The Developing Economies, XXVII-4 (December 1989)

STRUCTURE AND GROWTH OF AN OPEN DUAL ECONOMY: EXAMINING INDUSTRIAL POLICY

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INTRODUCTION

MODELS of dual economies that hypothesize some sort of distortion between the two sectors of agriculture and manufacturing have been accepted as appropriately expressing the economic structures of developing countries. The first of those is Lewis's unlimited labor supply theory [4] and its further expansion is Ranis and Fei's model [8]. One noteworthy example that came out after much subsequent refinement is Harris and Todaro's contribution which gives particularly elaborate attention to labor mobility between agricultural and manufacturing sectors and the probabilities of unemployment in manufacturing [3].

In an earlier work, I attempted to dynamically analyze the Harris and Todaro hypotheses [7]. The present paper may thus be considered a continuation of its predecessor. As with the former work, the manufacturing sector is considered as consisting of subsectors that produce consumable goods and that supply pure capital goods to the agricultural sector. However, the present paper is different in that in it, the dual economy trades with the rest of world. This is why I call its dual economy, an open dual economy. That, however, does not mean that it trades in all goods. The economy trades in agricultural products and consumable factory goods, but capital goods for agricultural use are not tradeable. The existence of these non-tradeable goods is an important tool for development policy.

Appropriate government control over the price of agricultural capital goods can have long-term effects on the industrial structure, or more broadly, on the trade structure. Setting those prices at high levels will repress the agricultural sector's accumulation of capital but will promote that accumulation for manufacturing. Many developing countries have, in fact, used industrialization policies similar to these in their economic planning. The task of this paper is to theoretically re-examine the kind of role these policies play in dual economies where the weight of agricultural (traditional) sectors is high.

Section I explains the paper's model, especially, the concept of short-term equilibrium achieved in the balance of supply and demand for non-tradeable goods with given capital stock in each sector. Section II sketches the comparative statics of the short-term equilibrium that accompanies changes in parameters which define the economic structure including relative international prices for tradeable goods, production technologies, and each sector's capital stock.

This paper was originally published in Japanese in *Ajia keizai*, Vol. 28, No. 10 (October 1987).

Section III dynamically analyzes the progress in each sector's capital accumulation maintaining the price of agricultural capital goods at a fixed level. A dual economy's industrial and trade structure is dependent on pricing policy and thus becomes indeterminate in the long run. However, long-run, steady-state equilibrium (the growth path that fixes each sector's ratio of capital to labor) is unique and can be arrived at through the proper use of pricing policy. Section IV shows that industrialization policy which controls the prices of agricultural capital goods is neutral in regard to long-term economic welfare. It also observes what effects certain parameters—such as the relative price of goods traded, and the agricultural sector's savings rate—have on steady-state equilibrium. Controlling savings rates and ratio of agricultural wage to manufacturing wage clearly improves economic welfare in the long run. The optimal solution features a "golden rule" that makes each sector's capital profit ratio equal its growth rate. Section V gives important interpretations and conclusions from the analytical results.

I. SHORT-TERM EQUILIBRIUM IN A DUAL ECONOMY

The economy of the country observed here has agricultural and manufacturing sectors. The agricultural sector produces good 1 and the manufacturing sector produces goods 2 and 3. Good 2 is a composite commodity that can be used for both consumption and production and good 3 is a capital good consumed by the agricultural sector. Goods 1 and 2 can be traded internationally but good 3 is a non-tradeable good. The country is small and the international prices for goods 1 and 2 are given to this country.

Good 3 may be thought of as an element in the makeup of the agricultural sector's infrastructure (development land, farm roads, irrigation equipment) or as a farm implement or machine. The former can naturally be assumed to be a non-tradeable good, while the latter is potentially a tradeable good, and is interpreted as removed from international competition by government protection. Good 3 can also be considered a composite commodity that is both non-tradeable and tradeable.

This section looks at short-term economic equilibrium given the country's aggregate labor force and each sector's capital stock. Family management is the rule in the agricultural sector and farm laborers receive a fixed proportion of value added per capita. In contrast, management in the manufacturing sector is capitalistic, wages are at a level dependent on per capita income in the agricultural sector, and quantity of labor employment is determined in such a way that the marginal value of labor productivity equals the wage level.[1] There are thus no guarantees of full employment.

[1] However, sectors producing goods 2 and 3 are treated slightly different. As will be discussed below, if employment in the sector producing good 2 is determined so that wages equal the marginal value of labor productivity, then employment in the sector producing good 3 is determined by the conditions of equilibrium for the good's supply and demand in the market. This is why analyses of short-term equilibrium regard the price of good 3 as one of the model's parameters. This is why the marginal value of labor productivity equivalent with wages is not mandatory.

The quantity of good i is Y_i, the quantity of labor used to produce those goods is N_i, and the capital stock is K_i. For the sake of simplicity, the production function of good i,

$$Y_i = F(N_i, K_i), \tag{1}$$

is assumed to be linearly homogeneous and the ratio of production output to labor y_i $(= Y_i/N_i)$ may be expressed as a function of the ratio of capital to labor k_i $(= K_i/N_i)$,

$$y_i = f_i(k_i). \tag{2}$$

Each sector's marginal value of productivity for capital and labor is assumed to be non-negative $[f'_i(k_i) \geqq 0,\ f_i(k_i) - k_i f'_i(k_i) \geqq 0]$, declining $[f''_i(k_i) < 0]$, and, moreover, exhibiting the characteristics of

$$\lim_{k_i \to 0} f'_i(k_i) = \infty,\ \lim_{k_i \to \infty} f'_i(k_i) = 0.$$

The agricultural sector saves a fixed proportion of income to purchase capital goods from the good 3 sector. Taking the per capita consumption of good 1 as c_1 and that of good 2 as c_2, the Cobb-Douglass utility function for laborers is,

$$u = \alpha^{-\alpha}(1-\alpha)^{\alpha-1} c_1^{\alpha} c_2^{1-\alpha},\ 0 < \alpha < 1. \tag{3}$$

Good 1 shall be chosen as a numéraire and good 2 and good 3 shall be assigned the relative prices p_2 and p_3 in terms of good 1. If the agricultural sector's savings rate at this time is s, and we assume that the laborers in that sector are price takers and that they maximize utility, the consumption quantities for goods 1 and 2 are:

$$c_1 = \alpha(1-s)f_1(k_1), \tag{4}$$

$$c_2 = (1-\alpha)(1-s)f_1(k_1)/p_2. \tag{5}$$

If these values are substituted into equation (3), then the utility of laborers in the agricultural sector is

$$u = (1-s)f_1(k_1)p_2^{\alpha-1}. \tag{6}$$

We assume that the manufacturing sector's real wages w (in utility unit) are determined as

$$w = a(1-s)f_1(k_1)p_2^{\alpha-1} \tag{7}$$

with the agricultural sector's utility as a standard. Since coefficient a is not always equal to 1, there is room for differences in wages between agriculture and manufacturing. For instance, if real wages are determined through bargaining agreements between labor and management, then the value of a will be greater the stronger the bargaining power—or the weaker the preference for employment—of labor vis-à-vis management.

