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SECTORAL EFFECTS OF FAVORABLE IMPORTED-INPUT PRICE SHOCKS*

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This paper examines the extent to which a favorable external shock such as the lower price of an imported input affects sectoral output and employment, the real exchange rate, and the wage in an economy where the input has no domestic production at all. The analytical framework is a real, short-run model based on a three-sector, three-factor, small open economy. The effect of the shock on the variables concerned depends on the structural characteristics of production and consumption in the economy. In the normal case, the traded sectors initially favored by the shock expand the most among sectors while the other tradables suffer. The real exchange rate may appreciate along with the upsurge of wages. However, the shock can produce many other possible cases: the nontraded sector may grow at the expense of the traded sectors including the favored sector. An extreme case is that the positive effect on output and employment may occur only at the traded sectors that are initially unfavored by the shock. The shock may bring about real depreciation, or a decline in nominal wages, too.

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I. INTRODUCTION

Non-oil-producing developing economies such as Korea were favored in 1986 when world oil prices fell by half and international interest rates declined dramatically. These external shocks from the international environment were

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beneficial to a heavily indebted Korea whose structure of production and consumption was highly dependent upon imported intermediate inputs such as oil. From 1986 to 1988, real income grew by over 12% on average, largely led by strong export growth. Saving surpassed investment for the first time since 1962 when economic development set forth, resulting in a substantial current account surplus and eliminating the growing concern about foreign indebtedness.

However, the economic boom, initiated by the external shock, was followed by the symptoms analogous to the Dutch disease experienced by the countries producing the primary products in the 1960s and 1970s. The economic growth rate slowed with reemerging inflationary pressure after 1988. Services led industrial growth and manufacturing production was squeezed. The Korean won appreciated in real terms vis-à-vis major trading partners. The upsurge in nominal and real wage rates surpassed productivity growth. Even the initially favored tradable sectors, which consisted mainly of capital-intensive and imported intermediate-input-intensive manufactures, suffered in export and production activities in 1989-1992. In 1990, the current account reverted to deficit from surplus as saving began to fall short of investment. The price of real estate and housing skyrocketed while the nontradables expanded along with a rise in their relative prices.

The situation where a boom in a tradable good may lead to the squeeze of the other tradables, called the Dutch disease, was the subject of many studies in the 1980s.[1] However, the literature on the Dutch disease has focused primarily on economies exporting primary products such as oil and coffee, and on the effects of new resource discovery. Little attention has been paid to the effects of a lower oil price on oil-importing economies. In contrast to oil-exporting economies, importing countries generally use oil as an intermediate input.

The main purpose of this paper is to examine the extent to which an exogenous decline in the price of imported intermediate inputs, such as oil, affects sectoral output and employment, real exchange rate, and nominal and real wages in an economy where the input has no domestic production at all. A simple analytical framework is used to show that a favorable external shock may bring about an adverse impact on some (or, all) tradables, real appreciation and a surge of wage rates depending on the structure of consumption and production. The analytical framework on supply aspects is based on the specifications from Buffie (1984, 1986, 1989), who examined the macroeconomic consequences of the oil price shock, devaluation and trade liberalization in a short-run model that incorporated an imported intermediate input. However, it differs from his model in several respects: First, the economy produces three goods rather than two (traded and nontraded) goods. Traded goods are further subdivided into the B sector and the M sector where the former is more

[1] For example, see Bruno (1982), Bruno and Sachs (1982), Cassing and Warr (1982), Corden and Neary (1982), Corden (1984), Eastwood and Venables (1982), Kamas (1986), Neary and van Wijnbergen (1984) and van Wijnbergen (1984a,b). Also, see Eaton (1987), Buffie (1992) and Roldos (1992) for an application of dynamic specific-factor models.

imported-input intensive in production than the latter. In other words, sector B is initially more favored by a lower price of imported inputs than sector M. Second, monetary considerations are ignored and thus only the relative price is determined. Income and expenditure are always equal so that there is no trade deficit. Trade imbalances and money can be easily incorporated into the model,[2] making the model more complicated without changing the essence of the analysis. Third, prices and wages are flexible so that full employment is always maintained in the economy. Real wage rigidity may also be added to the model, too. However, the main concern in this study is to explore the short- and medium-run impact on sectoral output and employment of favorable rather than adverse shocks.

Section 2 presents a real, static equilibrium model based on a three-sector, three-factor, small open economy. Section 3 analyzes the effect of a percentage decline in the price of imported inputs on sectoral output and employment, the real exchange rate, and wages. In section 4, a simulation exercise is carried out to examine the sensitivity of the change in the variables concerned for a percentage decline in imported-input price based on a given set of parameter values. The final section concludes the paper.

Ⅱ. THE ANALYTICAL FRAMEWORK

The assumption is of a small open economy producing two traded goods ($T=B.\ M$), and a nontraded good (N) by means of variable factors, labor (L_i) and an imported intermediate input (E_i), and fixed, sector-specific capital stocks (K_i). Good B is more imported-input intensive in production than good M. To highlight the role of imported-input price, we assume that good B uses an imported intermediate input for production, but good M does not.

The domestic prices of traded goods (P_i, $i=B,\ M$) are always equal to the exchange rate multiplied by the exogenously given world prices, and the terms of trade is unchanged. The domestic price of the imported input (Π) is the exchange rate multiplied by its world price. The price of a nontraded good (P_N) moves flexibly to equalize domestic supply and demand. Good B is the numeraire and units are chosen so that its price is unity ($P_B=1$) implying that P_N is the price of nontraded relative to traded goods, that is, the real exchange rate. A rise in P_N corresponds to real appreciation.

Supply

On the supply side, duality theory is employed to allow general functional

[2] Buffie (1984, 1989) employed a monetarist specification to take into account money and trade imbalances.

forms of technology. Assuming constant returns to scale and perfectly competitive firms, the sectoral factor demands are derived by Shephard's lemma as

$$L_i = Q_i C^i_W(W, \Pi, R_i) \tag{1}$$

$$E_i = Q_i C^i_\Pi(W, \Pi, R_i) \tag{2}$$

$$K_i = Q_i C^i_R(W, \Pi, R_i) \tag{3}$$

where Q_i is output in the i^{th} sector ($i = B, M, N$); C^i is the unit cost function in the i^{th} sector; W is the nominal wage; Π is the domestic price of an imported intermediate input; R_i is i^{th} sector's rental rate on capital; and a subscript in the cost function denotes the partial derivative with respect to the corresponding argument.

The zero profit condition implies

$$P_i = WC^i_W + R_i C^i_R + \Pi C^i_\Pi \tag{4}$$

Equations (1)-(4) produce a solution for Q_i, L_i, E_i, and R_i, as a function of W, Π, and P_i.

After substituting for Q_i in (1) from (3) and logarithmically differentiating the resulting equation, the derived demand for labor in sector i can be expressed as

$$l_i = \theta^i_L(\sigma^i_{LL} - \sigma^i_{LK})w + \theta^i_E(\sigma^i_{LE} - \sigma^i_{KE})\pi + \theta^i_K(\sigma^i_{LK} - \sigma^i_{KK})r_i \tag{5}$$

where $\sigma_{ij} = C_{ij}C/C_iC_j$ is the Hicks-Allen partial elasticity of substitution between factors i and j;[3] θ^i_j is the cost share of factor j in sector i production; and a small letter denotes the log differential of the relevant variable (for example, $w = dW/W$).

Note that using the envelope theorem, equation (4) can be rewritten as the following log differential of relevant variables:

$$p_i = \theta^i_L w + \theta^i_E \pi + \theta^i_K r_i. \tag{6}$$

Substituting for $\theta^i_K r_i$ in (5) from (6) yields the percentage change in the demand for labor in sector i as a linear function of p_i, w and π:

[3] See Uzawa (1962).

$$l_i = a_1^i p_i - a_2^i w - a_3^i \pi \tag{7}$$

where $a_1^i = \sigma_{LK}^i - a_{KK}^i > 0$, $a_2^i = \theta_L^i(2\sigma_{LK}^i - \sigma_{LL}^i - \sigma_{KK}^i) > 0$, and $a_3^i = \theta_E^i(\sigma_{LK}^i + \sigma_{KE}^i - \sigma_{KK}^i - \sigma_{LE}^i)$.

