker is shown in the fifth column of Table 3. All countries except Australia increase capital per worker. Korea, plausibly, records the highest growth followed by either the United Kingdom or the United States. Arable land per worker declines in most countries. Australia, Canada, and the United State are the three most land abundant countries represented in the data. As shown in Table 1, these three countries have relatively high reliance on the food sector in total manufacturing, and this is partly reflected in their arable land abundance.

Electricity Table 4 summarizes each country's electrical capacity in 2005. Relative to number of workers, Norway and Canada have high electrical capacities. Japan's electrical capacity, 4.12 kW, is slightly lower than the sample average of 4.87 kW. In most countries, electrical capacity grows faster than labor but slower than capital.

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[9] Although not reported here, the average annual growth rates between 1995 and 2005 are positive for all countries except for Japan, whose growth rate over the period is -0.42%.

The table also shows TFP in the sector containing electricity, gas, steam, and water supply. Ideally, the electricity supply would be available on its own. However, the OECD STAN database does not contain data at such a fine level.[10] Thus, I use TFP of the larger sector as a proxy for TFP of electricity supply. As in the manufacturing sector, the TFP level in the United State in 2005 is normalized to 1. Although only Netherlands has higher TFP levels than the United States in 2005, several countries later surpassed the 2005 U.S. TFP. In particular, Austria and Norway show rapid growth of TFP in this sector. Japan's TFP is about 70% of the 2005 U.S. TFP which is low in comparison with other sampled countries.

One reason for Japan's low TFP in electricity supply is that Japan's capital stock in this sector is relatively high. The ninth column of the table shows that the share of capital stock in the sector in 2005 is 9.2%, which is the highest among the sample countries, which had a mean of 4.05% share of capital stock in the same year.

5 Results

5.1 Basic results: long-run effects

Allowing the error terms of equations (16) to be correlated with each other, we estimate them by iterative seemingly unrelated regressions. Further, to correct for measurement errors in TFP indices, sector i's TFP in country c in year t is instrumented by the average of all other countries' sector i's TFP in the same year. The estimation results are presented in Table 5. The dependent variable is the percentage share of each sector's value added in GDP. The explanatory variables are the log TFP in all sectors and various factor endowments. Because the dependent variable is a percentage, a parameter estimate of 0.1 implies that a 10% increase in the explanatory variable will raise the value added share by 0.01 percentaeg points. Although all regressions include a full set of time dummies and fixed effects by

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[10] Some countries provide the data on electricity, gas, steam, and hot water supply (40 in the ISIC Rev. 3) and collection, purification and distribution of water (41 in the ISIC Rev. 3) separately. However, some large countries, in particular the United States, do not. Thus, it is unavailable to use the data at the 40 plus 41 level. However, production indices (output and value added) suggest that the weight of water supply (41) is relatively small. Hence, it is inferred that using TFP indices measured for electricity, gas, and water supply (4041) as a proxy for TFP of electricity supply may not be too far off.

country, the coefficients of these variables are suppressed for brevity.

First, all coefficients of the sector's own TFP are positive and highly statistically significant as expected. The greatest effect is in the electrical and optical equipment sector with a TFP of 2.633, which implies that a 10% increase in TFP raises the share of value added in GDP by 0.26 percentage points. Other sectors with relatively high coefficients in own TFP are metals (1.713), food (1.43), and transport equipment (1.160). In contrast, wood (0.189), mineral (0.356), rubber and plastics (0.625), and textiles (0.744) show relatively low coefficients in own TFP. In the case of wood, a 10% increase in TFP will raise the share of value added in GDP by only 0.02 percentage points.

The effects of cross-sector TFP are much more difficult to interpret. However, it is interesting that TFP in machinery has a positive impact on a relatively broad range of sectors, including wood, metals, electrical equipment, transport equipment, and other manufacturing. TFP in electrical equipment also tends to positively influence some other sectors, such as mineral, machinery, transport equipment, and other manufacturing. These results may suggest the degree of sectoral complementarity induced by forward linkages.

We now turn to factor endowments: two types of labor (skilled and unskilled) and capital stock. For unskilled labor, only the mineral and other manufacturing secorts have positive and statistically significant coefficients. For many other sectors, including food, chemicals, rubber and plastics, electrical equipment, and transport equipment, increases in unskilled labor lower the value added share in GDP. In the previous section, we confirmed that all countries except for the United States haven an increase of skilled labor and the growth rate of skilled labor is greater than that of unskilled labor everywhere but Denmark and the Unites States. The coefficients of skilled labor suggest that these increases contribute to raising the share of value added in the electrical equipment, metals, and machinery sectors (statistically significant at the 1% level).

With respect to capital, only the food and paper sectors have positive and statistically significant coefficient. The chemical sector also has a positive coefficient, but it is not statistically significant. The coefficients for the mineral, metals, and machinery sectors are negative and statistically significant. Overall, increases in capital stock do not much contribute to raising the share of value added in GDP for many manufacturing sectors. One possible reason for this is that some services sectors are highly capital intensive. For example, the capital labor ratio in real estate, renting and business activities (from 70 to 74 in the ISIC Rev. 3) is much higher than the manufacturing total in 2005 (omitted for brevity).[11]

The last row in Table 5 shows the impact of effective electric capacity. In many sectors, the coefficients are statistically significant. The highest value is for electrical equipment: the coefficient implies that a 10% increase in effective electric capacity will raise the share of value added in GDP by 0.12 percentage points. The second highest value is for transport equipment , at 0.654. The coefficients for machinery, chemicals, and paper are similar at about 0.3. Metals are 0.273. Negative coefficients are found for textile (-0.202) and mineral (-0.162). It is interesting to compare these results with those in Tachi and Ochiai (2011) and Tokui, Arai, and Miyagawa (2012). Tachi and Ochiai (2011) assume that all of Japan's nuclear power generation is replaced by thermal power generation and calculate changes to gross output by sector. Their results suggest that many manufacturing sectors, including chemicals, steel, nonferrous metals, would increase gross output and non-manufacturing sectors would decrease gross output. Tokui, Arai, and Miyagawa (2012) show that increases in the electricity price due to replacement of nuclear power generation with thermal power generation would bring about relatively large negative impacts on the production by the chemicals, steel, nonferrous metals, and electronics parts sectors. The estimation results presented here are close to those by Tokui, Arai, and Miyagawa (2012): the coefficient of effective electric capacity is positive and significant for chemicals and metal products (including steel and nonferrous metals), and electrical equipment.

Overall, two things are noteworthy. First, the effect of own TFP is much greater than factor endowments (or effective electric capacity). This result suggests that the Ricardian motive of technological difference works more compellingly than the Heckscher-Ohlin motive

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[11] Real estate, renting and business activities include real estate activities (70), renting of machinery and equipment (71), computer and related activities (72), research and development (73), and other business activities (74). Because the OECD STAN database does not provide the data on fixed capital formation at this level for all countries, I calculated the capital stock for real estate, renting and business activities (from 70 to 74).

of factor endowments in sectoral specialization. Taking account of the nature of our sample, which comprises OECD countries, it may not be surprising. However, this result echoes the result of Morrow (2010), which also studies both the Ricardian motive and the Heckscher-Ohlin motive in trade. Second, the impact of the effective capacity of electricity on the share of value added in GDP varies by sector. The size of the impact is non-negligible in sectors such as electrical equipment and transport equipment.

5.2 A dynamic model: short-run effects

The previous estimates are based on the neoclassical assumption of free movement of factors among sectors. A simple alternative specification for relaxing this assumption is to include a one-period lag of the dependent variable as an explanatory variable into the regression:

$$s^c_{it} = a_{it} + \gamma_i s^c_{i,t-1} + \sum_{j=1}^{N_T} a_{ij} \ln \theta^c_{jt} + \sum_{k=2}^{M} c_{ik} \ln \tilde{v}^c_{kt} + c_{im} \ln \widetilde{\theta^c_{mt} k^c_{mt}} + d_{ic} + e_{it} + \mu_i. \tag{18}$$

We expect that the one-period lagged dependent variable will explain variations in the dependent variable to a large extent. The speed of adjustment is expressed by the term of γ_t. The coefficients other than γ_i can be interpreted as short-run effects.[12] To maintain consistency with the previous regression, I simply add the one-period lagged dependent variable to the explanatory variables, employing the two-period lagged dependent variable as an instrument.[13] In addition, I impose the constraint that the coefficient of the lagged dependent variable is common to all sectors because of the symmetry of cross-sector TFP effects. Furthermore, for robustness, I also test another model, in where each sector is individually estimated by the Arellano-Bond estimator for dynamic panel models, dropping all symmetric constraints on cross-sector TFP effect.