In the short term being considered here, the high level of labor mobility between agriculture and manufacturing is supposed to cause the expected labor wage to level out. Let the employment probability in the manufacturing sector is e_I. Then the relation

$$e_I a = 1 \tag{8}$$

may be assumed to hold. If the aggregate labor force is N and the employment rate in the good i sector is n_i $(=N_i/N)$, then e_I is defined by[2]

$$e_I = \frac{n_2 + n_3}{1 - n_1}. \tag{9}$$

All labor income in the manufacturing sector is consumed and all capital income is invested. If we assume, for the sake of simplicity, that investment in each manufacturing sector is performed using goods produced in that sector, then the conditions for the demand and supply equilibrium of good 3, which is a non-tradeable good, may be written as:

$$[p_3 f_3(k_3) - a(1-s)f_1(k_1)]N_3 + sf_1(k_1)N_1 = p_3 f_3(k_3)N_3.$$

The left-hand side is aggregate demand for, the right is aggregate supply of, good 3 in value measured in terms of good 1. Rearranging this relationship, we have:

$$n_3 = \frac{n_1}{a(1-s)}. \tag{10}$$

From equations (8), (9), and (10), we get:

$$n_2 = \frac{1}{a}\left(1 - \frac{n_1}{1-s}\right), \tag{11}$$

$$n_I = \frac{1}{a}(1 - n_1), \tag{12}$$

$$n_T = \frac{1}{a}[1 + (a-1)n_1], \tag{13}$$

where, $n_I(= n_2 + n_3)$ is the employment rate for the manufacturing sector and $n_T(= n_1 + n_2 + n_3)$ is the employment rate for the aggregate economy. From equation (8), we also have $a = 1/e_I \geqq 1$.[3]

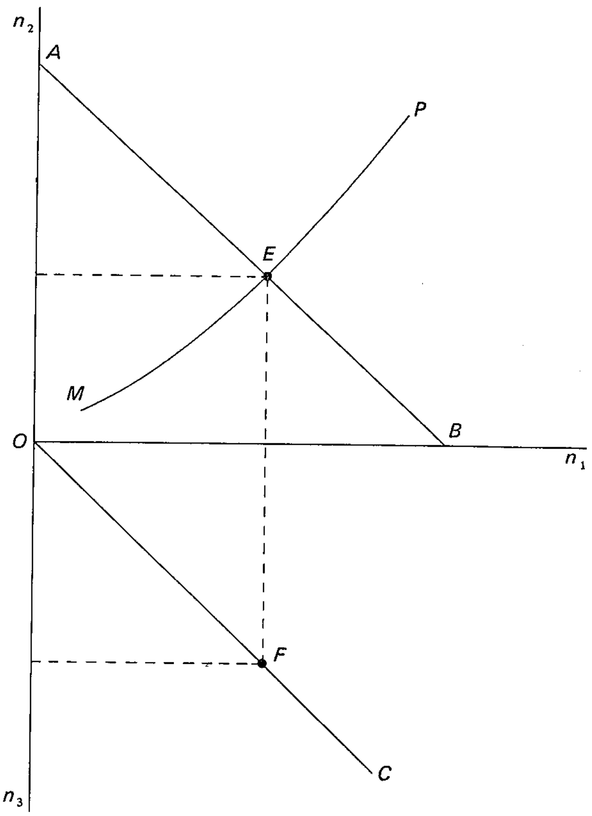
Because the marginal value of labor productivity is equivalent to wages in the production of good 2, taking the per capita capital stock for the sector producing good i as $z_i(= K_i/N)$, we can write it as:

$$p_2[f_2(z_2/n_2) - (z_2/n_2)f'_2(z_2/n_2)] = (1-s)af_1(z_1/n_2). \tag{14}$$

[2] Harris and Todaro [3] claim that labor moves between agriculture and manufacturing according to the difference in expected wages for both sectors. In Ohyama [7], I analyzed the process of labor mobility based on this concept, but will not go into the details of that analysis here.

[3] If $a<1$, then $e_I>1$, i.e., the probability of employment in the manufacturing sector exceeds 1. This is ruled out by definition. Wages in the manufacturing sector can not be set at a level lower than those in the agricultural sector under the present setup.

Fig. 1. Short-Term Equilibrium



If a, s, p_2, z_i, and z_2 are given in the short run, (11) and (14) will then determine the equilibrium value of n_1 and n_2, and equation (10) will then determine equilibrium value of n_3.

Figure 1 is a graph of this short-term equilibrium. Straight line AB in the upper quadrant graphs equation (11) and curve MP graphs equation (14). Line AB obviously slopes negatively and, from the assumption of diminishing marginal productivity, line MP can be readily confirmed as sloping positively. Intersection E indicates the equilibrium for n_1 and n_2. In addition, the lower quadrant's straight line OC shows the results of equation (10). The equilibrium value of n_3 can be read as a vertical coordinate of point F on OC, which corresponds to n_1's equilibrium value.

However, the price of good 3 in the above discussion, plays no role whatsoever in the adjustment of supply and demand. However, if perfect competition dominates the sector producing good 3, the marginal value of labor productivity will be equivalent to wages there as well, which implies

$$p_3[f_3(z_3/n_3) - (z_3/n_3)f'_3(z_3/n_3)] = (1 - s)af_1(z_1/n_1). \tag{15}$$

Because the equilibrium value of n_1 is already determined, and if z_3 is given, then the equilibrium value of p_3 derived from equation (15) is uniquely determined. However, even under the present assumption of a small country, producers in the sector producing good 3 will not inevitably behave as price takers. Because the equilibrium of supply and demand for good 3 will be achieved independently from pricing, there is a possibility that pricing will also be determined independently from the equilibrium of supply and demand. This problem will be discussed later.

