Korean augmented production function:

The role of services and other factors

in Korea’s economic growth

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Abstract

It is well known that economic growth and services have a positive association. Especially, the more
developed an economy is, the higher the share of the services sector. Economic structural changes and
economic development have drawn a considerable academic interest. Initially, many investigators such as
Fisher (1935), Clark (1940), Baumol(1967), Fuchs(1980), Inman(1985), Raa and Wolff(1996), Fixler and
Siegel(1999) have researched on this.

While most research has focused on service output, this study centers on the services as input. Services
are an important input for growth of manufacturing and even the sector of services. Particularly, the
interrelation between manufacturing and service input exists because the complexity of manufacturing
production and distribution is increased. However, this issue has received little attention in academic
research and empirical economics. Empirical studies on production function or productivity on an industry
level were performed mostly with a two- input framework prior to the 1980s. In this case, we can not
explicitly identify the role of services in the production process and economic growth. Studies undertaken
in the 1980s and later use the KLEM (capital-labor-energy-materials) production function framework in
which the role of materials and energy can be recognized additionally, but the role of services still cannot
be explicitly included. Recently, the need for taking services a separate input in the production function has
come to the fore. Therefore, the OECD productivity manual (OECD, 2001) generalizes the KLEM model
to KLEMS (capital-labor-energy-materials-services) model by including the services as an input. Thus, the
EU constructed EUKLEMS database for the international comparison of productivity among nations.

Even though the KLEMS production framework is used, an unexplained part still remained. It is usually
called the Solow residual or total factor productivity (TFP). Total factor productivity includes technological
(technical) innovations (TIs) and organizational innovations (OIs). Although many scholars have
emphasized the importance of TIs and some of OIs, there has been limited research about OIs in Korea. For what is worth, TIs have been used in some research. Therefore, this study will extend the research boundary to OIs to be included in production functions. Sanidas (2005) conducted research about OIs for the USA and Japan cases. According to his research the inventory to sales ratio was used as a well justified proxy for JIT/TI which is representative of OIs. More recently, Lim and Sanidas (2010) have provided similar and more rigorous evidence on the role of OIs in Korea. Thus, in our paper we will include OIs and TIs as control variables in order to estimate production functions.

Ultimately, this study aims at indentifying the role of services in Korea’s economic growth and the contribution of services to each industry using the KLEMS production function framework which includes capital, labor and intermediate inputs (energy, materials, services) plus some other control variables such as OIs and TIs. Thus, we can examine the role of service input separately. First, we want to look into service input share and its effect on Korean economic growth over time (1970–1980). Moreover, through analyzing data by industry, linkages between each industry (manufacturing and services) and service input can be specified. Korea’s service output share is the lowest in OECD countries and service input share is also lower than other advanced countries. This study will provide the reason for that. Secondly, we want to explain the unexplained TFP part by estimating newly established KLEMS production function which considers “OIs”. We would like to examine the production function with OIs and compare results between the models which include the OIs factor and the models which do not (the same applies for TIs). In addition, we will examine the effect of OIs by industries since it seems that OIs of service sectors are different from that of manufacturing. This analysis is valuable because OIs were introduced and developed remarkably during the 1980s and 1990s and up to now in Korea.
I. Introduction

It is well known that economic growth and services have a positive association. Especially, the more developed an economy is, the higher share of a services sector it has as a percentage of GDP. Economic structural changes and economic development have drawn a considerable academic interest. Basically, there are two main views about this topic.

Firstly, Fisher (1935) and Clark (1940) explained a structural shift as being demand driven. Structural change is caused by the difference between income elasticity of demand for goods and that for services. Summers (1985) and Baumol (1985) showed that income per capita and the share of a services sector might have a positive relationship on nominal basis but not in real basis (PPP). In contrast, Schettkat and Yocarini (2005) said that the share of services in final demand increases on a constant price basis as well as on a current price basis as per capita income increases. Second, Baumol (1967) and Fuch (1968) tried to explain this in a different way. They believed structural change is based on the supply side. According to “Baumol’s disease hypothesis”, resources are moved from the high efficient sector to the low efficient sector. Therefore, the economy shifts to the service economy as resources move from manufacturing (high productivity) to a services sector (low productivity).

In addition, there are empirical researches which examine the role of services in economic growth. Kuznetz (1968, 1972) and Marshall and Wood(1995) empirically verified the structural change in advanced economies. Francois and Reinert(1996) Kongsamut et al (1997) found that the share of services raises with the level of development through cross-country analysis. There is a positive relationship between the level of per capita income and the intensity of use of services in the manufacturing sector. Guerrieri and Meliciani (2003) recognized that services procured from services provider companies are becoming important to manufacturing. The close relationship between manufacturing and services and a diversified production process raise the content of services inputs for manufactured goods.

