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# Producer Services and Manufacturing Productivity: Evidence from Japan Industrial Productivity Database

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# Producer Services and Manufacturing Productivity: Evidence from Japan Industrial Productivity Database

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**Abstract**

As service sectors account for a growing share of economic activity in advanced economies, economists claim that the quality and cost of producer services supplied by the service sectors are crucial in supporting the competitiveness of manufacturing firms. This paper provides an empirical assessment on this argument by exploring a link between service-sector performance and manufacturing productivity in Japan for the period 1980-2005. Assuming that an improvement in producer services is measured with errors by a price deflator growth of service outputs, I propose an estimation framework in which an observed productivity depends partly on the performance of service sectors weighted by service-input intensities. Robust to a wide range of specifications and alternative indicators of services upgrading, I find little evidence that the service sectors contributed to productivity growth of the manufacturing sector. Thus, my findings do not support the claim that the upgrading of producer services improves manufacturing competitiveness.

*Keywords:* Producer Services, Service Sector, Productivity, Japan,

*JEL classification:* D24, L60, L80

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## 1. Introduction

Service sectors account for a dominant and rising share of economic activity in Japan, as the economic importance of service production in the Japanese economy has increased both absolutely and relatively to manufacturing production in recent decades. Based on the Japan Industrial Productivity Database 2009 (JIP), Figure 1 shows that the value-added of the broadly defined services as a share of aggregate production in Japan increased from 50% in middle 1970s to over 70% in middle 2000s.[1] In contrast, manufacturing sectors in the Japanese economy have steadily declined in importance, as the value-added share of manufacturing production has decreased from 30% in middle 1970s to below 20% in middle 2000s.

**[Figure 1 around here]**

Since Baumol (1967) argued that the growing share of a non-progressive sector would eventually lead to a "stagnation" of aggregate economic growth, economists have widely examined the implications of the expansion of service sectors in the economy. As Figure 1 indicates that the average growth rate of total factor productivity (TFP) adjusted by the Domar weight in the service sectors has not prominently increased relative to that in manufacturing sectors for the past decades, the "Baumol's disease" appears to be a legitimate concern at least

[1] JIP 2009 database is available at http://www.rieti.go.jp/jp/database/JIP2009/index.html. Refer to the Appendix for the JIP sector code.

for the Japanese economy.[2] These observed patterns are often taken as the basis for the argument that the liberalization of service markets in Japan is critical to improve the productivity of the service sectors in order to sustain the overall economic growth (Jones and Yoon, 2008).

Despite the seemingly depressing contribution of services to the economy, service sectors such as finance, transportation, and telecommunications, play a fundamental role in the function of economic activities through the provision of producer services. Financial institutions, for instance, ameliorate transactions costs due to imperfect information in an uncertain business environment, and facilitate the allocation of scarce financial resources over space and time. Transportation sectors link manufacturers with suppliers through the delivery of parts and components to point of final assembly, and with consumers via the transport of final products to point of consumption.

Table 1 shows the average service inputs as a share of total non-energy input in manufacturing industries for the periods 1973 through 2006. While the intensity of purchased services varies by industries, the service inputs account, on average, for over 30% of aggregate purchased inputs; the shares were 0.37 and 0.40 in chemicals and electrical machinery sectors during the period 2000-2006, respectively. These patterns indicate that manufacturing firms

[2] The Domar weight is defined as a ratio of sectoral gross output to aggregate value-added.

widely engage in contracting-out of business services, or “service outsourcing”, and the service sectors are deeply integrated in the vertical production chains of manufacturing sectors.

**[Table 1 around here]**

The immediate implication is that the performance of service sectors can indirectly contribute to economic growth through forward linkages with manufacturing production; an improvement in the quality and variety of producer services would support manufacturing sectors (Outlton, 2001). Recently, it is often argued that producer services supplied from service sectors are critical to the competitiveness of manufacturing firms in the globalizing economies (Francois, 1990; Arnold et al. 2007; Hoekman and Mattoo, 2008). The quality upgrading of service inputs plays a crucial role in facilitating manufacturing operations in developing countries (Arnold et al, 2008, Fernandes and Paunov, 2008). Despite the increasingly important issues, formal econometric work on these claims has been limited. In particular, there is little economic analysis on the implications of the quality upgrading of producer services with respect to the “inter-industry” linkages.

In this paper, I provide an empirical assessment on the role of producer services in manufacturing sectors by addressing the following questions. How is an improvement in producer services related to the growth of manufacturing productivity? Did the performance of service sectors improve manufacturing efficiency? What type of producer services is key to improving the efficiency of manufacturing production?

This paper proposes an estimation framework based on the work of Griliches and Lichtenberg (1984) in order to explore a link between service and manufacturing sectors. I start from the observation that an accurate measurement of the quality and availability of producer services is extremely difficult, which implies that a growth rate of service price deflators is measured with errors in official statistics for constructing input-output data. The errors of measurement in the price deflators of service outputs translate into measurement of service inputs of manufacturing operations. An observed growth of manufacturing productivity contains the measurement errors of changes in service prices arising from unobservable improvements in the quality of producer services.

The errors in service inputs are assumed to depend on the economic performance of service sectors measured by a variety of indicators, which is weighted by service inputs as a share of total non-energy inputs for each manufacturing sector in order to take into account cross-industry dependency on service sectors. The service link is related to manufacturing productivity growth. Thus, the proposed empirical specification serves to study the hypothesis that measures of the quality upgrading of producer services can have a stronger influence on manufacturing sectors that are more intensive in service inputs.

My estimation approach contrasts with prior work by Siegel and Griliches (1992) and ten RAA and Wolff (2001). The former paper examines only a simple correlation between manufacturing TFP growth and the average ratio of purchased service inputs to output across industries. The latter work studies the effect of service outsourcing on U.S. manufacturing productivity by decomposing the manufacturing TFP growth into a component of service inputs and a component of material inputs; the consolidated TFP growth rate embodies an effect of TFP growth in upstream service sectors. The difference in the standard and consolidated TFP growth rates is attributed to the effects of service outsourcing. In this paper, I relax the assumption that the price deflator of service outputs is measured with precision to compute manufacturing TFP growth rates, thereby allowing for regression analysis on the linkage between manufacturing productivity and the upgrading of service quality.

In the proposed estimation framework, this paper employs a comprehensive panel dataset on Japanese manufacturing industries. Specifically, the sample taken from the JIP 2009 covers 52 manufacturing industries and the period 1980-2005. Robust to a wide range of alternative specifications, I find little evidence that measures of the performance of aggregate service sectors have contributed to the growth rate of manufacturing productivity through forward linkages. This conclusion does not change when a variety of alternative measures such as TFP growth, labor productivity, and service worker shares are used. To the extent that these measures reflect partly unadjusted quality improvements of producer services, the evidence suggests that aggregate producer services did not play a significant role in accelerating Japanese manufacturing productivity in the past decades.

To address a concern that the characteristics of producer services are heterogeneous across service sectors, I also estimate the effect of service linkages with manufacturing productivity for a variety of specific service sectors: financial, insurance, road transportation, telecommunications, and information services. The results show that TFP growth rates in manufacturing sectors are not positively correlated with the service-link variable for the specific service sectors; the quality upgrading of specific producer services as measured by a wide range of indicators did not contribute to a change in manufacturing productivity growth. To the contrary, economic performance in some of the service sectors discourages manufacturing TFP growth. Possibly, the growing dependence of manufacturing sectors on specialized producer services may generate additional transaction costs to coordinate in-house production with service tasks produced outside the firm.