Goods 1 and 2 are goods for international trade. Under the small country assumption and with international prices as given, the country will export the difference in those goods for which supply exceeds demand, and import the difference in those goods for which demand exceeds supply. From equations (10) and (11), we can calculate the per capita demand for good 1, d_1, as

$$d_1 = \alpha(1-s)f_1(z_1/n_1), \tag{16}$$

and the per capita supply for good 1, v_1, as

$$v_1 = n_1 f_1(z_1/n_1). \tag{17}$$

If this country is exporting good 1 (food), then its per capita export x_1 is

$$x_1 = [n_1 - \alpha(1-s)]f_1(z_1/n_1). \tag{18}$$

The per capita demand d_2 for good 2 is made up from some for consumption and some for investment:

$$d_2 = [1 - \alpha - an_2(1-s)f_1(z_1/n_1)/p_2 + n_2 f_2(z_2/n_2)]. \tag{19}$$

The per capita supply v_2 is written as

$$v_2 = n_2 f_2(z_2/n_2).$$

Thus, if this country is importing good 2, its per capita import m_2 is:

$$m_2 = (1 - \alpha - an_2)(1-s)f_1(z_1/n_1)/p_2. \tag{20}$$

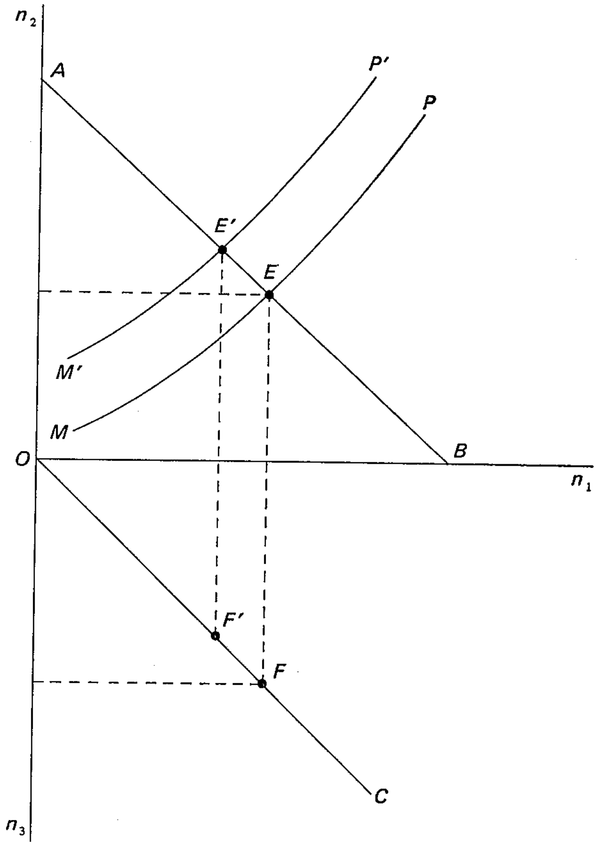
Equations (11), (18), and (20) imply that the balance $x_1 - p_2 m_2$ is exactly zero.

II. SHORT-TERM EFFECTS OF EXTERNAL DISTURBANCES

The short-term equilibrium described in the previous section is established by taking as given the relative price of good 2, the production technologies, the capital stock in each sector, the rates of saving, and the wage rates in the agricultural and manufacturing sectors. Thus, if these values were to change, then the elements in the short-term equilibrium would become different. This section examines the effects of external disturbances on the short-term equilibrium values of endogenous variables such as the rate of employment in, and quantities of export from, each sector.

Let us look, first at the effect of rises in the price of good 2. The initial point of equilibrium in Figure 2 is where AB and MP intersect at point E, and the corresponding point F on line OC. If the relative price p_2 of good 2 increases, the

Fig. 2. Short-Term Effects of Price Rises for Good 2



curve MP shifts to the left. Because the marginal value of productivity of labor employed in the production of good 2 rises under constant n_2, the productivity of labor in the agricultural sector must be increased and, thus, the employment rate in that sector be decreased to maintain the equilibrium relation in equation (14). Straight lines AB and OC will be unaffected when this happens. The new equilibrium will thus be indicated by the intersection of $M'P'$ and AB at point E', and the corresponding point F' on line OC. As the graph clearly shows, the employment rate for the sector producing good 2 climbs and the employment rates for the sectors producing goods 1 and 3 drop. The employment rate in the manufacturing sector derived from equation (12) also climbs and the employment rate for the aggregate economy as derived from equation (13) falls. The direction of change for good 3's price cannot be determined.[4]

[4] If equation (15) of the theory of marginal productivity holds for the sector producing good 3, the drop in n_1 and n_3 will cause both the left-hand side's marginal value of labor productivity $f_3(z_3/n_3)-(z_3/n_3)f'_3(z_3/n_3)$ and the right-hand side's average productivity for labor $f_1(z_1/n_1)$ to increase.

The effects on overseas trade may be gleaned by derivations of equations (18) and (20). If, for example, we differentiate equation (18) for p_2 and arrange it in order, we have:

$$\frac{\partial x_1}{\partial p_2}=\left[(f_1-k_1f'_1)+\frac{\alpha(1-s)}{n_1}k_1f'_1\right]\frac{\partial n_1}{\partial p_2}. \tag{21}$$

As we have already seen, $\partial n_1/\partial p_2<0$. This shows that if the price for good 2 rises, then the quantity of exports of good 1 will decrease. Differentiating equation (20) for p_2 also confirms that imports of good 2 will decrease.

