Jorgenson's Neo-Classical Model of a Dual Economy

The JORGENSON MODEL

Prof. D. W. Jorgenson[1] has presented a theory of development of a dual economy. He divides the economy into two sectors—the modern or manufacturing (industrial) sector, and the traditional or agricultural sector. There is asymmetry in the production relations in the two sectors. The agricultural sector is a function of land and labour alone; and the manufacturing sector of capital and labour alone. Population growth depends on the supply of food per capita only. If the food supply is more than sufficient for the population, there exists an agricultural surplus and labour is free from the land for employment in the manufacturing sector. If there is no agricultural surplus, all labour remains on the land. On the other hand, if an agricultural surplus exists, the labour force migrates from the agricultural sector to the manufacturing sector for employment. But the labour force available for employment in the manufacturing sector grows at a rate which is equal to the growth rate of the agricultural surplus. Due to a steady migration of labour from the backward agricultural sector to the modern sector, labour may demand higher wages in the latter sector. Therefore, there may be some wage differential in the two sectors. This differential is proportional to the manufacturing wage rate and is stable in the long run. This differential determines the terms of trade between manufacturing and agricultural sectors, and thereby the rate of investment in the manufacturing sector of a closed economy.

1. D. Jorgenson, The Development of a Dual Economy, *E.J. 71*, 1961 and Surplus Agricultural Labour and the Development of a Dual Economy. *O.E.P.*, 19, 1967.

However, the decline of the economy to its trap level of output can also be traced with the diminution of the agricultural surplus. As the agricultural surplus begins to diminish, the agricultural labour force grows at a rate which is more rapid than the growth rate of population. The labour force declines absolutely in the manufacturing sector and returns to the agricultural sector. The output in the manufacturing sector drops to zero and capital is decumulated at the rate given by the rate of depreciation. Ultimately, the process of capital accumulation comes to a halt. Food output per capita declines to a stationary level and population growth is reduced from its maximum rate. This is a low level equilibrium trap situation.

Assumptions of the Model

The Jorgenson model is based on the following assumptions:

1. The economy consists of two sectors — the agricultural sector and the manufacturing sector.

2. The output of the agricultural sector is a function of land and labour.

3. All land is fixed in supply.

4. The output of the manufacturing sector is a function of capital and labour.

5. Agricultural activity is subject to the law of diminishing returns to scale.

6. The manufacturing activity is subject to the law of constant returns to scale.

7. Technical changes take place at some constant rate and all changes are neutral.

8. It assumes a closed economy in which trade is in balance for goods of both sectors.

Agricultural Sector. First we start with the agricultural sector characterised by constant returns to scale with all factors variable as given by the Cobb-Douglas production function:

$$Y = e^{\alpha t} L^{\beta} P^{1-\beta} \qquad \text{....(1)}$$

where, Y represents agricultural output; $e^{\alpha t}$ is technical change which takes place at a constant rate (α) in the time (t); L is fixed quantity of land available in the economy; β is the share of landlords in the product which takes the form of rent; P is total population in this sector; and 1-β is the share of labour in the product paid.

Since the supply of land *(L)* is fixed, equation (1) can be written as

$$Y = e^{\alpha t} P^{1-\beta} \qquad \text{.....(2)}$$

To obtain agricultural output per man, we divide both sides of the above equation (2) by *P*, and we have,

$$\frac{Y}{P} e^{\alpha t} P^{1-\beta}$$

or $$y = e^{\alpha t} P^{1-\beta} \qquad \left[\because \frac{Y}{P} = y\right]$$

Now differentiating with respect to time,

$$\dot{y} = \alpha e^{\alpha t} P^{-\beta} + e^{\alpha t}(-\beta) P^{-\beta-1} \dot{P}$$

$$= e^{\alpha t} P^{-\beta} \left[\alpha - \frac{\beta}{P} \dot{P}\right. \qquad \left[\because P^{-1} = \frac{1}{P}\right.$$

$$= y \left[\alpha - \beta \frac{\dot{P}}{P}\right. \qquad \left[\because y = e^{\alpha t} P^{-\beta}\right]$$

or $$\frac{\dot{y}}{y} = \alpha - \beta\varepsilon \qquad \text{....(3)} \qquad \left[\because \varepsilon \frac{\dot{P}}{P}\right.$$

where, α is the rate of technical progress, β is the share of landlords in the product and ε is the net reproduction rate of population.