The same procedure can be taken to have the percentage change in the demand for the imported input as

$$e_i = b_1^i p_i - b_2^i w + b_3^i \pi \tag{8}$$

where $b_1^i = \sigma_{KE}^i - \sigma_{KK}^i > 0$, $b_2^i = \theta_L^i(\sigma_{KE}^i + \sigma_{LK}^i - \sigma_{KK}^i - \sigma_{LE}^i)$, and $b_3^i = \theta_E^i(2\sigma_{KE}^i - \sigma_{EE}^i - \sigma_{KK}^i) > 0$.

Strict concavity of the production function guarantees positive a_1^i and b_1^i. a_2^i and b_3^i must also be positive unless either factor is inferior. However, the signs of cross-price terms, a_3^i and b_2^i are ambiguous because of two conflicting forces, output and substitution effects. Suppose that the domestic price of imported inputs lowers exogenously ($\pi < 0$). It raises profit, which will increase the level of output and the rental rate on capital. With lower Π and higher R, the net substitution effect on labor demand is positive when the imported input is more substitutable for labor than for capital ($\sigma_{LE}^i - \sigma_{LK}^i > 0$) and negative when it is less substitutable ($\sigma_{LE}^i - \sigma_{LK}^i < 0$). On the other hand, the expansion of output generates more labor demand, which is represented as the term $\theta_j^i(\sigma_{KE}^i - \sigma_{KK}^i)$ ($j = E$, L). In the case where labor and imported input are *gross complements*, a_3^i and b_2^i are positive. This occurs when output effects dominate net substitution effects.[4] On the other hand, when net positive substitution effects are greater than output effects, these two inputs are gross substitutes and a_3^i and b_2^i are negative.

Assuming that the supply of labor is fixed, the full employment condition implies

$$\lambda_L^B l_B + \lambda_L^M l_B + \lambda_L^N l_N = 0, \tag{9}$$

where λ_L^i denotes the share of employment in sector i and $\sum_i \lambda_L^i = 1$. Combining equation (7) with (9) yields the endogenous change in nominal wage to equilibrate the labor market as a function of p_N and π such as:

$$a_2 w = a_1 p_N - a_3 \pi \tag{10}$$

[4] This statement is not necessarily true when capital and imported input are strongly complementary such that output effects become negative. The necessary condition for positive output effects is $\sigma_{KE}^i > -\sigma_{KL}^i \theta_L^i / (\theta_L^i + \theta_E^i)$.

where $a_2 \equiv \sum_i \lambda_L^i a_2^i$ ($i = B,\ M,\ N$) is the wage elasticity of the aggregate demand for labor; $a_3 \equiv \sum_i \lambda_L^i a_3^i$ denotes the cross-price elasticity of aggregate labor demand with respect to imported-input price whose sign and magnitude depend on output and substitution effects in each sector; and $a_1 \equiv \lambda_L^N a_1^N$ is the elasticity of aggregate labor demand with respect to the real exchange rate, given w and π.[5]

Demand

Turning to the demand side, a simple functional specification is employed as follows:

$$D_i = D_i(1,\ P_M,\ P_N,\ Y) \tag{11}$$

$$Y = Q_B + P_M Q_M + P_N Q_N - \Pi(E_B + E_M + E_N) \tag{12}$$

Demand is specified as a function of prices and nominal expenditure, abstracting the role of financial assets in determining demand.

Logarithmically differentiating function (11), the demand for nontraded goods may be written as a function of the change in the real exchange rate and in real income,

$$d_N = \varepsilon_N^* p_N + \eta_N (y - C_N p_N), \tag{13}$$

where ε_N^* and η_N are the compensated own-price elasticity and the income elasticity of demand for nontraded goods, respectively; and C_N is the share of nontraded goods in total expenditure. The source of a change in real income is the change in the price of imported intermediate input so that equation (12) generates

$$y^* \equiv y - C_N p_N = -\alpha\pi, \tag{14}$$

where $\alpha \equiv \Pi(E_B + E_M + E_N)/Y$ is the value of total imported intermediate inputs as a fraction of nominal income. Substituting (14) into (13) and applying the Slutsky decomposition, the demand for nontraded goods may thus be written as follows:

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[5] The zero degree of homogeneity of factor demand stands for $a_1^i = a_2^i + a_3^i$ for sector i. Notice, however, that $a_1 \neq a_2 + a_3$ since $p_B = p_M = 0$ due to no change in terms of trade and $P_B = 1$

$$d_N = -\tilde{C}_N \varepsilon^* p_N - a\eta_N \pi, \tag{15}$$

where $\tilde{C}_N \equiv (1-C_N)/C_N$ is the relative expenditure share of traded to nontraded goods and ε^* is the compensated cross-price elasticity of demand for nontraded goods with respect to the relative price of traded goods.

Equilibrium

The market for the nontraded sector clears at $d_N = q_N$ through price adjustment. With two variable inputs, the supply of good i may be expressed with a logarithmically differentiable form as:

$$q_i = \theta^i_L l_i + \theta^i_E e_i \tag{16}$$

Substituting (7) and (8) for l_i and e_i in (16) for the nontraded sector and then equating it with (15) generates the equilibrium real exchange rate, p_N, as a function of w and π:

$$(\psi^N + \tilde{C}_N \varepsilon^*) p_N = \psi^N_L w + (\psi^N_E - a\eta_N)\pi, \tag{17}$$

where $\psi^N \equiv (\theta^N_L a^N_1 + \theta^N_E b^N_1)$ is the supply elasticity of nontraded goods, and $\psi^N_L \equiv (\theta^N_L a^N_2 + \theta^N_E b^N_2)$ and $\psi^N_E \equiv (\theta^N_L a^N_3 + \theta^N_E b^N_3)$ are the elasticity of the supply of nontraded goods with respect to wage and imported-input price, respectively. Under the assumption that all goods are priced at cost, $\psi^i = \psi^i_L + \psi^i_E$ ($i = B, M, N$). Increasing marginal cost implies the positive sign of ψ^i_L and ψ^i_E; but, their signs can be reversed in the case where labor and imported inputs are gross substitutes ($a^i_3, b^i_2 < 0$).[6]

Equations (10) and (17) may be solved jointly for the effect of the change in imported-input price on p_N and w.

$$A p_N = -[a_3 \psi^N_L - a_2 \psi^N_E + a_2 a \eta_N]\pi \tag{18}$$

$$A w = -[a_3(\psi^N + \tilde{C}_N \varepsilon^*) - a_1 \psi^N_E + a_1 a \eta_N]\pi, \tag{19}$$

where $A = a_2(\psi^N + \tilde{C}_N \varepsilon^*) - a_1 \psi^N_L$. The term $(\psi^N + \tilde{C}_N \varepsilon^*)$ is the compensated elasticity of excess supply of nontraded goods at a given wage rate, while A denotes the same elasticity when the adjustment of the wage rate induced by a

[6] For example, ψ^i_E may have a negative sign in the case where sector i is relatively labor intensive and labor and imported input are strongly gross substitutes.

change in P_N is taken into account. A must be positive to satisfy the stability condition.

The first two terms in the RHS of (18) and (19) represent the cost effects of a change in Π on the supply of nontraded goods and the third term carries out its income effect on the demand. The second term denotes the direct cost effect of the change in Π while the first term represents the indirect cost effect, which takes place through its impact on the demand for the other factor, labor, in the nontraded sector. The sign of the total cost effects is not unambiguous since the direction of the indirect cost effect depends on whether labor and imported input are gross substitutes ($a_3<0$), or complements ($a_3>0$).