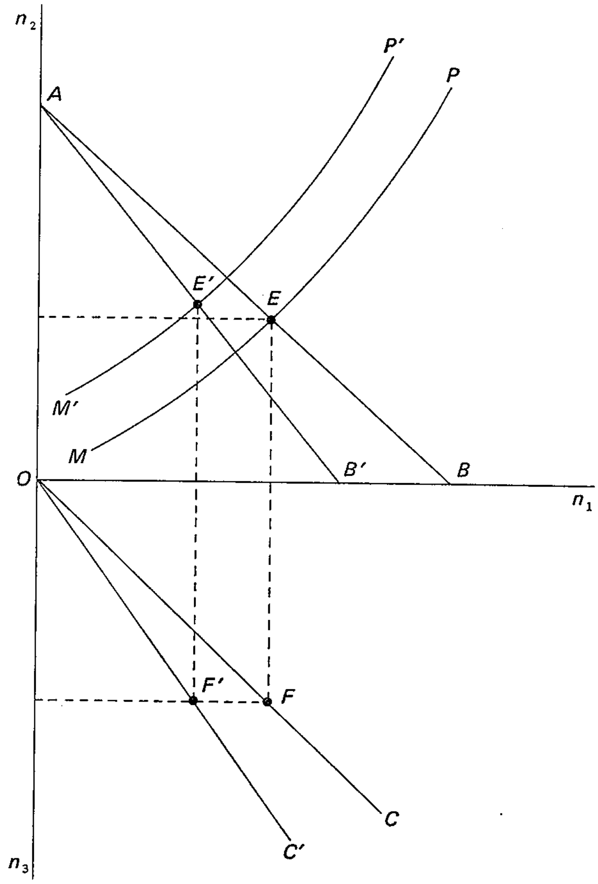
The effect that increased capital stock and increased productivity of labor in the sector producing good 2 have on the rate of employment and the quantity of imports in each sector is qualitatively the same as increased prices for good 2. The effect of capital accumulation and increased productivity in the sector producing good 1 is the complete reverse of the above. The latter is similar to the group of symptoms known as the Dutch disease.[5] The sector producing good 1 is known here as the agricultural sector but can also be interpreted as the natural resource or primary goods industry which is taken to be a problem in the Dutch disease. But in any case, the boom caused by technological progress or rising prices reduces the rate of employment in the manufacturing sector, expands related domestic industries, increases the import of industrial products, and increases the export of the particular product.

In contrast, the effects of capital accumulation and increases on productivity for the sector producing good 3 are not very pronounced in the short term. In fact, they have absolutely no effect on *AB* and *MP* in Figure 2, and thus there is no change whatsoever in the employment and overseas trade for each sector However, there are clear increases in quantity of production by the sector producing good 3 as well as promotion of capital accumulation. If the price of good 3 is constant, that increase goes entirely into internal capital accumulation. If the sector producing good 3 is competitive, then the relative price of good 3 decreases in order to satisfy the equilibrium relation of equation (15) for wages and the marginal value of productivity, and the part of the increment goes into the agricultural sector.

The effect of increased rates of saving in the agricultural sector are somewhat more complex. This is shown in Figure 3. When the rate of savings climbs, then both *AB* and *MP* shift to the left. *AB* shifts to the left because an increase in s means a decline in n_1 when n_2 in equation (11) is constant. The shift of *MP* to the left can be explained in the same way by equation (14). The result is a clear decline in the employment rate for the agricultural sector and a concomitant increase in the rate for manufacturing. Here, too, the rate of employment for the aggregate economy falls. From equation (10), however, *OC* shifts to the left because an increase in s means a decline in n_1 when n_3 is constant. Thus, the

[5] There is a lot of theoretical research available on the Dutch disease. Corden and Neary [1], for example, have used a three-good model that includes non-tradeable goods to analyze the effects of Hick's neutral technological process in the natural resource producing sector. However, this is a standard competitive model free from the distortions of a dual economy. The capital stock usable for the aggregate economy is also given.

Fig. 3. Effects of a Rising Rate of Savings in the Agricultural Sector



direction of change for the employment rate in sectors producing goods 2 and 3 is not certain. However, the two do not drop together. The effect of an increased savings rate on foreign trade is not clear. The effects of an increase in the wage ratio are similarly complicated. This time n_2 will decrease because AB will shift to the right and MP will shift to the left, but the direction of change for n_1 is uncertain and n_3 will apparently drop. It is not clear what the effects on trade will be.

III. DYNAMIC ANALYSES OF CAPITAL ACCUMULATION

Our attention up until now has been focused on an analysis of short-term equilibrium with the aggregate labor force and the capital stock in each sector as given. However, all these basic conditions will, generally, change over time.

Technological progress will cause the labor force, as measured in units of efficiency to increase. Investment activities will expand the capital stock in all sectors. This section places changes over time in clear equation form and dynamically analyzes the economic growth process on the assumption that the short-term equilibrium obtains at each point of time.

As has already been pointed out, we can hypothesize all kinds of alternative mechanisms for forming the price of good 3 because the present model establishes short-term economic equilibrium without waiting for the relative price of good 3 to adjust. If the sector producing good 3 is in perfect competition, the price of good 3 will be determined so that the marginal value of labor productivity equals the wage rate given at each point of time. However, there is little necessity for perfect competition to prevail. Industry can always raise prices to increase profits measured in units of good 3 because the sector producing good 3 is removed from international competition, equilibrium employment rate is determined without relation to prices, and wages are fixed in terms of good 1 units. Thus the businesses in the sector producing good 3 have an incentive to raise prices.

However, monopolization of the sector producing good 3 is not intuitively considered desirable. This is because the increase in prices may promote the accumulation of capital in that sector but would retard the accumulation of capital in the agricultural sector. This is a serious point since the only reason for the sector producing good 3's existence is in its ability to supply capital goods to the agricultural sector. Thus it is clear that the government must enact some sort of price controls. There can be many different kinds of controls, but for the sake of simplicity, we will, below, look at the price for good 3 as frozen at a certain level for a certain period of time.[6]

We assume that the aggregate labor force is growing at a constant rate λ, that the production function for each sector, and the structural parameters such as price p_2 of good 2 and savings rate s, are unchanging. If we ignore capital depreciation, the change over time in per capita capital stock for each sector can be derived by the dynamic equations:

$$\dot{z}_1 = sf_1(z_1/n_1)n_1/p_3 - \lambda z_1, \tag{22}$$

$$\dot{z}_2 = [f_2(z_2/n_2) - a(1-s)f_1(z_1/n_1)/p_2]n_2 - \lambda z_2, \tag{23}$$

$$\dot{z}_3 = [f_3(z_3/n_3) - a(1-s)f_1(z_1/n_1)/p_3]n_3 - \lambda z_3. \tag{24}$$

