Trade in Intermediate Goods: Implications for Productivity and Welfare in Korea

KIM Young Gui and PYO Hak K.

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EXECUTIVE SUMMARY

There have been voluminous contributions such as Daudin *et al.* (2011), Johnson and Noguera (2012), Koopmans *et al.* (2010), and Trefler and Zhu (2010) in measuring value added trade based on input-output tables as generalizations of the vertical specialization measures following Hummels *et al.* (2001). These studies focused on trade in intermediate goods as a key feature of recent global trade. In the case of Korea, about 50% of total exports and 70% of its total imports are intermediate goods trade. This paper contributes to the discussion about the trade in intermediate goods and productivity by revisiting Basu (1995), Jones (2011), and Lee and Pyo (2007) to examine implications of trade in intermediate goods for macroeconomic business cycles and productivity and welfare at the current stage of Korean development. The major revision of the Basu (1995) model is attempted by decomposing intermediate goods into domestically produced intermediate inputs and imported intermediate inputs to investigate implications of the model in a small open economy. The major finding is that the pro-cyclicality of the intermediate goods usage relative to labor usage and TFP changes in both value added and gross-output regressions are significantly weaker in a small open economy like Korea than the large economy of the United States. We also investigate the effects of misallocation and multiplier effects due to intermediate goods on industrial productivity and efficiency following the model of Jones (2011). Since the effects of misallocation can be intensified through the industrial input-output structure of the economy, we calculate the intermediate goods multiplier by Korea's 29 manufacturing industries. We find technical changes and the degree of inefficiency are related with the magnitude of multipliers, but we leave a fundamental identification problem to future research.

Keywords: Imported intermediate goods, productivity, business cycle, misallocation, input-output structure

JEL Classification: E2, F1, O1

Contributors

KIM Young Gui

Research Fellow at the Korea Institute for International Economic Policy (KIEP). He received his Ph.D. in Economics at the Michigan State University in 2009. His primary research fields of interest are Econometrics, International Trade, and Industrial Organization.

PYO Hak K.

Visiting Scholar at Korea Institute for International Economic Policy (KIEP) and Professor Emeritus, the Faculty of Economics, Seoul National University. He has served as Professor of International Economics and Econometrics at Seoul National University since 1981 until February 2013. Professor Pyo was the winner of Chung Ram Award in 1988 by Korea Economic Association for his study on the estimation of capital stock. He served as President of Korea Econometric Society in 1997 and as Chairman of Asia KLEMS Committee (www.asiaklems.net) during 2009-2013 and now serves as Advisor to the Committee. He published many articles in professional journals and books including "Inflationary Expectations, 'Endogenous Money,' and Economic Growth," with Jang H. Yoo, *Journal of Macroeconomics* (1986), "Excess Competition, Moral Hazard and Industrial Trauma in Korea, 1977-1998," in *Private Capital Flows in the Age of Globalization: The Aftermath of the Asian Crisis*, edited by U. Dadush, D. Dasgupta, and M. Uzan, The World Bank, Edward Elgar, Northampton, MA, 2000, "Financial Crisis and Relative Productivity Dynamics in Korea: Evidence from Firm-level Data (1992-2003)" (with Keun Hee Rhee), *Journal of Productivity Analysis* (2010), and "Chapter 26 Productivity and Economic Development," in *Oxford Handbook of Productivity Analysis*, edited by Sickles, Lovell, and Tatjée, Oxford University Press (2016, forthcoming).

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I. Introduction

There have been voluminous contributions such as Daudin *et al.* (2011), Johnson and Noguera (2012), Koopmans *et al.* (2010), and Trefler and Zhu (2010) in measuring value added trade based on input-output tables as generalizations of the vertical specialization measures following Hummels *et al.* (2001). These studies focused on trade in intermediate goods as a key feature of recent global trade. In the case of Korea, about 50% of total exports and 70% of its total imports are intermediate goods trade. This paper contributes to the discussion about the trade in intermediate goods and productivity by revisiting Basu (1995), Jones (2011), and Lee and Pyo (2007) to examine implications of trade in intermediate goods for productivity and welfare at the current stage of Korean development.

The first part of this paper aims to revise and extend the simple menu-cost

model of Mankiw (1991) and Basu (1995). Basu (1995) proposed a new approach to explain the pro-cyclical productivity. Hall (1990) explained procyclicality of productivity as a result of imperfect competition and increasing returns to scale, which implies that cyclical productivity should be related with only sectoral output, not aggregate output. Caballero and Lyons (1989) pointed out the possibility that sectoral productivity could be correlated with aggregate output through technological spillover. Bernanke and Parkinson (1991) suggested cyclical factor utilization (labor-hoarding) as an explanation. Basu (1995) used the model with intermediate goods in production to demonstrate that sticky price models can explain larger output fluctuations and can generate pro-cyclical productivity movements without assuming increasing returns to scale. The model was also used to estimate the markup and the degree of returns to scale with U.S. manufacturing data and compared with Hall's (1990) estimates.

The major revision of the Basu (1995) model is attempted by decomposing intermediate goods into domestically produced inputs (I^D) and imported intermediate inputs (I^M) to examine implications of the model in a small open economy. We find the pro-cyclicality of the intermediate goods usage relative to labor usage, which implies that the sticky price of intermediate goods plays an important role in pro-cyclical productivity. Also total factor productivity (TFP) changes in both value added and gross-output regressions were shown to be significantly weaker in a small open economy like Korea than the large economy of the United States.

In the second part of the paper we apply the model of Jones (2011) to a country-specific industry-panel data set and estimate multiplier effects and inefficiency by using a stochastic frontier model based on Lee and Pyo (2007) to examine implications for welfare (productivity loss) at the current stage of Korean development. There have been voluminous recent contributions such as Chari, Kehoe and McGrattan (2007), Restuccia and Rogerson (2008), Banerjee and Duflo (2005), Hsieh and Klenow (2009) and Jones (2011) who have examined the role of resource misallocation in explaining income differences across

countries and across industries within an economy. Jones (2011) demonstrates through a simple illustrative model how misallocation can reduce TFP and the effects of misallocation can be amplified through the industrial input-output structure of the economy because outputs of many firms are used as the inputs of other firms. Therefore, the larger the weights of intermediate inputs in gross output production, the larger the amplification effects of misallocation would be. In addition, if we decompose intermediate inputs into domestically produced inputs (I^D) and imported intermediate inputs (I^M), the amplification effects of two intermediate inputs would be different depending on the relative size and the distribution of the two intermediate inputs.

We consider explicitly each of the N sectors production function with physical (K) and human capital (H), domestic intermediate goods (I^D), imported intermediate goods (I^M) and an exogenous productivity term as the product of aggregate productivity (A) and sectoral productivity (η_i). Since the effects of misallocation can be intensified through the industrial input-output structure of the economy, we estimate the intermediate goods multiplier by Korea's 29 manufacturing industries. We follow Battese and Coelli (1992), Lee and Schmidt (1993), Kumbharkar (1990), Lee (2006a, 2006b) and Lee and Pyo (2007) to identify the sources of misallocation in the form of the patterns of productivity growth and changes in inefficiency in Korea's 29 manufacturing industries using the stochastic frontier approach with industry-panel data. We find large variations in temporal and cross-industry inefficiency, which explains why inefficiency has led the economy into a lower productivity regime.

2. Trade in Intermediate Goods and Pro-cyclical Productivity

2-1. The Model with Domestic and Imported Intermediate Goods

Following Mankiw (1991) and Basu (1995), we model the use of domestic and imported intermediate goods in an input-output structure so that all firms use intermediate inputs in production. There is a continuum of goods, indexed on [0, 1]. The representative consumer is assumed to maximize the following utility function:

$$u = \frac{1}{1-\phi} \int_0^1 Q_{i,F}^{1-\phi} \, di + \log\left(\frac{M}{P}\right) - L, \tag{1}$$

where $Q_{i,F}$ is the quantity of product i used for final consumption, ϕ is the reciprocal of the elasticity of substitution between different products $(0 < \phi < 1)$, M is money demand which is assumed to be equal to money supply in equilibrium, P is the general price level which is a Tornqvist aggregator of domestic inputs prices (P_i^d) and imported inputs prices $(\bar{P}_i^M)$ which are assumed to be determined in the competitive international markets and therefore, are given to the producer, and L is labor supply.