Table 6 presents the results. Not surprisingly, the coefficient of the lagged dependent variable is statistically significant and relatively large (0.556). Furthermore, as expected, the impacts of all other explanatory variables decline or become statistically insignificant. Several interesting things can be observed. First, the own-TFP effect continues to be positive and significant for all sectors with relatively small changes in most sectors. The food,

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[12] Multiplying $1/(1-\gamma_i)$ with the obtained coefficients generates the estimation in the long run.

[13] I follow the Anderson and Hsiao estimation with respect to inclusion of the dynamic term.

wood, mineral, metals, transport equipment, and other manufacturing sectors see slight increases in the own-TFP effect, while the textile, paper, chemicals, rubber, and machinery sectors see slight decreases. Electrical equipment is the only exception, showing a large drop in the own-TFP effect.[14] Second, although the own-TFP effect persists in the dynamic estimation, the cross-sector TFP becomes insignificant in most sectors. For example, machinery's cross-sector TFP effect is significant in six sectors (wood, chemicals, metals, electrical equipment, transport equipment, and other manufacturing) in the estimation of the long-run effects (Table 5). However, it is significant in only two sectors in the dynamic estimation. Third, most coefficients of skilled labor and capital are statistically insignificant. Skilled labor is statistically significant in electrical equipment and other manufacturing and capital is significant in paper and metals. Thus, once gradual adjustment in production specialization is accounted for, skilled labor and capital do not explain much about industrial specialization. This result may suggest that sectoral production adjustment through the economy-wide re-allocation of skilled labor and capital takes a relatively long time. Interestingly, the coefficients of unskilled labor remain significant in more sectors than those of skilled labor. This may reflect the difference in mobility between the two types of workers: the adjustment of unskilled workers is faster than that of skilled workers. Finally, the coefficient of effective capacity of electricity also becomes insignificant in many sectors. The coefficients are significant in four sectors, which is slightly more sectors than are significant for capital or skilled labor. This also may reflect the nature of electricity as a nondurable homogeneous intermediate input that can be more easily adjusted through the market than can skilled labor or capital.

This point is clearer in the alternative estimate using Arellano-Bond estimation. The results reported in Table 7 are qualitatively similar to those in Table 6. The one-period lagged dependent variable largely explains the dependent variable, and the impact of other explanatory variables becomes smaller or insignificant. Again, we can observe that skilled

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[14] Changes in the coefficients of the own-TFP term: food 1.430 → 1.729, textile 0.744 → 0.518, wood 0.189 → 0.249, paper 1.303 → 1.288, chemicals 1.285 → 1.193, rubber 0.625→ 0.580, mineral 0.356 → 0.387, metals 1.713 → 1.736, machinery 1.307 → 1.216, electrical equipment 2.633 → 1.240, transport equipment 1.160 → 1.303, other manufacturing 0.425 → 0.455

labor is insignificant in many sectors and capital becomes insignificant in textiles and paper. However, more sectors' coefficients of effective capacity of electricity remain significant than those of skilled labor and capital.

6 Implications: the Case of Japan

The estimation in the previous section indicates that shocks to the effective capacity of electricity influence industrial specialization in different ways. In general, their magnitudes are weaker than the own-TFP effect but greater than changes in factor endowments, such as skilled labor or capital. Hence, it is useful to obtain a sense of the estimated magnitudes of the impact of the effective capacity of electricity. In particular, we are interested in the case of Japan because declines in the effective capacity of electricity take place as nuclear power generation stops at individual plants and is replaced with thermal power generation.

Switching to thermal power generation can be thought of as rasing the production cost in the electricity supply sector. In our modeling, this is equivalent to dropping productivity in electricity generation, which lowers the effective capacity of electricity. It may be more difficult to raise electricity capacity in Japan partly because Japan has not yet reached a national consensus on new energy policy. Unfortunately, it is not easy to gauge what is equivalent to, for example, a 1% decline in the effective electricity capacity. In our simple modeling, a 10% increase in the production cost lowers the productivity by 10% (holding the markup rate constant). A recent study by Tokui, Arai, and Miyagawa (2012) claims that electricity price changes due to replacing nuclear generation with thermal generation vary from about -10% to more than 25% depending on region. Hence, I here simply observe the impact of a 10% decline in the effective capacity of electricity.

To assess the impact of the decline in the effective electricity capacity on industrial specialization, I use the coefficients from Table 5 (the last row). For example, a 10% decline in the effective capacity of electricity lowers the value added share in electrical equipment by 0.176 percentage points. To see Japan's relative position in the sample countries clearly, I plot the differences between Japan's value added share and the average value added share for each sector. Assuming that all countries have common homothetic preferences (a standard assumption in the trade literature), this relative value added share can be thought of as a proxy for comparative advantage.

Figure 2 presents the results of this exercise for 2005. In the figure, the industries are listed in descending order. Positive numbers indicate that Japan has greater value added share relative to the sample average. Industries where Japan has a relatively high share are electrical equipment (3033), machinery (2900), and transport equipment (3435). Industries where Japan has a relatively low share are paper (2122), textiles (1719), and wood (2000), excluding other manufacturing (3637). Though simple, the figure provides a useful snapshot of Japan's comparative advantages.[15] The right bars are the hypothetical relative value added share with a 10% decrease in effective electricity capacity.

At first glance, the total impact of the 10% decrease in effective electricity is not very large. However, it should be noted that it adversely affects the top three industries in which Japan is relatively more specialized. The chemical sector, in which Japan has a slightly higher share than the average, is also adversely affected. Thus, declines in effective electricity capacity may weaken Japan's comparative advantage.

The second assessment of our estimates is output elasticities. Table 8 presents the average of output elasticities with respect to own TFP and effective electricity capacity during 2000–2007. In most sectors, the magnitudes of output elasticities of electricity are less than half of those of own TFP (the exception is transport equipment). For example, while output elasticity of own TFP in electrical equipment is about 1.5, output elasticity of electricity is about 0.7. However, other sectors are much smaller such as about 0.18 in machinery and 0.35 in transport equipment. A 10% decrease in the effective capacity of electricity will lower output by 1.8% for machinery and 3.5% for transport equipment. Because Japan's annual TFP growth, estimated from Table 2, is about 1% in manufacturing, total, it might not be easy to avoid a decline in output in these manufacturing sectors if there is a 10% decline in the effective capacity of electricity.[16]

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[15] Food (1516) also shows a relatively high value added share in the figure. This may not necessarily mean that Japan has a comparative advantage in the food sector because the sample countries are limited to advanced economies.

[16] Note that these are the long-run impacts after full adjustment. As inferred from Table 6, output elasticities of electricity should be much smaller in the short run: roughly half in transport equipment and

7 Concluding Remarks

Motivated by the current difficulty in electricity power supply in Japan, this paper primarily assesses the impact of electricity constraints on manufacturing sectors. The results of the panel estimation performed in this paper are summarized as follows.

- The impact of the effective capacity of electricity on the share of value added in GDP varies by manufacturing sector. In addition, the scale of the impact is non-negligible in sectors such as electrical equipment and transport equipment. As a result, declines in the effective capacity of electricity may weaken Japan's comparative advantage.

- The effect of own-TFP is much greater than that of factor endowments (or effective electric capacity). This result suggests that the Ricardian motive of technological difference works more compellingly than does the Heckscher-Ohlin motive of factor endowments in sectoral specialization.

