DYNAMIC ADJUSTMENT MECHANISM TO A RISE IN PRICE OF RAW MATERIALS: FLEXIBLE EXCHANGE RATE CASE

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Recent years have witnessed drastic and persistent rises in oil price under the flexible exchange rate regime. Stress has been put on impacts of rises in the oil price on inflation, unemployment and welfare loss.[1] In order to investigate those impacts, it conventionally is assumed that the world consists of two countries: the oil exporters (OPEC) and the Rest. However, when we focus attention on a specific country, for instance, the United States or Japan, and study dynamic adjustment mechanism to a rise in price of raw materials (or petroleum), the two-country model may not be the best choice. After examining responses in the Rest due to a rise in oil price as done by W. M. Corden (2), we must add a priori assumptions on countries in the Rest.

> "One can begin with a very simple point. For the Rest as a whole there is really no balance-of-payments problem as a result of the oil price rise. ... The balance-of-payments problem, therefore, arises only where one looks at the different impact on different countries within the Rest (W. M. Corden (2, p. 113))."

Rather, for our analytical purpose, we shall divide the world into a medium-sized country, whose character will be described soon, and the rest, which, of course, includes the OPEC countries. Let us define the medium-sized country as the one having the following properties:[2] (1) she behaves a price-taker with respect to the import of raw materials; and (2) she possesses a monopolistic power over exportables and faces a downward-sloping demand curve. In this sense, as far as we are concerned to petroleum resources, most developed countries may be counted as being medium sized.

The purpose of this paper is to provide a simple theoretical model to meet current interests and to examine dynamic impacts of constant rises in the price of raw materials on unemployment, inflation and welfare. We

[1] See W. M. Corden (2, particularly Chapters 7, 8 and 9) and references given there.

[2] The concept of the "medium-sized" economy is studied by M. Teubal (10) in the different context.

are particularly interested in the dynamic adjustment process created by a rise in price of raw materials. Since price of raw materials is given to the country concerned and their price rise has a cost-inflationary effect on manufactured goods, it will create the terms of trade effect. This effect may be incorporated, through wage-price spiral, with the Phillips curve relationships.

Consider the situation where the price of raw materials is rising at the constant rate. As it has been established that an expansionary monetary policy cannot affect the equilibrium rate of unemployment, the monetary policy may not be effective to prevent any welfare losses. However, as stressed by K. Hamada and M. Sakurai (7), while the expansionary monetary policy does not affect the equilibrium rate of unemployment, the country may experience, for example, stagflation in the transitory period. Since we are interested in dynamic adjustment mechanisms to a rise in price of raw materials, our model is quite similar to the one employed by K. Hamada and M. Sakurai. Basic difference lies in the fact that we do not give primal importance on international transmission mechanism of stagflation. The reason essentially is related to the assumption of the medium-sized country. When the rest of the world consists of the exporting countries of raw materials and of their importing countries, we do not anticipate a simple and direct response on the medium-sized country through income variations in the rest of the world. While a rise in price of raw materials probably raises revenues of those countries which export raw materials and may push up the income of the rest of the world, incomes of those countries in the rest of the world which face a higher price of imported raw materials will in most cases be depressed. From the practical viewpoint, as mentioned in W. M. Corden (2), the income of the world as a whole may be declined. In this respect, we isolate impacts on the medium-sized economy from income variations in the rest of the world.[3] While most of our analysis are concerned to unanticipated shocks of a rise in price of raw materials, we shall investigate the case of anticipated shocks.[4] In fact, we shall show that introducing anticipated shocks yields quite different implications on the dynamic adjustment path. In the case of the unanticipated shocks, the economy will face stagflation after shocks. On the other hand, in the anticipated case, the economy will first experience temporary recession, and then

[3] A transmission mechanism may be introduced even in our framework. Suppose that an increase in the foreign revenue from raising the price of raw materials increases the demand for exportables by the medium-sized country. This can be treated as an increase in the marginal propensity to consume exportables (see discussions given in Section II.)