The price level, P, is defined as follows:[1]

$$P = \left(\int_0^1 P_i^{\frac{\phi-1}{\phi}} \, di \right)^{\frac{\phi}{\phi-1}}$$

$$P_i = \left(\frac{P_d}{\beta} \right)^{\beta} \left(\frac{\overline{P_M}}{1-\beta} \right)^{1-\beta}$$

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[1] The consumer maximizes the utility function (1) subject to a budget constraint, and the derived first order conditions are provided in the Appendix.

The production side consists of a continuum of monopolistic firms, each producing one variety of products. Each firm is assumed to maximize profits given the production function

$$Q_i = AL_i{}^{\alpha}K_i{}^{\beta}I_i{}^{1-\alpha-\beta}, \tag{2}$$

where

$$I_i \equiv \left(\int_0^1 I_{ki}^{1-\phi} \, dk \right)^{\frac{1}{1-\phi}}, I_{ki} = I_{ki}^{d}{}^{\gamma} I_{ki}^{M}{}^{1-\gamma}$$

and where Q_i is the gross output of the firm i, A is the total factor productivity, L_i is the labor input of the firm i, K_i is the capital input, and I_i is the quantity of intermediate input which is a Tornqvist aggregator of domestically produced intermediate inputs (I_i^d) and imported intermediate inputs (I_i^M) with shares of γ and $1 - \gamma$. Following Basu (1995), we assume all firms produce for both manufactured inputs and final goods and the final goods can serve as inputs for the production of other goods. We also assume constant return to scale in gross output production function.[2]

Under these conditions, each firm's profit-maximizing nominal price, P_i^*, is

$$\begin{aligned} P_i^* &= \frac{1}{1-\phi} \left(\upsilon w^{\alpha} r^{\beta} P^{1-\alpha-\beta} \right) \\ &\equiv \mu \upsilon \left(w^{\alpha} r^{\beta} P^{1-\alpha-\beta} \right), \end{aligned} \tag{3}$$

where μ is the markup, W is the nominal wage, r is the capital return, and υ is an unimportant constant. This equation shows that output price is set as a markup on marginal costs.

The optimal relative price for each firm i, p_i^*, is derived as

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[2] Unlike Hall (1990), Basu's (1995) model explains pro-cyclical productivity without increasing returns to scale.

$$p_i^* \equiv \frac{P_i^*}{P} = \mu v \left(\frac{w}{P}\right)^\alpha \left(\frac{r}{P}\right)^\beta \tag{4}$$

The optimal relative price is dependent on real wage and capital returns raised to the power α and $\beta(\alpha + \beta < 1)$. This means that the change in the optimal price is $\alpha + \beta$ times the percentage change in aggregate demand. The intuition behind this relationship is simple: with fixed prices an increase in output raises demand for labor and capital, which also raises the real wage and capital return. If intermediate goods are used in production, firms' marginal costs rise only in proportion to input factor shares, $\alpha + \beta$, because prices of intermediate goods are fixed.

For price stickiness to be a Nash equilibrium, the loss to each of not changing prices, assuming that another firm adjusts, is less than the menu cost of changing prices. The change in profit to a firm from not adjusting its price in response to an output shock can be approximated by a second-order approximation as follows:

$$\pi(p_{\text{new}}^*) - \pi(p_{\text{old}}^*) \approx \frac{1}{2}\pi''(p^*)(p_{\text{new}}^* - p_{\text{old}}^*)^2, \tag{5}$$

where π'' is the second derivatives of the profit function with respect to prices. To see how the profit loss changes with respect to $\alpha + \beta$, firms' losses are normalized so that the profit loss in the base case ($\alpha + \beta = 1$) is 1 as follows[3]:

$$\frac{\frac{\pi^* - \pi}{\pi^*}}{\left[\frac{\pi^* - \pi}{\pi^*}\right]|\alpha + \beta = 1} \tag{6}$$

From a relationship among the revenue share of intermediate goods in total revenue, α, and β and the fact that the share of intermediate goods in total

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[3] The base case means that a firm does not use intermediate goods in production.

revenue is $\left(1 - \frac{Q_F}{Q}\right)$, we can obtain

$$(1 - \alpha - \beta) = \mu(1 - \frac{Q_F}{Q}), \tag{7}$$

where Q_F is final production (value-added) and Q is total (gross) output. By equation (7), a negative relationship between $\alpha + \beta$ and markup (μ) given the share of intermediate inputs is defined. Basu (1995) estimates the share of inputs in U.S. manufacturing is about 0.5 and over. Therefore, the upper band of $\alpha + \beta$ is 0.5. Because the production function is Cobb-Douglas, the share of intermediate goods in total cost is $1 - \alpha - \beta$. Since we assume monopolistic competition, the cost share is equal to revenue share multiplied by the markup. With equation (7), we can obtain an implied value of markup corresponding to a range of values for $\alpha + \beta$.

To show one of the stylized facts of business cycles, pro-cyclicality of total factor productivity, Basu (1995) used a business cycle model with constant returns to scale. With this model, pro-cyclical productivity is driven by three properties: imperfect competition, lower inefficiency at higher level of output, intermediate goods in production.

We also specify the following value-added production function:

$$Q_{F_i} = AL_i^a K_i^b \tag{8}$$

According to Basu (1995), the percentage change in A, total factor productivity, is positive and monotonically increases as $a + b$ decrease. Also if $\mu = 1$ (perfect competition) or $\alpha + \beta = 1$ (no intermediate goods in production), productivity is not pro-cyclical.

$$\log Q_{F_i} = \log A_i + a\log L_i + b\log K_i \tag{9}$$

But we do not impose constant returns to scale on value-added production

function assuming separability of value-added production function from gross output production function.

Hall (1990) tested the invariance of the cost-based Solow residual at both the economy-wide and two-digit SIC levels by a value-added model.

$$\Delta \ln Q_F = \gamma(a\Delta\ln L + b\Delta\ln K_i), \qquad (10)$$

where a and b are the share of labor and capital in the total cost of producing value added, respectively. γ is Hall's estimate of the degree of returns to scale. Basu (1995) calibrates the model and examines derived implications with Hall's (1990) estimates. Basu's calibrated estimates from the gross-output model show a constant (or slightly decreasing) returns to scale which is in sharp contrast with Hall's (1990) finding of strongly increasing returns to scale. In the present paper, instead of calibrating the revised and extended model of Basu (1995), we impose these results by Basu of constant returns to scale in gross-output production and estimate the model directly by using the Korean manufacturing data (1970-2013) from the KIP database.

2-2. Empirical Results

1) Cyclical Regularities

One of the predictions by the model is that materials prices are countercyclical relative to the prices of substitutes such as labor and capital. The modified predictions from the above extended model with two intermediate inputs with all variables in logs would be

$$\left(\Delta P_{I,it}^d - \Delta P_{L,it}\right) = \text{constant}_i^d + \beta_1^d \Delta Y_{it} \qquad (11)$$

$$\left(\Delta P_{I,it}^M - \Delta P_{L,it}\right) = \text{constant}_i^M + \beta_1^M \Delta Y_{it}, \qquad (12)$$

where Y_{it} is sectoral output, $P_{L,it}$ is the price of labor, $P_{I,it}^d$ is the prices of domestically produced intermediate goods, and $P_{I,it}^M$ is the prices of imported intermediate goods.

Using a panel of annual observations on 21 manufacturing industries in the United States from 1959 to 1984, Basu (1995) reports the estimate of the elasticity which was constrained to be equal across industries as $\beta_1(-0.20)$ negative and significant. His interpretation of the result suggests that the real wage is significantly pro-cyclical. He argues further that labor becomes more expensive relative to intermediate inputs, which must lead producers to economize on labor and use intermediate goods more intensively. In our revised and extended model of Basu (1995), we will examine whether the substitutability between labor and intermediate goods can be extended to both or either of domestically produced intermediate inputs and imported inputs.