- Reflecting the size differences between the effects of own TFP and the effective capacity of electricity, output elasticities of the effective electricity capacity are much smaller than output elasticities of own TFP generally. However, if decreases in the effective capacity of electricity are relatively large (e.g., 10%), it may be difficult to compensate for the negative effects by improvement of own TFP.

- In the short-run, the effects of most explanatory variables are diminished or negated. The impact of the effective capacity of electricity tends to remain in some sectors, even though the magnitude significantly drops. This is common for unskilled labor. This may be a reflection of relatively rapid adjustment speed stemming from the homogeneous nature of electricity and unskilled labor.

Comparing these results with those from related studies, there are advantages in estimating international industrial panel data. First, the analysis becomes more general by capturing a relatively long-run tendency in industrial specialization across OECD countries.

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machinery and one-tenth in electrical equipment. However, output elasticity of own TFP also declines to some degree in the short-run.

Second, the estimation is based on an economic model, albeit a simple neoclassical model. Thus, it is easy to interpret estimates. Third, the data used here are a panel, which gives some flexibility in analysis: both long-run and short-run effects are examined. However, some aspects need further consideration. First, the model relies on the assumption of small economies, which may not always be appropriate. Second, the analysis is at the sector level, which makes it difficult to analyze firms' behavior, such as relocation of production sites to foreign countries, at a finer level. These issues are left for future research.

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Table 1: Share of value added in total manufacturing (%)

Industry	Year	AUS*	AUT	BEL	CAN*	DEU	DNK	ESP	FIN	GBR*	ITA	JPN	KOR	NLD	NOR*	USA
Food	1990	18.62	11.89	14.31	16.31	8.55	20.96	16.58	9.70	14.10	9.55	13.94	11.80	17.81	16.85	15.62
	2008	18.42	10.25	15.23	13.17	6.53	14.80	14.03	6.16	14.53	10.13	10.97	4.51	17.81	15.29	10.14
Textiles	1990	6.76	6.66	5.67	5.32	3.86	4.12	7.89	5.65	6.05	14.38	6.25	18.52	2.89	1.80	5.05
	2008	2.65	2.52	4.50	2.47	1.71	1.65	4.66	1.32	2.78	10.86	1.69	4.35	1.61	1.43	2.00
Wood	1990	3.80	5.24	1.33	5.20	1.34	2.06	2.47	4.83	2.02	2.46	1.90	0.94	1.57	4.62	3.95
	2008	3.80	4.41	1.82	6.43	1.30	2.32	2.25	3.44	1.89	2.37	0.66	0.44	1.59	4.08	1.90
Paper	1990	15.64	8.01	7.15	16.89	7.16	10.36	8.79	26.23	14.39	6.19	11.24	6.24	13.69	14.46	16.01
	2008	13.11	8.14	8.01	15.64	6.54	7.76	8.65	14.55	12.84	6.08	6.61	3.97	10.59	11.45	13.31
Chemicals	1990	9.90	4.98	13.94	7.51	9.11	5.56	9.20	8.12	7.70	6.82	7.22	8.74	11.94	11.33	15.50
	2008	7.39	8.30	18.89	7.21	10.64	14.17	9.50	5.95	11.31	6.92	7.07	8.25	16.34	11.03	9.67
Rubber	1990	4.17	3.37	2.74	3.50	4.41	6.07	3.42	4.96	5.05	3.55	5.15	6.74	2.96	2.28	4.07
	2008	3.42	3.42	4.95	4.93	5.17	4.79	4.35	3.07	5.16	3.82	4.30	4.77	3.03	1.82	3.06
Mineral	1990	3.13	8.10	5.95	3.21	3.35	5.08	7.01	5.73	3.73	6.10	4.16	6.19	4.10	3.95	3.66
	2008	4.80	5.54	5.07	3.13	3.00	3.85	7.70	2.95	3.66	5.55	2.98	3.35	3.25	4.12	2.08
Metals	1990	17.86	18.03	16.86	12.88	14.77	11.84	15.61	13.65	12.67	13.41	18.19	20.66	11.83	13.26	15.31
	2008	19.55	16.12	15.47	14.29	13.59	11.40	16.82	12.24	11.00	17.64	10.15	13.24	12.39	12.26	9.53
Machinery	1990	4.93	12.16	7.62	6.11	16.10	17.75	4.96	16.41	9.92	12.00	13.33	7.21	8.01	8.50	11.40
	2008	5.93	14.12	6.81	7.09	16.22	16.33	7.68	13.61	9.02	14.32	12.65	9.83	9.23	11.69	6.95
Electrical	1990	2.93	9.50	6.12	4.52	11.67	5.69	4.34	3.81	7.73	7.99	6.08	6.56	5.90	5.48	1.91
	2008	5.48	11.91	6.64	5.21	16.85	16.51	6.15	32.18	10.95	10.54	21.12	28.41	6.27	9.13	18.62
Transport	1990	5.44	4.70	7.51	11.28	12.59	3.73	9.97	6.19	10.07	7.87	10.22	10.06	4.05	13.13	15.01
	2008	8.55	8.30	6.14	13.24	16.10	1.89	10.83	2.71	11.27	5.68	14.70	15.51	5.53	14.48	11.31
Other	1990	3.58	5.73	3.86	4.43	3.29	8.13	5.25	4.08	4.84	5.13	3.09	5.93	8.49	2.97	7.01
	2008	3.90	5.58	2.85	5.07	2.67	5.28	4.92	1.74	4.52	4.97	2.02	1.50	7.18	3.98	6.04
Total	1990	13.51	16.10	17.49	14.84	21.40	16.34	14.66	14.84	15.17	19.47	18.91	17.68	12.48	13.75	12.25
	2008	9.79	18.57	15.89	14.00	20.31	14.39	11.92	26.55	10.89	17.90	20.61	31.47	11.54	9.17	13.31

Source: Author's calculations from the OECD STAN database.

Notes: See Table 9 for a list of industry names in full and industry codes. Due to data limitations, year 2008 data are not available for all countries. Year 2007 data are shown for the United Kingdom and Norway, year 2006 data for Canada, and year 2005 data for Australia.