Although most researches have focused on services outputs, this study centers on services as an input by estimating a production function. The most commonly used production functions for dealing with issues of growth and productivity are the Cobb-Douglas, constant elasticity of substitution (CES), and translogarithmic. Traditional production functions employ capital and labor as factor inputs. Sometimes, capital and labor are supplemented by land, materials or energy. However empirical studies on production function or productivity were performed mostly with a two-input framework prior to the 1980s. In this case, we can not explicitly identify the role of services in the production process and economic growth. Studies undertaken in the 1980s and later use the KLEM (capital-labor-energy-materials) production function framework in which the role of materials and energy can be recognized additionally, but the role of services still cannot be explicitly specified. Recently, the need for taking services a separate input in the production function has come to the fore. Therefore, the OECD productivity manual (OECD, 2001) generalizes the KLEM model to KLEMS (capital-labor-energy-materials-services) model by including a services input. Thus, the EU constructed EUKLEMS database. Banga and Goldar (2004) analyze the contribution of services to output growth and productivity in Indian manufacturing using the KLEMS framework with data of 148 industries for 18 years. Their analysis reveals that increased use of services has a positive effect on output growth in Indian manufacturing in the 1990s. Moreover, he constructed a multilateral total factor productivity index (MTFP) to study the impact of services inputs on manufacturing
productivity. He found that the productivity growth estimated for the post-reforms period is overstated when services are not considered.

There is some research on estimating the production function for Korean industries. Kim and Koo (1999) estimate an aggregate production function of manufacturing industries using panel data for 11 Korean regions covering 1977-1992. This study investigates the relationship between infrastructure and technical efficiency. Kim and Wang (2001) estimate a generalized production function. Using 330 companies’ data of 9 manufacturing industries, they can get the elasticity of each input factor and calculate the TFP growth rate by industry. They also estimate the effect of various factors such as size of firms, payment, market share on TFP growth. Shin (2005) investigates the shape of the aggregate production function of Korea using the constant elasticity of substitution (CES) production function. An empirical investigation was made over the 1970-2004 time period. Mostly, discussions about growth of the Korean economy presume a Cobb-Douglas production function. Other recent studies are those of Chung et al (2006), and Park and Ryu (2006. Note that none of these papers explores the CLEMS data as we do in the present study.

Another issue in estimating a production function is the existence of unexplained part (residual). It is usually called the Solow residual or total factor productivity (TFP). Total factor productivity includes technological (technical) innovations (TIs) and organizational innovations (OIs). Although many scholars have emphasized the importance of TIs and some of OIs, there has been limited research about OIs in Korea. For what is worth, TIs have been used in some researches. Therefore, this study will extend the research boundary to OIs to be included in production functions. Sanidas (2005) conducted research about OIs for the USA and Japan cases. According to his research the inventory to sales ratio was used as a well justified proxy for JIT/TI which is representative of OIs. More recently, Lim and Sanidas (2010) have provided similar and more rigorous evidence on the role of OIs in Korea. Cainelli (2008) analyzes the impact of innovative activities and agglomeration effects on firm’s productivity. He estimated the augmented Cobb-Douglas function to account for the impact of technological innovation and district-specific agglomeration effects on a firm’s productivity growth. His empirical results show that belonging to an industrial district and making product innovations are key factors in the productivity growth of firms. Lopez (2009) examined the relationship between OIs (in particular outsourcing) and productivity using an unbalanced panel of Spanish manufacturing firms. By developing and estimating a theoretical framework, he justified the addition of outsourcing measures to the specification of a “traditional” production function. He found that outsourcing intensity has a positive effect on productivity, mainly for firms belonging to light manufacturing industries.

This study aims at indentifying the role of services in Korea’s economic growth and the contribution of services to each sector using the KLEMS production function framework which includes capital, labor, intermediate inputs (energy, materials, services) and other control variables such as OIs and TIs. Thus, we can examine the role of services inputs separately. First, we look into the role of services inputs on Korean economic growth over time (1970-2005). Secondly, we examine how differently services input affects on each sector (manufacturing and services) before and after the financial crisis. Thirdly, we explain the TFP part by estimating the newly established KLEMS production data in which we also consider “OIs”. We compare results between the models which include the OIs factor and the models which do not (the same applies for TIs). In addition, we examine the effect of OIs by sector since it seems that the effect of OIs on a services sector is different from that on manufacturing. This analysis is valuable because OIs were introduced and developed remarkably during the 1980s and 1990s in Korea (Yoo, 2001).