According to Jorgenson, depending on the conditions of production and the net reproduction rate, the

agricultural sector is characterised either by a low level equilibrium trap in which output of food per head is constant and population and food supply are growing at the same positive rate (α-βε), or by a steady growth equilibrium in which output per head is rising and population is growing at its physiological maximum rate. The necessary and sufficient condition for a positive growth of output in the agricultural sector is $\alpha - \beta \varepsilon > 0$.

Its Policy Implications. The policy implications of the above analysis are that a backward agricultural economy can change its system by altering the parameters of its system. If the economy is in a low level equilibrium trap and β remains constant, it can come out of the trap situation by increasing the rate of technical change (α) so that the sign of the expression $\alpha - \beta \varepsilon$ is changed from negative to positive, and there is a steady increase in the output of food per head. Or the reproduction rate of population *(ε) may be reduced by birth control measures. So long as the rate of technical progress (α) is greater than the reproduction rate (ε), the growth of food output per head will take place. If they are equal (α = ε)*, the system will be in low level equilibrium trap.

Agricultural Surplus. It is only when food output per head is constantly rising, an agricultural surplus is generated. Jorgenson explains the agricultural surplus per member of the agricultural labour force as

$$y - y^{+} = s$$

where, *y* is the agricultural output per man, y^{+} is the level of output of food at which the net reproduction rate of population is the maximum, and *s* is the agricultural surplus.

If total agricultural output exceeds this rate, part of the labour force may be freed from the land to the manufacturing sector to produce goods with no decrease in the growth rate of the total labour force. If we denote the agricultural population by *A* and the manufacturing population by *M,* then the total population will be $P=A+M$. Where $A=P$, the whole labour force is engaged in agricultural production.

According to Jorgenson, in a dual economy, labour may be freed from the land at a rate which is just sufficient to absorb the agricultural surplus. But if the growth of manufacturing is not sufficiently rapid, some of the excess labour force will remain on the land and part or all of the surplus may be consumed in the form of increased leisure by the agricultural workers and there will be virtual destruction of the manufacturing activity. However, this dual economy model assumes a balance between the expansion of manufacturing labour force and the production of food which is described as

$$\frac{y^{+}}{y} = \frac{A}{P}$$

This relationship holds only when an agricultural surplus exists. In other words, when there is a positive agricultural surplus rather than a shortage of food, and $y > y^{+}$.

Manufacturing Sector. Now we take the conditions of production and capital accumulation in the manufacturing sector. The production function for the manufacturing sector is based on the assumption of constant returns to scale and is in the form:

$$X = f(K, M, t) \qquad \text{.....(4)}$$

where, *X is* the manufacturing output, *K* is the capital stock, *M* is the manufacturing labour force, and *t* is time.

If the relative share of labour in manufacturing output is constant and all technical change is neutral, then the production function becomes

$$X = A(t)\, K^{\sigma} M^{1-\sigma} \qquad \ldots(5)$$

where, *A(t)* is some function of time and 1—σ is the relative share of labour force *(M)*.

If the rate of growth is constant, then

$$\frac{\dot{A}}{A} = \lambda$$

or $$\dot{A} = \lambda A$$

By solving this as a differential equation, we have

$$A(t) = e^{\lambda t} A\,(O)$$

Substituting the value of *A(t)* in equation (5), we have

$$X = e^{\lambda t} A\,[O]\; K^{\sigma} M^{1-\sigma} \qquad \ldots(6)$$

Dividing *X* and *K* by *M*, and representing output per man by *x* and *k* respectively, and changing the units of *X* so that *A(O)*—1, the production function becomes

$$x = e^{\lambda t} k^{\sigma}$$

This is a technical progress function which expresses output per man as a function of capital per man.