The dot $(\cdot)$ indicates differentiation with respect to time. The steady-state equilibrium of this system is defined by $\dot{z}_1 = \dot{z}_2 = \dot{z}_3 = 0$, which implies

$$f_1(z_1/n_1) = \lambda(p_3/s)(z_1/n_1), \tag{25}$$

$$f_2(z_2/n_2) - \lambda(z_2/n_2) = a(1-s)f_1(z_1/n_1)/p_2, \tag{26}$$

$$f_3(z_3/n_3) - \lambda(z_3/n_3) = a(1-s)f_1(z_1/n_1)/p_3. \tag{27}$$

The terms n_1, n_2, and n_3 derived from the analysis of short-term equilibrium

[6] As will be shown below, the price of good 3, p_3, is uniquely determined on the economy's balanced growth path. In that sense, p_3 is an endogenous variable in the long run. However, it may be restricted in the short run.

are dependent on z_1 an z_2, and can be regarded as functions of z_1 and z_2. Thus, the above equations (22) and (23), or (25) and (26), become self-contained systems for the two variables z_1 *and* z_2. However, it should be noted that if we take equation (14) into consideration, we can also write (23) and (26) as

$$\dot{z}_2=[f'_2(z_2/n_2)-\lambda]z_2, \tag{28}$$

$$f'_2(z_2/n_2)=\lambda. \tag{29}$$

The value of $k_2(=z_2/n_2)$, which satisfies equation (29) for the given λ, is uniquely determined, as is the value of $k_1(=z_1/n_1)$, which satisfies equation (26) under the givens s, a, and p_2 for this value of k_2. Thus, the value of p_3 consistent with these values of k_1 and k_2 are also uniquely determined from equation (25). That is to say, if a steady-state equilibrium exists under givens λ, s, a, and p_2, then the price p_3 of good 3 must assume a corresponding appropriate value. In other words, the steady-state equilibrium exists only if p_3 is assigned to an appropriate level.

To check this point out, we take the conditions of short-term equilibrium (11) and (14) into consideration and differentiate (25) and (29) for z_1 and z_2, then place them in order to obtain the relations

$$\left.\frac{dz_1}{dz_2}\right|_{\dot{z}_1=0}=-(1-s)a\frac{k_1}{k_2}, \tag{30}$$

$$\left.\frac{dz_1}{dz_2}\right|_{\dot{z}_2=0}=-(1-s)a\frac{k_1}{k_2}. \tag{31}$$

From this we can see that the locus of z_1 and z_2 which satisfies $\dot{z}_1=0$ and $\dot{z}_2=0$ is a straight line with negative slope $-(1-s)a(k_1/k_2)$. Z_2Z_2 in Figure 4 is the locus of z_1 and z_2 which satisfies $\dot{z}_2=0$. Because this satisfies equations (26) and (29), the steady-state equilibrium k_1 and k_2 are achieved along the line. In contrast, Z_1Z_1 is the locus of z_1 and z_2, which satisfies $\dot{z}_1=0$. The position of this locus is dependent on the value of p_3 under given λ and s. The higher the value of p_3, the lower that position, coming closer to the origin. The arrows in the graph indicate the direction of change over time for z_1 and z_2 at that point.

Figure 4 depicts a case when the p_3 is too high. No matter what point z_1 and z_2 start out from in this instance, they will follow the dynamic paths such as ABC and $A'B'C'$. That is to say, z_1 ultimately decreases to zero and z_2 increases to infinity. This happens because the high price of capital goods in the agricultural sector acts on to sacrifice the accumulation of capital in the sector and to promote capital accumulation in manufacturing. Although not written in the graph, the opposite situation of p_3 being too low will ultimately increase z_1 and decrease z_2.

Steady-state equilibrium will be achieved only when p_3 is set at an appropriate level. When that level is reached, Z_1Z_1 and Z_2Z_2 will be perfectly equal. This matching is shown as ZZ in Figure 5. No matter where z_1 and z_2 begin, they will, with the passing of time, converge at the same point on ZZ. However, the steady-state equilibrium of z_1 and z_2 will not be determined uniquely. All points on straight line ZZ are potential points of steady-state equilibrium. No matter what point is eventually arrived at, it is dependent on where the initial

Fig. 4. Case of the Price for Good 3 Being Too High

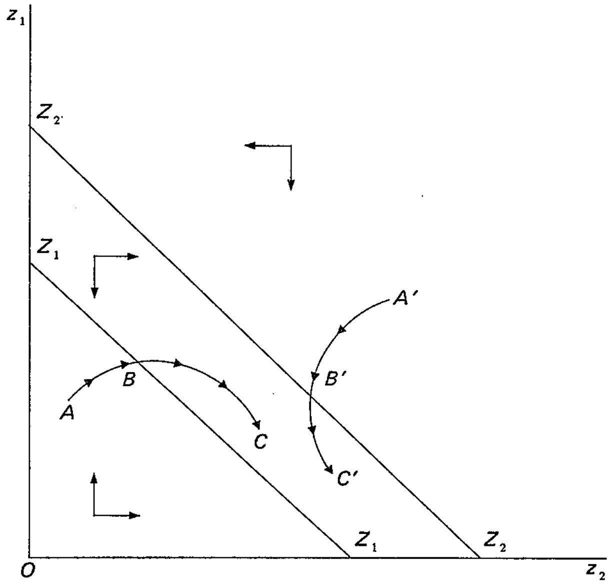
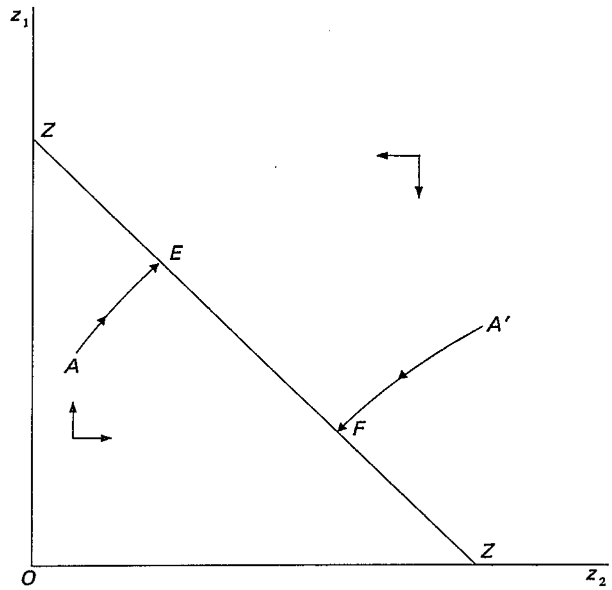


Fig. 5. Achieving Steady-State Equilibrium



start point is. However, the capital-labor ratios k_1 and k_2 for the agricultural sector and the sector producing good 2 become constant on line ZZ and their steady-state values become unique.