II. Services in Korean economy

1. The role of services as outputs in Korea economy

The share of services outputs in GDP has steadily increased and it went up to 68.7% in 2007. On the contrary, the share of agriculture, mining and quarrying outputs has decreased since the 1970s and recorded 3.3% in 2007, down from 31% in 1970 as Figure II-1 shows. By the end of 1980s, shares of both manufacturing and services have increased. However, the share of services outputs has shown upward tendency and that of manufacturing has shown downward tendency since the early 1990s. On the contrary the sector of agriculture has been steadily decreasing.

**Figure II-1 The share of services output in Korean economy’s Nominal GDP**

(Unit: %)

Korea’s services share is the lowest among OECD countries of 68.7% in 2007. According to Figure II-2, the USA and UK have high services share of 84.2% and 84.1% respectively. As examined above, although Korea’s services industry has grown significantly, it still is the lowest percentage compared to other advanced countries as seen in Figure II-2.
Services play an important role not only as an output but also as an intermediate input. Further, its importance as an intermediate input, which is classified as producer services has increased recently. Figure II-3 shows the share of each input\(^1\) (services, energy, materials) out of total intermediate inputs in Korean economy. The share of a services input has increased drastically since the late 1980s when the share of services outputs started to increase. Therefore, the increase of the services input is accompanied by the increase in services outputs. While the share of materials has decreased sharply since the end of the 1980s, the share of services inputs has increased remarkably since that time. The share of energy has decreased since the mid 1980s, but it has increased again since the mid 1990s. Therefore, it seems that the services input replaced materials. Of course, this might have happened only in some industries.

As the competition among firms is deepened, the demand for professional services has increased to improve product competitiveness. Production supporting services, which were procured within the companies in the past, depend on outsourcing more recently due to increased trend in information, knowledge and specialization (Guerrieri and Meliciani, 2003). More precisely, the proportion of financial services, business services has increased while that of wholesale and retail trade, accommodation, and restaurant and personal services has decreased. Financial services and business services are typical producer services which are usually used as an input. Therefore, this reflects that the importance of producer services as an input has been used more and more, in modern business.

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\(^{1}\) Intermediate inputs are decomposed into energy, materials, and services inputs; we have identified coal and lignite, crude petroleum and natural gas, uranium and thorium ores, metal ores, coke, refined petroleum products and nuclear fuel, gas, water, and electricity commodities as energy inputs; both primary commodities and remaining manufacturing commodities as material inputs, and remaining service inputs as service inputs
In Table II-1, we can see the detailed movement of the contribution of each input to output growth over time (1970-2005). Also, the different role of services inputs for total industry, manufacturing and services is specified. In terms of proportion to total output growth, the contribution of a services input takes up 8.27% in the 1970s and increased up to 21.99% in the 2000s. The contribution of a services input to services outputs was 10.8% in the 1970s and it increased up to 26.4% in the early 2000s while that of a services input to manufacturing sector recorded 5.32% in the 1970s and 16.02% in the 2000s. From this analysis, we deduct that the contribution of services inputs to services outputs is much bigger than that of services inputs to manufacturing. It shows that the role of a services input is becoming more important as Korea economy develops.
<Table Π-1> Contributions to output growth (Total industry, Manufacturing, Services)  
(Unit: %)

| Period          | Output Growth (1) | Intermediate input (2) | Materials (3) | Energy (4) | Services (5) | Labor (6) | Capital (7) | TFP (8) |
|-----------------|-------------------|------------------------|---------------|------------|--------------|-----------|-------------|--------|
| Total           |                   |                        |               |            |              |           |             |        |
| 1971-1980       | 8.06              | 4.48                   | 2.80          | 1.02       | 0.67 (8.27)  | 2.12      | 1.58        | -0.13  |
| 1981-1990       | 10.69             | 6.26                   | 4.31          | 0.66       | 1.29 (12.09) | 1.58      | 1.04        | 1.81   |
| 1991-2000 (exl.1998) | 8.31              | 4.73                   | 2.38          | 0.75       | 1.60 (19.23) | 1.11      | 0.93        | 1.55   |
| 2001-2005       | 4.66              | 3.12                   | 1.73          | 0.36       | 1.02 (21.99) | 0.69      | 0.44        | 0.41   |