[4] In the case of petroleum resources, the future oil price usually is announced after the regular OPEC meetings, prior to the actual increase.

stagflation after price of raw materials is actually raised.

This paper is organized as follows: Section 1 states basic equations of our model, where static properties are spelled out. Then in Section 2 dynamic aspects are introduced by the short-run and the long-run Phillips curve relationships. Section 3 examines main results derived from our model. Section 4 briefly touches upon the case where a rise in the price of raw materials is anticipated. Concluding remarks are given in Section 5.

1. Basic Equations of the Model

Consider a medium-sized country which exclusively imports raw materials from abroad and in return exports a (composite) manufactured good. In order to produce the manufactured good, both labor and raw materials are requisite. Denoting the employment of labor and the employment of raw materials by L and N respectively, we assume a simple type of the production function:

$$X=L^{\alpha}N^{\beta} \qquad 0<\alpha+\beta<1\,. \tag{1.1}$$

It is implicit in equation (1) that the fixed factor, called capital, is kept constant and that net capital accumulation is negligible.

The demand for labor and the demand for raw materials are given by their marginal productivities.

$$w=p\frac{\partial X}{\partial L}=p\alpha L^{\alpha-1}N^{\beta} \tag{1.2}$$

$$p_N=p\frac{\partial X}{\partial N}=p\beta L^{\alpha}N^{\beta-1}, \tag{1.3}$$

where w, p_N and p respectively stand for money wage, the domestic price of raw materials, and the price of the manufactured good. Since the international price of raw materials is given from the rest of the world, equation (1.3) determines the amount of raw materials which the medium-sized country will import at the current rate of exchange.

International arbitrage conditions are given by equations (1.4) and (1.5), when we assume away transportation costs.

$$p=ep^{*} \tag{1.4}$$

$$p_N=ep_N^{*}, \tag{1.5}$$

where starred variables are those in the rest of the world and e denotes the exchange rate.

Next, let us consider the consumption side. For simplicity, we assume that residents in the country spend their expenditure on the manufactured good. That is,

$$pC=E,$$

where E stands for the total expenditure. We assume that the only financial assets available in the world are monies and take the following form of the total expenditure function,[5]

$$E=\nu M,$$

where M and ν respectively show the stock of money outstanding and the consumption velocity of money. Combining the above two relations, we have:

(1. 6) $$pC=\nu M.$$

We assume that residents in the rest of the world spend a constant fraction of their expenditures on the manufactured good exported by the medium-sized country.[6]

$$p^*C^*=c^*E^* \qquad 0<c^*<1.$$

Assuming the same type of the total expenditure function for the rest of the world, we can rewrite the foreign demand for the manufactured good produced by the medium-sized country as equation (1. 7).

(1. 7) $$p^*C^*=c^*\nu^*M^*=\bar{\nu}^*M^*,$$

where $\bar{\nu}^*=c^*\nu^*$.

Let us turn our attention to the equilibrium market condition for the manufactured good, which is stated in equation (1. 8).

(1. 8) $$X=C+C^*.$$

By using equations (1. 6), (1. 7) and (1. 8) and the arbitrage condition, the equilibrium situation in the manufactured good market will be expressed by equation (1. 9).

(1. 9) $$X=\nu\frac{M}{p}+e\bar{\nu}^*\frac{M^*}{p}.$$

Equation (1. 9) characterizes the core of the assumption of the medium-

[5] J. M. Keynes (8) called this equation "the real balances quantity equation." Equation (1. 6) can be regarded as the expression for money-hoarding behaviours as well. For detailed discussion, see K. Hamada and M. Sakurai (7).