In the reminder of this paper, section 2 describes the related literature on producer services. Section 3 explains theoretical motivation, estimation framework, and data descriptions. Section 4 provides an estimation results. Section 5 concludes.

## 2. Related Literature

This section reviews two broad strands of the related literature to illustrate the importance of producer services in manufacturing sectors; macroeconomic consequences of the growing service sector and the globalization of services. From a macroeconomic point of view, there has been an argument that the expansion of service sectors characterized by low productivity growth would eventually slow down an aggregate productivity growth in advanced countries. Baumol (1967) is among the first to formally demonstrate that a shift of resources to a stagnant industry could drive down the aggregate rate of productivity growth to the rate in the stagnant industry. However, this conclusion can be overturned if the stagnant industry supplies only an intermediate input for other industries producing final goods and economic growth is measured only by the productivity of final good producers (Oulton, 2001). As long as productivity in the producer-service sector grows at a positive rate, a rising share of employment in producer services can sustain the productivity growth in downstream industries. The presence of an inter-industry linkage prevents a slowdown in the overall productivity growth. This possibility is supported by the work of Francois (1990) that provides a microeconomic foundation for the productivity-accelerating role of producer services in downstream manufacturing production. Because producer services coordinate interdependent tasks in complex production processes, the service sector promotes the degree of specialization in manufacturing operations, thereby generating productivity gains in downstream industries.

These discussions suggest that an inter-industry linkage between service and manufacturing sectors plays an important role in accounting for macroeconomic consequences of the service economy. However, there has been limited empirical work on these issues. Siegel and Griliches (1992) examine whether an increase in purchased services could explain a recovery in U.S. manufacturing productivity for the 1980s. They find little correlation between manufacturing TFP growth rates and the intensity of service purchases. Ten RAA and Wolff (2001) explore the effect of service outsourcing on U.S. manufacturing productivity by isolating a component of service inputs from a component of material inputs in the manufacturing TFP growth. Because the consolidated TFP growth rate embodies an effect of TFP growth in upstream service sectors, they argue that the difference in the standard and consolidated TFP growth rates accounts for the effect of service outsourcing. However, the quantitative difference between these TFP measures is fairly small, and their analytical approach does not allow for a statistical test on the effect of service outsourcing on manufacturing productivity.

In contrast to previous approaches, I propose an estimation framework to statistically test the linkage between manufacturing productivity and the upgrading of service quality. Under the assumption that the price deflator growth of service outputs is imprecisely measured, this approach allows for isolating the effect of service outsourcing from the effects of other determinants of manufacturing productivity. In addition, prior work focuses on the quantitative importance of purchased services whereas my analysis sheds light on the qualitative significance of producer services.

The strength of industry-level analysis lies in empirically assessing an aggregate impact of the cross-sectoral link between service and manufacturing sectors, which offers an insight on macroeconomic consequences of the rising service sector. On the other hand, firm-level analysis is likely to be limited in the sample coverage, but demonstrates a detailed link between firm characteristics and outsourcing.[3] Prior work, including Kimura (2002) for Japan, Girma and Görg (2004) for the U.K., and Görg and Hanley (2004) for Ireland, examines a relationship between domestic outsourcing and firm performance, respectively.[4] Although their empirical strategies such as the definition of outsourcing are fairly different, a general conclusion seems that contracting-out of service jobs such as accounting, consulting, and distribution are not systematically associated with firm performance as measured by profitability and productivity. Alternatively, purchased material inputs such as raw materials and components from outside the firm are positively associated with the firm performance.

Another strand of the related literature explores the globalization of service activities through trade and foreign direct investment (FDI) in services, and their impact on economic

[3] See Abraham and Taylor (1996) for empirical evidence on the causes of outsourcing based on U.S. establishment-level.
[4] Refer to Olsen (2006) for a nice survey on productivity effects of outsourcing and offshoring.

growth. As trade and investment flows in service sectors affect the variety, quality, and cost of producer services for final goods producer, a vertical linkage between manufacturing production and foreign suppliers of producer services is a focal point in the channels through which the globalization of services can promote economic growth (Hoekman and Mattoo, 2008). For instance, a relationship between FDI inflows in service sectors and manufacturing productivity is examined by Arnold et al. (2007) in the case of the Czech Republic for 1998-2003 and Fernandes and Paunov (2008) for Chilean manufacturing plants during 1992-2004. Investigating an effect of services liberalization on manufacturing sectors, they find a significantly positive association between services FDI and manufacturing productivity. The finding is interpreted as suggesting that the higher productivity of multinationals over domestic firms in service sectors improves service inputs of local manufacturing production. In contrast to these studies, the focus of my paper is not limited to producer services supplied from foreign firms; instead, I assess the broader impact of the producer services on manufacturing productivity in the advanced country, Japan, for the long period.

In the context of developing countries, Arnold et al. (2008) examine the effect of service-input availability on firm productivity in Sub-Saharan African manufacturing sectors for the early 2000s. They relate firm productivity to a survey measure of difficulty in access to producer services such as electricity, financial services, and telecommunications. Exploiting a regional variation in access to services, they find a positive link between service inputs and firm efficiency. However, it is difficult to assess the regional pattern as identifying the direction of causality; an improvement in business environments can account for productivity gains and access to service inputs. On the other hand, my analysis exploits panel data on 52 manufacturing industries over two decades to control for a wide range of unobserved industry- and time-specific effects.

## 3. Empirical Methodology

### 3.1. Theoretical Motivation

This paper explores the hypothesis that the quality upgrading of producer services contributes to productivity gains in manufacturing sectors. There are a number of alternative channels through which improvements in the quality, variety, and cost of service products could affect production efficiency of manufacturing firms that use the services. This paper focuses on the general role of specialized service providers in the manufacturing production process. In particular, the formal model by Francois (1990) offers the theoretical underpinning for a relationship between producer services and production in user industries.

A one-sector model in the monopolistic competition framework is developed to characterize increasing returns to scale at the firm level. Production technology exhibits the degree of specialization in labor, which serves as a single input of production. To introduce a role of producer services in the specialization process, services labor is employed to organize a complex set of distinct production processes. Producer-service costs increase in the degree of specialization. For a given amount of output, firms determine the degree of specialization to minimize costs of production and services labor. In this production structure with consumer demands characterized by a love of variety, the upgrading of producer services can generate productivity gains in production activities by promoting the division of labor in manufacturing production.

More intuitively, the linkage between producer services and production is that the growing extent of markets for manufacturing products increases the complexity of the production process. As the number of production workers rises in the operation of production, there is an increase in demand for producer services that are used to coordinate the finely fragmented stages of production. The expansion of production scale results in the greater degree of specialization in the production process. This contributes to an improvement in manufacturing labor productivity when specialized producer services for coordinating complicated tasks in production are also employed to reduce coordination costs. As a result of the market expansion, producer services can help manufacturing firms to improve the degree of specialization in production.