| Period          | Output Growth (1) | Intermediate input (2) | Materials (3) | Energy (4) | Services (5) | Labor (6) | Capital (7) | TFP (8) |
|-----------------|-------------------|------------------------|---------------|------------|--------------|-----------|-------------|--------|
| Manufacturing   |                   |                        |               |            |              |           |             |        |
| 1971-1980       | 8.74              | 6.56                   | 4.50          | 1.59       | 0.46 (5.32)  | 0.34      | 0.88        | 0.96   |
| 1981-1990       | 12.69             | 9.63                   | 7.45          | 1.14       | 1.03 (8.12)  | 0.79      | 0.80        | 1.47   |
| 1991-2000 (exl.1998) | 8.66              | 6.44                   | 4.06          | 1.24       | 1.15 (13.22) | 0.15      | 0.63        | 1.44   |
| 2001-2005       | 5.15              | 4.18                   | 2.94          | 0.42       | 0.82 (16.02) | 0.07      | 0.34        | 0.56   |

| Period          | Output Growth (1) | Intermediate input (2) | Materials (3) | Energy (4) | Services (5) | Labor (6) | Capital (7) | TFP (8) |
|-----------------|-------------------|------------------------|---------------|------------|--------------|-----------|-------------|--------|
| Services        |                   |                        |               |            |              |           |             |        |
| 1971-1980       | 8.40              | 3.11                   | 1.60          | 0.60       | 0.91 (10.81) | 3.75      | 2.23        | -0.69  |
| 1981-1990       | 9.79              | 4.05                   | 2.05          | 0.39       | 1.61 (16.42) | 2.48      | 1.31        | 1.95   |
| 1991-2000 (exl.1998) | 8.92              | 4.12                   | 1.34          | 0.50       | 2.27 (25.47) | 2.21      | 1.33        | 1.26   |
| 2001-2005       | 4.65              | 2.39                   | 0.85          | 0.31       | 1.23 (26.47) | 1.45      | 0.61        | 0.20   |

Note: i ) (2) is equal to (3)+(4)+(5)  
ii ) (1) is equal to (2)+(6)+(7)+(8)  
iii ) Numbers in parentheses are the respective contributions to gross output growth  
Source: “As calculated by authors based on EUKLEMS data”
III. Empirical analysis

1. Data and methodology

This empirical study uses the KLEMS Database which has a separated services input data. Moreover, it has long and continuous time series whereas the Bank of Korea’s Input-Output Table is constructed every 5 years. Industry classification of KLEMS is based on NACE\(^2\) which is compatible with ISIC\(^3\). Thus, we can easily match the KLEMS database with other international and Korean industrial data. This study also uses KISS VALUE (firm level data) which covers the period from 1980 to 2009 while the KLEMS Database (industry level data) covers the period from 1970 to 2005 (see Table III-1). Variables that are related to OIs and/or TIs (inventories, R&D, education and training expenditure, debt, sales) are collected from the KISS VALUE database. Since the industry classification of KISS VALUE follows KSIC, we matched all data to the KLEMS industry classification. Our analysis is conducted over 26 years (1980-2005) and 22 industries (see Appendix 1).

| Table III-1  Data Coverage and Sources |
|----------------------------------------|
| Data | KLEMS | KISS VALUE |
| Code | NACE | KSIC |
| Unit of analysis | Industry | Company |
| period coverage | 1970-2005 | 1980-2005 |
| Industry classification | Total: 24 industries Agriculture: 2 industries Manufacturing: 11 industries Services: 11 industries | Total: 22 industries Agriculture: 2 industries Manufacturing: 11 industries Services: 9 industries |

Source: Summarized by Authors

The econometric analysis of this study is based on the augmented Cobb-Douglas (Cainelli, 2008) function which includes OIs and TIs factors. The inventories to sales ratio is used as proxy for OIs. The R&D to sales ratio has been also accepted as the proxy for TIs. Other control variables are the education expenditure to sales ratio and the debt to sales ratio.

Model: \(Y = F(K, L, E, M, S, OIs, TIs, edu, debt, unexplained^4)\) \hspace{1cm} (1)

\[ Y: \text{gross Output (or value added)}, \]

\(^2\) NACE is a European industry standard classification system consisting of a 6 digit code

\(^3\) ISIC (International Standard Industrial Classification) is a United Nations system for classifying economic data

\(^4\) This part is captured by the constant in regression
2. Regression results

The estimation results of production function are shown in Table III-2. The estimation is conducted for total industry first and it has similar results in FE and RE. However, we will explain the results with the FE model which is more adequate according for the Hausman test. There are three FE models. FE model 1 is the traditional production model which has only accounting variables. FE model 2 is the augmented production function in which we are interested. This model shows us the effect of the extra variables (OIs, TIs, education expenditure ratio, debt ratio). To examine the result by industry, we use FE model 3. This model does not have a constant term because it includes dummies for all industries.