[6] There are least three kinds of commodities in the rest of the world: (1) the manufactured good produced in the medium-sized country; (2) nontraded goods in each country; and (3) commodities traded only among countries belonged to the rest of the wold. Generally speaking, c^* may not be constant. In fact, in order to emphasize foreign repercussions of revenues from raw materials, we can explicitly treat the marginal propensity to consume the manufactured good exported by the mediumsized country as a function of the foreign revenue of raw materials. That is,

$$c^*=c^*(p_N^*N) \quad \text{and} \quad \frac{dc^*}{d(p_N^*N)}>0.$$

For simplicity, here we assume c^* constant.

sized country. The equilibrium price of the manufactured good is endogenously determined and is not independent of the amount of the manufactured good the medium-sized country produces. For given values of M, M^* and e, the demand for the manufactured good is downwardly sloping.

Finally, we introduce the market-clearing condition in the foreign exchange market.

$$pC^*-p_NN=0\,. \tag{1.10}$$

Using equation (1. 8), we rewrite equation (1. 10).

$$pX-pC-p_NN=0\,. \tag{1.10'}$$

There are two remarks on equation (1. 10'). First, the exchange rate is determined so as to equalize import to export, which is equivalent to saying, in our model, domestic absorption equals import of raw materials. Second, equation (1. 10') may be regarded as the household budget constraint. Since the amount of $(pX-p_NN)$ is equal to the distributive national income attributive to domestic factors, equation (1. 10') confirms that all the factor earnings are consumed. Naturally, this implies that under the flexible exchange rate there is no money hoarding.

2. Dynamic Aspects of the Model

So far, we have not introduced dynamic factors in our framework. Dynamic flavors are mainly added by the short-run and the long-run Phillips curve relationships.

Equation (2. 1) describes the short-run Phillips curve.

$$\hat{w}=\phi(L)+\pi\,, \tag{2.1}$$

where π is the expected rate of inflation. The notation "$\hat{}$" indicated the rate of increase, for example, $\hat{w}=dw/wdt$. Equation (2. 1) defines the relationship between unemployment and the rate of wage increase.[7]

We assume the adaptive formation of price expectation, that is,

$$\dot{\pi}=\gamma(\hat{p}-\pi)\,. \tag{2.2}$$

In order to examine impacts of persistent rises in the price of raw materials, we consider a simple economic situation where the price of raw materials rises at a constant rate and monetary authorities supply money at constant rates.

[7] In the case of K. Hamada and M. Sakurai (7), the short-run Phillips curve relation is defined between output and the rate of wage increase. Since labor is the only factor of production in their case, our specification of the Phillips curve would basically be equivalent to theirs. However, in the two factor case, containing raw materials as the second factor, our specification is more traditional.

Equation (2. 3) indicates a constant increase in the price of raw materials.

(2. 3) $$\hat{p}_N^* = \bar{\theta}\,.$$

Equations (2. 4) and (2. 5) show exogenous rates of monetary expansion.

(2. 4) $$\hat{M} = \theta$$

(2. 5) $$\hat{M}^* = \theta^*\,.$$

Now, we are ready to derive dynamic configuration of the system. First, note the balance of payments equation (1. 10). Substituting equation (1. 7) and using the arbitrage condition, we shall have:

$$p_N^* N = v^* M^*\,.$$

The LHS of the above equation shows the export of raw materials from the rest of the world, while the RHS measures its import.

Totally differentiating the above relation, we can arrange the result as follows:

(2. 6) $$\hat{N} = \theta^* + \hat{v}^* - \bar{\theta}\,.$$

The term θ^* represents a demand-pull factor, whose increase implies a rise in the demand for the manufactured good and the higher employment rate of raw materials. On the other hand, the term $\bar{\theta}$ indicates a cost-push factor, whose increase means employment of raw materials becoming more expensive and reduction in their employment. The term associated to a change in v^*, i.e., $\hat{v}^*$, may describe repercussions from the rest of the world, due to a rise in the revenue of the rest of the world, exporting raw materials to the medium-sized country.[8] For simplicity, we assume $\hat{v}^* = 0$.

Totally differentiate equations (1. 2) and (1. 3).