Table 2: TFP in 1990 and 2005

Industry	Year	AUS	AUT	BEL	CAN	DEU	DNK	ESP	FIN	GBR	ITA	JPN	KOR	NLD	NOR	USA
Food	1990	0.427	0.496	0.772	0.955	0.532	0.656	0.668	0.395	0.835	0.699	0.854	0.465	0.675	0.628	0.908
	2005	0.467	0.717	0.774	1.028	0.564	0.620	0.543	0.735	0.874	0.668	0.691	0.512	0.913	0.751	1.000
Textiles	1990	0.879	0.658	0.645	0.887	0.711	0.745	0.715	0.677	0.890	0.901	0.690	0.329	0.864	0.755	0.606
	2005	0.708	1.033	1.044	0.991	1.037	0.848	0.707	1.086	1.251	0.998	0.485	0.506	1.246	1.253	1.000
Wood	1990	0.981	0.837	0.719	0.897	0.760	0.787	0.776	0.529	1.165	0.825	0.929	0.301	0.630	0.757	1.221
	2005	0.871	1.020	1.130	1.362	1.133	1.023	0.683	1.010	1.229	0.991	0.886	0.697	1.427	1.053	1.000
Paper	1990	0.517	0.489	0.629	0.500	0.523	0.513	0.780	0.459	0.842	0.743	0.709	0.389	0.682	0.643	0.629
	2005	0.595	0.776	0.735	0.704	0.648	0.588	0.660	0.832	0.849	0.677	0.570	0.462	0.819	0.731	1.000
Chemicals	1990	0.570	0.393	0.713	0.502	0.501	0.373	0.733	0.551	0.476	0.491	0.679	0.295	0.483	0.602	0.926
	2005	0.485	0.851	0.822	0.678	0.756	0.712	0.671	0.848	0.783	0.546	0.640	0.719	0.883	0.738	1.000
Rubber	1990	0.853	0.679	0.608	0.741	0.952	1.203	0.913	1.093	0.756	0.796	0.703	0.650	0.801	0.978	0.684
	2005	0.862	0.985	1.150	1.015	1.023	0.931	0.835	1.138	0.992	0.829	0.623	0.709	0.894	1.132	1.000
Mineral	1990	0.319	0.952	0.982	0.883	0.693	0.838	0.728	0.761	0.841	0.922	0.813	0.391	0.842	0.849	0.859
	2005	0.746	1.091	1.097	1.123	0.903	0.949	0.844	1.153	1.160	0.872	0.779	0.657	1.029	1.059	1.000
Metals	1990	0.686	0.815	0.893	0.680	0.902	0.882	0.820	0.754	0.874	0.679	0.890	0.502	0.776	0.816	0.797
	2005	0.792	1.037	1.012	0.998	0.959	0.812	0.803	1.037	1.012	0.800	0.847	0.896	1.021	1.008	1.000
Machinery	1990	0.504	0.901	1.066	1.087	0.937	1.010	0.897	0.891	0.818	0.906	0.850	0.262	0.962	1.137	1.032
	2005	0.837	1.228	1.279	1.343	1.204	0.925	1.053	1.282	1.118	0.971	0.735	0.718	1.184	1.140	1.000
Electrical	1990	0.243	0.494	0.518	0.456	0.517	0.439	0.439	0.273	0.455	0.678	0.175	0.105	0.311	0.546	0.070
	2005	0.663	0.949	0.910	0.850	0.921	0.775	0.620	1.713	1.034	0.837	0.625	0.619	0.526	0.898	1.000
Transport	1990	0.278	0.629	0.677	0.694	0.784	0.672	0.791	0.645	0.628	0.821	0.617	0.318	0.478	0.972	0.737
	2005	0.530	1.155	0.884	1.046	1.019	0.658	0.758	0.872	0.884	0.647	0.746	0.724	0.961	0.922	1.000
Other	1990	0.409	0.593	0.611	0.791	0.654	0.876	0.753	0.643	0.983	0.750	0.482	0.631	0.924	0.674	0.878
	2005	0.352	0.818	0.756	0.985	0.779	0.687	0.572	0.844	0.893	0.750	0.528	0.471	0.641	0.781	1.000
Total manu.	1990	0.443	0.591	0.748	0.647	0.662	0.666	0.701	0.492	0.687	0.704	0.575	0.275	0.661	0.718	0.576
	2005	0.559	0.874	0.909	0.874	0.823	0.723	0.664	1.011	0.899	0.714	0.655	0.623	0.891	0.838	1.000

Source: Author's calculations from the OECD STAN database.

Notes: See Table 9 for a list of industry names in full and industry codes. All TFP indices are measured relative to the TFP index in the United States in 2005.

Table 3: Factor endowments in 2005

Country	Labor		Unskilled labor		Skilled labor		Capital per worker		Arable land per worker	
	Level, 1000's	Growth rate	Percent of total	Growth rate	Percent of total	Growth rate	Level, 2005 $	Growth rate	Level, hectores	Growth rate
AUS	10,040	1.70	67.4	1.03	32.6	3.33	123,548	−0.34	4.92	0.21
AUT	4,031	0.68	84.8	−0.03	15.2	7.24	91,215	1.74	0.34	−0.18
BEL	4,258	0.59	71.6	−0.06	28.4	2.58	102,270	2.01	0.20	*n.a*
CAN	16,455	1.40	71.1	0.89	29.0	2.86	80,556	1.46	2.75	−0.03
DEU	38,835	1.63	80.7	1.18	19.2	3.94	73,785	1.32	0.31	−0.04
DNK	2,727	0.29	81.0	−0.02	19.0	1.83	80,956	2.89	0.86	−0.62
ESP	19,267	2.23	73.3	0.77	26.7	9.64	83,754	2.18	0.67	−1.15
FIN	2,389	−0.25	71.2	−1.45	28.8	4.19	85,547	1.17	0.93	−0.11
GBR	31,084	0.44	76.2	−0.48	23.8	4.72	51,828	3.40	0.18	−0.96
ITA	24,396	0.51	89.1	0.15	10.9	4.48	91,022	1.01	0.32	−0.98
JPN	63,918	−0.03	57.4	−1.78	42.6	3.45	92,306	2.08	0.07	−0.60
KOR	22,856	1.56	59.5	−0.38	40.5	6.12	76,504	5.61	0.07	−1.15
NLD	8,252	1.39	75.3	0.87	24.6	3.36	77,757	2.02	0.13	1.56
NOR	2,352	0.89	71.8	0.09	28.2	3.48	100,025	0.77	0.37	0.02
USA	150,223	1.11	67.7	2.77	32.3	−1.43	95,430	3.28	1.15	−0.49

Source: Author's calculations from the OECD STAN database and the World Bank WDI database.

Notes: The left column under each heading exhibits the level of total factor supply in 2005, chosen because the latest year in the sample data varies by country. The right column under each heading in the average annual growth rate from 1990 to 2005. Capital is measured in 2005 U.S. dollars.

Table 4: Summary of electricity-related variables

Country	Elec. capacity per worker		Elec. capacity per capital	TFP			Capital per worker		
	Level, kW	Growth rate	Growth rate	Level in 1990	Level in 2005	Growth rate	Level, 2005 US $	Share in total	Growth rate
AUS	4.78	0.22	0.56	0.574	0.613	0.44	6,257	5.06	0.28
AUT	4.67	0.13	−1.61	0.595	1.147	4.38	3,037	3.33	−1.17
BEL	3.73	0.19	−1.82	0.987	1.241	1.52	2,617	2.56	−0.16
CAN	7.43	−0.33	−1.79	0.819	0.983	1.22	3,861	4.79	−1.87
DEU	3.04	−0.37	−1.69	0.793	1.125	2.33	2,591	3.51	−0.32
DNK	4.82	2.13	−0.75	0.577	0.928	3.16	3,162	3.91	−1.85
ESP	4.21	1.94	−0.24	0.898	1.134	1.56	2,591	3.09	−0.38
FIN	6.70	1.52	0.35	0.533	0.881	3.35	3,081	3.60	0.55
GBR	2.61	0.27	−3.13	0.859	1.226	2.37	1,586	3.06	1.82
ITA	3.28	1.80	0.79	0.765	0.911	1.16	3,795	4.17	0.06
JPN	4.12	2.04	−0.03	0.562	0.668	1.16	8,492	9.20	1.75
KOR	2.65	4.86	−0.75	0.450	0.681	2.76	4,496	5.88	5.62
NLD	2.64	0.29	−1.73	1.153	1.527	1.87	1,645	2.12	−0.23
NOR	11.82	−0.73	−1.50	0.873	1.687	4.39	3,024	3.02	−3.15
USA	6.51	0.81	−2.46	1.082	1.000	−0.53	3,302	3.46	0.99

Source: Author's calculations from the OECD STAN database and the United Nations energy statistics.
Note: Capital is measured in 2005 U.S. dollars.