Our estimate of β_1 when we combine two inputs into one aggregate intermediate input as Basu (1995) did is negative (–1.00) and significant, implying that the elasticity which is constrained to be equal across industries shows significantly that the real wage relative to intermediate input prices is pro-cyclical. This is consistent with the findings by Basu (1995) that in a small open econo-

my in expansion, the cost of labor input becomes more expensive relative to the price of intermediate goods which could lead producers to economize on labor and use intermediate goods more intensively. Also the degree of price rigidities of intermediate goods could be larger in a relatively smaller open economy than the US economy. Basu (1995) argues that the labor quality data in the US manufacturing data of Jorgenson, Gollop and Fraumeni (1987) is significantly counter-cyclical. In our data set of KIPS (Korea Industrial Productivity) database, the labor input data was quality adjusted by sex, education levels and age levels.

It is interesting to note that the pro-cyclicality is higher with imported intermediate inputs (β_1^M=-0.97) than with domestically produced inputs (β_1^d= -0.92). As we already mentioned above, this might imply that prices of imported intermediates are given to a small open economy such as Korea and the degree of price rigidities of imported intermediate goods might be larger than those of domestic intermediates.

The next theoretical proposition is that materials usage is pro-cyclical relative to labor. We decompose intermediate goods into domestically produced goods (I_{it}^d) and imported goods (I_{it}^M) as follows:

$$\left(\Delta I_{it}^d - \Delta L_{it}\right) = \text{constant}_i^d + \beta_2^d \Delta Y_{it} \tag{13}$$

$$\left(\Delta I_{it}^M - \Delta L_{it}\right) = \text{constant}_i^M + \beta_2^M \Delta Y_{it} \tag{14}$$

Our estimates of β_2 in Table 1 are positive and significant in both the combined input model ($\beta_2 = 0.58$) and decomposed input model ($\beta_2^d = 0.57$ and $\beta_2^M = 0.64$). This is consistent to the positive estimate ($\beta_2 = 0.56$) of Basu (1995), who claimed that the materials usage in U.S. manufacturing is pro-cyclical relative to labor. In the case of Korean manufacturing, we also find that material usage is pro-cyclical relative to labor. At the time of business expansion with demand-pull, Korean manufacturing firms may find both domestically produced and imported inputs more cheap relative to labor and therefore

economize on the use of primary inputs. A comparison of the results of equation (13) and (14) indicates that the pro-cyclicality in using intermediate inputs relative to labor is weaker in the use of domestically produced inputs than in the use of imported inputs. The industries which use more imported intermediate goods tend to economize on labor input and use imported input more strongly than the industries which use more domestically produced inputs. There is stronger substitutability between labor and imported intermediate inputs than between labor and domestically produced inputs, which is consistent with Korean manufacturing firms' behavior of outsourcing and off–shoring business activities.

Basu (1995) revisits the issue of labor-hoarding in the context that the use of pro-cyclical intermediate goods is driven by labor-hoarding. He obtains the elasticity estimate as 0.56 without labor market variables and 0.41 with labor market characteristics such as the ratio of production workers to nonproduction workers, the average number of overtime hours worked and the number of hours worked by an average worker in each industry. Both estimates are positive and significant so that Basu concludes the intermediate usage is pro-cyclical and might be driven partly by labor-hoarding. We have used average working hours as a proxy variable for cyclical labor utilization to control for labor-hoarding. The estimates after controlling for labor hoarding by each industry's average working hours (AGH_i) are smaller in magnitudes ($\beta_2^d = 0.55$ and $\beta_2^M = 0.57$) but still positive and significant. Because the estimate of AGH_i in equation (13) is insignificant, the pro-cyclical domestic intermediate usage might not be explained by labor-hoarding for Korea's case.

2) Specific Hypotheses

(a) Sensitivity of intermediate goods-output ratio to changes in relative prices

The model was tested by the following three hypotheses. The first hypothesis was whether changes in the intermediate goods to output ratio are consistently related to changes in the relative price of these inputs. In our revised

model, the intermediate goods are decomposed into domestically produced goods and imported goods as follows;

$$\left(\Delta I_{it}^{d} - \Delta Y_{it}\right) = \text{constant}_{i}^{d} + \beta_{3}^{d}(\Delta P_{L,it} - \Delta P_{I,it}^{d}) \tag{15}$$

$$\left(\Delta I_{it}^{M} - \Delta Y_{it}\right) = \text{constant}_{i}^{M} + \beta_{3}^{M}(\Delta P_{L,it} - \Delta P_{I,it}^{M}) \tag{16}$$

Basu's estimate of β_3 was 0.12 and significant. Basu (1995) states that if the production function is in fact Cobb-Douglas, the estimate of β_3 is equal to the share of labor(α). Our estimates in Table 1 shows 0.03 (0.008 with domestically produced intermediate goods and 0.036 with imported intermediate goods),[4] which is far less than the estimate of Basu and which implies markup higher than 1.706 when $\alpha = 0.1$ according to Basu's calibrated result (Table 3 in his paper). The lower estimate of $\alpha = \beta_3$ seems to indicate the omission of capital stock in both gross-output and value added production function. In order to reflect this issue, we have adopted the gross-output and value-added production functions with explicit capital input separately from intermediate inputs in generating total factor productivity (TFP).

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[4] For robust check, we estimate the modes with different model specifications and estimation methods but the main results do not change much. Also we try an instrumental estimation method in order to control potential endogeneity of outputs, but we fail to obtain appropriate estimates because our instrument variables (military expenditures and oil prices suggested by Basu) are dropped when we add year dummies.

Table 1. Empirical Regularities of Extended Basu (1995) Model with Two Intermediate Goods

Dependent Variable	Explanatory Variables					
	ΔY_i	ΔY	AGH_i	$\Delta P_{L,i} - \Delta P_{I,i}$	$\Delta P_{L,i} - \Delta P^d_{I,i}$	$\Delta P_{L,i} - \Delta P^M_{I,i}$
$\Delta P_{I,i} - \Delta P_{L,i}$	-1.01*** (0.022)					
$\Delta P^d_{I,i} - \Delta P_{L,i}$	-0.92*** (0.022)					
$\Delta P^M_{I,i} - \Delta P_{L,i}$	-0.97*** (0.026)					
$\Delta I_i - \Delta L_i$	0.58*** (0.030)					
	0.55*** (0.035)		0.011 (0.007)			
$\Delta I^d_i - \Delta L_i$	0.57*** (0.031)					
	0.55*** (0.036)		0.008 (0.007)			
$\Delta I^M_i - \Delta L_i$	0.64*** (0.035)					
	0.57*** (0.040)		0.028*** (0.008)			
$\Delta I_i - \Delta Y_i$		0.004 (0.016)				
				0.03*** (0.007)		
$\Delta I^d_i - \Delta Y_i$		-0.015 (0.017)				
					0.008 (0.008)	
$\Delta I^M_i - \Delta Y_i$		0.158*** (0.032)				
						0.036** (0.015)

Note: *, **, ***: significant at 10%, 5%, 1 % level respectively. The sample period is 1972-2012. I^d_i, I^M_i and L_i are industry materials for domestic and import, and labor input; $P^d_{I,i}$, $P^M_{I,i}$ and $P_{L,i}$ are the associated prices. Y_i and Y are industry and manufacturing gross output and AGH_i is the number of hours worked by an average worker in each industry. All variables are in logs.

