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Product Innovation and Employment in an Open economy

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ABSTRACT

The paper provides a theoretical framework explaining the impact of product innovation on the economic system when a new good, in an open economy, assuming duopolistic market structures is introduced. It also explores how this new introduction gets affected by the microeconomic preferences of the different economic players in the economic system. We begin by developing a static economic model analyzing how consumers make their preferences between old goods and newly introduced goods using a Cobb-Douglas utility function and then show how the macroeconomic factors namely consumption, savings, wage and employment affect the production of these two goods. We analyze two cases, first when there is an existence of surplus labour in the economy and the second when the surplus labour does not exist. The model results in some interesting conclusions, an important one being that in the presence of surplus labour, the expansion of a new good sector leads to a higher employment in the economy as well as the consolidation of the old good sector. Interestingly in the second case when the surplus labour does not exist, the increased demand for labour as a result of the development of the new good sector decreases the labour employed in the old good sector. But assuming a mature old good sector and economies of scale, the production of the old good increases but the old good sector shrinks.

Keywords- Product Innovation, Two sector Open Macro model, Creative Destruction

JEL Codes- C02,C61, O11, O12

INTRODUCTION

Innovation may be described as the process of translating an idea into a good or a service that creates value. It involves a deliberate application of information, imagination and initiative in deriving greater or different values from the available resources and includes all processes by which new ideas are generated and converted into useful products. However few static macroeconomic models if any deal explicitly with innovation regarding it to be long term process best analyzed in dynamic models. If at all, it is process innovation associated with rising productivity which is analyzed by static models usually modeled as a shift of the production function and associated with it the marginal productivity of labour with its usual conclusions for output produced, prices etc.

This paper on the other hand provides a theoretical framework explaining the impact of product innovation on the economic system when a new good assuming duopolistic market structures is introduced. It further explores how demand for this new good gets affected by the microeconomic preferences of the different economic players in the economic system. We begin by developing a static economic model analyzing how consumers make their preferences between old goods and newly introduced goods and then show how the macroeconomic factors namely consumption, savings, wage and employment affect the production of these two goods. The model results in some interesting conclusions, an important one being that the expansion of a new goods sector leads to higher employment in the economy as well as the consolidation of the old goods sector i.e. shrinkage in the number of firms in this sector.

The number of new goods industries as well as the number of old good industries is taken to be fixed.L_1 and L_2 are respectively the labour employed in the new and the old good sector with the total labour force in the economy $L>L_1+L_2$ i.e. an existence of surplus labour . In this case the development of the new good industry not only increases labour demand in the new good sector but through increased purchasing power via the wages earned, also increases the production in the old good sector. Hence product innovation results in the overall development of the economy.

We also examine what happens in the case when a surplus labour force does not exist in the economy. In this case the increased demand for labour as a result of the development of the new good sector decreases the labour employed in the old good sector. But assuming a mature old goods sector and economies of scale, the production of the old goods increases but the number of firms in old good sector shrinks, hence resulting in 'creative destruction'.

THE MODEL

In this model we have developed a theoretical framework for introducing innovation into the system. We assume that the economy is an open economy along with a government sector playing an active role in generating aggregate demand. The consumers demand both domestically produced as well as the foreign goods. The market is assumed to follow a oligopolistic market structure for the production of the old good *y* and a duopolistic market structure for production of the new innovative good *x*. The entire economy is divided between two classes of people. One class of people comprises of the workers engaged in the production of both the goods. The other class comprises of the capitalists that invests its capital in the production of both the commodities. Now for the labour services rendered, the workers receive remuneration in form of wages. The wages given in the new good sector are taken to be w_1 and those in the old good sector are taken to be w_2 with $w_1 > w_2$. The capitalist class in return for its investment in the production process earns a rate of interest or profit. Further it is assumed that the economy is not fully employed and that there is an existence of surplus labour in the economy.

The household sector constitutes the demand side of the market. The government sector too contributes in creating demand for both the new as well as the old good. Simultaneously the government deducts tax at the rate assumed to be *t*.