Table 5: Estimates of value added share

	Food	Textiles	Wood	Paper	Chemicals	Rubber	Mineral	Metals	Machinery	Electrical	Transport	Other
TFP food	1.430***	0.020	0.029	−0.286***	−0.206***	−0.117***	−0.084**	0.151**	−0.003	−0.028	−0.093	−0.060
	(0.075)	(0.056)	(0.030)	(0.052)	(0.040)	(0.030)	(0.028)	(0.056)	(0.056)	(0.035)	(0.050)	(0.033)
TFP textiles	0.020	0.744***	−0.027	−0.125*	−0.222***	−0.028	0.023	0.026	−0.110	0.045	−0.029	−0.078*
	(0.056)	(0.086)	(0.030)	(0.055)	(0.045)	(0.030)	(0.027)	(0.060)	(0.060)	(0.035)	(0.058)	(0.036)
TFP wood	0.029	−0.027	0.189***	0.095***	0.004	0.061***	0.027	−0.027	0.068*	0.008	−0.110***	0.111***
	(0.030)	(0.030)	(0.023)	(0.027)	(0.021)	(0.017)	(0.016)	(0.031)	(0.030)	(0.016)	(0.026)	(0.018)
TFP paper	−0.286***	−0.125*	0.095***	1.303***	−0.017	0.065*	−0.089***	−0.016	0.018	−0.111**	−0.100*	−0.100**
	(0.052)	(0.055)	(0.027)	(0.065)	(0.037)	(0.029)	(0.027)	(0.052)	(0.053)	(0.040)	(0.049)	(0.032)
TFP chemicals	−0.206***	−0.222***	0.004	−0.017	1.285***	−0.094***	−0.000	−0.039	−0.172***	0.021	0.080	−0.156***
	(0.040)	(0.045)	(0.021)	(0.037)	(0.044)	(0.021)	(0.019)	(0.042)	(0.044)	(0.028)	(0.043)	(0.026)
TFP rubber	−0.117***	−0.028	0.061***	0.065*	−0.094***	0.625***	−0.066***	0.030	0.020	0.005	−0.011	0.007
	(0.030)	(0.030)	(0.017)	(0.029)	(0.021)	(0.027)	(0.018)	(0.030)	(0.029)	(0.018)	(0.024)	(0.019)
TFP mineral	−0.084**	0.023	0.027	−0.089***	−0.000	−0.066***	0.356***	0.039	−0.009	0.043**	−0.076***	0.096***
	(0.028)	(0.027)	(0.016)	(0.027)	(0.019)	(0.018)	(0.025)	(0.028)	(0.028)	(0.013)	(0.022)	(0.018)
TFP metals	0.151**	0.026	−0.027	−0.016	−0.039	0.030	0.039	1.713***	0.169**	0.135**	−0.192***	0.096**
	(0.056)	(0.060)	(0.031)	(0.052)	(0.042)	(0.030)	(0.028)	(0.080)	(0.060)	(0.049)	(0.056)	(0.034)
TFP machinery	−0.003	−0.110	0.068*	0.018	−0.172***	0.020	−0.009	0.169**	1.307***	0.182***	0.193**	0.126***
	(0.056)	(0.060)	(0.030)	(0.053)	(0.044)	(0.029)	(0.028)	(0.060)	(0.085)	(0.047)	(0.060)	(0.034)
TFP electrical	−0.028	0.045	0.008	−0.111**	0.021	0.005	0.043**	0.135**	0.182***	2.633***	0.084	0.036
	(0.035)	(0.035)	(0.016)	(0.040)	(0.028)	(0.018)	(0.013)	(0.049)	(0.047)	(0.141)	(0.050)	(0.019)
TFP transport	−0.093	−0.029	−0.110***	−0.100*	0.080	−0.011	−0.076***	−0.192***	0.193**	0.084	1.160***	0.077*
	(0.050)	(0.058)	(0.026)	(0.049)	(0.043)	(0.024)	(0.022)	(0.056)	(0.060)	(0.050)	(0.088)	(0.031)
TFP other	−0.060	−0.078*	0.111***	−0.100**	−0.156***	0.007	0.096***	0.096**	0.126***	0.036	0.077*	0.425***
	(0.033)	(0.036)	(0.018)	(0.032)	(0.026)	(0.019)	(0.018)	(0.034)	(0.034)	(0.019)	(0.031)	(0.029)
Unskilled	−0.377***	0.110	0.031	−0.038	−0.606***	−0.114*	0.286***	−0.006	−0.066	−3.636***	−0.911***	0.394***
	(0.091)	(0.092)	(0.042)	(0.106)	(0.076)	(0.052)	(0.036)	(0.146)	(0.133)	(0.397)	(0.135)	(0.048)
Skilled	0.033	0.130	0.071*	0.035	−0.022	0.080*	0.145***	0.435***	0.423***	1.407***	0.035	0.162***
	(0.069)	(0.069)	(0.032)	(0.079)	(0.058)	(0.038)	(0.026)	(0.108)	(0.100)	(0.301)	(0.102)	(0.038)
Capital	0.188**	−0.504***	−0.028	0.218**	0.068	−0.070*	−0.055*	−0.385***	−0.349***	−0.510	0.105	−0.206***
	(0.061)	(0.062)	(0.027)	(0.069)	(0.050)	(0.034)	(0.023)	(0.095)	(0.087)	(0.261)	(0.090)	(0.033)
Elec. capacity	−0.111	−0.202**	−0.022	0.291***	0.298***	0.132***	−0.162***	0.273**	0.303**	1.176***	0.654***	−0.216***
	(0.064)	(0.064)	(0.029)	(0.075)	(0.055)	(0.037)	(0.024)	(0.104)	(0.094)	(0.286)	(0.096)	(0.034)

Notes: See Table 9 for a list of industry names in full and industry codes. Values in parentheses are standard errors. Country and year dummies are included. There are 261 observations in total for the system regression. *, **, and *** indicate significance at the 10 %, 5%, and 1% levels, respectively.

Table 6: Estimates of value added share with lagged dependent variable

	Food	Textiles	Wood	Paper	Chemicals	Rubber	Mineral	Metals	Machinery	Electrical	Transport	Other
Lagged share	0.556^{**}	0.556^{**}	0.556^{**}	0.556^{**}	0.556^{**}	0.556^{**}	0.556^{**}	0.556^{**}	0.556^{**}	0.556^{**}	0.556^{**}	0.556^{**}
	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)
TFP food	1.729^{**}	0.036	0.025	-0.342^{**}	-0.096^{+}	-0.136^{**}	−0.023	-0.125^{+}	0.022	-0.095^{+}	−0.062	−0.016
	(0.094)	(0.049)	(0.031)	(0.070)	(0.054)	(0.034)	(0.036)	(0.068)	(0.066)	(0.055)	(0.060)	(0.039)
TFP textiles	0.036	0.518^{**}	0.023	0.038	−0.051	−0.047	0.046	-0.082^{+}	0.186^{**}	−0.043	0.072^{+}	0.031
	(0.049)	(0.056)	(0.026)	(0.050)	(0.039)	(0.031)	(0.030)	(0.049)	(0.047)	(0.036)	(0.040)	(0.031)
TFP wood	0.025	0.023	0.249^{**}	0.033	-0.046^{+}	0.070^{**}	-0.036^{+}	0.033	0.051^{+}	0.002	-0.058^{*}	0.089^{**}
	(0.031)	(0.026)	(0.022)	(0.032)	(0.024)	(0.019)	(0.019)	(0.031)	(0.029)	(0.023)	(0.025)	(0.019)
TFP paper	-0.342^{**}	0.038	0.033	1.288^{**}	−0.019	−0.004	−0.030	0.087	−0.023	-0.110^{+}	−0.009	-0.127^{**}
	(0.070)	(0.050)	(0.032)	(0.103)	(0.057)	(0.034)	(0.036)	(0.072)	(0.070)	(0.063)	(0.066)	(0.040)
TFP chemicals	-0.096^{+}	−0.051	-0.046^{+}	−0.019	1.193^{**}	−0.021	-0.057^{*}	-0.122^{*}	0.021	−0.069	−0.067	0.011
	(0.054)	(0.039)	(0.024)	(0.057)	(0.062)	(0.025)	(0.027)	(0.055)	(0.054)	(0.048)	(0.051)	(0.030)
TFP rubber	-0.136^{**}	−0.047	0.070^{**}	−0.004	−0.021	0.580^{**}	0.022	-0.089^{**}	0.034	0.016	0.013	0.040^{+}
	(0.034)	(0.031)	(0.019)	(0.034)	(0.025)	(0.036)	(0.024)	(0.033)	(0.030)	(0.023)	(0.025)	(0.022)
TFP mineral	−0.023	0.046	-0.036^{+}	−0.030	-0.057^{*}	0.022	0.387^{**}	−0.009	0.056^{+}	−0.028	−0.026	0.070^{**}
	(0.036)	(0.030)	(0.019)	(0.036)	(0.027)	(0.024)	(0.034)	(0.035)	(0.033)	(0.024)	(0.027)	(0.023)
TFP metals	-0.125^{+}	-0.082^{+}	0.033	0.087	-0.122^{*}	-0.089^{**}	−0.009	1.736^{**}	0.063	0.042	-0.145^{*}	0.044
	(0.068)	(0.049)	(0.031)	(0.072)	(0.055)	(0.033)	(0.035)	(0.099)	(0.068)	(0.061)	(0.064)	(0.039)
TFP machinery	0.022	0.186^{**}	0.051^{+}	−0.023	0.021	0.034	0.056^{+}	0.063	1.216^{**}	−0.063	0.115^{+}	0.097^{**}
	(0.066)	(0.047)	(0.029)	(0.070)	(0.054)	(0.030)	(0.033)	(0.068)	(0.094)	(0.063)	(0.068)	(0.037)
TFP electronics	-0.095^{+}	−0.043	0.002	-0.110^{+}	−0.069	0.016	−0.028	0.042	−0.063	1.240^{**}	−0.044	−0.036
	(0.055)	(0.036)	(0.023)	(0.063)	(0.048)	(0.023)	(0.024)	(0.061)	(0.063)	(0.102)	(0.070)	(0.028)
TFP transport	−0.062	0.072^{+}	-0.058^{*}	−0.009	−0.067	0.013	−0.026	-0.145^{*}	0.115^{+}	−0.044	1.303^{**}	0.008
	(0.060)	(0.040)	(0.025)	(0.066)	(0.051)	(0.025)	(0.027)	(0.064)	(0.068)	(0.070)	(0.099)	(0.031)
TFP others	−0.016	0.031	0.089^{**}	-0.127^{**}	0.011	0.040^{+}	0.070^{**}	0.044	0.097^{**}	−0.036	0.008	0.455^{**}
	(0.039)	(0.031)	(0.019)	(0.040)	(0.030)	(0.022)	(0.023)	(0.039)	(0.037)	(0.028)	(0.031)	(0.033)
Unskilled	0.021	0.115	−0.083	−0.090	−0.137	−0.031	0.208^{**}	0.199	0.108	-0.711^{*}	−0.044	0.207^{*}
	(0.174)	(0.110)	(0.068)	(0.209)	(0.151)	(0.067)	(0.070)	(0.202)	(0.225)	(0.294)	(0.286)	(0.085)
Skilled	−0.046	0.046	−0.077	−0.021	−0.006	−0.001	0.034	0.266	0.017	0.460^{+}	0.394^{+}	0.009
	(0.143)	(0.090)	(0.056)	(0.172)	(0.124)	(0.055)	(0.058)	(0.166)	(0.185)	(0.241)	(0.233)	(0.070)
Capital	−0.011	-0.101^{+}	0.042	0.140	−0.036	−0.025	−0.056	−0.146	−0.158	−0.106	−0.132	-0.108^{*}
	(0.096)	(0.061)	(0.037)	(0.115)	(0.083)	(0.037)	(0.039)	(0.111)	(0.124)	(0.162)	(0.157)	(0.047)
Elec. capacity	0.099	0.028	0.020	−0.033	0.027	0.024	-0.075^{*}	−0.145	0.144	0.127	−0.011	0.003
	(0.079)	(0.050)	(0.031)	(0.095)	(0.069)	(0.030)	(0.032)	(0.092)	(0.102)	(0.133)	(0.129)	(0.039)