Since the model does not clearly distinguish the boundaries of firm activities, producer services do not have to be supplied exclusively by workers who are formally employed at firms; instead, manufacturing firms can purchase producer services from specialized service providers. The theoretical link between producer services and production efficiency is carried over to the case where firms contract out service tasks. Once the outsourcing of services labor is allowed, specialized service providers can exploit scale economies in supplying business services to potential customers in markets. The economies of scale allow the independent service suppliers to reduce the cost of producing service inputs as compared to the services that are produced only within the firm. An improvement in quality, availability, and costs of producer services promotes the division of labor in downward manufacturing sectors. Thus, the performance of service suppliers could generate productivity gains in user manufacturing production via forward linkages.[5]

### 3.2. Estimation Framework

The purpose of this paper is to estimate an economic contribution of service-sector performance to a change in production efficiency in downward manufacturing sectors. The

[5] The theoretical linkage between producer services and the division of labor in production provides a basis for an empirical investigation on the relationship between service-sector performance and manufacturing productivity. Nevertheless, transmission channels could plausibly vary by specific characteristics of producer services. In particular, I examine the role of financial, transportation, and information services in explaining manufacturing productivity in section 4.

theory suggests that an improvement in the quality and variety of intermediate inputs produced in service sectors should encourage the degree of specialization in manufacturing operations in response to the rising demand for manufactured products. This channel leads to an increase in the productivity growth of manufacturing sectors. Furthermore, improved performance in the service sectors should have a stronger positive influence on manufacturing sectors that are more heavily dependent on intermediate inputs from the service sectors.

An operational framework for estimation is needed to explore forward linkages with productivity changes in manufacturing industries. A main issue is to estimate the extent of the quality upgrading of producer services from service sectors. There are profound and difficult problems in measuring the output and quality of producer services (Griliches, 1992). Since measurement problems are beyond the scope of this paper, I postulate that a change in the quality and variety of business services are not accurately reflected in the price deflator growth of service outputs. It is less controversial to assume the existence of measurement errors in service-output prices than to assume producer services as accurately reflecting quality changes. In fact, measurement problems on service inputs allow for estimating the link between service performance and manufacturing productivity; the real value of intermediate inputs in input-output tables would account totally for a change in the quality of service inputs *if* the quality upgrading were perfectly reflected in a change of service price deflators.

Given the presence of measurement errors in the service price deflator, I draw on the work of Griliches and Lichtenberg (1984) to construct an estimation framework for the purpose of this paper. Assume that manufacturing production at the industry level follows a Cobb-Douglas production function of non-service and service inputs for sector i and time t:

$$Q_{i,t} = A_{i,t} X_{i,t}^{\alpha} S_{i,t}^{\beta} \quad (1)$$

where Q is output, A is a Hick-neutral technology efficiency, X is a vector of non-service inputs such as labor, capital, and materials, and S is a composite of intermediate service inputs.[6] Taking the natural logarithm and first differences with respect to time for each variable, equation (1) is rewritten as:

$$\Delta \ln Q_{i,t} = \Delta \ln A_{i,t} + \alpha \Delta \ln X_{i,t} + \beta \Delta \ln S_{i,t} \quad (2)$$

where △ indicates the first differencing.

Assume that there exist errors in measurement of the growth rate of service output deflator for the failure to account for a change in the variety and quality of producer services. From a point of view in downward manufacturers, the measurement errors translate into a deviation in service input deflators. Given that transactions in producer services are measured with precise value, accounting identity between service inputs, values, and deflators gives the following:

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[6] A composite of service input, S, consists of a variety of producer services in service sectors.

$$\Delta \ln S^*_{i,t} = \Delta \ln VS_{i,t} - \Delta \ln PS^*_{i,t} \tag{3}$$

where $S^*$ is measured quantity of service inputs, VS is nominal value of service inputs, and $PS^*$ is a measured price deflator of service inputs. The difference between true and measured quantities of service inputs is expressed as:

$$\Delta \ln S_{i,t} - \Delta \ln S^*_{i,t} = \Delta \ln PS^*_{i,t} - \Delta \ln PS_{i,t} = E_{i,t} \tag{4}$$

where E indicates the extent of deviation in a measured growth rate of service inputs from the true growth rate. To focus on the link between quality changes in service inputs and productivity, I assume that the actual amount of output and non-service inputs are measured with correct price deflators. After expressing measured and true TFPs with the corresponding service inputs, the difference between measured and true TFPs is denoted as:

$$\Delta \ln A^*_{i,t} - \Delta \ln A_{i,t} = \beta(\Delta \ln S_{i,t} - \Delta \ln S^*_{i,t}) = \beta E_{i,t} \tag{5}$$

Rearranging the terms in equation (5) allows me to express the measured growth rate of production efficiency in sector i for time t as a function of the true total factor productivity and the measurement errors in the service input deflator:

$$\Delta \ln A^*_{i,t} = \Delta \ln A_{i,t} + \beta E_{i,t} \tag{6}$$

To investigate the central hypothesis that improved performance in service sectors contributes to productivity growth in purchasing sectors, I further assume that the errors in measurement of service price deflators arise from improvements in producer services that are unobservable for statisticians. Because manufacturing sectors that are more intensive in service inputs may benefit more strongly from spillover effects of service upgrading, I presume that a benefit of improved producer services is distributed to downstream manufacturing sectors in proportion to input sales from service suppliers to total non-energy input purchases in the manufacturing sectors. Specifically, I define the deviation in the measured growth of service deflators for service inputs from service sector k as follows:

$$E_{i,t} = \gamma \sum_k \frac{\text{Inputs from service sector k in sector i at time t}}{\text{Total non-energy inputs in sector i at time t}} \times \text{Service\_Performance}_{k,t} \qquad (7)$$

where the service performance variable captures a change in service outputs of service sector k.

An important issue in this formulation is to measure economic performance in service sector k as a proxy of unobservable improvements in producer services. The estimation framework based on Griliches and Lichtenberg (1984) is built on the assumption that service price deflators are measured with errors, making possible to estimate the link between service and manufacturing sectors. Nevertheless, I need alternative indicators of service performance in a wide array of service sectors. Because it is not possible to measure a variation in the quality of producer services across sectors over time in a consistent way, I employ the following variables on service sector characteristics as an approximate indicator of overall service performance: TFP, value added per worker, labor quality index, technical worker share, services worker share, and IT capital stock share.

Arranging equations (6) and (7) gives the following empirical specification on the role of service linkages in manufacturing productivity:

$$\Delta \ln A^{*}_{i,t} = \delta_1 + \delta_2 \text{Service\_Link}_{i,t} + \delta_z Z^{'}_{i,t} + \mu_i + \mu_t + \varepsilon_{i,t} \qquad (8)$$

where service link is performance in service sectors weighted by the service input intensity in sector i, Z is a vector of control variables that may influence productivity growth, $\mu_i$ is fixed-industry effects, $\mu_t$ is fixed-year effects, and ε is an error term. [7] As previously discussed, I predict that the service link should promote productivity growth in manufacturing sectors via forward linkages. The expected sign for its coefficient should be positive.[8] For the control variables, I include a share of IT capital in aggregate capital stock, a share of skilled labor in total employment, and an import penetration ratio in manufacturing industries.

### 3.3. Description of Japan Industrial Productivity Database 2009

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[7] Since true total factor productivity in equation (6) is not observable to econometricians, I assume that it is absorbed in the error term. It seems reasonable to consider that true productivity growth excluded from the model is sufficiently uncorrelated with the service link variable so that it would not cause a serious bias in an estimated coefficient of the service link.