(2. 7) $$v\hat{w} = \hat{p} + (\alpha - 1)\hat{L} + \beta\hat{N}\,.$$

(2. 8) $$\hat{p}_N = \hat{e} + \bar{\theta} = \hat{p} + \alpha\hat{L} + (\beta - 1)\,\hat{N}\,.$$

In deriving the latter relationship, we have used the arbitrage condition, equation (1. 5).

Now let us derive a variation in the equilibrium price of the manufactured good. Using equations (1. 1), (1. 9) and (2. 6),

(2. 9) $$\hat{p} = \delta_1\theta + \delta_2(\hat{e} + \theta^*) - \alpha\hat{L} - \beta(\theta^* - \bar{\theta})\,,$$

where $\delta_1 = \dfrac{pC}{pX}$ (=domestic consumption ratio), $\delta_2 = \dfrac{pC^*}{pX}$ (rate of import) and $\delta_1 + \delta_2 = 1$. Substituting (2. 9) into (2. 8), we have:

[8] If the income of the rest of the world is raised by an increase in the revenue from exporting raw materials and subsequently the export of the medium-sized country is increased, v^* is considered to be increased. See footnote 6.

$$\hat{e} = \theta - \theta^* . \tag{2.10}$$

Therefore, *under flexible exchange rates and under the assumption of unitary elasticity of substitution in consumption, the rate of depreciation in the exchange rate is equal to the difference between the growth rates of money supply of the home country and that of the rest of the world* (Hamada-Sakurai). Note any changes in price of raw materials do not affect the exchange rate at all in this special case.[9]

Substituting (2. 9) and (2. 10) into (2. 7), we shall obtain the basic framework of differential equations for the medium-sized country under the flexible exchange rate regime.

$$\hat{L} = \theta - \pi - \phi(L) \tag{2.11}$$

$$\dot{\pi} = r\left\{\theta + \beta(\bar{\theta} - \theta^*) - \alpha\hat{L} - \pi\right\} . \tag{2.12}$$

Equilibrium solutions may be obtained by putting all the time derivatives equal to zero. Writing equilibrium values as $\bar{L}$ and $\bar{\pi}$, we have,

$$\phi(\bar{L}) = \theta - \bar{\pi} \tag{2.13}$$

$$\bar{\pi} = \theta + \beta(\bar{\theta} - \theta^*) . \tag{2.14}$$

We immediately notice that under the assumption of the medium-sized country, that country cannot pursue independent monetary policy. *The equilibrium rate of inflation is influenced both by the rate of monetary expansion in the rest of the world and by the rate of increase in price of raw materials. If and only if the constant rate of increase in the raw materials' price is exactly offset by the rate of foreign monetary expansion, the domestic monetary authority can pursue independent monetary policy.*[10]

3. Impacts of a Rise in Price of Raw Materials

In this section, we examine the case where the international price of raw materials suddenly rises at the rate $\bar{\theta}$. How this rise will affect inflation, unemployment and welfare? How much domestic monetary policy is effective? Most of our emphases will be put on dynamic adjustment process of the economy.

[9] In the case of non-unitary elasticity of substitution, equation (2. 10) does not hold. Instead of (2. 10), one generally has

$$\dot{e} = \theta - \bar{\theta} - \frac{1}{\sigma}(\theta^* - \bar{\theta}) + \left(\frac{1}{\sigma} - 1\right)\frac{\delta_L}{1-\delta_N}\hat{L} ,$$

where δ_L and δ_N respectively denote shares of labor and raw materials.

[10] We may consider $\bar{\theta}$ as a proxy to the equilibrium rate of inflation in the rest of the world. Then we may expect that foreign inflation is caused by expansionary foreign monetary policy. That is, we may assume $\bar{\theta} = \theta^*$. However, since the rest of the world consists of raw materials importers, there is no justifiable reason to presuppose $\bar{\theta} = \theta^*$.