Note: See Table 9 for a list of industry names in full and industry codes. Values in parentheses are standard errors. Country and year dummies are included. There are 233 observations in total for the system regression. *, **, and *** indicate significance at the 10 %, 5%, and 1% levels, respectively.

Table 7: Estimates of value added share with lagged dependent variable (Arelano–Bond)

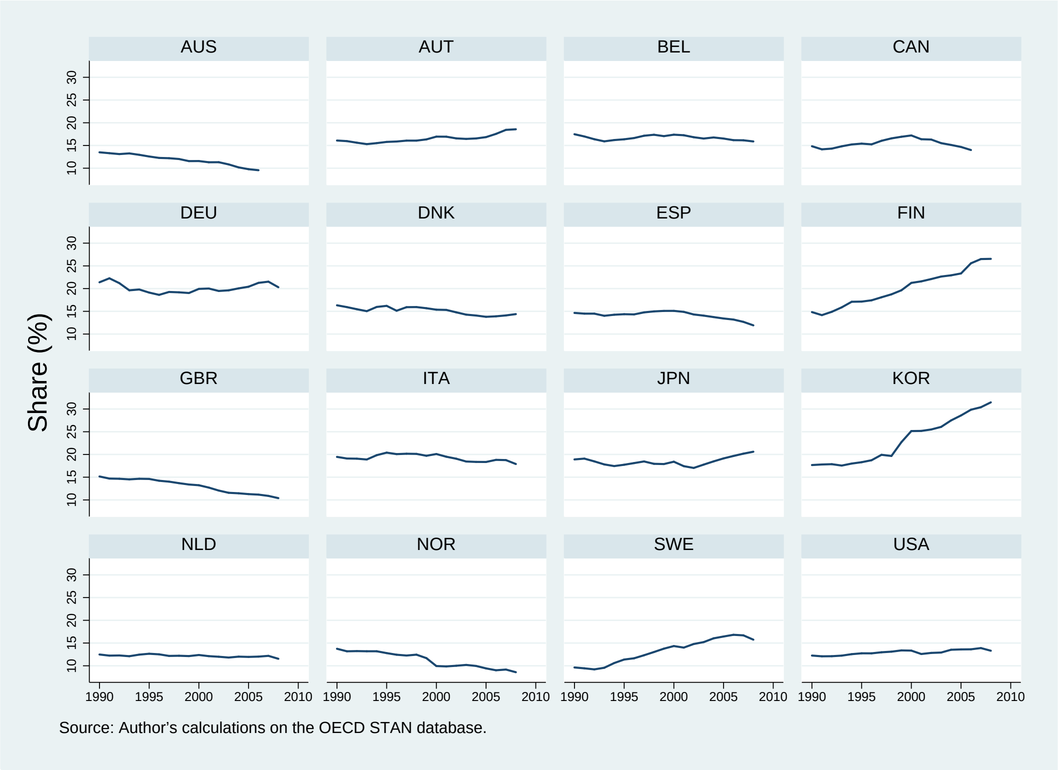
	Food	Textiles	Wood	Paper	Chemicals	Rubber	Mineral	Metals	Machinery	Electrical	Transport	Other
Lagged v.a. share	0.581^{***}	0.769^{***}	0.611^{***}	0.649^{***}	0.510^{***}	0.737^{***}	0.530^{***}	0.734^{***}	0.670^{***}	1.003^{***}	0.572^{***}	0.553^{***}
	(0.038)	(0.029)	(0.037)	(0.041)	(0.030)	(0.030)	(0.042)	(0.033)	(0.036)	(0.024)	(0.042)	(0.031)
TFP food	1.067^{***}	-0.101^{*}	-0.019	-0.359^{***}	-0.143^{*}	-0.121^{***}	0.008	-0.084	0.095	-0.173	-0.204	0.052
	(0.083)	(0.049)	(0.030)	(0.088)	(0.057)	(0.032)	(0.028)	(0.098)	(0.098)	(0.148)	(0.116)	(0.033)
TFP textiles	-0.106	0.191^{***}	0.028	-0.043	-0.295^{***}	-0.049	0.010	0.039	-0.266^{**}	-0.114	-0.178	-0.040
	(0.074)	(0.052)	(0.030)	(0.090)	(0.058)	(0.033)	(0.029)	(0.100)	(0.100)	(0.152)	(0.119)	(0.034)
TFP wood	-0.042	0.061	0.123^{***}	-0.083	0.066	0.093^{***}	0.044^{*}	0.078	0.076	0.148	-0.166^{*}	0.041
	(0.045)	(0.031)	(0.019)	(0.056)	(0.035)	(0.020)	(0.017)	(0.061)	(0.062)	(0.093)	(0.072)	(0.021)
TFP paper	-0.309^{***}	0.062	0.071^{*}	0.669^{***}	0.043	-0.031	-0.037	0.040	-0.117	0.101	-0.278^{*}	-0.142^{***}
	(0.079)	(0.054)	(0.032)	(0.100)	(0.060)	(0.034)	(0.030)	(0.103)	(0.104)	(0.152)	(0.123)	(0.036)
TFP chemicals	-0.130^{**}	-0.047	-0.023	-0.003	0.897^{***}	0.023	-0.001	0.053	-0.082	0.061	0.099	-0.057^{*}
	(0.049)	(0.033)	(0.020)	(0.059)	(0.050)	(0.021)	(0.019)	(0.065)	(0.064)	(0.097)	(0.080)	(0.023)
TFP rubber	0.070	0.107^{*}	-0.039	0.086	-0.057	0.250^{***}	-0.092^{**}	-0.269^{**}	0.137	-0.150	0.142	0.038
	(0.073)	(0.050)	(0.030)	(0.089)	(0.057)	(0.034)	(0.029)	(0.097)	(0.097)	(0.142)	(0.116)	(0.034)
TFP mineral	-0.289^{***}	-0.012	0.023	-0.062	-0.027	0.065^{**}	0.211^{***}	0.038	-0.177^{*}	0.014	-0.060	0.104^{***}
	(0.057)	(0.040)	(0.023)	(0.069)	(0.044)	(0.025)	(0.024)	(0.076)	(0.076)	(0.110)	(0.090)	(0.026)
TFP metals	0.193^{*}	-0.122^{*}	-0.029	-0.077	-0.205^{***}	-0.114^{**}	-0.006	0.808^{***}	0.085	0.227	-0.076	0.078^{*}
	(0.078)	(0.053)	(0.031)	(0.095)	(0.060)	(0.034)	(0.031)	(0.110)	(0.104)	(0.150)	(0.123)	(0.036)
TFP machinery	-0.118	0.078	0.012	-0.080	0.120^{*}	0.015	0.012	0.154	0.662^{***}	0.107	0.194	-0.022
	(0.068)	(0.046)	(0.027)	(0.082)	(0.052)	(0.029)	(0.026)	(0.089)	(0.092)	(0.133)	(0.106)	(0.031)
TFP electrical	-0.023	0.015	0.002	-0.054	0.008	0.030^{**}	0.015	0.036	0.089^{**}	0.300^{***}	0.104^{**}	0.004
	(0.023)	(0.016)	(0.009)	(0.028)	(0.018)	(0.010)	(0.009)	(0.031)	(0.031)	(0.067)	(0.037)	(0.011)
TFP transport	0.076	0.004	-0.032	0.196^{**}	-0.074	-0.033	-0.066^{***}	-0.258^{***}	0.035	-0.345^{***}	0.762^{***}	0.078^{***}
	(0.049)	(0.033)	(0.020)	(0.060)	(0.039)	(0.021)	(0.019)	(0.066)	(0.065)	(0.101)	(0.086)	(0.023)
TFP other	-0.071	0.013	0.075^{***}	-0.030	-0.095^{*}	0.036	0.059^{**}	0.012	0.196^{**}	-0.010	0.202^{*}	0.312^{***}
	(0.051)	(0.035)	(0.021)	(0.062)	(0.040)	(0.022)	(0.020)	(0.068)	(0.068)	(0.099)	(0.081)	(0.025)
Unskilled	-0.182^{*}	-0.136^{*}	0.020	-0.071	-0.178^{**}	-0.083^{*}	0.141^{***}	0.008	-0.156	-0.585^{***}	-0.452^{***}	0.198^{***}
	(0.077)	(0.053)	(0.030)	(0.090)	(0.061)	(0.033)	(0.031)	(0.100)	(0.100)	(0.146)	(0.120)	(0.036)
Skilled	-0.006	-0.015	0.023	-0.016	-0.020	0.016	0.074^{***}	0.119	0.091	-0.033	0.034	0.042
	(0.053)	(0.037)	(0.022)	(0.065)	(0.041)	(0.024)	(0.021)	(0.072)	(0.072)	(0.105)	(0.083)	(0.025)
Capital	0.049	-0.002	-0.014	0.062	0.035	-0.004	-0.044^{*}	-0.131^{*}	-0.186^{**}	0.082	-0.058	-0.067^{**}
	(0.046)	(0.035)	(0.018)	(0.055)	(0.035)	(0.021)	(0.018)	(0.061)	(0.061)	(0.088)	(0.072)	(0.022)
Elec. capacity	0.071	0.057	0.011	0.159^{**}	0.058	0.050^{*}	-0.091^{***}	-0.003	0.161^{*}	0.183	0.301^{***}	-0.044
	(0.049)	(0.034)	(0.020)	(0.060)	(0.039)	(0.021)	(0.019)	(0.064)	(0.065)	(0.094)	(0.081)	(0.023)