(b) Sensitivity of Changes in TFP to Changes in Input Mix

The second proposition we test is whether changes in input mix are responsible for changes in total factor productivity. Modifying the Basu (1995) model, we decompose material inputs into domestically produced input (I_{it}^d) and imported input (I_{it}^M).

$$\Delta \text{TFP}_i = \text{constant}_i + \beta_4 (\Delta I_{it} - \Delta L_{it}) \tag{17}$$

$$\Delta \text{TFP}_{it} = \text{constant}_i^d + \beta_4^d (\Delta I_{it}^d - \Delta L_{it}) \tag{18}$$

$$\Delta \text{TFP}_{it} = \text{constant}_i^M + \beta_4^M (\Delta I_{it}^M - \Delta L_{it}) \tag{19}$$

We also modify the way we generate TFP for both value added and gross output. Instead of calculating the growth rate of TFP based on cost shares as attempted by Hall (1990) and Basu (1995), we estimate TFP (A) directly from the following Cobb-Douglas production function with constant returns to scale imposed:

$$Q_i = A L_i^{\alpha} K_i^{\beta} I_i^{d\gamma} I_i^{M(1-\alpha-\beta-\gamma)}$$

$$\frac{Q_i}{L_i} = A \frac{L_i^{\alpha}}{L_i^{\alpha}} \cdot \frac{K_i^{\beta}}{L_i^{\beta}} \cdot \frac{I_i^{d\gamma}}{L_i^{\gamma}} \cdot \frac{I_i^{M(1-\alpha-\beta-\gamma)}}{L_i^{(1-\alpha-\beta-\gamma)}} \tag{20}$$

We estimate:

$$\log Q_i = \log A + \alpha \log L_i + \beta \log K_i + \gamma \log I_i^d + (1-\alpha-\beta-\gamma) \log I_i^M$$

$$log Q_i - log L_i = log A + \beta(log K_i - log L_i) + \gamma\left(log I_i^d - log L_i\right)$$

$$+(1-\alpha-\beta-\gamma)(\log I_i^M - \log L_i) \tag{21}$$

We generate $TFP_i(A)$ in value added production as follows:

$$(\log Q_i) = \log A + a \log L_i + b \log K_i \tag{22}$$

The estimates of β_4 reported in Table 2 indicate two findings. First, the degree of pro-cyclicality of both gross-output and value added TFP in response to changes in the intermediate inputs–labor mix in Korean manufacturing is much less than in the U.S. manufacturing. Basu's estimates of value-added based TFP and gross-output based TFP regressions were 0.33 and 0.12 respectively. In contrast, our estimates are 0.25 and –0.029 respectively without much difference in decomposed TFP estimates (0.25 in value-added and –0.029 in gross-output TFP regressions). Second, the pro-cyclicality is highly stronger with value-added TFP than with gross-output TFP in Korean manufacturing compared to estimates in Basu (1995) for U.S. manufacturing.

While Basu finds evidence of significant pro-cyclicality of both value-added (ΔTFP_i^{VA}) and the gross-output residual (ΔTFP_i^{GO}) from U.S. manufacturing data, we find pro-cyclicality in value-added but no (zero) cyclicality in gross-output data of Korean manufacturing. The results remained the same when we decomposed intermediate inputs into domestically produced ones and imported ones. By explicitly considering imported intermediate goods, we allow firms to choose an optimal level of imported intermediates usage to maximize their profit. Because TFP is measured based on residuals, we speculate that more input usage is attributed to low TFP.

(c) Difference in estimates of internal returns to scale and external effects from aggregate activity between value-added data and gross-output data

Finally we can test if there is a significant difference between value-added data and gross-output data in terms of estimates of internal returns to scale (γ) and external effects (κ) from aggregate activity by the following specification:

$$\Delta Y_{it} = \text{constant}_i + \gamma \Delta X_{it} + \kappa \Delta X_t , \qquad (25)$$

where ΔX_i is the cost share-weighted sum of sectoral input growths and ΔX is growth of aggregate (manufacturing) inputs, similarly cost weighted. ΔY_i^{VA} is the growth of value added; ΔY_i^{GO} is the growth of gross output. This test shows

the degree of extent of how well Hall's argument can explain the pro-cyclicality of TFP in Korea.

The estimates by Basu (1995) were $\gamma = 0.63$ and $\kappa = 0.79$ for value added growth regression and $\gamma = 0.96$ and $\kappa = 0.01$ for gross-output growth regression. Our estimates reported in Table 2 are $\gamma = 0.44$ and $\kappa = 0.89$ for value added growth regression and $\gamma = 0.95$ and $\kappa = 0.08$ for gross-output growth regression. Our estimates from Korean manufacturing data reveal much smaller degree of internal returns to scale and stronger externality effects than Basu's estimates from U.S. manufacturing. This contrasts with the results of Hall (1990), who finds significantly increasing returns to scale using value-added data. In our estimates, there are no constant returns to scale ($\gamma = 0.44$) found in the value added growth regression as Basu's ($\gamma = 0.63$) but there is near constant returns to scale ($\gamma = 0.95$) in the gross-output growth regression while in Basu (1995) the estimate ($\gamma = 0.96$) of returns to scale in gross-output is almost equal to 1, implying constant returns to scale. Our estimate of externality coefficient from value-added growth regression ($\kappa = 0.89$) is consistent with the Caballero-Lyons (1989) stylized fact that it is evidence for a true technological externality.

Table 2. Value-added and Gross Output Results with Two Intermediate Goods

Dependent Variable	Explanatory Variables						
	$\Delta I_i - \Delta L_i$	$\Delta I_i^d - \Delta L_i$	$\Delta I_i^M - \Delta L_i l$	ΔX_i^{VA}	ΔX^{VA}	ΔX_i^{GO}	ΔX^{GO}
ΔTFP_i^{VA}	0.25*** (0.019)						
		0.25*** (0.019)					
			0.21*** (0.017)				
ΔY_i^{VA}				0.44*** (0.064)	0.89*** (0.081)		

Table 2. Continued

ΔTFP_i^{GO}	-0.029 (0.007)						
		-0.029 (0.007)					
			-0.022 (0.006)				
ΔY_i^{GO}						0.95*** (0.011)	0.073** (0.019)

Note: *, **, ***: significant at 10%, 5%, 1 % level respectively. Standard errors are given in parentheses. The sample period is 1972-2012. ΔY_i^{VA} and ΔY_i^{GO} are growth rates of industry value added and gross output. ΔX_i^{VA} is the sum of the growth rates of industry capital and labor inputs, each weighted by its share in the production of value added. ΔX^{VA} is the analogue for aggregate manufacturing. ΔX_i^{GO} is the sum of the growth rates of industry capital, labor and intermediate goods, each weighted by its share in the production of gross output. ΔX^{GO} is the analogue for aggregate manufacturing. ΔTFP_i^{VA} is the growth rate of industry total factor productivity calculated from value added and capital and labor inputs: $\Delta TFP_i^{VA} = \Delta Y_i^{VA} - \Delta X_i^{VA}$. ΔTFP_i^{GO} is the growth rate of industry total factor productivity calculated from gross output and capital, labor and intermediate goods: $\Delta TFP_i^{GO} = \Delta Y_i^{GO} - \Delta X_i^{GO}$. ΔI_i and ΔL_i are growth rates of intermediate goods and labor input.

3. Trade in Intermediate Goods, Misallocation and Productivity Loss in Korea

3-1. Model of Misallocation and Multiplier Effects in Input-Output Framework

According to Jones (2011), there are only two fundamental reasons for income differences across countries: either different production possibilities or different allocations. In particular, misallocation amplified through an input-output structure can explain a substantial part of differences in TFP.

We follow Long and Plosser (1983) and Jones (2011) to consider how intermediate goods generate a multiplier by adopting the following gross output (Q) production function with capital (K), labor (L) and intermediate goods (I).

$$Q_t = \bar{A}\big(K_t^{\alpha}L_t^{1-\alpha}\big)^{1-\sigma}I_t^{\sigma}, \tag{26}$$

where I_t is decomposed into domestically produced intermediate input (I_t^D) and imported intermediate input (I_t^M).