To study the adjustment process to the equilibrium, we employ phase diagrams. In Figure 1, the locus of $\hat{L}=0$ is drawn as a downward-sloping curve, due to the property of the short-run Phillips curve that $\phi'>0$: the locus of $\dot{\pi}=0$ is drawn as an upward-sloping curve. The dynamic adjustment paths of L and π are depicted by arrows.

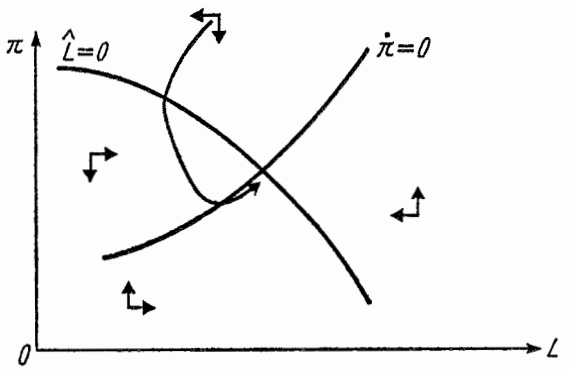

Figure 1.

First, consider expansionary domestic monetary policy. An increase in the rate of domestic money supply will shift both curves upward by the same distance, so that the new equilibrium will be straight above the old equilibrium without changing the equilibrium rate of unemployment. In the transition, employment and the expected rate of inflation approach the new equilibrium by a counterclockwise movement, so that there will be a temporary boom in the economy. In Figure 2, the economy moves E to E', experiencing a temporary boom.

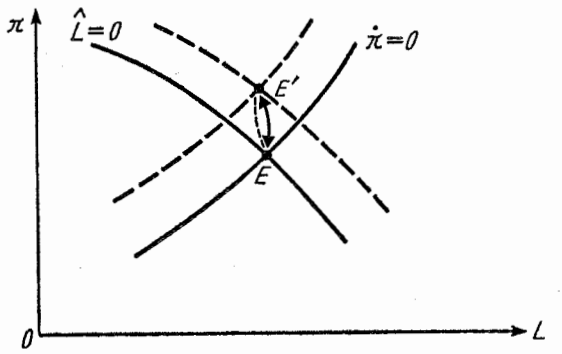

Figure 2.

Now, let us consider a rise in price of raw materials. This increase will shift the $\dot{\pi}=0$ line upward, as seen in Figure 3. The new equilibrium is located at point E', where people expect higher rates of inflation due to

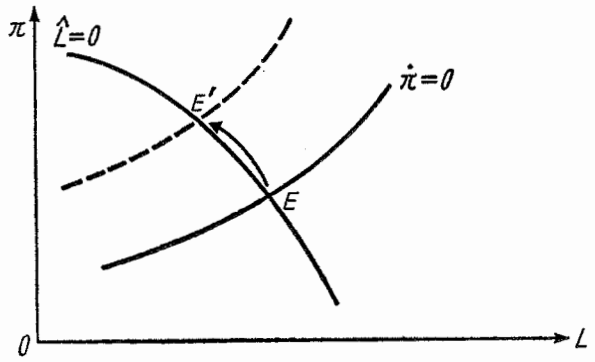

Figure 3.

a cost-push factor and at the same time an increase in the expected rate of inflation will discourage employment of labor. Therefore, the economy will reach the new equilibrium along the path as indicated by an arrow in Figure 3. The rise in the international price of raw materials typically causes stagflation to the medium-sized country. At the new equilibrium, the country suffers a higher rate of inflation and a higher rate of unemployment. Combining this result with the one examined in the expansionary monetary case, we may conclude: *If the country chooses an expansionary monetary policy in order to meet persistent rises in the international price of raw materials, stagflation may be temporarily mitigated but the country will eventually face higher rates of inflation. On the other hand, if the country takes a contractionary monetary policy, she may first face severe stagflation, but can reduce rates of inflation in the long run.*

Next, consider an expansionary foreign monetary policy. It is evident that such a policy will stimulate the export of the medium-sized country, which under the given international price of raw materials increases the import of raw materials in the country. Therefore, production of the manu-