From the results for the augmented production function, we can discern several conclusions. First, we can see the negative coefficients for the inventory ratio and the debt ratio as expected. This means that, the lower inventory ratio and debt ratio an industry has, the more output it can achieve. The low inventory ratio is the indicator of efficient production systems which are accomplished by organizational innovations (Sanidas, 2005, Lim and Sanidas, 2010). The low debt ratio indicates financial strength (Groppelli, 2000). Other factors such as R&D (TIs) and education expenditure ratio have positive effects on outputs. Second, we see that the coefficients of services input in FE Model 2 and FE Model 3 are smaller than that of services input in FE Model 1. This brings out the possibility that the effect of services inputs is over-estimated with the traditional production function. The effect of a services input goes down if we add these new variables. Thus we can infer that the extra variables we introduce are closely related to the services input. Third, compared to the constant of FE Model 1, the constant of FE Model 2 is smaller. Therefore, some of unexplained part in (1) is identified by introducing the OIs and TIs factors. Fourth, Table III-3 also shows the individual industry effect. Generally, the services industries have bigger constants, which means that the effect of other factors (not explicitly added here) are crucial in services industries. Especially, it shows that the financial intermediation and education industries are more affected by other, not included here, factors.
**Table III-2 Estimation results (Total Industry)**

| Variable               | FE         | Model 2     | Model 3     | Model 1     | Model 2     |
|------------------------|------------|-------------|-------------|-------------|-------------|
| lnE                    | 0.130***   | **0.145***  | 0.128***    | 0.128***    | **0.145***  |
| lnM                    | 0.290***   | **0.516***  | 0.500***    | **0.283***  | **0.429***  |
| lnS                    | **0.299*** | **0.174***  | **0.202***  | **0.292***  | 0.218***    |
| lnL                    | **0.123*** | **0.145***  | 0.138***    | 0.133***    | **0.159***  |
| lnK                    | 0.139***   | **0.088***  | 0.073***    | 0.156***    | **0.107***  |
| L.ininventories        | -0.002**   | -0.001**    | -0.001**    | -0.001**    | -0.001**    |
| L.inrd                 | 0.004***   | 0.003***    | 0.003***    | 0.009**     | 0.009**     |
| Inedu                  | **0.023*** | 0.017***    | 0.017***    | 0.018***    | 0.018***    |
| Indebt                 | 0.031***   | 0.023***    | 0.023***    | -0.018**    | -0.018**    |
| constant               | 3.142***   | **2.063***  | 3.040***    | 2.391***    |

**Agriculture, fishing and mining**

- Agriculture, hunting, forestry and fishing: 2.793***
- Mining and quarrying: 3.095***

**Manufacturing**

- Food, beverages and tobacco: 2.230***
- Textiles, textile, leather and footwear: 1.984***
- Wood and of wood and cork: 2.160***
- Pulp, paper, paper, printing and publishing: 2.170***
- Chemical, rubber, plastics and fuel: 2.235***
- Other non-metallic mineral: 2.144***
- Basic metals and fabricated metal: 2.152***
- Machinery, nec: 2.172***
- Electrical and optical equipment: 2.188***
- Transport equipment: 2.227***
- Manufacturing nec; recycling: 2.135***

**Services**

- Electricity, gas and water supply: 2.705***
- Construction: 2.313***
- Wholesale and retail trade: 2.531***
- Hotels and restaurants: 2.156***
- Transport and storage and communication: 2.403***
- Financial intermediation: 3.776***
- Real estate, renting and business activities: 2.639***
- Education: 3.119***
- Other community, social and personal services: 2.479***

|                      | Number of Obs. |          |          |          |          |
|----------------------|----------------|----------|----------|----------|----------|
|                      | within         | 0.965    | 0.984    | 0.986    |          |
| R2                   | between        | 0.918    | 0.787    |          |          |
|                      | overall        | 0.935    | 0.912    |          |          |

Legend: * p<0.1; ** p<0.05; *** p<0.01
We can confirm the FE estimation result by also using the GMM approach, which takes into account the endogeneity problem of some or all variables (see references ...). In Table III-3, GMM model 1 is the traditional production function and GMM model 2 is the augmented production function. Comparing models 1 and 2, we can see that the effect of energy and labor increases when passing from model 1 to 2 and the effect of material, services, capital decreases. The inventories ratio and debt ratio have negative coefficients whereas the education expenditure ratio and R&D ratio have positive coefficients. The coefficient of services input decreases when estimating the augmented production function. Although the difference is not that large, there is still possibility of over-estimating in the traditional production function. An other salient point is that the constant increased in the augmented model due to the inclusion of the extra (not accounting) variables.