Ⅲ. SECTORAL EFFECTS OF AN EXOGENOUS DECLINE IN AN IMPORTED-INPUT PRICE

Based on the analytical framework described in the previous section, we examine the impact of a lower price of an imported input ($\pi<0$) on sectoral output and employment, real exchange rate, and wages. Regarding imported-input intensities in each sector, there are three possible cases: (i) $\theta_E^B>\theta_E^N>\theta_E^M$, (ii) $\theta_E^B>\theta_E^M>\theta_E^N$, and (iii) $\theta_E^N>\theta_E^B>\theta_E^M$. Among them, case (iii) is excluded from this study because we are more interested in analyzing the case where even if nontradables are less imported-input intensive than tradables, a lower price of imported inputs may lead to real appreciation and an adverse effect on tradables. Additionally, case (ii) is replaced by $\theta_E^B>0$, $\theta_E^M=\theta_E^N=0$. The technical reason is that we assume $\theta_E^M=0$. The role of the nontraded sector is same for both case (i) and case (ii). Moreover, if the nontraded sector is the least imported-input intensive, a lot of indeterminate cases occur in the impact of real appreciation (or, depreciation) on two traded goods even though their imported-input intensities differ significantly. Thus, we focus on two cases in this section: The first case is that only the B sector uses an imported input ($\theta_E^B>\theta_E^M=\theta_E^N=0$). The second case is that an imported input is also used in the nontraded sector (θ_E^B, $\theta_E^N>0$, $\theta_E^M=0$). In section 4 where a simulation exercise is carried out, we examine the case that the nontraded sector is less imported-input intensive than the B sector ($\theta_E^B>\theta_E^N>\theta_E^M=0$).

3.1 Imported input used only in the *B* sector

Consider the case where only the B sector uses an imported input ($\theta_E^B>0$, $\theta_E^M=\theta_E^N=0$). From equations (7), (8), (16), (18), and (19), the change in sectoral output due to a percentage change in the price of the imported input can be derived as follows:[7]

$$Aq_N = -\psi_L^N[-a_3 \tilde{C}_N \varepsilon^N + (a_2 - a_1)a\eta_N]\pi \quad (20)$$

$$Aq_M = -\psi_L^M[-a_3(\psi^N + \tilde{C}_N \varepsilon^*) - a_1 a\eta_N]\pi \quad (21)$$

$$Aq_B = -[A\psi_E^B - \psi_L^B a_3(\psi^N + \tilde{C}_N \varepsilon^*) - \psi_L^B a_1 a\eta_N]\pi, \quad (22)$$

where $a_3 = \lambda_L^B a_3^B$ and $\psi^N = \psi_L^N$.

The change in the price of the imported input affects sectoral employment and output through shifting supply and demand curves, namely through *the supply effect* and *the spending effect.* The supply effect depends crucially on whether labor and imported input are gross substitutes or complements.

Gross complements

Suppose they are gross complements, where output effects dominate net substitution effects ($a_3 > 0$). A lower price of imported input used only in the B sector will raise that sector's profit, which increases the demand for the mobile factor, labor, employed there. This creates excess demand in the labor market and raises the wage rate, thus drawing labor out of both the M and nontraded sectors to the B sector.

The movement of labor out of the nontraded sector leads to a fall in the output of that sector, which causes excess demand for nontraded goods at the initial real exchange rate. A real appreciation (that is, a rise in the price of nontraded goods) must occur to eliminate the excess demand, thus mitigating the decline in the output of that sector led by labor movement to the B sector. However, the output of the nontraded sector cannot be higher than that in the initial equilibrium unless the nontraded-good market is unstable. On the other hand, a real appreciation caused by excess demand for nontraded goods draws labor out of the B and M sectors to the nontraded sector, implying the further decline in the output of the M sector.

The first term in (20) represents the change in the output of the nontraded sector due to the supply effect. The term consists of two parts. For $\pi < 0$, the first part, $-\psi_L^N a_3(\psi^N + \tilde{C}_N \varepsilon^*)$, represents a loss in the output of nontraded goods because of an increase in the wage rate due to excess demand for labor led by both real appreciation and a rise in sector B's profit. The second part, $(\psi_L^N)^2 a_3$, describes an output gain attributed to real appreciation. These two parts taken together yield the first term in (20), reflecting that the output of nontraded goods falls absolutely due to the supply effect. On the other hand, the first term in (21) represents the further decline in the output of the M sector

[7] Similarly, the percentage change in sectoral employment can be derived from equations (7), (18), and (19).

because of real appreciation, indicating the role of the real exchange rate in determining labor movement. The intuition behind this is that the rise in the real labor costs is greater in the M sector than in the nontraded sector since the price of traded goods remains constant.

The first term in (22) refers to the positive impact of a decline in Π on the output of the B sector, the magnitude of which relies upon the supply elasticity of good B with respect to the imported-input price. But the initial output effect is mitigated by a higher wage rate due to excess demand for labor, denoted by the second term in (22). In total, however, the positive supply effect cannot be reversed as labor moves out of both the nontraded and M sectors to the B sector, denoted by the first terms in (20) and (21).[8]

Next, turn to the spending effect of the change in the price of the imported input. In order to ignore the supply effect for a while, we assume that all markets are in equilibrium before the shock occurs. A lower price of imported input raises real income, which results in excess demand for nontraded goods at the initial exchange rate. Again, there must be a real appreciation to restore the equilibrium, so the output of the nontraded good rises relative to its initial level, which is represented by the first term of the parenthesis in the second term in (20). On the other hand, the demand shift of the nontraded sector creates excess demand for labor and thus increases the wage rate, somewhat dampening the rise in the output of that sector. The second term of the parenthesis in (20) depicts this dampening effect on the output of nontraded goods. Real appreciation causes labor to move out of both the B and M sectors to the nontraded sector. The last terms in (21) and (22) measure the extent of the contraction of the output of the two traded sectors due to this spending effect.

The parameters, which influence the demand shift of nontraded goods, are the share of imported inputs in income and the marginal propensity to consume those goods. Larger values of these parameters lead to a greater demand for labor in the nontraded sector. The actual changes in employment and output are determined by the real wage elasticity of the aggregate demand for labor, $(a_2 - a_1)$, and the elasticity of the supply of nontraded goods with respect to wage rate, ψ_L^N. However, the spending effect on the output of the nontraded sector is always positive even though an increase in wages due to the excess demand for labor negatively affects the output of that sector. The reason is that

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[8] For proof, the positive supply effect infers $(a_2 - a_1)\psi_E^B - a_3\psi_L^B > 0$ which is derived from rearranging the first two terms in (22). As the simplest case satisfying $a_3 > 0$, assume a CES production function where the partial elasticities of substitution between factors are identical, $\sigma_{LK}^i = \sigma$ and $\sigma_{KE}^B = \sigma_{EL}^B = \sigma$. The function implies $a_2^i = [(1-\theta_E^i)/\theta_K^i]\sigma$, $a_3^i = (\theta_E^i/\theta_K^i)$, $\psi_L^i = (\theta_L^i/\theta_K^i)\sigma$ and $\psi_E^i = (\theta_E^i/\theta_K^i)\sigma$. After substituting these values into the corresponding terms, the above inequality can be rewritten as $\frac{a_2^B + (\lambda_L^M/\lambda_L^B)a_2^M}{a_3^B} > \frac{\theta_L^B}{\theta_K^B}$. The LHS is equivalent to $\frac{\theta_L^B}{\theta_K^B} + \left(1 + \frac{\lambda_L^M}{\lambda_L^B}\frac{1}{\theta_K^M}\right)$ which is greater than the RHS.

the real wage rate must rise in the traded sectors since the prices of output remain constant while nominal wages are higher. This causes labor to move out of both traded sectors to the nontraded sector, implying that real exchange rate should appreciate enough to lower the real wage rate in the latter sector.[9]

When the supply and spending effects are combined, what is unambiguous is that both contribute to an increase in nominal wage and real appreciation.[10] Both lead to move labor out of the M sector so that the sector's output falls absolutely after a decline in Π. However, the output response in the nontraded sector is not unambiguous since the supply effect lowers that sector's output while the spending effect raises it. The output response in the B sector, which initiated a boom in the economy, is not clear either, because of the real income effect on the demand for nontraded goods. The nontraded sector expands at the expense of the traded sectors to the extent that the spending effect dominates the supply effect. The possible case is that even the B sector's employment and output may fall below their initial values along with those of the M sector.[11]