[8] Equation (8) can be combined with the original production function to obtain an alternative empirical specification with the dependent variable of output:

$$\Delta \ln Q_{i,t} = \delta_1 + \delta_2 \text{Service\_Link}_{i,t} + \alpha \Delta \ln X_{i,t} + \beta \Delta \ln S^{*}_{i,t} + \delta_z Z^{'}_{i,t} + \mu_i + \mu_t + \varepsilon_{i,t}$$

This specification is an alternative way to test the hypothesis that manufacturing sectors benefit from an enhancement of business services to increase the growth rate of their output. However, my main specification is based on equation (8) because results are not significantly sensitive to this specification. Estimation results on equation (8) are not reported, but available upon request.

This paper employs the 2009 version of Japan Industrial Productivity Database (JIP). This database is prepared by the Research Institute of Economy, Trade, and Industry (RIETI) in cooperation with Hitotsubashi University. The primary objective of the JIP 2009 is to provide a comprehensive database for investigating the structural change of Japanese industries and economic growth for the long term. The JIP 2009 includes a wide variety of indicators on industry characteristics for 108 sectors between 1970 to 2006: capital service input indices and capital costs, labor service input indices and labor costs, nominal and real values of inputs and outputs, and TFP. Additional datasets on trade, FDI, and market reforms are also provided. While details of the estimation methodology are found in Fuako and Miyagawa (2008), this section briefly describes the JIP 2009, which is a single data source of my analysis.

A dependent variable is the measured growth rate of manufacturing productivity. In the JIP 2009, TFP growth rates at the sector level are calculated in the following equation:

$$\Delta \ln(T_i) = \Delta \ln(Q_i) - \omega_{X,i}\Delta \ln(M_i) - \omega_{L,i}\Delta \ln(L_i) - \omega_{K,i}\Delta \ln(K_i) \quad (9)$$

where $\triangle$ denotes first differencing of a variable, T is an indicator of technology efficiency, Q is output, M is intermediate input, L is labor, and K is capital. A cost share of total expenditures expressed by $\omega$ for each input is the simple average of cost shares at time t and t-1, with the first subscript indicating a type of input. Specifically, intermediate input costs are an aggregate volume of intermediate inputs in nominal terms from input-output tables of the JIP; labor costs are the sum of the product of nominal wage rates and labor inputs disaggregated by labor characteristics and sector; capital costs are the sum of the product of nominal capital prices and capital stocks disaggregated by capital goods and sector.

The service link variable is created from service input intensities and performance indicators of service sectors. Following Ahn et al. (2008), service activity is defined to include sectors 66 through 107 as classified by the JIP industry code. For example, the broad service sector consists of retail, finance, insurance, transportation, and telecommunications. A detailed list of service sectors is shown in the Appendix.[9] Using a real volume of intermediate goods in input-output tables of the JIP 2009, I create a matrix of intermediate inputs from a particular service sector in manufacturing sectors. Then, service inputs are divided by the aggregate volume of intermediate inputs excluding those from the energy sectors: mining, petroleum products, coal products, electricity, gas and heat supply, waterworks, water supply for industrial use. Finally, the same matrix of service input intensities across manufacturing industries is constructed between 1980 and 2005.

An improvement in producer services supplied by each service sector is measured by a variety of indicators on service-sector characteristics. Specifically, I use TFP, value added per worker, labor quality index, information technology (IT) capital stock share, technical worker

[9] Manufacturing industries include sectors 8 through 59 without 30 and 31 in the JIP code.

share, and service worker share. The value added per worker is created by dividing aggregate total value added with the total number of workers in each sector. Labor quality index is made from labor input index and man-hour index; a difference between the growth rate of labor input and man-hour index is interpreted as a change in the quality of labor input. IT capital stock is estimated by a perpetual inventory method for an aggregate value of software and hardware investment for each industry. A share of IT capital stock is constructed by dividing it with total capital stock. Technical and service worker shares are the number of technical and service workers as a share of total employment in each industry, respectively. Lastly, I combine data on service input intensities and service performance to create the service-link variable as specified in equation (7).

Control variables include a share of IT capital stock, an employment share of skilled labor measured by non-production workers, and an import-penetration intensity in manufacturing sectors. The import penetration is constructed by dividing the volume of imports with the sum of domestic production and imports minus exports. Summary statistics of the samples are provided in the Appendix.

## 4. Estimation Results

### 4.1. Aggregate Service Sectors

This section starts to show the basic result on equation (8) estimated with an ordinary least square (OLS) method. Since errors in each cluster of manufacturing sectors could be correlated, standard errors clustered at the industry level are reported with the estimated coefficients. The specification is estimated with sector and year dummy variables to control for industry- and time-fixed effects. The dependent variable is a growth rate of TFP in manufacturing sectors. The coefficients of the service-link variables indicate a relationship between service-sector characteristics and manufacturing productivity.

Column (1) of Table 2 shows that the estimated coefficient of the service link via TFP in service sectors is not statistically different from zero. In columns (2) to (6), I employ the service-link variable with other indicators of service sectors in each specification. Consistent with the result in column (1), any of the coefficients of the service link is not statistically significant. The results suggest that an improvement in producer services measured by a wide range of variables did not have a significant impact on the growth rate of productivity across manufacturing sectors through forward linkages. While it is often claimed that the competitiveness of manufacturing firms is supported by reliable producer services in local markets, the basic results do not lend support to the presence of a linkage between service and manufacturing sectors.

**[Table 2 around here]**

How are these results related to the past findings on the inter-industry linkages between service and manufacturing sectors? While my focus is on service performance, ten RAA and Wolff (2001) argue that the outsourcing of services tasks – a low productivity part of production – improves the observed growth of manufacturing productivity. While the TFP growth rate in U.S. manufacturing sectors was 0.87 percentage points for the period 1977-1987, they estimate that services outsourcing contributed to about 0.06 percentage points. This result is taken as suggesting the productivity-accelerating effects of the contracting-out of service tasks. However, the relatively small contribution of purchased services to manufacturing efficiency accords with my findings that the linkage between service and manufacturing sectors is weak in Japan. In contrast, Arnold et al. (2008) find that performance in specific service sectors has a significantly positive association with firm productivity in 10 Sub-Saharan African countries between 2001 and 2005. Collectively, these studies may imply that producer services have a larger positive impact on manufacturing firms in developing countries than those in developed countries.

There are three control variables in each specification. Among these variables, the within-industry share of skilled labor in total employment has a significantly positive impact on manufacturing productivity growth across the specifications. In column (1), the magnitude of the coefficient indicates that a 10% point increase in the skilled-labor share is predicted to increase manufacturing TFP by a 1.3% point. While the estimated coefficient of skilled labor needs to be carefully interpreted for possible endogeneity bias, it is reasonable to conclude that skill upgrading of workers within manufacturing industries played an important role in productivity improvements in Japan for the past decades. On the other hand, the share of IT capital stock has the insignificant coefficients across the specifications in Table 2. Motohashi (2005) employs a sample of Japanese firms for 1991-2000 to study an impact of IT use on firm performance. He estimates that the share of IT capital stock at the firm-level accounted for about 12% of value added of manufacturing firms. As there may be substantial heterogeneity in IT investment and firm performance, my estimates at the industry level suggest that a variation in benefits of IT investment to productivity gains can be much larger across firms than across industries.