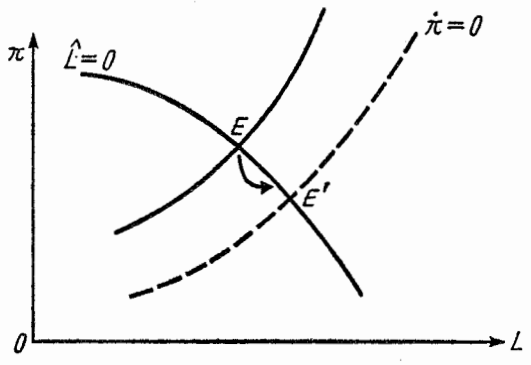

Figure 4.

factured good will be expanded, so that employment of labor will be encouraged with depressing the price of the manufactured good. Effects of the expansionary foreign monetary policy is exactly opposite to those of the rise in the price of raw materials. As shown in Figure 4, the economy will have boom to reach a new equilibrium point E', where the economy may enjoy lower rates of inflation and of unemployment.

Finally, consider welfare loss causes by a rise in the price of raw materials. Since the level of welfare in the country is measured by C, we rewrite the form of the domestic consumption function.

$$C=\nu\frac{M}{p}.$$

Welfare variation will be computed by

$$\hat{C}=\hat{M}-\hat{p}=\theta-\hat{p}. \tag{3.1}$$

Using (2. 9) and (2. 10), we note that $\hat{p}$ depends upon three components,

$$\hat{p}=\theta-\alpha\hat{L}+\beta(\bar{\theta}-\theta^*). \tag{3.2}$$

The first one is a monetary factor (θ). One percent of an increase in money supply, *ceteris paribus*, raises the same percentage in the price of the consumption good. Second factor is the effect of production related to labor employment. An increase in labor employment encourages production of the commodity and reduces its price. The third factor is the effect of production related to employment of raw materials.[11] A rise in price of raw materials, ceteris paribus, reduces the import of raw materials, which reduces production of the commodity and creates its excess demand. Substituting (3. 2) into (3. 1),

$$\hat{C}=\alpha\hat{L}-\beta(\bar{\theta}-\theta^*). \tag{3.3}$$

When the economy moves from E to E' in Figure 3, at each moment of time it always suffers unemployment ($\hat{L}<0$). Therefore, we may conclude: *if the price of raw materials rises, the country will suffer welfare loss because of*: (1) *adjustment costs, largely related to an institutional element in the labor market and* (2) *inflationary price effect due to a cost-push element.*[12]

[11] Note that using equation (2. 6) we can rewrite (3. 2) as

$$\hat{p}=\theta-\alpha\hat{L}-\beta\hat{N}.$$

[12] Alternatively, since factor earnings paid to raw materials are always taken to the rest of the world, the rise in the price of raw materials would imply less distributive domestic income available to consume the commodity.

4. Anticipated Shocks

In the previous section, we only treated the case where people have an unanticipated change in price of raw materials. As demonstrated in C. Wilson (11), in addition to the fact that anticipated shocks are realistic possibility, they may yield substantially different dynamic implication. Suppose that raw materials exporters in the rest of the world announces the increase in the future price at time t_0 ($<t_1$), where time t_1 expresses the time at which the price of raw materials will actually be raised. After the announcement, people will expect the price of the manufactured good will rise, which in turn will push the wage rate (cost-push inflation). Therefore, people form price expectation before an actual rise in the price of raw materials occurs and the actual rate of inflation will be jumped to a point like E' in Figure 5. It should be noted that once the price of raw materials actually is raised the economy will move basically the same time path drawn in Figure 3.[13] Therefore, the importance is imposed on the transitory period.