To see sectoral differences in the change in output, equations (20)-(22) can be rewritten as follows.

$$-\frac{q_B - \dfrac{\psi_L^B}{\psi_L^M} q_M}{\pi} = \psi_E^B \tag{23}$$

$$-\frac{q_B - \dfrac{\psi_L^B}{\psi_L^N} q_N}{\pi} = \psi_E^B - \psi_L^B \frac{a_3 \psi^N + a_2 a \eta_N}{A} \tag{24}$$

The LHS of (23) denotes a weighted difference between the change in sector B's output and that of the M sector for a percentage decline in the price of the imported input where the weight is the sectoral elasticities of the supply of goods with respect to wage. For instance, ψ_L^i is simply $(\theta_L^i / \theta_K^i)\sigma$ in the case where the partial elasticities of substitution among factors are identical. If both sectors have identical relative labor intensities, the gap between the change in output of sector B and that of sector M is exactly ψ_E^B for a percentage decline in Π. In this example, $\psi_E^B = (\theta_E^B / \theta_K^B)\sigma$, implying that the gap would be greater in favor of sector B to the extent that this sector is more

9 This argument is equivalent to $a_2 - a_1 > 0$. For proof, $a_2 - a_1 = (\lambda_L^B a_2^B + \lambda_L^M a_2^M + \lambda_L^N a_2^N) - \lambda_L^N a_1^N = (\lambda_L^B a_2^B + \lambda_L^M a_2^M + \lambda_L^N a_2^N) - \lambda_L^N (a_2^N + a_3^N) = \lambda_L^B a_2^B + \lambda_L^M a_2^M > 0$ since $a_3^N = 0$.

10 Refer to (18) and (19) when $\psi_E^N = 0$

11 The exact condition that both B and M sectors lose employment and output is
$0 = \frac{\psi_E^M}{\psi_L^M} < \frac{\psi_E^B}{\psi_L^B} < \frac{1}{A}[a_3(\psi^N + \tilde{C}_N \varepsilon^*) + a_1 a \eta_N]$.

imported-input intensive and the elasticity of substitution among factors is larger. According to (24), on the other hand, the gap between the change in output of the B sector and that of the nontraded sector becomes smaller as the RHS of (24) has another negative term, which reflects the output effect of real appreciation and of the change in real income.

Gross substitutes

Consider, in contrast, that labor and imported input are gross substitutes ($a_3 < 0$), for which the outcome of the supply effect may be exactly opposite: a lower price of imported input would make labor move to the M and nontraded sectors from the B sector, thus creating excess supply in the labor market and lowering the wage rate. Output of both M and nontraded goods will increase. The excess supply of nontraded goods results in real depreciation, causing the further rise in output of good M. Output of good B, initially favored by a shock, may decrease to the extent that sector B is relatively labor-intensive and the gross substitutability between labor and imported input is strong.

When both the supply and spending effects are combined, the nontraded sector certainly gains employment and output. Sector B loses employment. However, the effects on the nominal wage rate, the real exchange rate and output of traded sectors depend upon the relative size of the two effects. When the supply effect exceeds the spending effect, first, the nominal wage rate would decrease along with real depreciation. Second, sector M's employment and output would rise rather than fall. Third, if the substitutability between labor and the imported input is very strong with the lesser degree of real depreciation, sector B is the only one that loses employment and output.

When the demand effect exceeds the supply effect, on the other hand, the nominal wage rate increases and the real exchange rate appreciates as for the case of gross complementarities. The only one that gains employment and output is the nontraded sector.

To see the condition for gross substitutability more clearly, using the symmetry property and the adding-up condition on the partial elasticities of substitution, $-l_i/\pi = a_3^i$ in (7) can be rewritten as

$$a_3^i = \theta_E^i\left[(1+\frac{\theta_L^i}{\theta_K^i})\sigma_{LK} + (1+\frac{\theta_E^i}{\theta_K^i})\sigma_{KE} - \sigma_{EL}\right], \tag{25}$$

where the partial elasticities of substitution between factors are assumed to be identical among sectors. Rearranging (25) suggests that the sufficient condition for gross substitutability between labor and imported input should be $\sigma_{EL} > (1+\theta_L^i/\theta_K^i)\sigma_{LK} + (1+\theta_E^i/\theta_K^i)\sigma_{KE}$. That is, this condition holds only for an extreme case where the partial elasticity of substitution between labor and imported input is so large that it is at least greater than the weighted sum of the partial elasticity of substitution between capital and labor and that between capital and imported input. It may also hold for the case where capital and imported input are strongly complementary.[12] However, this condition may be violated by virtually any production function where all factors are Hicks-Allen substitutes ($\sigma_{ij} > 0,\ i \neq j$).[13]

[Table 1] Summary of the effect of a decline in imported-input price on sectoral output and employment, real exchange rate, and nominal wage when only the B sector uses the imported input ($\theta_E^B > 0,\ \theta_E^N = \theta_E^M = 0$).

	Gross complements ($a_3^i,\ b_2^i > 0$)			Gross substitutes ($a_3^i,\ b_2^i < 0$)		
	Supply effect	Spending effect	Total effect	Supply effect	Spending effect	Total effect
q_N	↓	↑	?	↑	↑	↑
q_B	↑	↓	?	?	↓	?
q_M	↓	↓	↓	↑	↓	?
l_N	↓	↑	?	↑	↑	↑
l_B	↑	↓	?	↓	↓	↓
l_M	↓	↓	↓	↑	↓	?
p_N	↑	↑	↑	↓	↑	?
w	↑	↑	↑	↓	↑	?

3.2 Imported input in the nontraded sector

To be more realistic, this section allows an imported input to be used in both the B sector and the nontraded sector, but not in the M sector ($\theta_E^B,\ \theta_E^N > 0,\ \theta_E^M = 0$). Then the change in sectoral output becomes,

$$Aq_N = -[(a_2\psi_E^N - a_3\psi_L^N)\tilde{C}_N\varepsilon^* + \{a_2\psi_E^N + (a_2 - a_1)\psi_L^N\}\alpha\eta_N]\pi \tag{26}$$

$$Aq_M = -\psi_L^M[-a_3(\psi^N + \tilde{C}_N\varepsilon^*) + a_1\psi_E^N - a_1\alpha\eta_N]\pi \tag{27}$$

$$Aq_N = -[A\psi_E^B - \psi_L^B\{a_3(\psi^N + \tilde{C}_N\varepsilon^*) - a_1\psi_E^N + a_1\alpha\eta_N\}]\pi, \tag{28}$$

[12] In their estimation of a 2-level CES function where labor is separable from capital and imported input, Berndt and Wood (1979) assert that capital-oil complementarity and labor-oil substitutability are strong enough to make this condition hold.

[13] Rader (1968) points out that factors used by the firm are never gross substitutes in the normal case where an increase in the input of one factor increases the marginal productivity of the others.

where $a_3 = \lambda_L^B a_3^B + \lambda_L^N a_3^N$ and $\psi^N = \psi_L^N + \psi_E^N$.

To examine the supply effect, consider only the case that labor and imported input are gross complements. What differs from the previous case is that a lower price of imported input also raises the profit of the nontraded sector at a given real exchange rate. Consequently, the excess demand for labor would be greater as labor is demanded more not only by the B sector but also by the nontraded sector. The result is a larger increase in nominal wages, which draws more labor out of the M sector. In contrast with the previous case, however, real exchange rate must depreciate since the nontraded good market shall be in excess supply. Real depreciation will mitigate the increase in nominal wages.