Table III-3 GMM Estimation results (Total Industry)

| Dependent Variable: lnY | GMM Model 1       | GMM Model 2       |
|-------------------------|-------------------|-------------------|
| lnE                     | 0.098***          | 0.123**           |
| lnM                     | 0.345***          | 0.328***          |
| lnS                     | 0.279***          | 0.271***          |
| lnLH                    | 0.120**           | 0.162***          |
| lnK                     | 0.141**           | 0.121**           |
| L.Ininventory           |                   | -0.036***         |
| lnrd                    |                   | 0.013**           |
| Ineducation             | 0.092*            |                   |
| lnDebt                  | -0.037***         |                   |
| _cons                   | 2.813***          | 3.411***          |

|                           | Number of Obs.    | Number of group |
|---------------------------|-------------------|-----------------|
|                           | 550               | 22              |
| Arellano-Bond test for AR(1) in first differences | z =2.16 Pr>z=0.031 | z =-2.04 Pr>z=0.042 |
| Arellano-Bond test for AR(2) in first differences | z =1.78 Pr>z=0.075 | z =1.08 Pr>z=0.279 |
| Sargan test of overid. restrictions | chi2(13)=7.58 Prob>chi2=0.130 | chi2(6)=12.51 Prob>chi2=0.051 |
| Hansen test of overid. restrictions | chi2(13)=15.34 Prob>chi2=0.287 | chi2(6)=4.11 Prob>chi2=0.661 |

Table III-4 compares our results between the manufacturing and the services sectors. Generally, the effect of energy, materials and labor is larger in manufacturing than those in services whereas the effect of services and capital inputs is lower in manufacturing than those in services sector as expected. Also, the inventory ratio has a negative coefficient in manufacturing while it is not significant in services. This is reasonable because a services sector lags behind manufacturing in terms of OIs. On the other hand, the debt ratio has negative effect on outputs for all sectors, manufacturing and services separately. Although the coefficient of the inventory ratio in
manufacturing is larger than in total industry, the difference is trivial. However, the difference of the debt ratio’s coefficient is considerable. The debt ratio has less effect on manufacturing than that on services. R&D (TIs) and education expenditure have consistently positive coefficients in all three cases. Regarding the services input, the coefficient of the services input in services outputs is much larger than that of a services input in manufacturing, which proves that services as an input is more substantial in services sector than in manufacturing as expected. Concerning the other variables, materials and labor have bigger coefficients in manufacturing than in services and the capital input has smaller coefficient in manufacturing than in services sector as expected. In the case of energy, it is not significant in services and its coefficient in manufacturing is somehow larger than that in services. Lastly, the constant for services is largest among three cases. This means that the services sector is influenced by many other factors which are not specified yet, in any study (as per literature review).

Table III-4 Comparison of estimation results between manufacturing and services sectors

| Dependent Variable | Total Industry | Manufacturing | Services |
|--------------------|----------------|---------------|----------|
| lnE                | 0.145***       | 0.149***      | 0.008    |
| lnM                | 0.516***       | 0.603***      | 0.370*** |
| lnS                | 0.174***       | 0.149***      | 0.273*** |
| lnL                | 0.145***       | 0.117***      | 0.078**  |
| lnK                | 0.088***       | 0.037***      | 0.223*** |
| L.Ininventory      | -0.002**       | -0.003**      | 0.006    |
| lnrd               | 0.004***       | 0.005**       | 0.020*   |
| lneducation        | 0.023***       | 0.000*        | 0.045*** |
| lndebt             | -0.031***      | -0.001*       | -0.072***|
| _cons              | 2.063***       | 1.546***      | 3.257*** |

R2 within 0.984 0.996 0.968
between 0.787 0.993 0.498
overall 0.912 0.994 0.897
Number of Obs. 477 268 163
Number of Industry 22 11 9

Table III-5 compares results between before and after the 1998 Financial Crisis. We can track the change of each input’s effect for manufacturing and services sector through this comparison. First, looking into the case of total industry, it shows us significant results for “before the Financial Crisis” while it does not for “after the Financial Crisis”. For manufacturing, the effect of a services input and the inventory ratio increased after the financial crisis. It is well known that Korea’s firms are re-organized after the Financial Crisis (Haggard, 2001). As part of this re-organization (some of OIs), many manufacturing firms improved their production system more efficiently, and started to procure services from outside their firms. Another important point is that
the coefficient of the debt ratio increased. This means that output was affected more easily by financial conditions after the Financial Crisis.

On the contrary, for the services sector, the coefficient of the services input goes down after the Financial Crisis. Thus, we find that the services sector does not increase services outsourcing compared to manufacturing sector or the effect of a services input decreases after the financial crisis. Although the effect of the inventory ratio increases, the difference is trivial. The effect of the debt ratio increases while the effect of R&D decreases. In particular, the sign of the education ratio’s coefficient is changed from positive to negative. This shows that the importance of education expenditure has less effect than other factors such as the efficient production system (inventory ratio) and financial conditions (debt ratio) on output after the Financial Crisis.