However, if the steady-state values of z_1, z_2, and p_3 are taken as given, the corresponding steady-state value of z_3 will be uniquely determined by equation (27). Clearly, the dynamic path for z_3 is dependent on the dynamic paths for z_1 and z_2. As the simplest case, let us consider one in which the steady-state equilibrium for z_1 and z_2 has already been arrived at. If z_1 and z_2 do not change, n_1 and n_3 will also remain constant and we partially differentiate equation (24) with respect to z_3, to obtain

$$\frac{\partial \dot{z}_3}{\partial z_3} = f'_3(z_3/n_3) - \lambda.$$

Thus, stabilizing steady-state equilibrium requires that $f'_3(z_2/n_3) \leqq \lambda$ in the vicinity of the equilibrium. We have already seen that the number of steady-state equilibria possible for z_1 and z_2 is infinite. Thus the same applies to z_3. The steady-state equilibrium of the capital-labor ratio k_3 for the sector producing good 3 is also determined uniquely.

IV. INDUSTRIAL STRUCTURE AND ECONOMIC WELFARE

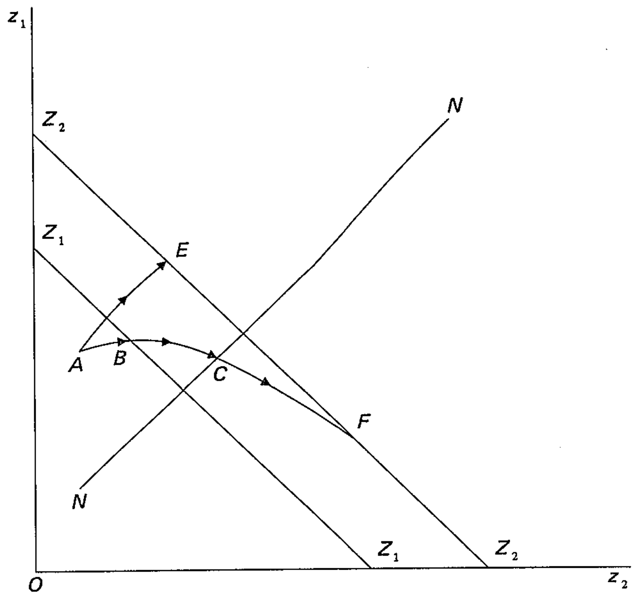
If the various structural parameters and production functions are given and the price of good 3 is set at an appropriate level, the economy will move toward a steady-state equilibrium with the passage of time. That would be a balanced growth path in which all economic variables increase at a rate equal to the growth of the labor force. On a balanced growth path, the capital-labor ratio in all sectors would be held constant by definition. However, the per capita capital stock for each sector would not be uniquely determined on this path either. This reveals long-term indeterminancy of the industrial structure, or that of the trade structure.

These points can be readily seen in Figure 6. Both E and F satisfy the conditions for steady-state equilibrium and there is no change in the ratio of capital to labor for any sector. However, the per capita capital stock for the agricultural sector and for the sector producing good 3, which supplies the agricultural sector with capital goods, is larger at point E than at point F, while this size relationship for the sector producing good 2 is reversed. In other words, point E has a large proportion of agricultural and related sectors and point F has a large proportion of the other manufacturing sector. The degree of industrialization is higher at point F than at point E.

If the industrial structure is not uniquely determined, the trade structure will not be either. Curve NN in Figure 6 is the locus of z_1 and z_2 such that foreign trade becomes zero. For foreign trade to become zero, it is necessary and sufficient that

$$n_1 = \alpha(1 - s) \tag{32}$$

Fig. 6. Role of Indeterminancy and Manufacturing Policy in the Trade and Industrial Structure



from equation (18). Because the analysis of short-term equilibrium indicates that n_1 is the increasing function of z_1 and the decreasing function of z_2, it shows that this locus slopes positively. Above *NN* we have $n_1 > \alpha(1 - s)$ so that this country exports good 1. Below *NN* it imports good 1. Thus, trade at point *E* consists of exports of good 1 (food) and imports of good 2 (manufactured product), and at point *F*, the pattern is the exact opposite.

Even with the basic economic structure in this graph as given, the trade and industrial structures will be completely different depending on the point reached on curve *ZZ*. This causes certain questions to arise. First, of the infinite number of points on line *ZZ*, are there any which can be selected by policies? In other words, can we use policy steps to increase the degree of industrialization in the industrial and trade structures? The second question is: assuming that the policy steps are possible, can they be used to heighten the national economic welfare over the long term? Under present programs, the answer to the first question is yes but the answer to the second is no.

With regard to the first question, the government of this country can affect the industrial and trade structures in the long run by appropriate adjustments, over time, in the price of good 3. This point will also be illustrated geometrically. The initial values of z_1 and z_2 (historically given, say) are supposed to be at point *A* in Figure 6. If, at the same time, the value of p_3 is fixed at its steady-state equilibrium level from the beginning, z_1 and z_2 will increase with the passage of time until they reach point *E*. If, in contrast, p_3 is initially set at a higher level and adjusted through time to drop gradually to the steady-state equilibrium level, the dynamic path of z_1 and z_2 will shift to the right. *ABCF* illustrates that path. The curve Z_1Z_1 here is the locus of z_1 and z_2 which satisfies $\dot{z}_1=0$ in correspondence to level p_3 set at an initially high level. If this price is fixed until z_1 and z_2 reach point B on Z_1Z_1 and then begins to gradually decline, dynamic path *ABCF* can be realized. This country exports good 1 until point C is reached, but after that it exports good 2. In other words, the trade structure changes at point C.