The supply effect on the output of nontraded goods, denoted by the first term in (26), consists of two parts: The first one, $\psi_E^N\{a_2 \tilde{C}_N \varepsilon^* - (a_1 - a_2 - a_3)\psi_L^N\}$, represents the output effect due to the change in real price of imported inputs while the second one, $-\psi_L^N\{a_3 \tilde{C}_N \varepsilon^* - (a_1 - a_2 - a_3)\psi_E^N\}$, produces the same effect due to the change in the real wage rate. With the second terms in the braces being canceled out, these two parts add up to the first term in (26). Thus the first term of the parenthesis in (26), which is positive, signifies that the net profit of the nontraded sector remains positive after real depreciation is taken into account. Compared with (20), the second term of the parenthesis reflects the larger negative output effect of an increase in the wage rate as the nontraded sector demands more labor, too. The extra term, $(a_2\psi_E^N - \lambda_L^N a_3^N \psi_L^N)$, which is positive,[14] denotes that the positive effect of the lower real price of imported input dominates the additional negative effect of the higher real wage. In sum, the supply effect on nontraded goods becomes positive as the net profit effect exceeds the wage effect.

A larger increase in nominal wage, that is, in real wage given the price of traded goods, creates a further decline in the output of the traded sectors, as represented by the first term in (27) and by the second term in (28). However, the extent of the increase in wage is mitigated by real depreciation caused by the shift in the supply of nontraded goods. The effect of real depreciation on the output of the traded sectors is denoted by a new term, $a_1\psi_E^N\psi_L^i$ $(i = M, B)$ in (27) and (28). Overall, to the extent that the nontraded sector is relatively more imported-input intensive, the real exchange rate depreciates more and nominal wages rise less, thus attenuating the negative supply effect on the employment and output of the traded sectors.[15]

[14] To prove this, consider the case where the elasticities of substitution between factors are identical. Then,

$$a_2\psi_E^N - \lambda_L^N a_3^N \psi_L^N = \frac{\theta_E^N}{\theta_K^N}\left[\sum \lambda_L^i \left(1 + \frac{\theta_L^i}{\theta_K^i}\right) - \frac{\lambda_L^N \theta_L^N}{\theta_K^N}\right]\sigma^2$$

$$= \frac{\theta_E^N}{\theta_K^N}\left[1 + \sum_{i=B,M} \frac{\lambda_L^i \theta_L^N}{\theta_K^i}\right]\sigma^2 > 0$$

Summing up the supply effect, the M sector is the only one that loses employment and output for $\pi < 0$. Real exchange rate depreciates. Nominal wages rise, but the magnitude of this rise depends largely upon relative factor intensities in sectors and the substitutability between labor and imported input.

There is no fundamental change in the spending effect if the nontraded sector uses an imported input. As before, a lower price of the imported input raises real income, which brings about a real appreciation. What differs now is that the output of nontraded goods rises further for a given real appreciation since the supply elasticity of these goods is relevant not only to the wage rate but also to the imported-input price, as shown in the first term of the brace in (26).

Compared with the previous case, the nontraded sector expands more in both employment and output when the supply and spending effects are combined. The direction of the change in the real exchange rate is uncertain: If the supply effect is larger than the spending effect, the real exchange rate can depreciate. The reverse case results in real appreciation, but its magnitude is smaller than that for the previous case. Wages rise less to the extent that the real exchange rate appreciates less and labor and imported input are less complementary. However, the loss of good M's output is greater as the other sectors demand more labor.

As before, sectoral differences in the change in output can be explicitly derived from equations (26)-(28). No change is observed in the difference between the B and M sectors. However, the gap between the change in the output of good B and that of nontraded good can be rewritten as:

$$-\frac{q_B - \frac{\psi_L^B}{\psi_L^N} q_N}{\pi} = \psi_E^B - \psi_L^B \frac{a_3 \psi^N + a_2 a \eta_N + \frac{\psi_E^N}{\psi_L^N} \{a_2 (1 + \tilde{C}_N \varepsilon^*) - a_1 \psi_L^N\}}{A}. \quad (29)$$

What differs from (24) is that there are new terms in the bracket, which represent the difference in the two sectors' output changes due to the additional change in wage rate. The last term in the brace denotes the additional change in output due to a decline in wage rate associated with real depreciation.

[15] The first two terms in the bracket of (27) and in the brace of (28) represent the change in employment in the traded sectors owing to the change in the wage rate. These terms can be rewritten as

$$[-\lambda_L^B a_3^B (\psi_L^N + \tilde{C}_N \varepsilon^*)] - [\lambda_L^N a_3^N \tilde{C}_N \varepsilon^* + \lambda_L^B a_3^B \psi_E^N + \lambda_L^N (a_3^N \psi_L^N - a_2^N \psi_E^N)].$$

The first bracketed term is identical with the first term in (21). The terms in the second bracket denote the additional change in employment of that sector when imported inputs are also used in the nontraded sector. Less labor would be drawn out of the traded sectors if $\lambda_L^N a_2^N \psi_E^N$ dominates the other terms in the bracket, that is, the nontraded sector is relatively more imported input intensive. Otherwise, the traded sectors lose labor more. The sufficient condition for the latter to hold is $a_3^N \psi_L^N - a_2^N \psi_E^N > 0$. If the partial elasticities of substitution between factors and employment share are identical for all sectors, this condition implies $(\theta_E^B / \theta_L^B) > (\theta_E^N / \theta_L^N)$.

However, the fact that the nontraded sector may expand more owing to both the supply and spending effects implies that the sign of the brace is positive. That is, new terms in (29) exactly measure an extra expansion of the nontraded good's output over that of good B. Note that the nontraded sector can expand more than sector B even if the former is less imported-input intensive than the latter.

[Table 2] Summary of the effect of a decline in imported-input price on sectoral output and employment, real exchange rate, and nominal wage when an imported input is used in both the B sector and the nontraded sector. (θ_E^B, $\theta_E^N > 0$, $\theta_E^M = 0$)

	Gross complements (a_3^i, $b_2^i > 0$)			Gross substitutes (a_3^i, $b_2^i < 0$)		
	Supply effect	Spending effect	Total effect	Supply effect	Spending effect	Total effect
q_N	↑	↑	↑	?	↑	?
q_B	↑	↓	?	?	↓	?
q_M	↓	↓	↓	↑	↓	?
l_N	↑	↑	↑	↓	↑	?
l_B	↑	↓	?	↓	↓	↓
l_M	↓	↓	↓	↑	↓	?
p_N	↓	↑	?	?	↑	?
w	?	↑	↑	↓	↑	?

Ⅳ. SIMULATION

The preceding two sections demonstrated how the change in sectoral output brought on by a change in imported-input price was associated with various parameters such as the factor substitution pattern, the relative factor intensities, the relative expenditure share of nontraded goods, the share of imported inputs in income, and the income elasticity of goods. A specific production function, which characterizes the identical partial elasticities of substitution among factors, was employed to prove a rationale for the degree, and the direction, of the change in sectoral output. This section demonstrates a simulation exercise that examines the sensitivity of the numerical outcome of the change in sectoral output with no specific functional forms. The exercise also explores the accompanied numerical change in sectoral employment, real exchange rate, nominal wage, and real wage for a given set of parameter values.

The following values have been assumed for the parameters that do not vary in the simulation.[16]

[16] The parameters for simulation are based on those of the Korean economy, which has no domestic oil production. The values assigned to λ_i are those of the year of 1985, just before

$\lambda_N = 0.5, \ \lambda_B = 0.25, \ \lambda_M = 0.25, \ \varepsilon^* = 0.4, \ \eta_N = 1, \ \sigma_{KL} = 0.5$

The values of other parameters are allowed to vary as follows.[17]

$C_N = 0.4, 0.2; \ \alpha = 0.15, 0.3; \ \sigma_{EL} = 0.5, 1.5; \ \sigma_{KE} = -1.5, 0.5, 1.5;$
$\theta^i_L = 0.3 - 0.7.$

The partial elasticities of substitution between factors are assumed to be identical among sectors.