Let us assume a constant fraction($\bar{\imath}$) of gross output is used as an intermediate good:

$$I_{t+1} = \bar{\imath}Q_t \tag{27}$$

Then GDP is defined as gross output net of spending on intermediate goods:

$$Y_t \equiv (1-\bar{\imath})Q_t = \text{TFP} \cdot K_t^{\alpha}L_t^{1-\alpha}, \text{TFP} \equiv (\bar{A}\bar{\imath}^{\sigma}(1-\bar{\imath})^{1-\sigma})^{\frac{1}{1-\sigma}} \tag{28}$$

TFP is dependent on the allocation of resources to intermediate goods. It will be maximized when $\bar{\imath} = \sigma$, which is the optimal spending share on inter-

mediates. For any other spending share, however, TFP will be lower and this effect will be amplified as the intermediate goods share increases.

Let us also assume a constant fraction $\bar{s}$ of GDP is saved and invested and labor is exogenous and constant:

$$K_{t+1} = \bar{s}Y_t + (1 - \delta)K_t = \bar{s}(1 - \bar{x})Q_t + (1 - \delta)K_t \qquad (29)$$

The level of GDP per worker in a steady state $(y_t \equiv Y_t/L_t)$ is

$$y^* \equiv \frac{Y}{L} = \left(\bar{A}\bar{I}^\sigma (1 - \bar{I})^{1-\sigma} \left(\frac{\bar{s}}{\delta} \right)^{\alpha(1-\sigma)} \right)^{\frac{1}{(1-\alpha)(1-\sigma)}} \qquad (30)$$

Jones (2011) notes that the effects of misallocation or basic productivity differences get multiplied and that since the misallocation applies to a produced good, its effects are amplified: there is an exponent of $\frac{1}{(1-\alpha)(1-\sigma)} > 1$ that applies to misallocation.

Let's assume the economy consists of N sectors and each sector produces with the following Cobb-Douglas technology:

$$Q_i = A_i \left(K_i^{\alpha_i} H_i^{1-\alpha_i} \right)^{1-\sigma_i-\lambda_i} \underbrace{I_{i1}^{D\,\sigma_{i1}} I_{i2}^{D\,\sigma_{i2}} \cdot \ldots \cdot I_{iN}^{D\,\sigma_{iN}}}_{\text{domestic IG}} \underbrace{I_{i1}^{M\,\lambda_{i1}} I_{i2}^{M\,\lambda_{i2}} \cdot \ldots \cdot I_{iN}^{M\,\lambda_{iN}}}_{\text{imported IG}},$$

$$(31)$$

where i indexes the sector. A_i is an exogenous productivity term, which is the product of aggregate productivity A and sectoral productivity η_i: $A_i \equiv A\eta_i$. K_i and H_i are the quantities of physical capital and effective labor embodied by human capital and used in sector i. Two kinds of intermediate goods are used in production: I_{ij}^D is the quantity of domestic good j used by sector i, and I_{ij}^M is the quantity of the imported intermediate good j used by sector i. We adopt the Armington assumption (imported intermediate goods from dif-

ferent sources are different), so that they are not perfect substitutes. We abuse notation by assuming there are N different intermediate goods that can be imported and by indexing these by j as well. The parameter values in this production function satisfy $\sigma_i \equiv \sum_{j=1}^{N} \sigma_{ij}$ and $\lambda_i \equiv \sum_{j=1}^{N} \lambda_{ij}$ and $0 < \alpha_i < 1$, so the production function assumes constant returns to scale.

Each domestically produced good can be used for final consumption, c_j or can be used as an intermediate good:

$$c_j + \sum_{i=1}^{N} I^D_{ij} = Q_j, \quad j = 1, \dots, N \tag{32}$$

Rather than specifying a utility function over the N different consumption goods, it is more convenient to aggregate these final consumption goods into a single final good through another log-linear production function:

$$Y = C_1^{\beta_1} \cdot \dots \cdot C_N^{\beta_N}, \tag{33}$$

where $\sum_{i=1}^{N} \beta_i = 1$.

This aggregate final good can be used as consumption or export to the rest of the world:

$$C + X = Y \tag{34}$$

It is these exports that pay for the imported intermediate goods. Considering the long-run steady state of a model, we impose balanced trade:

$$X = \sum_{i=1}^{N} \sum_{j=1}^{N} \bar{p}_j I^M_{ij}, \tag{35}$$

where $\bar{p}_j$ is the exogenous world price of the imported intermediate goods.

Finally, we assume fixed, exogenous supplies of physical capital and human capital.

$$\sum_{i=1}^{N} K_i = K \qquad (36)$$

$$\sum_{i=1}^{N} H_i = H \qquad (37)$$

As reviewed by Acemoglu, Johnson and Robinson (2005), misallocation is the equilibrium outcome of the political economy interacting with institutions and distribution of resources including physical capital, human capital and intermediate input mix. Jones (2011) demonstrates why improvements in the allocation of resources would not take place in the most distorted countries because the immediate gains are so large despite the potentially enormous increase in the size of the economic pie that is possible in the long run if the allocation of resources can be improved by the ruling elite of the political economy. Jones (2011) further argues that the intermediate goods for economic growth, development and macroeconomics should be regarded as another form of capital and therefore, the capital share should be treated as 2/3, higher than most of empirical estimates around 1/3, implying that the neoclassical growth model should generate a larger multiplier on changes in productivity or the investment rate.

Jones (2011) has estimated the aggregate multipliers for the 35 countries from the OECD Input-Output Database, which contains 48 industries and 35 countries. The multipliers estimated include the contribution not only from imported intermediate goods but the aggregate intermediate goods share. He noted that the simple approximation of "one over one minus the intermediate goods share" does a very good job of approximating the true multiplier. The average value for the multiplier estimated ranges from the highest value of 2.53 in China, 2.10 in Korea, 1.83 in Japan, 1.77 in the United States to the lowest values of 1.59 in India and 1.51 in Greece. The average value for the multiplier in the OECD sample was about 1.9.