The consumer's preferences are assumed to follow a Cobb-Douglas utility function. These consumers, who essentially comprise of the worker class of the economy, devote a part of their consumption expenditure to both the old good, *y*, as well as the new good, *x*. Also the savings of the labour class are assumed to be invested entirely in the production of the old good *y*.

In the new goods sector a proportion of the capitalists' profit is also invested, hence creating investment demand for the new good. Likewise, a proportion of the capitalists' profit is also invested in the production of the old good.

The model is divided into four sections. In the first section describing the behavior of the household sector or the consumers, we derive the demand functions for the two goods-the new good *x* and the old good *y*. In the second section, we describe the new good sector and analyze how the production of this new innovation driven good affects the employment in the specific sector and in the overall economy as a whole. In the third section we describe the production process of the old good. In the following section we present the three macroeconomic equations representing the demand side and the supply side of both the new good sector and the old good sector along with the savings-investment equality equation describing how the overall savings of the economy are mobilized and invested. Finally in the last section the results derived are stated.

THE HOUSEHOLD SECTOR

The household sector is at the core of the demand side in our model. The consumers have a demand for both the old goods and the new goods. The total number of new goods and old goods are assumed to be a fixed quantity, *n* and *m* respectively.

The consumer's preferences for the two goods are assumed to follow a Cobb-Douglas utility function given by

$$U = x_1^{\bar{\beta}} x_2^{\bar{\beta}} x_3^{\bar{\beta}} \text{............} x_n^{\bar{\beta}} \left(\sum_{i=1}^{m} y_i\right)^{1-\beta} \qquad 1)$$

where U represents the utility function of a single consumer

m= no. of old goods *y*= old good industry

n= no. of new goods *x*= new good industry

The proportion of his income that the representative consumer spends on the new goods and the old goods is given by β and *(1-β)* respectively. In our utility function we assume that the new goods take multiplicative form. Hence the proportion of income that the consumer devotes to each new good x_j is β^{-} i.e. the consumer spends an equal proportion of his income on each new good . As such $n\beta^{-} = \beta$ where *n* is the total number of new goods produced by the new goods industry. Also $0 < \beta < 1$.

The old goods are assumed to follow a Bertrand oligopolistic market structure that produces homogeneous goods. Hence the old goods y_i are perfect substitutes, however we assume that $y_1 = y_2 = y_3 = \cdots \ldots \ldots = y_m = y^{-}$. This means that the quantity demanded of each old good y_i is the same. Hence the representative consumer's utility function takes the form

$$U=\prod_{j=1}^{n} x_{1}^{\overline{\beta}} \left(\sum_{i=1}^{m} y_i\right)^{1-\beta} \qquad 2)$$

The total income of the consumer is represented by the consumer's budget constraint that is defined as under

$$W=\sum_{i=1}^{m} p_y y_i + \sum_{j=1}^{n} p_x x_j \qquad 3)$$

Where W= the total income earned by the consumer

p_y = price of good y and p_x = price of good x

A constrained-optimization exercise leads to the consumer's demand for the two goods.

$y_i^* = \frac{W(1-\beta)}{p_y m}$ and $\overline{x}_j^* = \frac{W\beta}{p_x n}$ 4)[1]

which are the equilibrium values for the two goods. From these calculated values we can conclude that the consumer's demand for the old good y is positively related to his income W and $(1-\beta)$ which shows how important the good is for him or how much the consumer prefers it. A high value of β means that the consumer does not attaches much value to it and hence devotes a small proportion of his income towards its purchase. The consumer's demand for old good is also negatively related to the price of the old good p_y and the total number of all the old goods available in the economy m.

Similarly, the consumer's demand for the new goods is positively related to his income W and β which shows the relative importance of the good or how much the consumer prefers it. Also the demand for new good is negatively related to its price p_x and the number of total new goods in the market n.