Table III-5 Before and After the 1998 Financial Crisis

| Dependent Variable | Before financial crisis | After financial crisis |
|--------------------|-------------------------|------------------------|
|                    | Total                   |                        |
| lnE                | 0.162***                | 0.094                  |
| lnM                | 0.446***                | 0.734***               |
| lnS                | 0.127***                | 0.049                  |
| lnL                | 0.272***                | 0.016                  |
| lnK                | 0.176***                | 0.027                  |
| L. lnininventory   | -0.004**                | 0.001                  |
| lnrd               | 0.001*                  | 0.012**                |
| lneducation        | 0.019***                | 0.016**                |
| lndebt             | -0.022***               | -0.002**               |
| _cons              | 1.363***                | 2.974***               |
| R2                 |                         |                        |
| within             | 0.9863                  | 0.9669                 |
| between            | 0.9156                  | 0.7101                 |
| overall            | 0.946                   | 0.7191                 |
| Number of obs      | 295                     | 140                    |
| Number of industry | 22                      | 22                     |

| Dependent Variable | Manufacturing           |
|--------------------|-------------------------|
| lnE                | 0.172***                |
| lnM                | 0.579***                |
| lnS                | **0.094***              |
| lnL                | 0.213***                |
| lnK                | 0.100***                |
| L. lnininventory   | -0.003**                |
| lnrd               | 0.007**                 |
| lneducation        | 0.017***                |
In this section, we also include the summary of coefficients as estimated in our models. One reason for doing this is to check for the existence of economies of scale. In Table III-6, we compare results from our different types of production functions. The estimation result of the non-augmented production reveals that Korea has diseconomies of scale or at the most constant returns to scale (about 0.98 to 0.99), however, the estimation results of augmented production function, to which we added extra variables, shows that Korea achieves economies of scale (FE 2) or constant return to scale (RE 2, GMM).

Table III-6 Summary of coefficients and indication of economies of scale for total industry

| Types of Function | Non-Augmented Production Function | Augmented Production Function |
|-------------------|-----------------------------------|-------------------------------|
|                   | FE 1 | RE 2 | GMM 1 | FE 2 | RE 2 | GMM 1 |
| lmE               | 0.13 | 0.128 | 0.098 | 0.145 | 0.145 | 0.123 |
| lnM               | 0.29 | 0.283 | 0.345 | 0.516 | 0.429 | 0.328 |

legend: * p<0.1; ** p<0.05; ***p<0.01
If we look at the result by sector (see Table III-7 the columns indicating “whole period”), there are economies of scale in total industry and manufacturing; however, services have diseconomies of scale. If we split up for before and after the 1998 financial crisis (see Table III-7), the results reveal different trends for each sector. For total industry, there are still economies of scale before the financial crisis, but there is not any more after the financial crisis. Manufacturing achieves economies of scale before the financial crisis but these economies are substantially reduced after the financial crisis. In regard of services sector, it has achieved economies of scale before the financial crisis and these economies have substantially increased after the financial crisis.

### Table III-7 Summary of coefficients and indication of before and after the 1998 Financial Crisis

| Sectors | Total | Manufacturing | Services |
|---------|-------|---------------|----------|
| Before/After the 1998 financial crisis | Whole period | Before | After | Whole period | Before | After | Whole period | Before | After |
| ln\(E\) | 0.145 | 0.162 | 0.094 | 0.149 | 0.172 | 0.163 | 0.008 | 0.071 | 0.330 |
| ln\(M\) | 0.516 | 0.446 | 0.734 | 0.603 | 0.579 | 0.568 | 0.37 | 0.331 | 0.222 |
| ln\(S\) | 0.174 | 0.127 | 0.049 | 0.149 | 0.094 | 0.313 | 0.273 | 0.162 | 0.023 |
| ln\(L\) | 0.145 | 0.272 | 0.016 | 0.117 | 0.213 | 0.017 | 0.078 | 0.248 | 0.445 |
| ln\(K\) | 0.088 | 0.176 | 0.027 | 0.037 | 0.100 | 0.025 | 0.223 | 0.277 | 0.148 |
| Total of accounting variables’ coefficients | 1.068 | 1.183 | 0.920 | 1.055 | 1.158 | 1.086 | 0.952 | 1.089 | 1.168 |
| L.\(\text{In}\)\(\text{invent}\) | -0.002 | -0.004 | 0.001 | -0.003 | -0.003 | -0.020 | 0.006 | -0.012 | -0.038 |
| ln\(rd\) | 0.004 | 0.001 | 0.012 | 0.005 | 0.007 | 0.026 | 0.02 | 0.035 | 0.011 |
| ln\(educ\) | 0.023 | 0.019 | 0.016 | 0.000 | 0.017 | 0.013 | 0.045 | 0.036 | -0.079 |
| ln\(\text{debt}\) | 0.031 | -0.022 | -0.002 | -0.001 | -0.009 | -0.015 | -0.072 | -0.063 | -0.124 |
| Total of the extra variables’ coefficients | 0.056 | -0.006 | 0.027 | 0.001 | 0.012 | 0.004 | -0.001 | -0.004 | -0.230 |
| constant | 1.363 | 2.974 | 1.546 | 0.971 | 1.361 | 3.257 | 2.554 | 2.728 |
IV. Discussion, Implications and Conclusions