Many countries with planned economies have actually attempted industrialization promotion policies that set the price of capital goods used in the agricultural sector at high levels. The second question is whether this kind of industrialization policy is good from the standpoint of the country's economic welfare. In the present model, long-term economic welfare is defined as the expected utility of all laborers at steady-state equilibrium and that coincides with the utility of laborers in the agricultural sector. The capital-labor ratio k_1 is uniquely determined in any steady-state equilibrium no matter what the values of z_1 and z_2 are. We can thus clearly see from equation (6),

$$u=(1-s)f_1(k_1)p_2^{\alpha-1},$$

that industrialization policy is neutral to economic welfare in the long run. Within the framework of the present model, we cannot say that industrialization policy contributes to long-term improvements in economic welfare.[7]

If the good 2's relative price, the savings rate, the ratio of wages between manufacturing and agricultural sectors, and other parameters change, there will be accompanying long-term changes in the capital-labor ratio of each sector, the price of good 3, economic welfare, and other endogenous variables in the steady-state equilibrium. Let us carry out a comparative dynamic analysis of some of these changes in structure. We differentiate totally the condition of steady-state equilibrium (26) taking the production functions for each sector and the growth rate in the labor force as given. Making use of equation (29), we get

$$\hat{k}_1=\frac{f_1}{k_1f'_1}\left(\hat{p}_2-\hat{a}+\frac{s}{1-s}\hat{s}\right). \tag{33}$$

The symbol (^) indicates the variable's logarithmic derivative (infinitesimal rate of change). For example, $\hat{p}_2=dp_2/p_2$. If we totally differentiate equation (25) and substitute equation (33) into the result, we have

$$\hat{p}_3=\frac{f_1-k_1f'_1}{k_1f'_1}(-\hat{p}_2+\hat{a})+\frac{f'_1-\lambda p_3}{(1-s)f'_1}\hat{s}. \tag{34}$$

Finally, by differentiating equation (27) and substituting equation (34) into the result, we obtain

[7] This conclusion is of course premised on the nonexistence of dynamic external economies and the economies of scale (internal economies) frequently pointed out as the special characteristic of the manufacturing sector. The agricultural and manufacturing sectors are differentiated here only on the point that the agricultural sector is familistically managed and the industrial sector is capitalistically managed (behavior that maximizes and reinvests profits).

$$\frac{f'_3-\lambda}{f_3-\lambda k_3}\hat{k}_3=\frac{1}{k_1 f'_1}[f_1\hat{p}_2-(f_1-k_1 f'_1)\hat{a}]-\frac{f'_1-\lambda p_3}{(1-s)f'_1}\hat{s}. \tag{35}$$

There is no need to interpret these results one by one. For example, a rise in good 2's relative price p_2 causes the agricultural sector's capital-labor ratio k_1 to rise and good 3's price p_3 to decline. The capital-labor ratio of the sector producing good 2 is given, in view of equation (29), and thus the marginal labor productivity of that sector is also given. Therefore, a rise in good 2's price increases the value of marginal labor productivity there. In consequence, the capital-labor ratio of the agricultural sector goes up. However, that calls for a decline in the price of good 3 which is an agricultural capital good. When that happens, it is unclear what the effect will be on the capital-labor ratio k_3 of the sector producing good 3. The effect of a rise in the ratio of agricultural-to-manufacturing wages a will be in the opposite direction of p_2's effect. An increase in savings rate s will drive up the agricultural sector's capital-labor ratio and increase the price for good 3. It is not clear what the effect of this change will be on capital stock in the sector producing good 3.

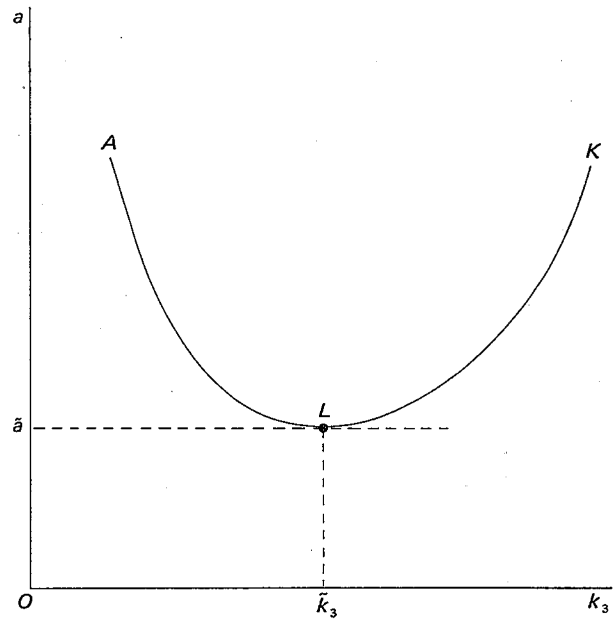
The effects that changes in these parameters will have on the welfare level in a steady-state equilibrium is easily calculated. Here, too, we take the production function and growth rate as given. Totally differentiate (6) and use (33) and (34) to derive the relationship:

$$\hat{u}=\frac{\alpha}{1-s}\hat{p}_2-ap_2^{\alpha-1}\hat{a}. \tag{36}$$

An increase in the price of good 2 will increase the general price level and simultaneously drive up the capital-labor ratio of the agricultural sector. Economic welfare will increase since the effects of the former is greater than the effects of the latter. On the other hand, a rise in the ratio of manufacturing to agricultural wages (average consumption) will reduce welfare. What is worthy of our attention here is that a change in the agricultural sector's savings rate will have no effect whatsoever on economic welfare. In fact, the effect of an increased capital-labor ratio in the agricultural sector completely cancels out the effect of decreased consumption.