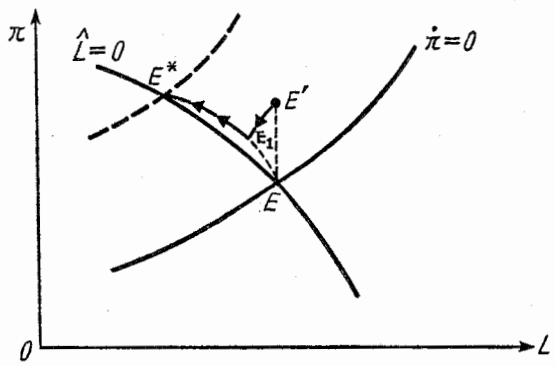

Figure 5. Anticipated Shocks.

Now, due to the anticipated rise in the price of raw materials, the commodity price is raised, which is absorbed in an increase in the wage rate. Because of the higher wage rate, production of the commodity is discouraged, which gradually depresses the wage rate and the rate of inflation. Therefore, recession occurs in the economy. When the price of raw materials actually is raised, the country will be in stagflation. The economy will move toward E^* from E' through E_1. *When there is the announcement of future price rise in raw materials, anticipated shocks first create recession and then put the economy in stagflation.*

[13] From equations (2.11) and (2.12), we can write $\hat{L}$ and $\dot{\pi}$ as follows: $\hat{L}=f(\pi, L)$ and $\dot{\pi}=g(\pi, L:\bar{\theta})$. Once the configuration of $\pi(t)$ and $L(t)$ at t_1 is given, the system of differential equations yields the same qualitative properties as shown by the time path in Figure 3.

5. Concluding Remarks

This paper has analyzed impact of a rise in price of raw materials on some of industrialized countries, such as the United States or Japan. We did not take a traditional two-country approach to attack this problem, because the division of the country concerned and the rest of the world does not seem appropriate in this case. As W. M. Corden has suggested, it is more persuasive to consider exporting countries of raw materials (the OPEC countries, for instance) on the one hand and the Rest on the other hand. However, when we are concerned to impacts of price rises on the specific country, we must add a priori assumptions to single out inherent properties in the particular country. Rather than taking this two-step approach, we have introduced the medium-sized economy model, on the basis of the Hamada-Sakurai model.

Some of our conclusions are;

(1) When price of raw materials rises, the economy will experience stagflation. If that rise is anticipated, the economy will first face recession.

(2) While an expansionary monetary policy can mitigate the degree of stagflation due to the rise in the raw materials' price, it will end up with a higher rate of inflation.

(3) The rise in the raw materials' price definitely creates welfare losses both in the transitory period and in the long run.

(4) An expansionary foreign monetary policy exerts a favorable influence on both employment and the price level.

In the process of deriving conclusions above we have proved that most of monetary characteristics in our model are quite similar with those in Hamada-Sakurai. For instance, under the assumption of unitary elasticity of substitution in consumption, the rate of depreciation in the exchange rate is equal to the difference between the growth rates of money supply of the home country and that of the rest of the world. However, in our model, difference should be stressed, in contrast to the Hamada-Sakurai model, that monetary authorities can not pursue independent monetary policies even at the steady state.

While we have emphasized the importance of imports of raw materials and assumed away the existence of domestic supply of raw materials, our

treatment may be enriched if we allow domestic supply of raw materials* and/or nontraded goods in our framework.

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* A simple way to introduce domestic supply of raw materials is as follows: Let N_d be the amount of raw materials supplied domestically. Then their production function may be expressed by;

(1) $$N_d = N_d(L_d).$$

The demand for labor needed to produce N_d is determined by

(2) $$w = p_N \partial N_d / \partial L_d .$$

The total amount of raw materials employed in the country, N, is

(3) $$N = N_d + N_f ,$$

where N_f is imports of raw materials.

We added three equations and three variables (N_d, L_d and N_f) and can solve the system. Of course, we must modify some equations in the paper. For instance, the balance, of payment equation should be rewritten as; $B = pC^* - p_N N_f$. Also, the short-run Phillips relationship should similarly be rewritten by

$$\hat{w} = \phi(L + L_d, \pi)$$