Import-penetration intensities across manufacturing sectors have an insignificant influence on manufacturing productivity. Contrary to a common concern that import competition is detrimental to domestic industries, I do not find evidence that the import penetration decreases manufacturing productivity at the industry-level. However, this result may also be influenced by possible aggregation bias to some extent. For example, Ito and Kawakami

(2008) find that small and medium firms in industries with intensive import competition are likely to experience a lower growth of employment and sales for 1995-2003 in Japan. Their results imply that a clear distinction on the firm size can play an important role in identifying the relationship between import competition and productivity.

The previous regressions have controlled for unobservable industry-specific effects that were constant for the period of interest. But there were possible changes in specific industry characteristics such as technological innovation, market demand, or government regulation. Unobserved changes in the manufacturing industry could be correlated with service linkages in a way to downplay a role of service links. Thus, I take first differencing of equation (8) to remove fixed-effects across industry and time. Furthermore, sector and year dummy variables are included in the first-differenced specification to control for the unobservable factors that may drive *constant changes* in the characteristics of manufacturing industries. Table 3 shows an estimation result of the first-differenced model of equation (8).[10] Consistent with the previous results, all of the specifications in columns (1) to (6) do not show the significant coefficients of the service link created with a variety of indicators on service-sector characteristics. A change in the service-link variable has little impact on a change in the growth rate of TFP in manufacturing sectors. Thus, the conclusion that service sectors do not influence manufacturing

[10] I also employ GMM estimation with instrument variables to directly address potential endogeneity of service link variables. As the GMM results are similar to those from OLS estimation of the first-differenced specification, they are provided in the Appendix.

productivity through forward linkages is robust to the different specification.

**[Table 3 around here]**

**4.2. Specific Service Sectors**

A major concern about the estimation results up to this point is that each service sector can play a heterogeneous role in providing producer services to manufacturing firms (Hoekman and Mattoo, 2008). Since a type of intermediate service inputs is not necessarily identical across service industries, an effect of improved producer services on manufacturing productivity may depend on individual service sectors. It implies that estimated coefficients of the service link may reflect aggregation bias across service sectors. To address this problem, I construct service-link variables for specific service industries: finance, insurance, road transportation, telecommunications, and information services. Data on a cross-industry intensity of service inputs and economic performance in a particular service sector are obtained from the JIP 2009. Using the specific service links, I estimate the first-differenced model of equation (8) with sector and year dummy variables to control for industry-specific effects in the growth rate of manufacturing productivity.

I start to examine a role of financial and insurance sectors in manufacturing productivity. As Levine (1997) illustrates a variety of functions of financial development in economic growth, the provision of financial services is vital to business activities in manufacturing sectors. The emergence of financial systems ameliorates transactions costs due to imperfect information in an uncertain business environment, and facilitates the allocation of scarce financial resources over space and time. An improvement in the quality of financial services reduces transaction costs associated with the degree of specialization in production processes. Consequently, a decline in coordination costs of the complex production enhances the division of labor in manufacturing operations, which is likely to lead to productivity improvements. While it is difficult to establish a clear direction of causality between financial developments and specialization in manufacturing production, the hypothesis is that the service link should be associated positively with manufacturing productivity.

Columns (1) and (2) of Table 4 show a list of the coefficients of service links for financial and insurance services sectors, respectively.[11] Contrary to the theoretical intuition, any of the coefficients of the service link are not significantly positive across the various definitions of the service links. In the case of the finance sector, some of the service-link variables have the significantly negative coefficients, which indicate that improved performance in financial services discourages the growth rate of TFP in manufacturing sectors. These results are in

[11] Estimation results are available on request.

contrast with previous empirical findings. For example, Levine (1997) summarizes the empirical findings that aggregate productivity growth is correlated positively with a variety of financial development indicators such as the size of financial intermediaries, the importance of private banks relative to a central bank, and the level of commercial bank credit across 80 countries over the period 1960-1989. Furthermore, Rajan and Zingales (1998) show that industrial sectors in the greater need of external financing tend to grow faster in countries that are more financially developed, which indicates the importance of financial markets for industrial development. As compared with these studies, my analysis does not support a positive link between financial services and efficiency in manufacturing production. The implication is that financial services could play a significant role in the expansion of industrial sectors, but may not be crucial in enhancing the productivity of industrial productions.

Transportation sectors provide important producer services for manufacturing firms. Transportation is a key element of manufacturing operations at least in two aspects to connect manufacturers with suppliers and consumers; the delivery of parts and components to point of final assembly and the transport of final products to point of consumption. The efficient and timely distribution of parts and final products in the domestic market comprises a critical part of the manufacturing production (Limão and Venables, 2001; Djankov et al., 2006). As production becomes complex, transport tasks gain in importance. An increase in the number and variety of parts and final goods implies that transportation services must be supplied in an appropriate mode to coordinate a complicated set of tasks in operations. As transportation must take into account a wide range of characteristics of intermediate and final goods such as volume, form, and timeliness, suppliers of transport services can specialize in the provision of specific transport services to exploit the gains of specialization. Consequently, an improvement in the quality and availability of transport services will reduce coordination costs associated with transport tasks in manufacturing production, which is likely to enhance productivity.

Column (3) of Table 4 shows the estimation result of the effect of service links with a road-transportation sector on manufacturing productivity. The road transportation is analyzed as a proxy for general transport services. While service performance in the transport sector is measured by a variety of indicators, the coefficients of the service-link variables are insignificant. I find little evidence that the measures of the quality upgrading of transport services improve manufacturing productivity. Fernald (1999) studies the role of public investment in road infrastructure in the productivity growth of U.S. industries. He finds that U.S. industries that are intensive in vehicle use tend to benefit disproportionately from road growth, but marginal benefits of infrastructure investments tend to decline over. In contrast, my paper directly analyzes the effects of transportation services on industrial productivity in the case of Japan, but the evidence does not point to the productivity-accelerating role of transport services.

Lastly, I analyze the linkage between information services and productivity. An exchange of information constitutes a central stage of production processes. A headquarters of a manufacturing firm undertakes the processing of business information in consumer markets, industries, and macroeconomy. The management decisions are strategically made on the basis of corporate resources and business environments. Within the firm, its headquarters provides a wide range of informational services such as product development, process innovations, and managerial tasks for the operation of its production plant. Within the plant, a final assembly of components and parts involves coordination between production workers to operate a large-scale production processes simultaneously, which requires an intense exchange of information. To improve the flow of information, firms can link distinct segments of corporate organizations with IT networks, which are established by investment in information and communication technology. While purchased computers can directly contribute to a reduction of information costs, outsourcing of information services plays a large role in an introduction and maintenance of comprehensive IT systems. A specialized knowledge of IT networks from service producers is critical to an efficient and operational form of IT systems in production processes.

Columns (4) and (5) of Table 4 show the estimate of the service link variables with telecommunications and information sectors, respectively. To the extent that the quality upgrading of information services is captured at least partly by a variety of indictors, the estimated coefficients should represent the role of informational services in explaining productivity growth of manufacturing industries. The results indicate that the coefficients of the service link are not significantly positive across specifications. To the contrary, the service links of value-added per worker and labor quality index in the information services have the significantly negative impact on manufacturing productivity. An improved labor productivity in information sectors as a proxy for the quality upgrading of information services depresses the TFP growth of manufacturing sectors that are linked with the information sector via forward linkages.