THE NEW GOOD SECTOR

The new good x, produced in a duopolistic market structure has the following inverse demand function

$$p_x = \frac{A}{q_1+q_2} \qquad 5)$$

where q_1 is the output produced by each of the two firms and as such the total amount produced by one new good industry $x = q_1 + q_2$. The total number of industries engaged in the production of the new goods under a duopolistic framework are assumed to be a fixed number denoted by n. And since there are two firms in each industry, the total fixed number of new firms involved in the new good's production is $2n$.

The new good x faces a downward sloping demand curve with its production function given by

$$q_I = \gamma_1 l_1^{\frac{1}{2}} \qquad 6)$$

Here again $q_{□}$ gives the output produced by each duopolistic firm with □ ranging from 1 to 2. l_1 is the labour employed in one duopolistic firm and $\gamma_1$is some constant. From this expression we get the value for $l_1 = (\frac{q_{□}}{\gamma_1})^2$. Now with $2n$ number of firms engaged in the manufacturing of the new good, the total labour requirement of the entire new good industry, denoted as $L_{1,}$ is

[1] Steps available from the corresponding author on request

$$L_1 = 2n\left(\frac{q_I}{\gamma_1}\right)^2 \qquad 7)$$

To find out how much quantity of the new good is produced by each of the duopolistic firm, we again resort to optimization technique and maximize the profit of each duopolist.

The revenue earned by each duopolist firm is the price of the new good, p_x, multiplied by the quantity sold by the duopolist, q_I. The price charged by both the duopolies will be the same while the quantity sold by them will differ depending upon the production capacity of each. Let the quantity sold by the two duopolistic firms be q_1 and q_2. As far as the cost of each duopolistic firm is concerned, it is simply the total labour employed in each firm multiplied by the wages given out to those labourers. The wages in the new good sector as already mentioned above, are taken to be w_1 and the labour employed by each firm is l_1. Hence the cost function $C = w_1 l_1$

Next carrying out the following optimization exercise for profit maximization, where profit $\Pi = R - C$

$$\prod\nolimits_I = p_x q_I - w_1 l_1 \qquad 8)$$

Substituting $p_x = \frac{A}{q_1 + q_2}$ and $L_1 = 2n\left(\frac{q_I}{\gamma_1}\right)^2$, we get

$$\prod\nolimits_1 = \frac{A}{(q_1 + q_2)} q_1 - w_1\left(\frac{q_1}{\gamma_1}\right)^2 \qquad 9)$$

$$\prod\nolimits_2 = \frac{A}{(q_1 + q_2)} q_2 - w_1\left(\frac{q_2}{\gamma_1}\right)^2 \qquad 10)$$

Consequently the optimization exercise leads to the following results[2]

$$q_1 = q_2 = \frac{\gamma_1}{2}\sqrt{\frac{A}{2w_1}} \qquad 11)$$

And
$$p_x = \frac{\sqrt{2Aw_1}}{\gamma_1} \qquad 12)$$

From equation (11) we can conclude that the quantity produced by each of the duopoly firm is equal. Hence with equal quantity sold and same prices, (equation 12), the revenue incurring to each of the duopolistic firm will be the same i.e.

$$R_1 = R_2 = \left\{\frac{\sqrt{2Aw_1}}{\gamma_1}\right\}\left\{\frac{\gamma_1}{2}\sqrt{\frac{A}{2w_1}}\right\} = \frac{A}{2} \qquad 13)$$

Substituting the value obtained for q_I in equation (11) into the cost function $C = w_1 l_1$ gives

[2] Steps available from the corresponding author on request

$$C = w_1 \left(\frac{\gamma_1^2 \frac{A}{8w_1}}{\gamma_1} \right) = \frac{A}{8} \quad 14)$$

Further substituting the values obtained for revenue and cost functions into the firm's profit function gives

$$\prod{}_1 = \frac{A}{2} - \frac{A}{8} = \frac{3A}{8} \quad 15)$$

Hence the profit of each duopolist $= \frac{3A}{8}$. And since each duopolistic industry consists of two firms, the profit of each industry producing a new good is $\frac{3A}{4}$. Therefore the total profit earned by all the n number of industries engaged in the production of new goods can be given by

$$n\frac{3A}{4} \quad 16)$$

Finally upon substituting the value of $q_1$as obtained in equation (11) in equation (7), we get the total labour force employed in the new good sector, L_1 i.e.