Notes: See Table 9 for a list of industry names in full and industry codes. Values in parentheses are standard errors. Country and year dummies are included. There are 247 observations in total for the system regression. *, **, and *** indicate significance at the 10 %, 5%, and 1% levels, respectively.

Table 8: Elasticity of output (Japan)

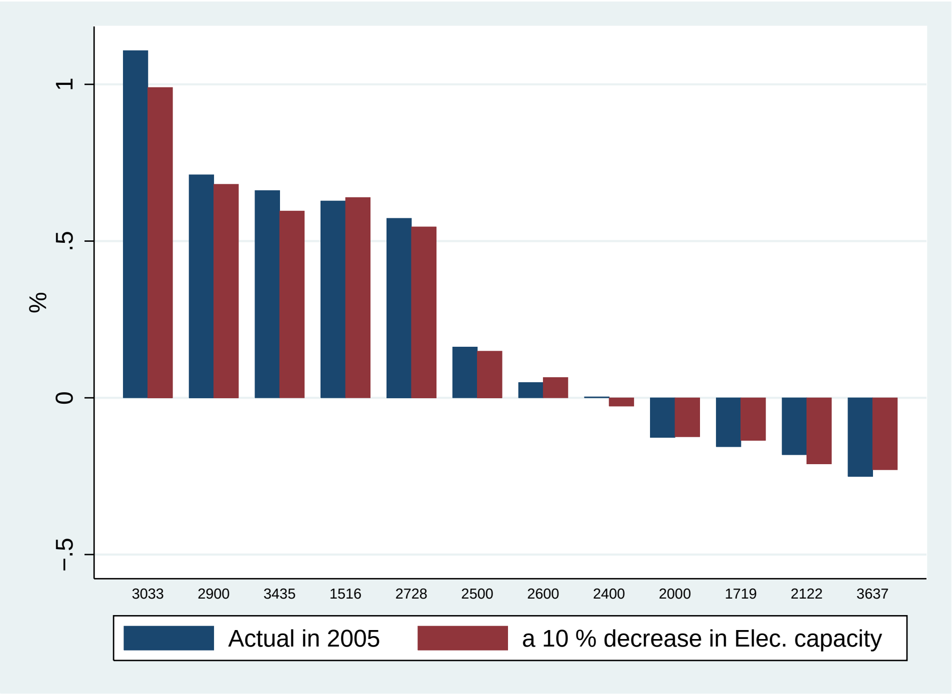
Industry	ISIC Rev.3	Elasticity of output	
		TFP	Electricity
Food	(1516)	0.601	−0.015
Textiles	(1719)	1.465	−0.366
Wood	(2000)	0.888	−0.073
Paper	(2122)	0.817	0.209
Chemicals	(2400)	0.874	0.229
Rubber	(2500)	0.781	0.193
Mineral	(2600)	0.562	−0.223
Metals	(2728)	0.663	0.131
Machinery	(2900)	0.665	0.179
Electrical	(3033)	1.456	0.670
Transport	(3435)	0.582	0.346
Other	(3637)	0.948	−0.450

Notes: See Table 9 for a list of industry names in full and industry codes. All elasticities are simple mean of 2000–2007.



Source: Author's calculations on the OECD STAN database.

Figure 1: Manufacturing as a share of GDP



Note: This figure plots Japan's relative value added share for each sector in 2005. A share above 0 indicates that Japan's share is higher than the sample average. Plots are, from the left to the right, electrical equipment (3033), machinery (2900), transport equipment (3435), food (1516), metals (2728), rubber (2500), mineral (2600), chemicals (2400), wood (2000), textile (1719), paper (2122), other manufacturing (3637).