## 5. Discussion and Conclusion

The growing importance of service sectors characterizes the Japanese economy as it applies to almost all of advanced economies. A stagnant productivity growth of the service sector in Japan raises a concern of the "Baumol's disease" that an expansion of low-productivity sectors could eventually drive down aggregate economic growth to the rate in the stagnant sector. However, the service sector plays a fundamental role in providing producer services for manufacturing production. As manufacturing firms extensively engage in "service outsourcing", the service sectors are deeply linked with vertical chains of manufacturing production. This fact often leads to the claim that the quality upgrading of producer services can improve manufacturing productivity (Francois, 1990, Oulton, 2001). As a result, the service sector is expected to contribute indirectly to economic growth.

This paper attempts to offer an empirical assessment on the role of producer services in manufacturing production. Specifically, I propose an empirical framework to study the effect of quality improvements of services on manufacturing productivity. The estimation strategy starts from the observation that improvements in the quality, variety, and availability of services may not accurately be reflected in the growth rate of service price deflators. Measurement errors in the price deflators of service outputs enter the observed productivity growth rate of manufacturing sectors through the purchased of service inputs.

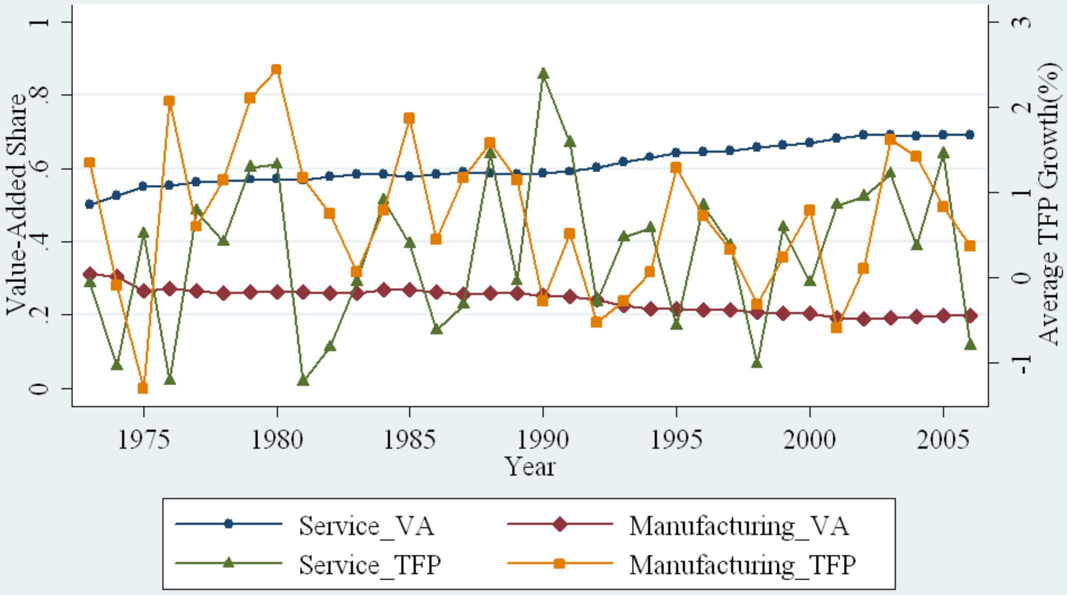
I assume that the errors of measurement in service inputs resulting from unobserved quality changes is related to the performance of service sectors such as labor productivity; good performance proxies quality upgrading that is not explained in the price deflator growth of service outputs. Manufacturing productivity is related to the performance of the service sectors weighted by the cross-sectoral intensity of service inputs. To implement the estimation, I exploit comprehensive panel data on industry characteristics from the Japan Industrial Productivity (JIP) database 2009; the sample covers 52 manufacturing and 42 service sectors for the period 1980-2005 in Japan.

Contrary to the claim that producer services are critical to the competitiveness of manufacturing industries, I find little evidence that a variety of measures of the economic performance in the service sectors improve total factor productivity in Japanese manufacturing sectors. The findings are robust to a wide range of alternative measures of service performance, empirical specifications, and estimation methods. In addition, I address aggregation bias of heterogeneous producer services by exploring five service sectors individually. Consistent with the results of the aggregate service sector, the service linkage plays little role in accelerating productivity growth rates in manufacturing sectors. To the contrary, some measures of the service linkage have even a significantly negative impact on manufacturing efficiency, possibly implying that the growing dependence on specialized service providers may create additional transaction costs to coordinate in-house production with service tasks produced outside the firm.

In assessing a role of service sectors in economic growth, the evidence in this paper points to the importance of a direct contribution of service-sector productivity. Contracting-out of a low productivity component of service tasks in production may indeed prevent a slowdown in manufacturing productivity growth from occurring. On the other hand, improved quality of producer services may not necessarily promote the competitiveness of manufacturing industries. However, these implications must be subject to further econometric evidence as there are limitations in this paper. One of key issues lies in measurement of observed and unobserved changes in the quality of producer services. The presence of measurement errors in a price deflator growth of service output is necessary for estimating the service linkage, but measures of economic characteristics on the service sectors are *assumed* to reflect a component of quality changes that is not accounted for by the official price deflator. These assumptions raises the question of whether the insignificant effects of service links result either from the *absence* of measurement errors or from imperfection of the measures of unobserved quality upgrading.

Figure 1. Sectoral Contribution and Productivity in Japanese Economy

Service and Manufacturing Sector for Year 1973-2006




Note: Service sector includes industry 66-107 in the JIP code; manufacturing sector consists of industry 8-59 without 30 and 31; average TFP growth is computed with Domar weight.

Source: Japan Industrial Productivity Database 2009

**Table 1. Service Input as a Share of Total Non-energy Input by Manufacturing Industry**

| Industry \ Period | 1973-1979 | 1980-1989 | 1990-1999 | 2000-2006 |
|---|---|---|---|---|
| Food and Beverages | 0.248 | 0.249 | 0.201 | 0.191 |
| Chemicals | 0.363 | 0.344 | 0.357 | 0.374 |
| Non-metalic Minerals | 0.525 | 0.483 | 0.487 | 0.497 |
| Basic Metals | 0.334 | 0.340 | 0.331 | 0.316 |
| Fabricated Metal Product | 0.310 | 0.296 | 0.289 | 0.272 |
| Machinery and Equipment | 0.282 | 0.275 | 0.299 | 0.280 |
| Electrical Machinery | 0.266 | 0.305 | 0.351 | 0.398 |
| Transport Equipment | 0.165 | 0.166 | 0.180 | 0.203 |
| Other Manufacturing | 0.323 | 0.305 | 0.284 | 0.275 |
| Simple Average | 0.313 | 0.307 | 0.309 | 0.312 |

Source: Japan Industrial Productivity Database 2009

Note: Service input includes inputs from the JIP sector codes 66 through 107; total inputs exclude energy inputs from the JIP sector codes 7, 30, 31, 62, 63, 64, and 65.