$$L_1 = 2n \left(\frac{\frac{\gamma_1}{2}\sqrt{\frac{A}{2w_1}}}{\gamma_1} \right)^2 = \frac{An}{4w_1} \quad 17)$$

which implies that $L_1 = f(A)$. The value of A is the revenue generated in one new good industry is derived later in the text. This result is an important one because it shows that as the number of industries producing new goods, n, increases, the demand for labour also increases. When new industries come up they create new employment opportunities. As such the surplus labour existing in the economy gets employed. We can therefore conclude that product innovation increases employment.

THE OLD GOOD SECTOR

The old good y is assumed to be produced in a Bertrand oligopolistic market structure where each firm produces homogeneous product, that are perfect substitutes hence each having the same price p_y. The wage in the old good sector is taken to be w_2 and the total labour employed is L_2.

The production function of the old good y takes the form $y = \gamma_2 l_2$ where y is the output produced by each oligopolistic firm,γ_2 is some constant and l_2 is the labour employed in one such firm. We have assumed m as the no. of firms in the old good industry, which is fixed, and as such the total labour requirement of the old good sector

$$L_2 = ml_2 \quad 18)$$

Hence the total output produced of good y which is just the multiplicative product of the total numbers of firms engaged in the production of the old good and the amount of output produced by each of these firms is $my = m\gamma_2 l_2$ which implies that

$$my = \gamma_2 L_2 \quad 19)$$

Since the old good follows a Bertrand oligopolistic market structure, the firms enter into price competition that reduces the profit to zero. Therefore the capitalists do not earn any profit. The revenue generated p_2y is equal to the cost incurred in the production process which is w_2L_2. Hence profit $\Pi = 0$.

Now because our model has two goods, we may assume the price of good y, p_y =1 as in the Uzawa (1961) model.

THE MACROECONOMIC EQUATIONS

We now come to the three macroeconomic equations in the model representing the demand side and the supply side of both the new good and the old good. We also include a savings-investment equality equation indicating how the total savings in the economy are mobilized and invested. Solving these three equations gives us the equilibrium value for the amount of revenue generated in the new good duopolistic sector.

The demand for the two goods x and y, comes from the savings, investment and the consumption portion of the wage incomes, w_1 and w_2, of the labourers, employed in the new goods as well as the old goods sector respectively. We also have a government sector and a foreign trade sector that contributes in creating aggregate demand for both the new and the old goods sector. The government deducts tax at the rate t and incurs expenditure on both the goods.

The total value of demand for the new good x is

$$\beta(1-s)(1-t)w_1L_1+\beta(1-s)(1-t)w_2L_2+\beta(1-s)(1-t)\prod_x+(1-\rho)2nk+G_n+X_n-M_n=2p_xnq_I \quad 20)$$

We assume that the demand for the new good comes from only the consumption portion of the income of the labourers engaged in both the new good sector L_1 as well as the old good sector L_2. Here the expression $\beta(1-s)(1-t)w_1L_1+\beta(1-s)(1-t)w_2L_2$ shows that 'β' proportion out of the total consumption from the wage income (wL) left after deducting tax at the rate of 't' i.e. disposable income$(1-t)wL$ goes into demanding the new good. In this expression's' is the marginal propensity to save of the consumer and hence $(1-s)$ gives the consumer's marginal propensity to consume. The wage income wL is composed of the wage incomes of the labour involved in the new good sector and those in the old good sector. The wage income in the new good sector is w_1 and that in the old good sector is w_2.Hence whole expression represents the consumption demand for the new good. Apart from this, 'β' proportion of the profits of the capitalists in the new good industry, Π_x, is also invested in the new good sector. This profit, as found out in section II, equation (16) is $n\frac{3A}{4}$.