Rate of Capital Accumulation. Next Jorgenson studies the determination of the rate of capital accumulation. According to him, the first approach is through the fundamental *ex post* identity between the sum of investment and the consumption of manufactured goods, on the one hand, and manufacturing output, on the other. He assumes with Kaldor that industrial workers do not save and property owners do not consume out of their property income. Then, the consumption of manufactured goods, in both the manufacturing and agricultural sectors, is equal to the share of labour in the product of the manufacturing sector. The industrial wage rate is determined by the marginal producitvity condition:

$$\frac{\partial M}{\partial X} = (1-\sigma)x = w$$

where, *x is* output per man, 1—α is the relative share of labour in the total product, and *w* is the industrial wage rate. The necessary condition for the maximisation of profits is that the industrial wage rate should be equal to the marginal product of labour. It is assumed that profits are maximised in the manufacturing sector and not in the agricultural sector. The agricultural workers can be expected to respond to wage differentials between industry and agriculture only if industrial wages are greater than agricultural

income. Itis, therefore, assumed that the differential which is necessary to cause movement of agricultural labour into the industrial sector is roughly proportional to the industrial wage rate.

$$wM + \mu\, wA = (1-\sigma)\, X + qY$$

where, *wM* is the industrial wage bill, *μ wA* is total agricultral income expressed in manufactured goods, (1—σ) *X* is total consumption of manufactured goods by workers in both sectors, and *qY* is the value of agricultural output measured in manufactured goods. The variable *q* is the terms of trade between agriculture and industry. It is assumed that all agricultural income, whether in the form of rent or wages, is consumed. So investment in the manufacturing sector is financed entirely out of the incomes of property-holders in that sector.

Jorgenson points out that once the share of labour in industrial output is distributed to workers in the form of food and consumption goods, and agricultural workers have received the proportion of industrial output which must be traded for food, the remainder of industrial output is available for capital accumulation or investment. He defines capital accumulation as investment less depreciation, and depreciation is regarded as a constant fraction of capital stock:

$$\dot{K} = I - \eta K$$
$$I = \dot{K} - \eta K \qquad \ldots(8)$$

where, η is the rate of depreciation, *I* is investment, and *K* is net capital accumulation.

The total industrial output is equal to consumption plus investment:

$$X=(1-\sigma)\, X - I \qquad \ldots(9)$$

where, *X* is the total industrial output, (1–σ*) X is* its consumption and *I* is investment.

This equation implies the following relation between output and capital stock By substituting equation (8) in equation (9), we have

$$X = (1-\sigma)\, X - \dot{K} - \eta K$$
or $$X = X - \sigma X - \dot{K} - \eta K$$
or $$X = \dot{K} - \eta K \qquad \ldots(10)$$

In the above equation (10),σ *X* represents saving, while investment is made up of two components: one, net capital accumulation, $\dot{K}$ and two, replacement investment η*K*.

By using the production function $X = e^{\lambda t} K^{\sigma} M^{1-\sigma}$ to eliminate *X*, the level of output in the manufacturing sector in the above equation (10), we have

$$+ \eta K = \sigma e^{\lambda t} K^{\sigma} M^{1-\sigma}$$

which is the fundamental equation for the development of a dual economy.

CONCLUSION

A backward traditional economy grows when there is a positive and growing agricultural surplus and capital accumulation. Once the economy starts growing, it continues to grow. The actual pattern of growth is determined by two fixed initial conditions: *first*, the size of the total population at the time when sustained growth begins; and *secon*d, the size of the initial capital stock. Of these, only the influence of the initial capital stock dies out quickly. The greater the rate of depreciation and the greater the relative share of labour (1–σ), the more rapidly the effects of the initial capital endowment disappear. Further, there is no critical level of initial capital endowment below which no sustained growth is possible. Even the smallest initial capital stock gives rise to sustained growth. In other words, the combination of a positive and growing agricultural surplus and a small positive initial capital endowment gives rise to take-off into self-sustained capital accumulation and increase in output. For long run equilibrium growth, capital and output grow at the same rate, even when there is neutral technical progress. When there is technical progress, population grows at its maximum rate, and capital and output grow at a more rapid rate, i.e., $\lambda/(1-\sigma)+\varepsilon$, where λ is the rate of technical progress and $(1-\sigma)$ is the share of labour. The rate $\lambda/(1-\sigma)+\varepsilon$ is like Harrod's natural growth rate *Gn*.

Finally, the condition which is necessary and sufficient for sustained growth of output in both the agricultural and manufacturing sectors is $\alpha - \beta\varepsilon > O$, where α is the rate of technical progress, ε is the maximum rate of population growth and $1-\beta$ is the share of labour in the product. Thus the development of a dual economy depends not only on the existence of an agricultural surplus in the agricultural sector but also on technical conditions in the manufacturing sector. The more rapid the rate of technical progress, the higher the saving ratio, and the more rapid the rate of population growth, the more rapid is the pace of growth in the industrial sector. Ultimately, the industrial sector develops more, dominates in the economy, and becomes more and more like the advanced economic system described by the Harrod-Domar growth theory.