**Table 2. OLS Regression of Service Link for 1980-2005**

Dependent Variable: TFP Growth Rate in Manufacturing Sectors

| Variable | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Service Link via TFP | -0.224 | | | | | |
| | (0.580) | | | | | |
| Service Link via Value | | 0.002 | | | | |
| Added per Worker | | (0.003) | | | | |
| Service Link via Labor | | | -0.032 | | | |
| Quality Index | | | (0.039) | | | |
| Service Link via Technical | | | | -0.334 | | |
| Worker Share | | | | (0.263) | | |
| Service Link via Service | | | | | -0.302 | |
| Worker Share | | | | | (0.290) | |
| Service Link via IT Capital | | | | | | -0.328 |
| Stock Share | | | | | | (0.400) |
| IT Capital Stock Share | -0.068 | -0.067 | -0.061 | -0.074 | -0.074 | -0.071 |
| | (0.066) | (0.063) | (0.064) | (0.063) | (0.061) | (0.065) |
| Skilled Worker Share | 0.131* | 0.127* | 0.138* | 0.128* | 0.126* | 0.131* |
| | (0.061) | (0.059) | (0.059) | (0.060) | (0.059) | (0.062) |
| Import Penetration | -0.014 | -0.014 | -0.012 | -0.013 | -0.013 | -0.015 |
| | (0.022) | (0.022) | (0.021) | (0.022) | (0.022) | (0.023) |
| Year Dummy | Yes | Yes | Yes | Yes | Yes | Yes |
| Sector Dummy | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 |
| R-square | 0.135 | 0.135 | 0.135 | 0.136 | 0.135 | 0.135 |

Note: Robust standard errors clustered at the industry are in parentheses, with ***, **, and * indicating the 1, 5, and 10 percent significance levels, respectively; a constant term is not reported.

**Table 3. OLS Regression of Service Link for 1980-2005**

Dependent Variable: First Difference of TFP Growth Rate in Manufacturing Sectors

| First-Differenced Variable | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Service Link via TFP | -0.708 | | | | | |
| | (1.084) | | | | | |
| Service Link via Value | | -0.002 | | | | |
| Added per Worker | | (0.016) | | | | |
| Service Link via Labor | | | -0.082 | | | |
| Quality Index | | | (0.146) | | | |
| Service Link via Technical | | | | -0.311 | | |
| Worker Share | | | | (0.675) | | |
| Service Link via Service | | | | | -0.215 | |
| Worker Share | | | | | (0.699) | |
| Service Link via IT Capital | | | | | | -2.760 |
| Stock Share | | | | | | (2.283) |
| IT Capital Stock Share | 0.038 | 0.048 | 0.047 | 0.042 | 0.050 | 0.070 |
| | (0.469) | (0.473) | (0.480) | (0.477) | (0.477) | (0.489) |
| Skilled Worker Share | 0.143 | 0.142 | 0.142 | 0.148 | 0.145 | 0.138 |
| | (0.208) | (0.206) | (0.207) | (0.208) | (0.207) | (0.208) |
| Import Penetration | -0.147 | -0.149 | -0.151 | -0.148 | -0.150 | -0.155 |
| | (0.191) | (0.192) | (0.192) | (0.193) | (0.194) | (0.193) |
| Year Dummy | Yes | Yes | Yes | Yes | Yes | Yes |
| Sector Dummy | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 1250 | 1250 | 1250 | 1250 | 1250 | 1250 |
| R-square | 0.029 | 0.028 | 0.029 | 0.029 | 0.028 | 0.030 |

Note: Robust standard errors clustered at the industry are in parentheses, with ***, **, and * indicating the 1, 5, and 10 percent significance levels, respectively; a constant term is not reported.

**Table 4. OLS Estimates of Coefficients of Service Link in Individual Service Sectors**

Dependent Variable: First Difference of TFP Growth Rate in Manufacturing Sectors

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Service Sector<br><br>First-Differenced Variable | Financial Services | Insurance Services | Road Transportation Services | Tele-communication Services | Information Services |
| Service Link via TFP | -1.393 | 5.069 | -3.056 | -16.23 | -5.750 |
| | (1.796) | (6.779) | (1.695) | (16.13) | (7.774) |
| Service Link via Value Added | -0.084*** | -0.541 | -0.121 | -0.034 | -0.756** |
| per Worker | (0.021) | (0.554) | (0.062) | (0.052) | (0.234) |
| Service Link via Labor Quality | -0.485 | -4.473 | -0.660 | -0.388 | -6.505* |
| Index | (0.354) | (4.984) | (0.455) | (2.874) | (2.773) |
| Service Link via Technical | -46.19* | -621.5 | -462.1 | -29.30 | -11.80 |
| Worker Share | (17.629) | (347.427) | (332.4) | (48.47) | (7.063) |
| Service Link via Service | -93.68* | -1814.6 | -41.46 | -865.7 | -162.3 |
| Worker Share | (44.91) | (1157.735) | (28.82) | (1801.9) | (86.90) |
| Service Link via IT Capital | -8.998 | -73.92 | -18.71 | -19.62 | 5.228 |
| Stock Share | (4.579) | (62.173) | (16.86) | (17.38) | (33.31) |

Note: Robust standard errors clustered at the industry are in parentheses, with ***, **, and * indicating the 1, 5, and 10 percent significance levels, respectively; each specification includes IT capital stock share, skilled worker share, import penetration, and year and sector dummies.

## Appendix

**Table A1. List of Industries in JIP 2009 Database**

| Category | JIP Code | JIP Industry Classification |
|---|---|---|
| Primary | 1 | Rice, wheat production |
| Primary | 2 | Miscellaneous crop farming |
| Primary | 3 | Livestock and sericulture farming |
| Primary | 4 | Agricultural services |
| Primary | 5 | Forestry |
| Primary | 6 | Fisheries |
| Energy-related | 7 | Mining |
| Manufacturing | 8 | Livestock products |
| Manufacturing | 9 | Seafood products |
| Manufacturing | 10 | Flour and grain mill products |
| Manufacturing | 11 | Miscellaneous foods and related products |
| Manufacturing | 12 | Prepared animal foods and organic fertilizers |
| Manufacturing | 13 | Beverages |
| Manufacturing | 14 | Tobacco |
| Manufacturing | 15 | Textile products |
| Manufacturing | 16 | Lumber and wood products |
| Manufacturing | 17 | Furniture and fixtures |
| Manufacturing | 18 | Pulp, paper, and coated and glazed paper |
| Manufacturing | 19 | Paper products |
| Manufacturing | 20 | Printing, plate making for printing and bookbinding |
| Manufacturing | 21 | Leather and leather products |
| Manufacturing | 22 | Rubber products |
| Manufacturing | 23 | Chemical fertilizers |
| Manufacturing | 24 | Basic inorganic chemicals |
| Manufacturing | 25 | Basic organic chemicals |
| Manufacturing | 26 | Organic chemicals |
| Manufacturing | 27 | Chemical fibers |
| Manufacturing | 28 | Miscellaneous chemical products |
| Manufacturing | 29 | Pharmaceutical products |
| Energy-related | 30 | Petroleum products |
| Energy-related | 31 | Coal products |
| Manufacturing | 32 | Glass and its products |
| Manufacturing | 33 | Cement and its products |
| Manufacturing | 34 | Pottery |
| Manufacturing | 35 | Miscellaneous ceramic, stone and clay products |
| Manufacturing | 36 | Pig iron and crude steel |
| Manufacturing | 37 | Miscellaneous iron and steel |
| Manufacturing | 38 | Smelting and refining of non-ferrous metals |
| Manufacturing | 39 | Non-ferrous metal products |
| Manufacturing | 40 | Fabricated constructional and architectural metal products |
| Manufacturing | 41 | Miscellaneous fabricated metal products |
| Manufacturing | 42 | General industry machinery |
| Manufacturing | 43 | Special industry machinery |
| Manufacturing | 44 | Miscellaneous machinery |
| Manufacturing | 45 | Office and service industry machines |
| Manufacturing | 46 | Electrical generating, transmission, distribution and industrial |
| Manufacturing | 47 | Household electric appliances |
| Manufacturing | 48 | Electronic data processing machines, digital and analog computer equipment and accessories |
| Manufacturing | 49 | Communication equipment |
| Manufacturing | 50 | Electronic equipment and electric measuring instruments |
| Manufacturing | 51 | Semiconductor devices and integrated circuits |
| Manufacturing | 52 | Electronic parts |
| Manufacturing | 53 | Miscellaneous electrical machinery equipment |
| Manufacturing | 54 | Motor vehicles |
| Manufacturing | 55 | Motor vehicle parts and accessories |
| Manufacturing | 56 | Other transportation equipment |
| Manufacturing | 57 | Precision machinery and equipment |
| Manufacturing | 58 | Plastic products |
| Manufacturing | 59 | Miscellaneous manufacturing industries |