Imported input used only in the *B* sector

First, consider the case of $\theta^B_E > 0$, $\theta^M_E = \theta^N_E = 0$. Table 3A presents the possible changes in sectoral output for a percentage decline in imported-input price based on the above parameter values and $\theta^B_E = 0.2$. As expected, the outcome depends crucially on whether labor and imported input are gross complements or substitutes. For the cases that guarantee *gross complementarity* ($a^B_3 > 0$), a decline in imported-input price produces a rise in the output of B and the nontraded goods. However, the output of good M falls. With $\sigma_{KE} = 1.5$, $\sigma_{EL} = 0.5$, $\alpha = 0.3$, and $C_N = 0.4$, for instance, the output of good B and N rises by 3.2% and 0.5% for a 10% decline in Π, respectively, while that of good M falls by 3.8%. A decline in the output of good M is mitigated when that sector has the highest cost share of labor (case 3). When the spending effect is weaker ($\alpha = 1.5$), sector B is the only one that gains output.

For the case of a fixed $C_N = 0.4$, table 3B presents the changes in sectoral employment, real exchange rate and nominal wage rate for a percentage decline

world oil prices fell by half. The values of ε^* and η_N are drawn from Baek (1986, Chapter 5) where aggregate demand functions of traded and nontraded goods are estimated for Korea for the period 1960-1980. The estimated values of ε^* and η_N range from 0.34 to 0.45 and from 0.97 to 1.06, respectively.

[17] The upper values of C_N and α are the 1985 estimates for Korea. The assigned values of σ_{ij} are based on their short-run estimates of some of the previous studies. According to Burgess (1974), who studied the U.S. case using aggregate time series data for the period 1947-1968, σ_{KE} ranged from 2.56 to 3.88 and σ_{EL} from 1.05 to 1.51. Baek (1986) estimated the aggregate two-level CES production functions for traded and nontraded goods for Korea over the period 1960-1981, and found that σ_{KL} fluctuated from 0.61 to 0.68 and $\sigma_{VE} = \sigma_{KE} = \sigma_{EL}$ from 0.75 to 2.97 depending on the functional forms. On the other hand, Berndt and Wood (1979) and Berndt (1991) employed the translog specification to estimate the production function for the U.S. manufacturing for the period 1947-1971. Their estimates of σ_{ij} are $\sigma_{KL} = 0.97$, $\sigma_{KE} = -3.60$, $\sigma_{KM} = 0.35$, $\sigma_{LM} = 0.61$, $\sigma_{EM} = 0.83$, and $\sigma_{EL} = 0.68$ where E = energy and M = nonenergy intermediate materials.

in imported-input price. The real exchange rate and nominal wage rate rise for all sets of parameter values. Their percentage changes become greater for higher σ_{KE}, but smaller for higher σ_{EL}, as expected. Sectoral employment closely follows the path of sectoral output: sector B is the one that draws labor most. As gross complementarities between labor and imported input are getting weaker, however, it is possible that sector B needs less labor to produce more output. When all partial elasticities between factors are 0.5 and $\alpha=0.3$, for example, sector B loses employment despite an increase in its output.

[Table 3A] Changes in sectoral output for a percentage decline in imported-input price ($\theta_E^B=0.2,\ \theta_E^N=\theta_E^M=0$)

	$\alpha=1.5$						$\alpha=3.0$						
	$\sigma_{EL}=0.5$			$\sigma_{EL}=1.5$			$\sigma_{EL}=0.5$			$\sigma_{EL}=1.5$			
	q_N	q_B	q_M	q_N	q_B	q_M	q_N	q_B	q_M	q_N	q_B	q_M	σ_{KE}
$C_N=0.2$													
	0.10	-0.36	0.06	0.14	-0.35	0.11	0.13	-0.36	-0.00	0.17	-0.36	0.06	-1.5
Case 1	-0.01	0.07	-0.11	0.03	0.19	-0.04	0.02	0.15	-0.16	0.06	0.17	-0.10	0.5
	-0.06	0.40	-0.15	-0.02	0.43	-0.12	-0.03	0.38	-0.24	0.01	0.41	-0.17	1.5
	0.03	-0.32	0.08	0.05	-0.31	0.15	0.04	-0.33	0.04	0.06	-0.32	0.10	-1.5
Case 2	-0.01	0.22	-0.14	0.00	0.27	-0.07	0.00	0.19	-0.17	0.02	0.25	-0.11	0.5
	-0.02	0.42	-0.22	-0.01	0.49	-0.15	-0.01	0.38	-0.25	0.00	0.45	-0.18	1.5
	0.03	-0.36	0.08	0.04	-0.35	0.12	0.04	-0.36	0.04	0.05	-0.35	0.09	-1.5
Case 3	0.00	0.17	-0.09	0.01	0.19	-0.03	0.01	0.16	-0.12	0.02	0.18	-0.06	0.5
	-0.01	0.41	-0.16	-0.00	0.44	-0.10	0.00	0.40	-0.19	0.01	0.43	-0.13	1.5
$C_N=0.4$													
	0.11	-0.36	0.03	0.14	-0.35	0.11	0.16	-0.37	-0.09	0.21	-0.36	-0.00	-1.5
Case 1	0.03	0.15	-0.18	0.06	0.17	-0.10	0.08	0.11	-0.29	0.12	0.14	-0.20	0.5
	-0.01	0.36	-0.28	0.02	0.40	-0.19	0.05	0.32	-0.38	0.09	0.36	-0.29	1.5
	0.04	-0.33	0.03	0.06	-0.32	0.10	0.07	-0.35	-0.08	0.08	-0.33	0.00	-1.5
Case 2	0.01	0.17	-0.19	0.02	0.23	-0.12	0.04	0.10	-0.28	0.05	0.17	-0.20	0.5
	-0.00	0.35	-0.27	0.01	0.43	-0.20	0.02	0.26	-0.35	0.04	0.35	-0.27	1.5
	0.04	-0.36	0.03	0.05	-0.35	0.09	0.07	-0.36	-0.05	0.08	-0.36	0.01	-1.5
Case 3	0.02	0.16	-0.13	0.03	0.18	-0.07	0.05	0.14	-0.21	0.06	0.16	-0.14	0.5
	0.01	0.39	-0.20	0.02	0.42	-0.14	0.04	0.36	-0.28	0.05	0.39	-0.21	1.5

Note: Case 1: $\theta_L^N=0.7,\ \theta_L^B=\theta_L^M=0.3$; Case 2: $\theta_L^B=0.7,\ \theta_L^N=\theta_L^M=0.3$;
Case 3: $\theta_L^M=0.7,\ \theta_L^B=\theta_L^N=0.3$;

[Table 3B] Changes in real exchange rate, wage and sectoral employment for a percentage decline in imported-input price
($\theta_E^B=0.2,\ \theta_E^N=\theta_E^M=0$)