This paper has attempted to examine the role of services as both as output and input. The overview of Korea’s services sector provided with the general observation that Korea’s services outputs has grown rapidly since the early 1990s and, accordingly, a services input has increased in the same period having replaced other intermediate inputs such as materials and energy. Particularly, it is noticeable that the contribution of services input to services outputs is much larger than that of a services input to manufacturing. This is verified in our empirical study.

This paper examines the augmented production function, which includes OIs and TIs, as well as other factors using panel analysis. From this analysis, we find that the effect of services inputs and capital can be over-estimated when we estimate a traditional production function. Our results show that services industries are also dependent on other unexplained factors in addition to classical inputs (capital, labor, intermediates). Regarding the extra introduced variables, the inventories ratio (OIs) and the debt ratio have a positive effect on outputs (via a negative coefficient). The R&D (TIs) ratio and the education expenditure ratio have positive effect on outputs (with positive coefficient) as expected. Moreover, the decreased constants in the augmented production function confirm that some unexplained part of the residual error can be specified with these additional variables.

From the comparison of the role of a services input between manufacturing and services sector, we provide some evidence that the services sector has been more affected by a services input than manufacturing sector has. We also compare the results between before and after the Financial Crisis. Thus, the manufacturing sector is reorganized and outsources services more and more after the Financial Crisis. The services sector also reorganized but does not depend on services outsourcing as much as manufacturing does. The increase of the debt ratio’s coefficient shows that output has become more sensitive to financial conditions in both sectors after the Financial Crisis.

According to our Korea’s economy achieved economies of scale or constant return to scale when we estimate the augmented production function while it does not when the non-augmented production is estimated. We also analyzed returns to scale for “before and after the financial crisis” by sector. This analysis revealed that there are substantial differences regarding economies of scale for each sector between the periods before and after the 1998 Financial Crisis.

Although we also introduced several variables into the production function, this study still has some limitations. First, this study is mainly based on the fixed effect model which does not fully consider endogeneity problems. Although we introduced some GMM estimation, SURE model and further GMM estimation should be further conducted to overcome the endogeneity issue. Second, a firm level analysis rather than an industry level analysis might offer versatile results since a firm level analysis can consider characteristics of firms (size, openness, technological ability etc).

Consequently, the present paper ends up with suggesting several implications which are related to the services input and OIs. Because the share of services output is increasing in Korean economy, the more extensive use of services input can drive the growth of total output through the growth of services outputs. Also it follows from our analysis that, when one carries out empirical work with a traditional production function, they should pay close attention not to over-estimate or under-estimate the effect of each input.
## Appendix

### Table 1  Industry classification of EUKLEMS

| Industry classification | Categorization |
|-------------------------|----------------|
| 1 | Agriculture, hunting, forestry and fishing |
| 2 | Mining and quarrying |
| 3 | Food, beverages and tobacco |
| 4 | Textiles, textile, leather and footwear |
| 5 | Wood and of wood and cork |
| 6 | Pulp, paper, paper, printing and publishing |
| 7 | Chemical, rubber, plastics and fuel |
| 8 | Other non-metallic mineral |
| 9 | Basic metals and fabricated metal |
| 10 | Machinery, nec |
| 11 | Electrical and optical equipment |
| 12 | Transport equipment |
| 13 | Manufacturing nec; recycling |
| 14 | Electricity, gas and water supply |
| 15 | Construction |
| 16 | Wholesale and retail trade |
| 17 | Hotels and restaurants |
| 18 | Transport and storage and communication |
| 19 | Financial intermediation |
| 20 | Real estate, renting and business activities |
| 21 | Public admin and defence; compulsory social security |
| 22 | Education |
| 23 | Health and social work |
| 24 | Other community, social and personal services |

Note: KISS VALUE doesn’t have data for 21 and 23, thus, we drop these industries for this study.

Source: Authors’ summary from KLEMS and KISS VALUE.
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