Even if the relative international market price of good 2 is given, the ratio of manufacturing to agricultural wages may be manipulable by policy means. In that case, the government can heighten economic welfare by reducing a. This is a point common to the industrial protection theories of Manoilesco [5], Hagen [2], and others. It is assumed here that wages in the agricultural sector are a fixed proportion of average labor productivity. But there are no guarantees that it is equivalent to marginal productivity. Wages in the sector producing good 2 are assigned to a level that is a times the wages of the agricultural sector and labor is employed there until the marginal value of labor productivity equals the wage level. Thus the marginal values of labor productivity between sectors become generally different. A similar intersectoral distortion is a problem in the Manoilesco and Hagen

Fig. 7. The Ratio of Manufacturing to Agricultural Wages in the Long-Term Equilibrium



theories of protectionism as well. Adjustments in wage ratio a serve to equalize the marginal value of labor productivity.[8]

What we must be cautious about here are the restrictions on the values assumed by a. Equation (35) clearly shows that when s and p_2 are given, the relationship between a and k_3 as illustrated by the U-shaped curve AK in Figure 7. The value $\tilde{k}_3$ of the k_3 that corresponds to point L, the lowest point on the curve, satisfies

$$f'_3(\tilde{k}_3)=\lambda. \tag{37}$$

From this equation and equation (27), we derive

$$f_3(\tilde{k}_3)-k_3f'_3(\tilde{k}_3)=a(1-s)f_1(k_1)/p_3 \tag{38}$$

At this point, the marginal value of labor productivity in the sector producing good 3 is equal to that in the sector producing good 2.[9] Equations (33) and (35)

[8] The basis for Manoïlesco's [5] and Hagen's [2] theories of protectionism is that to move labor from agriculture to manufacturing in the process of economic development, wages in agriculture must be maintained constantly higher than those in manufacturing and as a result, private marginal costs in manufacturing are higher than social marginal costs. Negishi [6] justified the protection of manufacturing for the same reasons using a model of a dual economy more similar to the present setup. However, the pulling down of a is not, in the normal sense, a protectionist policy.

[9] As pointed out, we must not forget the restriction $a\geqq 1$. In Figure 7, $\tilde{a}$ is the value of a that corresponds to $\tilde{k}_3$, but if $\tilde{a}<1$, a can only go as far as it can to 1. However, as equation (13) shows us, full employment is achieved when $a=1$.

show that when k_3 is held constant, the relationship between a and s is exactly the same. I have chosen to omit a graph showing the relationship between a and s, but its minimum point entails

$$f'_1(k_1) = \lambda p_3. \tag{39}$$

Thus, from equation (25), we have:

$$(1-s)f_1 = f_1 - k_1 f'_1. \tag{40}$$

Here, wages in the agricultural sector are equal to marginal productivity. If equations (29), (37), and (39) are satisfied, i.e., if the marginal productivity of capital in all sectors equals the growth rate of labor, then the expected utility of all labor in steady-state equilibrium will be at maximum. This is, of course, what is known as the "golden rule" of economic growth.

V. INTERPRETATIONS AND CONCLUSIONS

Many traditional models of growth in dual economies set up pre-modern agricultural sectors in parallel with modern manufacturing sectors but ignore foreign trade. Naturally they cannot adequately clarify how government industrialization policy affects economic welfare and the international division of labor. This paper assumes an open dual economy that trades freely with foreign countries, and that has two subsectors in its manufacturing sector, one that produces consumer goods and another that produces pure capital goods for the agricultural sector. The consumable goods are tradeable goods, and agriculture's capital goods are non-tradeable goods.

In the present model of dual economy, the government can manipulate the price of capital goods for agriculture without causing short-term disturbances in market equilibrium. By setting these prices at high levels, it can promote especially the industrialization of the industrial and trade structures in the long run. However, whether such policies are generally desirable is another question. A rise in the prices of agricultural capital goods delays the accumulation of capital in that sector, which holds down the average income, which in turn suppresses wages in the manufacturing sectors that are linked to agriculture and that promotes the accumulation of manufacturing capital. That results in a manufacturing sector that grows, over time, more rapidly than the agricultural sector. Industrialization mechanisms of this kind will impede consumption from now into the near future, and, in that sense, are undesirable.

Under the present arrangements, there is little reason that such an industrialization policy should be supported in the intermediate or long run. In fact, the expected utility of labor in steady-state equilibrium depends on the average productivity of agricultural labor, and if production technology in the agricultural sector and ratio of agricultural-to-manufacturing wages are given, that utility will be uniquely determined no matter what the degree of industrialization. In other words, industrialization policy in itself cannot change the economic welfare that can be achieved in the long run. However, attention must be given to the present model's abstraction of economies of scale and dynamic external economies, both of which are considered important features of manufacturing. Thus it would not do to interpret the above conclusions as general negations of industrialization policy. In general, industrialization policy may be conducive to economic growth, but it is only when the benefits of the internal and external economies that accompany industrialization could compensate the costs of decreases in consumption that arise on the way.

Arguments related to wages in the manufacturing sector and savings in the agricultural sector are equally interesting from a policy standpoint. If manufacturing wages are reduced and the gap in wages between agriculture and manufacturing is narrowed, the expected utility for laborers will increase in the long run. This will be caused by the long-term settling of wages in manufacturing to a constant level. It will shrink the difference between agricultural and manufacturing wages and raise the average productivity of agricultural labor. However, there are limits to the range of values that can be assumed by the ratio of agricultural to manufacturing wages in steady-state equilibria. The lower limit of the range can be further lowered by suppressing saving in the agricultural sector. If these policies are operated ideally, the rate of return on capital investment and the growth rate of output in each sector will be equalized. This golden rule can be put into effect by market forces in economies that have perfect competition in all sectors, that invest profits in each sector and that perfectly consume wage income.

REFERENCES

1. CORDEN, W. M., and NEARY, J. P. "Booming Sector and De-industrialization in a Small Open Economy," *Economic Journal,* Vol. 92, No. 368 (December 1982).
2. HAGEN, E. E. "An Economic Justification of Protectionism," *Quarterly Journal of Economics,* Vol. 72, No. 4 (November 1958).
3. HARRIS, J. R., and TODARO, M. P. "Migration, Unemployment and Development: A Two-Sector Analysis," *American Economic Review,* Vol. 60, No. 1 (March 1970).
4. LEWIS, A. "Economic Development with Unlimited Supplies of Labour," *Manchester School of Economics and Social Studies,* Vol. 22, No. 2 (May 1954).
5. MANOILESCO, M. *The Theory of Protection and International Trade* (London: King & Son, 1931).
6. NEGISHI, T. *General Equilibrium Theory and International Trade* (Amsterdam: North-Holland, 1972).
7. OHYAMA, M. "Chiiki-kan rōdō idō to toshi no shitsugyō [Inter-regional labor mobility and urban unemployment], *Mita gakkai zasshi,* Vol. 71, No. 2 (April 1978).
8. RANIS, G., and FEI, J. C. "A Theory of Economic Development," *American Economic Review,* Vol. 51, No. 4 (September 1961).