	$\sigma_{EL}=0.5$						$\sigma_{EL}=1.5$						
	l_N	l_B	l_M	p_N	w	r_w	l_N	l_B	l_M	p_N	w	r_w	σ_{KE}
$a=0.3$													
	0.23	-0.41	-0.06	0.23	0.09	-0.00	0.28	-0.56	-0.00	0.27	0.00	-0.07	-1.5
Case 1	0.12	-0.03	-0.21	0.36	0.29	0.15	0.17	-0.20	-0.14	0.30	0.20	0.08	0.5
	0.07	0.13	-0.27	0.15	0.38	0.21	0.12	-0.04	-0.24	0.36	0.29	0.14	1.5
	0.22	-0.39	-0.06	0.39	0.08	-0.08	0.26	-0.53	0.00	0.37	-0.00	-0.15	-1.5
Case 2	0.12	-0.04	-0.20	0.44	0.28	0.10	0.16	-0.17	-0.14	0.42	0.20	0.03	0.5
	0.08	0.08	-0.24	0.46	0.35	0.16	0.12	-0.04	-0.20	0.44	0.27	0.10	1.5
	0.24	-0.39	-0.08	0.38	0.05	-0.10	0.27	-0.55	0.02	0.37	-0.01	0.16	-1.5
Case 3	0.15	0.03	-0.34	0.42	0.21	0.04	0.19	-0.14	-0.24	0.41	0.14	-0.02	0.5
	0.12	0.23	-0.46	0.44	0.28	0.10	0.15	0.04	-0.35	0.42	0.21	0.04	1.5
$a=0.15$													
	0.16	-0.34	0.02	0.06	-0.03	-0.06	0.20	-0.48	0.08	0.01	-0.11	-0.11	-1.5
Case 1	0.04	0.05	-0.13	0.21	0.18	0.10	0.09	-0.10	-0.07	0.15	0.10	0.04	0.5
	-0.01	0.23	-0.20	0.27	0.28	0.17	0.03	0.07	-0.14	0.21	0.19	0.11	1.5
	0.15	-0.33	0.02	0.18	-0.03	-0.10	0.19	-0.44	0.07	0.16	-0.10	-0.17	-1.5
Case 2	0.13	0.08	-0.14	0.23	0.19	0.10	0.07	-0.05	-0.08	0.22	0.12	0.03	0.5
	-0.01	0.22	-0.19	0.26	0.27	0.17	0.03	0.09	-0.14	0.24	0.20	0.11	1.5
	0.15	-0.34	0.05	0.18	-0.03	-0.10	0.18	-0.50	0.14	0.16	-0.09	-0.15	-1.5
Case 3	0.06	0.09	-0.22	0.22	0.13	0.04	0.09	0.07	-0.12	0.20	0.07	-0.01	0.5
	0.02	0.29	-0.34	0.24	0.20	0.11	0.06	0.12	-0.24	0.22	0.14	0.05	1.5

Note: $rw \equiv w - C_N p_N$ = Change in real wage rate.

Now consider the opposite case where labor and imported input are gross substitutes. With σ_{KE}=-1.5, $\sigma_{EL}=0.5$ and other varying parameter values, sector B's output falls by 3.6% for a 10% decline in imported-input price (table 3A). The nontraded and M sectors both benefit from the shock. However, sector M's output still falls short of its previous level when the spending effect is relatively strong. When the positive supply effect becomes relatively strong, on the other hand, sector M's output expands. For $a=0.15$ and $C_N=0.2$, sector M gains output more than the nontraded sector in the case where the latter is relatively less labor intensive.

According to table 3B, the degree of real appreciation has been significantly reduced with strong complementarity between capital and imported input, as expected. The nominal wage rate changes little and even declines as a becomes smaller. Labor moves to the nontraded sector mostly out of the B sector. As the demand effect becomes relatively weaker, labor is also drawn into the M sector. Of course, the degree of employment gains moves positively with the relative labor intensity in each sector.

Imported input in the nontraded sector

Next, consider the case where an imported input is also used in the nontraded sector, but less intensively than in the B sector ($\theta_E^B > \theta_E^N > \theta_E^N = 0$). Tables 4A and 4B present the changes in the same variables profiled in tables 3A and 3B, respectively, when parameter values remain the same except $\theta_E^N = 0.1$. When labor and imported input are *gross complements*, the B and nontraded sectors both gain output while sector M loses it for all possible parameter values. Although the nontraded sector uses the imported input less intensively, it expands more than sector B for high α and C_N (i.e., the strong spending effect) and for moderate substitutability between factors. Compared with the previous case, sector M declines less because the real exchange rate appreciates less along with a smaller increase in the nominal wage rate as shown in table 4B. The force behind this is the stronger supply effect over the spending effect. For $\alpha = 0.15$, for instance, the real exchange rate even depreciates with little change in the wage rate for high σ_{KE} and σ_{EL}.[18]

The changes in sectoral employment closely follow the pattern of those of the previous case in table 3A. One exception is that the nontraded sector will draw more labor from the traded sectors when the spending effect on labor is larger (higher α) and the supply effect is smaller (lower σ_{EL}).

In the case where labor and imported input are gross substitutes, sector B loses its output and employment while sector M gains them. The output for the nontraded goods expands less and even declines for $\sigma_{KE} = -1.5$. At such an extreme value, the supply elasticity of these goods becomes negative with respect to the imported-input price. Additionally, the nominal wage rate is more likely to fall as the demand for labor decreases. On the other hand, the real exchange rate will appreciate more because the spending effect becomes weaker while the negative supply effect increases with greater substitutability between labor and imported input. With greater real appreciation, the nontraded sector gains employment even in the case where it loses output.

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[18] Higher σ_{EL} does not affect ψ_L^N and ψ_E^N, but lowers a_3^i by θ_E^i. Thus the first terms in parentheses of (18) and (19) become smaller, implying its negative effect on p_N and w for $\pi < 0$. If the values of σ_{EL} and σ_{KE} are up by the same magnitude (say, $\Delta\sigma_{EL} = \Delta\sigma_{KE} = 1$), $\Delta\psi_L^N = \Delta\psi_E^N$, $\Delta a_3^i = \theta_E^i(\theta_E^i / \theta_K^i)$, $\Delta a_2^i = \theta_E^i(1 + \theta_L^i / \theta_K^i)$, and $\Delta a_1^i = \theta_E^i / \theta_K^i$. Since, $0 < \theta_E^i < \theta_L^i < 1$, the second terms in the parentheses always exceed the first terms for a given change in the elasticity of substitution. Therefore, either higher σ_{EL} or σ_{KE} leads to lower real exchange rate and nominal wage in the supply side.

[Table 4A] Changes in sectoral output for a percentage decline in imported-input price($\theta_E^B=0.2,\ \theta_E^N=0.1,\ \theta_E^M=0$)

	$\alpha=1.5$						$\alpha=3.0$						
	$\sigma_{EL}=0.5$			$\sigma_{EL}=1.5$			$\sigma_{EL}=0.5$			$\sigma_{EL}=1.5$			
	q_N	q_B	q_M	q_N	q_B	q_M	q_N	q_B	q_M	q_N	q_B	q_M	σ_{KE}
$C_N=0.2$													
	0.05	-0.35	0.02	0.11	-0.35	0.04	0.07	-0.36	0.01	0.14	-0.35	0.03	-1.5
Case 1	0.08	0.16	-0.03	0.17	0.19	-0.01	0.13	0.14	-0.04	0.22	0.18	-0.02	0.5
	0.07	0.38	-0.05	0.17	0.43	-0.02	0.12	0.36	-0.06	0.22	0.41	-0.03	1.5
	-0.14	-0.31	0.03	-0.12	-0.29	0.06	-0.14	-0.31	0.03	-0.13	-0.29	0.05	-1.5
Case 2	0.06	0.20	-0.03	0.09	0.30	-0.01	0.08	0.17	-0.04	0.11	0.28	-0.01	0.5
	0.14	0.36	-0.06	0.17	0.50	-0.03	0.17	0.32	-0.06	0.20	0.46	-0.04	1.5
	-0.15	-0.36	0.15	-0.13	-0.35	0.25	-0.15	-0.35	0.12	-0.13	-0.35	0.23	-1.5
Case 3	0.08	0.17	-0.12	0.10	0.20	-0.00	0.10	0.16	-0.16	0.12	0.19	-0.04	0.5
	0.15	0.39	-0.24	0.18	0.44	-0.11	0.18	0.38	-0.27	0.21	0.43	-0.15	1.5
$C_N=0.4$													
	0.07	-0.36	0.01	0.13	-0.35	0.04	0.12	-0.36	-0.01	0.18	-0.35	0.02	-1.5
Case 1	0.11	0.15	-0.04	0.17	0.19	-0.01	0.20	0.12	-0.06	0.26	0.17	-0.02	0.5
	0.11	0.37	-0.06	0.18	0.44	-0.02	0.21	0.33	-0.08	0.27	0.40	-0.04	1.5
	-0.16	-0.33	0.01	-0.14	-0.30	0.04	-0.17	-0.34	-0.01	-0.15	-0.32	0.02	-1.5
Case 2	0.08	0.18	-0.04	0.10	0.29	-0.01	0.13	0.11	-0.06	0.15	0.23	-0.03	0.5
	0.15	0.35	-0.06	0.17	0.50	-0.03	0.21	0.27	-0.07	0.23	0.43	-0.04	1.5
	-0.16	-0.36	0.05	-0.14	-0.35	0.17	-0.17	-0.36	-0.04	-0.15	-0.36	0.09	-1.5
Case 3	0.09	0.16	-0.15	0.11	0.20	-0.02	0.05	0.14	-0.24	0.16	0.18	-0.09	0.5
	0.16	0.39	-0.24	0.18	0.44	-0.10	0.22	0.36	-0.32	0.24	0.42	-0.18	1.5

Note: Case 1: $\theta_L^N=0.7,\ \theta_L^B=\theta_L^M=0.3$; Case 2: $\theta_L^B=0.7,\ \theta_L^N=\theta_L^M=0.3$;
Case 3: $\theta_L^M=0.7,\ \theta_L^B=\theta_L^N=0.3$;

The changes in sectoral employment closely follow the pattern of those of the previous case in table 3A. One exception is that the nontraded sector will draw more labor from the traded sectors when the spending effect on labor is larger (higher α) and the supply effect is smaller (lower σ_{EL}).