We applied the estimation of multiplier to a country (Korea)-specific 29 manufacturing industries' panel data. The estimated parameters of capital share (α) and intermediate goods share (σ) for domestic intermediate goods, im-
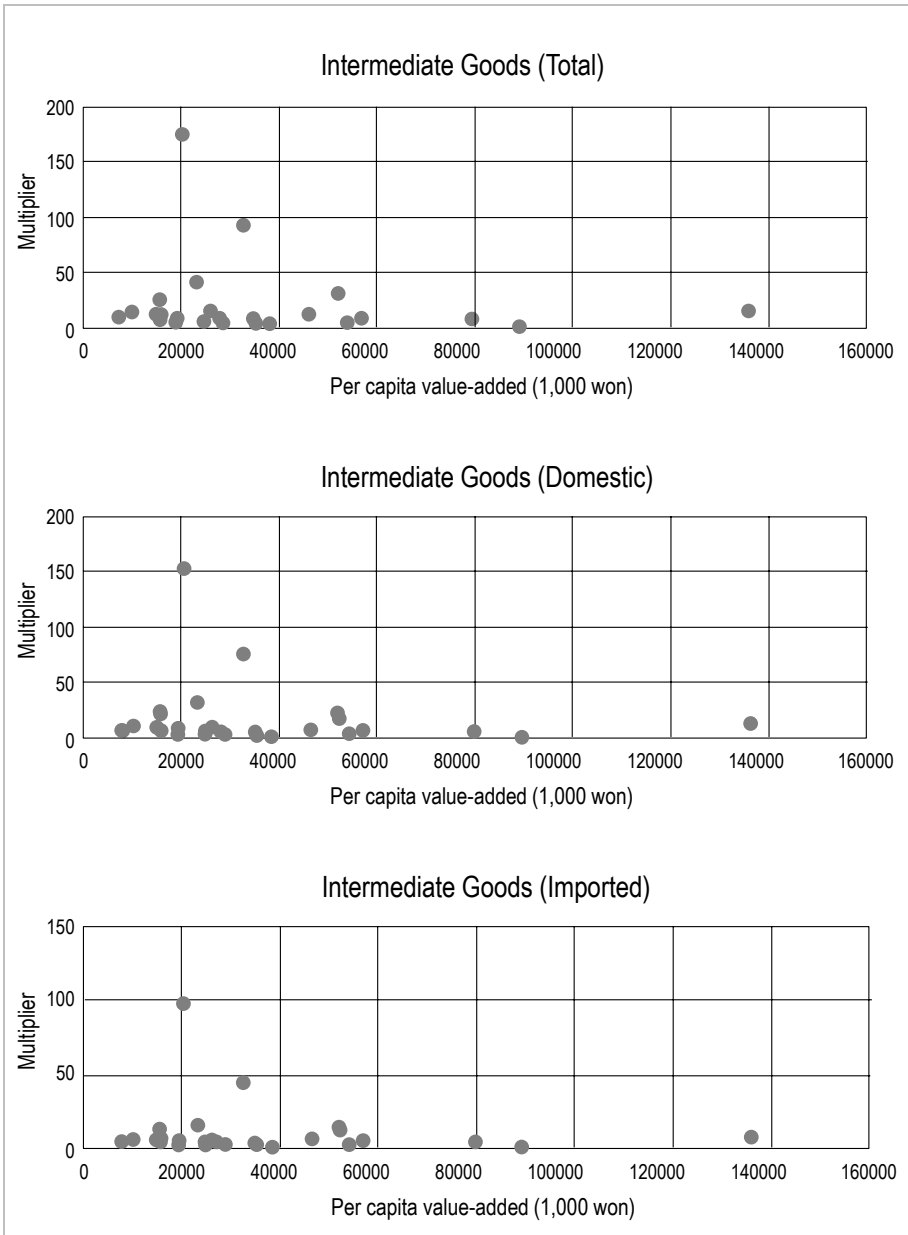
ported intermediate goods and total intermediate goods multipliers are presented in Table 3. The total multipliers range from the highest value of 174 (Rubber and Plastic Products) to the lowest value of 1.80 (Petroleum Refinery and Nuclear Fuel) with the manufacturing average of 15. Therefore, we note the disparity of multiplier effects among manufacturing industries is fairly large. The large multiplier effects are due to the high value of estimated capital share (α). For example, there are seven manufacturing industries such as Rubber and Plastic Products (0.99) and Railway Products (0.98) of which estimated capital shares are above 0.90. Since the average share of intermediate goods (σ) in gross output is 0.55 and varies within the range of 0.31 and 0.71, the total multiplier effect ($\frac{1}{(1-\alpha)(1-\sigma)}$) is mainly influenced by the magnitude of estimated capital share.

We have also plotted estimated multipliers against the per-capita value added of each industry in Figure 1. Except notable outlier industries such as Rubber and Plastic Products (21) and Railway Products (37), total estimated multipliers fall in the range between 1.80 and 41.32. The relationships between multipliers and per capita value-added are not particularly discernable but there is a large per-capita income (value-added) difference among 29 manufacturing industries. As Jones (2011) noted, there is a large literature which have considered various mechanisms through which misallocation can reduce TFP and can lead to income differences among countries. He conjectured that the effects of misallocation can be amplified through the input-output structure of the economy. We observe here in the industry panel data of 29 manufacturing industries during the period of 1972-2013 that such a large income differences can exist within a country like Korea. This suggests misallocation of inputs among industries can lead to income differences among industries.

Table 3. Estimated Multipliers across a Range of 29 Manufacturing Industries in Korea

	Industry	A	Domestic		Imported		Total	
			σ_d	$\dfrac{1}{(1-\alpha)(1-\sigma_d)}$	σ_m	$\dfrac{1}{(1-\alpha)(1-\sigma_m)}$	σ	$\dfrac{1}{(1-\alpha)(1-\sigma)}$
21	Rubber and Plastic Products	0.99	0.41	152.63	0.08	98.10	0.48	174.75
37	Railway Products	0.98	0.47	75.88	0.10	44.50	0.57	93.13
24	Fabricated Metal Product	0.93	0.56	33.02	0.09	16.10	0.65	41.32
26	Office Machinery and Computers	0.92	0.46	23.20	0.15	14.67	0.61	31.88
23	Basic Metals	0.90	0.46	18.53	0.21	12.60	0.68	30.81
38	Other Product	0.92	0.49	25.00	0.04	13.28	0.52	26.90
14	Wood	0.91	0.51	22.10	0.08	11.86	0.59	26.33
9	Food and Beverages	0.78	0.58	10.87	0.13	5.24	0.71	15.59
10	Tobaccos	0.87	0.42	12.92	0.09	8.23	0.51	15.39
13	Tanning and Dressing of Leather, Footwear	0.83	0.49	11.47	0.12	6.69	0.61	15.12
27	Insulated Wire	0.83	0.36	9.04	0.17	6.94	0.54	12.43
25	Machineries	0.82	0.42	9.51	0.14	6.33	0.56	12.42
11	Textiles	0.79	0.49	9.38	0.12	5.46	0.61	12.40
32	Scientific Instruments and Equipment	0.83	0.33	8.94	0.18	7.29	0.52	12.31
12	Dressing and Dyeing of Fur, Articles of Fur	0.75	0.49	7.94	0.12	4.65	0.61	10.44
16	Publishing	0.81	0.38	8.52	0.06	5.58	0.44	9.44
20	Chemical Products	0.80	0.36	8.01	0.07	5.49	0.43	8.95
15	Pulp and Paper	0.75	0.47	7.44	0.07	4.27	0.54	8.63
30	Telecommunication Apparatuses	0.69	0.46	6.00	0.15	3.78	0.61	8.27
34	Motor Vehicles	0.70	0.50	6.50	0.10	3.66	0.60	8.18
35	Ships	0.71	0.47	6.49	0.10	3.82	0.57	7.94
17	Printing	0.76	0.39	6.88	0.06	4.49	0.45	7.63
28	Electronic Machineries	0.66	0.37	4.61	0.17	3.54	0.54	6.35
31	Radio and Television	0.54	0.46	4.00	0.15	2.52	0.61	5.52
22	Non-metallic Minerals	0.68	0.33	4.71	0.07	3.39	0.39	5.23
29	Electronic Valves and Tubes	0.50	0.41	3.37	0.19	2.48	0.60	4.99
19	Pharmacy	0.63	0.36	4.25	0.07	2.91	0.43	4.75
36	Aircraft	0.29	0.47	2.66	0.10	1.56	0.57	3.26
18	Petroleum Refinery	0.20	0.23	1.62	0.07	1.34	0.31	1.80
	average	0.75	0.43	17.43	0.11	10.72	0.55	21.45

Intermediate Goods (Total)

Intermediate Goods (Domestic)

Intermediate Goods (Imported)

3-2. Productivity Growth and Efficiency Changes in Industry-Panel Data

For empirical analysis, a log-linearized stochastic frontier gross output production function with constant returns to scale imposed is assumed to specify the technology in industries, as follows:

$$\ln y_{it} = \alpha_t + \sum_j \delta_j \ln x_{jit} + \delta_t T + v_{it} - \theta_t(\eta_g)u_i$$
$$j, l = K, L, I^D, I^M \tag{38}$$

with $\sum \delta_j = 1$ and a neutral technical progress imposed and where y is gross output, and K, L, I^D, I^M, and T are capital stock, labor, domestically produced intermediate input, imported intermediate input, and time trend respectively. From Equation (38), technical change and elasticity of input can be derived as

$$TP_{it} = \partial \ln y_{it} / \partial T = \delta_t \tag{39}$$
$$\varepsilon_j = \partial \ln y / \partial \ln x_j = \delta_j \tag{40}$$

To consider the measurement of technical efficiency, the separation of $\widehat{u_{it}}$ from $\widehat{\alpha_{it}}$ follows the same method used by Lee (2006b) and Lee and Pyo (2007):

$$\widehat{\alpha_t} = \max_i \theta_t(\widehat{\eta_g}) \widehat{\alpha_i}, \tag{41}$$

where $\widehat{\alpha_t} = \left[\theta(\eta_g)'\theta(\eta_g)\right]^{-1}\theta(\eta_g)'e_i(\hat{\beta})$ and the inefficiency term u_{it} is then estimated as

$$\widehat{u_{it}} = \widehat{\alpha_t} - \theta_t(\widehat{\eta_g})\widehat{\alpha_i}, \quad \forall i \in \text{Group g.} \tag{42}$$

Because the dependent variable is natural log transformed, the technical ef-

ficiency scores are calculated from Equation (42) as follows:

$$\widehat{TE}_{lt} = \exp(-\widehat{u_{lt}}) = \exp[-(\widehat{\alpha_t} - \theta_t(\widehat{\eta_g})\widehat{\alpha_l})] \qquad (43)$$

Here, technical efficiency is a relative concept and the average efficiency index is related to the variance of α_i: the higher the variance, the smaller the average efficiency. This relative efficiency concept should be taken into account in application studies. Temporal flow of efficiency measure and its ranking is more meaningful for the analysis than absolute measure of efficiency.