*(continued)*

| | | |
|---|---|---|
| - | 60 | Construction |
| - | 61 | Civil engineering |
| Energy-related | 62 | Electricity |
| Energy-related | 63 | Gas, heat supply |
| Energy-related | 64 | Waterworks |
| Energy-related | 65 | Water supply for industrial use |
| Services | 66 | Waste disposal |
| Services | 67 | Wholesale |
| Services | 68 | Retail |
| Services | 69 | Finance |
| Services | 70 | Insurance |
| Services | 71 | Real estate |
| Services | 72 | Housing |
| Services | 73 | Railway |
| Services | 74 | Road transportation |
| Services | 75 | Water transportation |
| Services | 76 | Air transportation |
| Services | 77 | Other transportation and packing |
| Services | 78 | Telegraph and telephone |
| Services | 79 | Mail |
| Services | 80 | Education (private and non-profit) |
| Services | 81 | Research (private) |
| Services | 82 | Medical (private) |
| Services | 83 | Hygiene (private and non-profit) |
| Services | 84 | Other public services |
| Services | 85 | Advertising |
| Services | 86 | Rental of office equipment and goods |
| Services | 87 | Automobile maintenance services |
| Services | 88 | Other services for businesses |
| Services | 89 | Entertainment |
| Services | 90 | Broadcasting |
| Services | 91 | Information services and internet-based services |
| Services | 92 | Publishing |
| Services | 93 | Video picture, sound information, character information production and distribution |
| Services | 94 | Eating and drinking places |
| Services | 95 | Accommodation |
| Services | 96 | Laundry, beauty and bath services |
| Services | 97 | Other services for individuals |
| Services | 98 | Education (public) |
| Services | 99 | Research (public) |
| Services | 100 | Medical (public) |
| Services | 101 | Hygiene (public) |
| Services | 102 | Social insurance and social welfare (public) |
| Services | 103 | Public administration |
| Services | 104 | Medical (non-profit) |
| Services | 105 | Social insurance and social welfare (non-profit) |
| Services | 106 | Research (non-profit) |
| Services | 107 | Other (non-profit) |
| - | 108 | Activities not elsewhere classified |

**Table A2. Summary Statistics**

| Variable | No. of Observations | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Total Factor Productivity Growth | 1300 | 0.01 | 0.056 | -0.674 | 0.608 |
| Service Link via TFP | 1300 | 0.002 | 0.004 | -0.015 | 0.032 |
| Service Link via Value Added per Worker | 1300 | 2.245 | 0.953 | 0.278 | 6.601 |
| Service Link via Labor Quality Index | 1300 | 0.287 | 0.098 | 0.044 | 0.588 |
| Service Link via Technical Worker Share | 1300 | 0.017 | 0.016 | 0 | 0.119 |
| Service Link via Service Worker Share | 1300 | 0.021 | 0.016 | 0 | 0.074 |
| Service Link via IT Capital Stock Share | 1300 | 0.019 | 0.011 | 0.002 | 0.068 |
| IT Capital Stock Share | 1300 | 0.081 | 0.063 | 0.005 | 0.366 |
| Skilled Worker Share | 1300 | 0.331 | 0.085 | 0.149 | 0.613 |
| Import Share | 1300 | 0.082 | 0.103 | 0.00006 | 0.689 |
| **First Difference Specification** | | | | | |
| Total Factor Productivity Growth | 1250 | -0.00082 | 0.079 | -1.282 | 0.763 |
| Service Link via TFP | 1250 | -0.0002 | 0.006 | -0.028 | 0.022 |
| Service Link via Value Added per Worker | 1250 | -0.05 | 0.156 | -1.501 | 2.117 |
| Service Link via Labor Quality Index | 1250 | -0.002 | 0.016 | -0.159 | 0.223 |
| Service Link via Technical Worker Share | 1250 | -0.001 | 0.006 | -0.098 | 0.011 |
| Service Link via Service Worker Share | 1250 | -0.001 | 0.006 | -0.06 | 0.012 |
| Service Link via IT Capital Stock Share | 1250 | -0.001 | 0.001 | -0.011 | 0.018 |
| IT Capital Stock Share | 1250 | 0.004 | 0.008 | -0.057 | 0.054 |
| Skilled Worker Share | 1250 | 0.002 | 0.007 | -0.025 | 0.039 |
| Import Share | 1250 | 0.005 | 0.017 | -0.127 | 0.131 |

**Table A3. GMM Estimation of Service Link for 1980-2005**

Dependent variable: TFP Growth Rate in Manufacturing Sectors

| Variable | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Service Link via TFP | 0.843 | | | | | |
| | (1.118) | | | | | |
| Service Link via Value Added per Worker | | 0.003 | | | | |
| | | (0.002) | | | | |
| Service Link via Labor Quality Index | | | 0.017 | | | |
| | | | (0.017) | | | |
| Service Link via Technical Worker Share | | | | 0.193* | | |
| | | | | (0.095) | | |
| Service Link via Service Worker Share | | | | | 0.173 | |
| | | | | | (0.135) | |
| Service Link via IT Capital Stock Share | | | | | | 0.362 |
| | | | | | | (0.211) |
| IT Capital Stock Share | 0.102 | 0.118 | 0.125 | 0.119 | 0.111 | 0.118* |
| | (0.065) | (0.067) | (0.067) | (0.067) | (0.063) | (0.055) |
| Skilled Worker Share | 0.021 | 0.010 | 0.012 | 0.010 | 0.018 | 0.012 |
| | (0.015) | (0.015) | (0.015) | (0.015) | (0.015) | (0.014) |
| Import Penetration Share | -0.002 | 0.011 | 0.000 | 0.004 | 0.016 | 0.011 |
| | (0.027) | (0.029) | (0.029) | (0.026) | (0.028) | (0.031) |
| Year Dummy | Yes | Yes | Yes | Yes | Yes | Yes |
| Sector Dummy | No | No | No | No | No | No |
| Observations | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 |
| R-square | 0.047 | 0.055 | 0.053 | 0.055 | 0.055 | 0.055 |
| Hansen J Statistics (p-value) | 0.590 | 0.327 | 0.256 | 0.804 | 0.853 | 0.532 |

Note: Robust standard errors clustered at the industry are in parentheses, with ***, **, and * indicating the 1, 5, and 10 percent significance levels, respectively; a constant term is not reported; instruments for service link variables are first- and second-lags of the service link as well as service linkage variables constructed with regulation index and foreign investment in the corresponding service sectors, taken from the JIP 2009.

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