Another feature of Jorgenson's dual economy model which characterises long run equilibrium is the absence of a 'critical minimum effort' necessary for a take-off into self-sustained growth of the Leibenstein type. Whatever the initial capital endowment of the manufacturing sector, sustained growth must continue. In fact, the beginning of growth of manufacturing output is invariably accompanied by a "big push' of activity with an extraordinary high rate of growth of the output.

A CRITICAL APPRAISAL

Jorgenson expounded a theory of development of a dual economy based on the neo-classical production function, and applicable to the historical situation of Japan and countries of South East Asia. His model is superior to the dualistic models of Boeke, Lewis, Rei-Fanis among others. This is because these models deal with 'special situations' or 'unsolved problems' created by concentration on a single output or a single production relation. On the other hand, his model is more realistic because it takes into consideration population, labour force, capital and technical change in discussing the development of a dual economy. However, he admits that his model does not present the universal theory of economic growth and development but a theory which is applicable to a well defined and empirically significant situation.

Its Weaknesses. However, the Jorgenson model has the following weaknesses:

1. Jorgenson's claim that his model is superior to the classical models of a dual economy, as it is based

on the empirical evidence of the Japanese economy, cannot be accepted because he compares the short-run predictions of the classical models with the asymptotic results of bis neo-classical model.

2. Jorgenson rules out the possibility of capital accumulation in agriculture and in support cites the case of the Japanese economy and Asian agriculture. As such, he excludes capital from the production function of the agricultural sector. This is unrealistic because a number of empirical studies, such as by Shukla for India, Nakamura for Japan, and Hansen for Egypt have shown that the use of capital has made rapid increases in labour productivity and farm production.

3. Another weakness of Jorgenson's model is that he assumes the supply of land as fixed in his agricultural production function. But the supply of land even in a backward agricultural economy can be increased over the long run through land reforms and land reclamation, thereby increasing the area under cultivation. This may result in a larger agricultural surplus.

4. Jorgenson's model is weak in that it emphasises the role of only supply factors such as labour, capital and technical change, and neglects the demand factors which also play an important role in the development of a dual economy.

5. Jorgenson also neglects the important role played by the service sector in the development of agricultural and industrial sectors of a dual economic system.

JORGENSON VS. FEI-RANIS

The Fei-Ranis model divides the process of economic development into three stages. But it differs from Jorgenson's model only with regard to the first stage. Jorgenson skips the first stage of the F-R model and assumes from the beginning of his analysis that the transfer of labour from agriculture to industry will actually result in a decline in the total agricultural output unless offset by an increase in productivity. If agricultural technology is assumed constant, the problem of feeding the labour force in the urban sector and the shortage of capital for non-farm jobs can delay the process of economic transformation.

Jorgenson's argument is more forceful than F-R that the process of capital formation (or accumulation) and economic development cannot proceed smoothly without technological change in the agricultural sector. Only when technological changes raise agricultural productivity to a level where agricultural output is sufficient to feed not only those who remain in agricultural but also the migrating workers from agriculture to industry will the necessary condition for economic transformation be satisfied.

It is common to both the Jorgenson model and the Fei-Ranis model that the process of economic transformation initiated by the withdrawal of surplus labour from agriculture can be disrupted by an alteration in the domestic terms of trade against industry and in favour of agriculture. As John Mellor points out, a change in the domestic terms of trade towards agriculture is likely to have three different effects which may delay or interrupt the process of economic development. *Firs*t, if savings in the agricultural sector are lower than in the non-farm sector, a transfer of resources from the latter to the former because of a change in the domestic terms of trade between the two sectors would slow down the rate of capital fomation. However, it is posible that the rise in agricultural prices, as compared with industrial prices, would encourage the entrepreneurial class to become interested in the modernisation of agriculture, which would lead to large agricultural output and surpluses. *Second*, a relative rise in

domestic agricultural prices will no doubt adversely affect the exports of primary products which constitute the bulk of exports of the developing countries. If this happens, it will reduce the country's net foreign exchange earnings and have adverse repercussions on the development of the economy as a whole. *Third*, higher food prices will discourage the migration of farm workers to the urban sector. Higher food prices will also raise the level of normal wages in industry. This will put a downward pressure on profit. Low profit and high wages will retard the process of economic transformation.