The next step that we considered was how to categorize 29 Korean manufacturing industries into a number of groups. In this empirical exercise, we made three different groups depending on the size of estimated multiplier effects: The first group is composed of top-10 industries with highest multiplier effects, the second group is the next 10 industries and the last third group is the remaining 9 industries with lowest multipliers.

The parameter estimates for the production frontiers are presented in Table 4. The estimates of both the Battese and Coelli (1992) model and two group-specific Battese and Coelli (1992) model are shown for comparison. The parameter estimates are generally significant except the coefficient of imported intermediate goods. The t-values are generally larger in the group-specific 1 model with the BC specification (G-BC) than in the BC model. In the two models, the coefficients of temporal neutral technical change are in the range of 2.2−2.4% and highly significant. When we decomposed it into three groups in in the G-BC specification, the estimated coefficient was larger (2.3%) with the group 3 (lower multiplier effect and lower misallocation group) than the group 1 (1.6%) and the group 2 (1.8%). Therefore, we note the rate of temporal neutral technical change was larger with the manufacturing group with lower degree of misallocation and multiplier effects. The hypothesis that there is the same pattern of technical change among three groups can be rejected.

The parameter η in the BC model indicates the average temporal pattern of

technical inefficiency over all industries and its estimate is statistically significant at 1%. However, the G-BC model provides with three different parameters relevant to the temporal pattern of inefficiency. The second null hypothesis we tested is that there was an identical temporal pattern of technical inefficiency across all industries ($H_0: \eta_1 = \eta_2 = \eta_3$). All of the group-specific estimates of η_1, η_2 and η_3 have large enough t-values to show their statistical significance. The three estimates are approximately close to the range 0.034-0.035 without group-specific time dummy variables and this implies that even though the magnitude of inefficiency in Group 3 (9 lower multiplier industries) is slightly bigger than Group 1 and Group 2, the difference does not seem to be statistically significant. But with the group-specific time dummy variables, the degree of inefficiency is larger with the group 3 (-0.039) than the group 1 (-0.036) and the group 2 (-0.035) If the null hypothesis were true, the estimation model would be that of BC. Rejecting the hypothesis does not necessarily mean that the misallocation across industries is attributed to differences in inefficiencies because we have a fundamental identification problem. Even though we can observe intermediate goods shares, we cannot decompose data into distortions and differences in technologies as Jones mentioned in the paper.

More formally we use the generalized likelihood ratio (LR) test of Lee (2006b) which computes the ratio of the difference between restricted SSE and unrestricted SSE to the pooled SSE. The first hypothesis in Table 4 is that there is the same pattern of technical change among three groups. The second null hypothesis was that there was an identical temporal pattern of technical inefficiency across all industries ($H0: \eta_1 = \eta_2 = \eta_3$). If the null hypothesis were true, the estimation model would be that of BC. Rejecting the hypothesis does not necessarily mean that the misallocation across industries is not attributed to differences in inefficiencies because we have a fundamental identification problem. Even though we can observe intermediate goods shares, we cannot decompose data into distortions and differences in technologies as Jones mentioned in the paper.

	Battese and Coelli (1992)	Group-specific 1 Battese and Coelli (1992)	Group-specific 2 Battese and Coelli (1992)
$(\ln K)$	0.069 (0.008)	0.082 (0.008)	0.081 (0.008)
$(\ln L)$	0.075 (0.012)	0.084 (0.011)	0.069 (0.011)
$(\ln I^D)$	0.781 (0.012)	0.774 (0.011)	0.792 (0.012)
$(\ln I^M)$	0.005 (0.006)	0.001 (0.006)	0.002 (0.006)
T	0.024 (0.001)	0.022 (0.001)	
T_1			0.016 (0.002)
T_2			0.018 (0.002)
T_3			0.023 (0.002)
η	-0.034 (0.001)		
η_1		-0.034 (0.001)	-0.036 (0.001)
η_2		-0.034 (0.001)	-0.035 (0.001)
η_3		-0.035 (0.001)	-0.039 (0.001)

Note: Standard errors of estimates are in parenthesis.

Table 5. Log Likelihood Test for Three Models

LR Test	chi2	Prob > chi2
Test 1 (model 1 / model 2)	26.32	0.00008
Test 2 (model 2 / model 3)	29.12	0.00014
Test 3 (model 1 / model 3)	55.44	1.062e-10

4. Conclusion

In the first part of the paper, we have focused on the revision and extension of the Basu (1995) model. We decomposed intermediate inputs explicitly into domestically produced goods and imported goods. The major finding is that the pro-cyclicality of the intermediate goods usage relative to labor usage and TFP changes in both value added and gross-output regressions are significantly weaker in a small open economy like Korea than the large economy of the United States.

We find from the Korean manufacturing data (1972-2012) that the real wage relative to intermediate input prices is pro-cyclical. This is consistent with the findings by Basu (1995) that in a small open economy in expansion, the cost of labor input becomes more expensive relative to the price of intermediate goods, which could lead producers to economize on labor and use intermediate goods more intensively. It is interesting to note that the pro-cyclicality is higher with imported intermediate inputs (β_1=-0.97) than with domestically produced inputs (β_1=-0.92). The industries which use more imported intermediate goods tend to economize on labor input and use imported input more strongly than the industries which use more domestically produced inputs. There is stronger substitutability between labor and imported intermediate inputs than between labor and domestically produced inputs, which is consistent with Korean manufacturing firms' behavior of outsourcing and off–shoring business activities.

In the case of Korean manufacturing, we also find that the material usage is pro-cyclical relative to labor. At the time of business expansion with demand-pull, Korean manufacturing firms may find both domestically produced and imported inputs cheaper relative to labor and therefore economize on the use of primary inputs. The degree of price rigidities of intermediate goods could be smaller in a relatively smaller open economy than the U.S. economy.

Regarding a set of hypothesis tested in Basu (1995), we tested the first hypothesis of whether changes in the intermediate goods to output ratio are con-

sistently related to changes in the relative price of these inputs. In our revised model, the intermediate goods are decomposed into domestically produced goods and imported goods. Our estimates shows 0.03 (0.008 with domestically produced intermediate goods and 0.036 with imported intermediate goods) which is far less than the estimate of Basu and which implies markup higher than 1.706 when α=0.1 according to Basu's calibrated result. Basu's estimates of value-added based TFP and gross-output based TFP regressions were 0.33 and 0.12 respectively. In contrast, our estimates are 0.25 and –0.029 respectively without much difference in decomposed TFP estimates (0.25 in value-added and –0.029 in gross-output TFP regressions. The degree of pro-cyclicality of value added TFP in response to changes in the intermediate inputs–labor mix in Korean Manufacturing is slightly less than in the US manufacturing. While Basu finds evidence of significant pro-cyclicality of both value-added (ΔTFP_i^{VA}) and the gross-output residual (ΔTFP_i^{GO}) from U.S. manufacturing data, we find pro-cyclicality in value-added but no (zero) cyclicality in gross-output data of Korean manufacturing. The results remained the same when we decomposed intermediate inputs into domestically produced ones and imported ones.