In the case where labor and imported input are gross substitutes, sector B loses its output and employment while sector M gains them. The output for the nontraded goods expands less and even declines for $\sigma_{KE}=-1.5$. At such an extreme value, the supply elasticity of these goods becomes negative with respect to the imported-input price. Additionally, the nominal wage rate is more likely to fall as the demand for labor decreases. On the other hand, the real exchange rate will appreciate more because the spending effect becomes weaker while the negative supply effect increases with greater substitutability between labor and imported input. With greater real appreciation, the nontraded sector gains employment even in the case where it loses output.

[Table 4B] Changes in real exchange rate, wage and sectoral employment for a percentage decline in imported-input price
($\theta_E^B = 0.2$, $\theta_E^N = 0.1$, $\theta_E^M = 0$)

	$\sigma_{EL}=0.5$						$\sigma_{EL}=1.5$						
	l_N	l_B	l_M	p_N	w	r_w	l_N	l_B	l_M	p_N	w	r_w	σ_{KE}
$a=0.3$													
Case 1	0.27	-0.40	-0.03	0.34	0.07	-0.07	0.26	-0.50	0.07	0.24	-0.09	-0.18	-1.5
	0.15	-0.02	-0.23	0.24	0.28	0.18	0.12	-0.11	-0.10	0.12	0.11	0.06	0.5
	0.10	0.14	-0.31	0.23	0.37	0.27	0.06	0.06	-0.18	0.11	0.20	0.15	1.5
Case 2	0.25	-0.37	-0.02	0.79	0.06	-0.26	0.23	-0.46	0.08	0.75	-0.09	-0.39	-1.5
	0.13	-0.03	-0.20	0.31	0.27	0.15	0.10	-0.06	-0.10	0.27	0.13	0.02	0.5
	0.08	0.09	-0.27	0.18	0.34	0.27	0.04	0.08	-0.17	0.14	0.21	0.15	1.5
Case 3	0.26	-0.38	-0.15	0.78	0.03	-0.28	0.23	-0.50	0.05	0.75	-0.08	-0.38	-1.5
	0.17	0.04	-0.29	0.29	0.27	0.15	0.13	-0.08	-0.09	0.26	0.08	-0.02	0.5
	0.13	0.23	-0.35	0.16	0.27	0.21	0.08	0.11	-0.15	0.12	0.15	0.10	1.5
$a=0.15$													
Case 1	0.18	-0.34	0.04	0.15	-0.04	-0.10	0.17	-0.42	0.14	0.06	-0.18	-0.20	-1.5
	0.05	0.06	-0.15	0.10	0.18	0.14	0.02	-0.02	-0.04	-0.01	0.02	0.03	0.5
	-0.01	0.23	-0.24	0.10	0.27	0.26	-0.04	0.15	-0.12	-0.00	0.09	0.10	1.5
Case 2	0.16	-0.30	0.05	0.51	-0.04	-0.25	0.15	-0.38	0.14	0.48	-0.17	-0.37	-1.5
	0.04	0.08	-0.14	0.12	0.19	0.14	0.00	0.05	-0.05	0.09	0.06	0.02	0.5
	-0.01	0.22	-0.21	0.02	0.27	0.26	-0.06	0.21	-0.12	-0.02	0.14	0.15	1.5
Case 3	0.16	-0.34	-0.02	0.50	-0.04	-0.25	0.13	-0.45	0.16	0.49	-0.14	-0.34	-1.5
	0.07	0.10	-0.17	0.11	0.13	0.08	0.03	-0.02	0.01	0.07	0.02	-0.01	0.5
	0.03	0.29	-0.23	0.00	0.20	0.20	-0.02	0.18	-0.05	-0.03	0.09	0.10	1.5

Note: $rw \equiv w - C_N p_N$ = Change in real wage rate

Finally, the changes in the real wage rate for a percentage decline in imported-input price are calculated in tables 3B and 4B to examine its impact on income distribution. As expected, more complementarity between labor and imported input leads to greater income redistribution in favor of workers. When the imported input is also used in the nontraded sector, the real wage moves further in favor of workers. A 10% decline in imported-input price raises the real wage rate by as much as 2.7% for high σ_{KE}(= 1.5) and low σ_{EL}(= 0.5) and for other given parameter values. When labor and imported input are gross substitutes, however, the result is exactly opposite. In the case where the traded sectors are relatively labor intensive with the values of σ_{KE}=-1.5 and σ_{EL}= 0.5, the real wage rate declines by 3.9% when the nontraded sector also uses the imported input.

V. SUMMARY AND CONCLUDING REMARKS

If the origin of a shock is the change in imported-input prices, its sectoral effects vary depending on the structural characteristics of consumption and production in the economy. Some tradables (the B sector) initially favored by the shock may grow at the expense of the other tradables (the M sector). The nontraded sector expands along with real appreciation and the rise in wages. Mobile resources, such as labor, move to the B sector and the nontraded sector at the expense of the M sector.

The necessary, but not sufficient, condition for this outcome is that imported input and labor are gross complements. If the spending effect is strong and the nontraded sector is relatively more labor intensive, labor tends to move to the nontraded sector out of both traded sectors. If imported input and labor are gross substitutes, on the other hand, sector B loses employment to the other sectors, and the nontraded sector expands more than the traded sectors.

When the nontraded sector is also favored by the shock, that sector may gain output and employment more than the B sector even if the former uses the imported input less intensively than the latter. If imported input and labor are gross substitutes, however, output of the nontraded sector may decline, too. An extreme case is that only the M sector expands.

It is most likely that the real exchange rate appreciates and nominal wages rise after the favorable shock. It is possible, however, that the real exchange rate depreciates when the spending effect is weak, and that nominal wages decline when labor and imported input are strongly substitutable. Income distribution crucially depends on factor substitutabilities and the relative expenditures of nontraded goods.

A major aim of this paper is to explore how an import price shock leads to asymmetric growth and resource reallocation across sectors in the short- and medium-run. The long-run effects of the shock on economic growth and capital accumulation cannot be analyzed within the analytical framework presented in the text. Recently, Kim (2000) presented a small, open, dependent economy model to investigate the long-run effects of an oil price shock. However, the economy in his model consists of only two sectors (tradable and nontradable); the role of oil as an intermediate input is not explicitly taken into account in the dynamic and steady state analysis. Spatafora and Warner (1999) present a long-run model for terms-of-trade shocks, which still focuses on natural resource boom and Dutch Disease effects. Much more is left to be done in building a long-run model for imported-input price shocks.

An empirical investigation is required to identify the actual impact of an imported-input price shock on sectoral output and employment, and on the real exchange rate. In contrast to the case of a natural resource boom, however, it is almost impossible to get an individual country's sectoral imported-input data, preventing a cross-section or panel estimation for oil-importing economies. Thus, the next step is to estimate macroeconomic and sectoral effects of imported-input price shocks with time-series data of an individual oil-importing economy.

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