Figure 2: Changes in Japan's share of value added in GDP

A Data Appendix

A.1 Value added

To obtain internationally comparable value added, we need an inter-country price level index. The use of PPP price levels for GDP when converting value added in national currency to international dollars is often criticized.[17]

However, as Harrigan (1997a) noted, it is difficult to obtain internationally comparable price indices for value added for each sector. Hence, I compromise by using PPP price levels for machinery and equipment instead of GDP. More specifically, the OECD statistics provide 2005 PPP benchmark results in which disaggregated PPP exchange rates (national currencies per U.S. dollar) are available. By dividing the PPP exchange rate for machinery and equipment by the nominal exchange rate, we obtain price levels of machinery and equipment, standardized to output in 2005 for each country. Note that these price levels are relative to a base country's price levels and dimensionless. They are rather crude approximations, but I apply these price levels of machinery and equipment in 2005 to all industries used for estimation. For example, although the PPP exchange rate for machinery and equipment in Japan is 165 yen per U.S. dollar, the nominal exchange rate is 110 yen per U.S. dollar. Hence, the price level of machinery and equipment in Japan is 1.5.

Because PPP exchange rates at this disaggregated level are not available for other years (except for 2008) in the OECD statistics, I use value added deflators reported in the OECD STAN database to set price levels of standardized output for other years. By assuming that all price levels change at the same rate as the relative changes in value added deflators, I obtain the price level of p_{jn}^t for each sector in country n. Then, the PPP exchange rate for each sector e_{jn}^t is calculated by multiplying p_{jn}^t by the nominal exchange rate E_n^t, namely, $e_{jn}^t = E_n^t p_{jn}^t$.

With these PPP exchange rates, I convert value added in local currency to value added in internationally comparable units. Then, dividing value added in internationally comparable units by value added deflators for the Unites States (base year 2000), I eventually obtain the real value added in units of 2000 dollars of standardized goods.

A.2 Capital

Capital is calculated by the perpetual inventory method. The evolution of capital stock K follows

$$K_t = (1 - \delta)K_{t-1} + I_t, \tag{19}$$

where δ is the depreciation rate and I_t is investment. Following standard practices, I calculate the initial capital stock K_0 by two methods. First, I regard the sum of investment flows in the first ten years as a proxy for the initial capital stock. At the sector-level, available data for investment start in 1980. Thus, the sum of real investment between 1980 and 1989 serves as the capital stock in 1990. Second, assuming that the sector is in a

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[17] Harrigan (1997a) points out that PPP price levels for GDP are inappropriate because they (i) include import prices and exclude export prices, (ii) include transport and distribution margins, (iii) include indirect taxes and exclude subsidies, and (iv) refer to final output and not intermediate goods.

steady-state in the initial year, I calculate the initial capital stock as $I_0/(g+\delta)$ where I_0 is real investment in the initial year and g is the output growth rate of the sector. By this method, I can calculate the capital stock from the first year in the sample data (1980). For obtaining I_0, I use the average of I between 1980 and 1982 (to reduce the influence of business cycles). For g, I use the median of the first ten years (for negative median values, I let $g = 0$).

Data for sector-level capital stock come from the OECD STAN database. Gross fixed capital formation (GFCF) in the OECD STAN database is reported in current price local currency. To obtain internationally comparable real investment flows, I use the PPP of capital goods from 2005 PPP benchmark results by OECD (available at OECD Stat.Extracts) and deflators of gross fixed capital formation (GFCP) from the OECD STAN database. Units are millions of international 2005 dollars.

A.3 Labor

Data on labor employment by sector are from the OECD STAN database. To compute TFP, I use hours worked by employees (HRSE) after adjusting by human capital stock. To construct human capital, I take the average years of schooling in the population over 25 years old from Barro and Lee (2010). Following Caselli (2005), human capital stock h is calculated as follows:

$$h = e^{\phi(s)}$$

where s is average years of schooling. The function $\phi(s)$ is given by

$$\phi(s) = \begin{cases} 0.134s, & \text{if } s \leq 4; \\ 0.134 \cdot 4 + 0.101(s-4), & \text{if } 4 < s \leq 8; \\ (0.134+0.101) \cdot 4 + 0.068(s-8), & \text{if } s \geq 8, \end{cases}$$

where the marginal effect of schooling decreases in a piecewise manner.

To calculate the endowment of labor, total employment in the STAN database (EMPN) is classified by education level, which is obtained from Barro and Lee (2010). I define skilled workers as those with tertiary education. The remaining workers are unskilled (no schooling, primary schooling only, and secondary schooling only). Barro and Lee (2010) give the population ratios by education for every five years. I simply interpolate the data for intervening years.

A.4 Land

Arable land (thousands of hectors) up to 2008. From the World Bank WDI database.

Table 9: Industry List

	ISIC Rev.3	
Food	15	Food products and beverages
	16	Tobacco products
Textiles	17	Textiles
	18	Wearing apparel, dressing and dyeing of fur
	19	Leather, leather products and footwear
Wood	20	Wood and products of wood and cork
Paper	21	Pulp, paper and paper products
	22	Printing and publishing
Chemicals	24	Chemicals and chemical products
Plastics	25	Rubber and plastics products
Mineral	26	Other non-metallic mineral products
Metals	27	Basic metals
	28	Fabricated metal products, except machinery and equipment
Machinery	29	Machinery and equipment, n.e.c.
Electrical and optical equipment	30	Office, accounting and computing machinery
	31	Electrical machinery and apparatus, n.e.c.
	32	Radio, television and communication equipment
	33	Medical, precision and optical instruments
Transport Equipment	34	Motor vehicles, trailers and semi-trailers
	35	Other transport equipment
Manufacturing n.e.c	36	Manufacturing n.e.c.
	37	Recycling

Table 10: List of sample countries

country	ISO code	Available data years
Australia	AUS	1990–2005
Austria	AUT	1990–2008
Belgium	BEL	1995–2008
Canada	CAN	1990–2006
Germany	DEU	1990–2008
Denmark	DNK	1990–2008
Spain	ESP	1990–2008
Finland	FIN	1990–2008
U.K.	GBR	1990–2007
Italy	ITA	1990–2008
Japan	JPN	1990–2006
Korea	KOR	1990–2005
Netherlands	NDL	1990–2008
Norway	NOR	1990–2007
U.S.	USA	1990–2008

B Hypothesis Tests

The estimation equation in (16) assumes the symmetric cross-sector TFP effects for all sectors ($a_{ij} = a_{ji}$ for all i and j such that $i \neq j$) and linear homogeneity of the production function ($\sum_{k=1}^{M} c_{ik} + c_{im} = 0$). The Wald test statistics for these assumptions are presented here. In addition, the test statistics with respect to the significance of the TFP, factor endowment, and effective electricity capacity effects are given here.

Symmetry restrictions on cross-sector TFP are rejected: the p values is indistinguishable from 0 ($\chi^2(66)$). For the linear homogeneity of the production function, the null hypothesis $H_0 : \sum_{k=1}^{M} c_{ik} + c_{im} = 0$ is rejected for food, textiles, paper, chemicals, mineral, electrical equipment, and other manufacturing; it is not rejected for wood, rubber, and transport equipment. The TFP, factor endowment, and effective electricity capacity are jointly significant for each relevant equation.

Table 11: Hypothesis tests

	Food	Textile	Wood	Paper	Chemicals	Rubber	Mineral	Metals	Machinery	Electrical	Transport	Others
Homogeneity	0.003	0.000	0.198	0.000	0.001	0.586	0.000	0.031	0.019	0.000	0.386	0.005
Significance tests												
All TFP	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
All endowments	0.000	0.000	0.143	0.005	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000
All endowments & Electricity	0.000	0.000	0.189	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes: All figures are p values. The test statistics for homogeneity is $\chi^2(1)$, for the significance of TFP coefficients is $\chi^2(12)$, for the significance of factor endowments and electricity capacity together is $\chi^2(4)$, and for the significance of factor endowments is $\chi^2(3)$. See Table 9 for a list of industry names in full and industry codes.