The lower estimate of $\alpha = \beta_3$ seems to indicate the omission of capital stock in both gross-output and value added production function. In order to reflect this issue, we have adopted the gross-output and value-added production functions with explicit capital input separately from intermediate inputs in generating total factor productivity (TFP). The second proposition we tested is whether changes in input mix are responsible for changes in total factor productivity. We found that the degree of pro-cyclicality of both gross-output and value added TFP in response to changes in the intermediate inputs–labor mix in Korean manufacturing is much less than in the US manufacturing. Third, we tested if there is a significant difference between value-added data and gross-output data in terms of estimates of internal returns to scale (γ) and external effects (κ) from aggregate activity. Our estimates reported are $\gamma = 0.44$ and κ=0.89 for value added growth regression and γ=0.95 and $\varkappa = 0.08$ for

gross-output growth regression. Our estimates from Korean manufacturing data reveal a much smaller degree of internal returns to scale and stronger externality effects than Basu's estimates from U.S. manufacturing.

In conclusion, the cyclical behavior in manufacturing sector of a small open economy can be quite different from that of a large economy because they can change not only the input mix between intermediate goods and labor but also the composition of intermediate inputs between domestically produced goods and imported goods. In general they exhibit less degree of pro-cyclicality, because they tend to adjust intermediate input mix by outsourcing.

In the second part the paper, we have extended the model of Jones (2011) to apply it into a cross-section of industries in a specific economy (Korea) rather than a cross-section of countries and to show the relationship between misallocation and inefficiency through input-output economics. We have estimated multipliers in Korea's 29 manufacturing industries during the period of 1972–2013 by estimating the two key parameters of capital share in value-added production function and the share of intermediate goods in gross output production. We have validated the proposition advanced by Jones (2011) that the larger the capital share and the intermediate input share, the larger the multiplier effects would be.

In order to identify the sources of misallocation and its propagation through multiplier effects, we have used the frontier gross-output production function with constant returns to scale and neutral technical progress imposed. We have estimated both the Battese and Coelli (1992) model and its group-specific version and found that the technical progress is statistically significant and all the inefficiency parameters are also statistically significant. And we could reject the null hypothesis of equality in the pattern of inefficiency among three groups with different multipliers. Rejecting the hypothesis does not necessarily mean that the misallocation across industries is not attributed to differences in inefficiencies because we have a fundamental identification problem. We leave it to future research.

APPENDIX

By maximizing the utility function (1) subject to a standard budget constraint, the consumer's first order conditions are derived as follows:

$$w = M$$

$$Q_{i,F} = \left(\frac{w}{P_i}\right)^{\frac{1}{\phi}}$$

$$Q_{i,F}{}^d = \left[\left(\frac{\beta}{1-\beta}\right)\left(\frac{P_M}{P_d}\right)\right]^{1-\beta} Q_{i,F}$$

$$Q_{i,F}{}^M = \left[\left(\frac{1-\beta}{\beta}\right)\left(\frac{P_d}{P_M}\right)\right]^{\beta} Q_{i,F}$$

Solving a minimization problem of cost subject to the production function (2) produces the input demands for each firm i:

$$I_{ki} = \left(\frac{P_k}{P}\right)^{-\frac{1}{\phi}} \left(\frac{w}{P}\right) \left(\frac{1-\alpha-\beta}{\alpha}\right) L_i$$

$$L_i = \left(\frac{\alpha}{\beta}\right)^{\beta} \left(\frac{\alpha}{1-\alpha-\beta}\right)^{1-\alpha-\beta} \left(\frac{\gamma}{w}\right)^{\beta} \left(\frac{P}{w}\right)^{1-\alpha-\beta} Q_i$$

$$K_i = \left(\frac{\beta}{\alpha}\right)^{\alpha} \left(\frac{\beta}{1-\alpha-\beta}\right)^{1-\alpha-\beta} \left(\frac{w}{\gamma}\right)^{\alpha} \left(\frac{P}{\gamma}\right)^{1-\alpha-\beta} Q_i$$

Substituting input demands into the cost function gives the following form:

$$C_i = \upsilon w Q_i \left(\frac{\gamma}{w}\right)^{\beta} \left(\frac{P}{w}\right)^{1-\alpha-\beta}$$

where $\upsilon = \left(\frac{1}{\alpha}\right)\left(\frac{\alpha}{\beta}\right)^{\beta} \left(\frac{\alpha}{1-\alpha-\beta}\right)^{1-\alpha-\beta}$

By summing up demands for a firm's output as final goods and as intermediate inputs, we can obtain the total output of each firm.

$$Q_i = \left[\left(\frac{w}{P}\right)^{\alpha+\beta} \left(\frac{1-\alpha-\beta}{\alpha}\right)^{\alpha+\beta} \left(\frac{\alpha}{\beta}\right)^{\beta} \left(\frac{\gamma}{w}\right)^{\beta} P^{1/\phi} Q + w^{1/\phi}\right] P_i^{-1/\phi}$$

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국문요약

본 연구에서는 수입중간재와 생산성 간의 관계에 대한 최근 논의를 토대로 한국 경제에 주는 시사점을 연구하였다. 본 연구는 크게 두 파트로 구분되는데, 첫째 파트에서는 Basu(1995)의 연구를 확장하여 국산중간재와 수입중간재가 생산에 투입되는 모형을 설정한 후, 수입중간재가 생산성의 경기동조화에 미치는 영향을 살펴보았다. 분석 결과, 미국에 비해 소규모 개방경제인 한국의 경우에는 수입중간재의 가격이 외부에서 결정되고, 국산중간재 이외에 수입중간재라는 대체가능한 투입요소가 가용하여 생산성의 경기동조화 현상이 다소간 완화되는 것으로 분석되었다. 둘째 파트는 Johnes(2011)와 Lee and Pyo(2007)를 토대로 한국의 투입산출구조 속에서 한 산업의 배분 비효율성이 여타 산업에 어떻게 파급되는지를 살펴보고, 그 결과 각 산업의 생산 비효율성(후생감소)이 어떻게 달라지는지 분석하였다. 한국의 29개 제조업을 대상으로 분석한 결과, 기술변화와 비효율성의 정도는 산업별 승수(multiplier)와 관련되어 있다는 점을 발견하였다. 다만 근원적인 식별문제는 후속연구로 남게 되었다.

핵심용어: 수입중간재, 생산성, 경기변동, 비효율적 배분, 투입산출구조

김영귀(金榮貴)

한양대학교 경제학 학사
한양대학교 일반대학원 경제학 석사
미시간주립대학교 경제학 박사
대외경제정책연구원 무역통상본부 지역무역협정팀 연구위원
(現, E-mail: ygkim@kiep.go.kr)

저서 및 논문

『한국의 FTA 10년 평가와 향후 정책방향』 (공저, 2014)
『국내 제조업 생산성의 결정 요인과 수출 간의 관계에 대한 분석』 (공저, 2015) 외

표학길(表鶴吉)

한국계량경제학회 회장(1997)
Asia KLEMS Committee 초대위원장(2009~2013)
서울대학교 경제학부 교수(1981~2013)
서울대학교 경제학부 명예교수
대외경제정책연구원 초청연구위원
(現, E-mail: pyohk@plaza.snu.ac.kr)

저서 및 논문

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   우편 또는 FAX 이용하여 가입신청서 송부 (수시접수)
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Trade in Intermediate Goods:
Implications for Productivity and Welfare in Korea

KIM Young Gui and PYO Hak K.

Several studies focused on trade in intermediate goods as a key feature of recent global trade. In the case of Korea, about 50% of total exports and 70% of its total imports are intermediate goods trade. This paper contributes to the discussion about the trade in intermediate goods and productivity by revisiting Basu (1995), Jones (2011), and Lee and Pyo (2007) to examine implications of trade in intermediate goods for macroeconomic business cycles and productivity and welfare at the current stage of Korean development.