Further, the expression $(1-\rho)2nk$ represents the investment demand for the new good with $2n$ being the number of firms in the new good sector and 'k'the total capital requirement in the new good sector. Hence out of the total capital requirement in the new good sector, a proportion denoted as$(1-\rho)$ gets devoted to the new good sector. The government's demand for the new good is represented as G_n while X_n-M_nrepresent the foreign good sector with X_n being the exports and M_n being the imports.

The right hand side of this equation depicts the supply side of the duopolistic market where the new good is traded. It gives the total value of output produced in the market. It is equal to the price of the new good p_x multiplied by the total number of firms in the new good industry $2n$ and the output produced by each of these firms $q_{?}$.

Now at equilibrium the left hand side representing the demand for the new good is equal to the right hand side which gives the supply of the good and hence the market clears. Equation (20) hence gives us our first macroeconomic equation.

The second macroeconomic equation depicts the demand and supply side of the old good in the Bertrand oligopoly market.

$$(1-\beta)(1-s)(1-t)w_1L_1+(1-\beta)(1-s)(1-t)w_2L_2+(1-\beta)(1-s)(1-t)\prod_x+\rho2nk+ G_m+X_m-M_m=mp_yy \quad 21)$$

The left hand side of the equation represents the demand side of the market. The demand for the old good y comes from the consumption as well as the savings portion of the income of the laborers. The expression $(1-\beta)(1-s)(1-t)w_1L_1+(1-\beta)(1-s)(1-t)w_2L_2$ shows that $(1-\beta)$ proportion of the total consumption out of wage income (wL) left after deducting tax at the rate of t i.e. disposable income $(1-t)wL$ goes into demanding the new good. Apart from this $(1-\beta)$proportion of the profits of the capitalists, Π_x, in the new good industry is also invested in the old good industry. This profit, again as found out in section II, equation (16) is $n\frac{3A}{4}$. Next, the expression $\rho 2nk$ represents the investment demand for the old good with $2nk$ being the total capital requirement in the new goods sector. Hence out of the total capital requirement, a proportion denoted as ρ gets devoted to the old goods sector. The government's demand for the old good is represented as G_m while $X_m - M_m$represent the foreign good sector with X_m being the exports and M_m being the imports.

The right hand side of the equation gives us the value of the output of the old good produced which is the supply side of the market. It is equal to the multiplicative product of the number of firms engaged in the production of the old good, m the amount of output produced by each of these firms, y, and the price of the old good p_y.

In equilibrium the left hand side representing the demand for the old good is equal to the right hand side which gives the supply of the old good and hence the market clears. Equation (21) therefore gives us our second macroeconomic equation.

The third macroeconomic equation gives us the savings-investment equality in the Keynesian sense.

The investment in the system is nothing but the total capital requirement of the new good sector i.e. $I = 2nk$ which is the product of the total number of firms in the new good sector, $2n$, and the total capital requirement of each of these firms, k. This is equal to the savings of the labour class employed in both the new and the old good sector. Hence

$$\rho s(1-t)(w_1L_1 + w_2L_2 + \Pi) + (1-\rho)s(1-t)(w_1L_1 + w_2L_2 + \Pi) = 2nk \qquad 22)$$

We now have a system of three macroeconomic equations, namely equations (20), (21) and (22). From equation (22) we can derive the expression for the labour employed in the old good sector i.e.[3]

$$L_2 = \frac{1}{w_2}\left\{\frac{2nk}{s(1-t)} - w_1L_1 - \Pi\right\} \qquad 23)$$

Substituting this value of L_2 along with the values of $p_x = \frac{\sqrt{2Aw_1}}{\gamma_1}$, $q_i = \frac{\gamma}{2}\sqrt{\frac{A}{2w_1}}$ and

$\Pi_x = n\frac{3A}{4}$ as obtained earlier under the new good sector section II, in equation (20) gives

$$\beta(1-s)(1-t)w_1L_1 + \beta(1-s)(1-t)w_2\left\{\frac{1}{w_2}\left[\frac{2nk}{s(1-t)} - w_1L_1 - \Pi\right]\right\} + \beta(1-s)(1-t)\Pi_x + (1-\rho)2nk + G_n + X_n - M_n = 2\frac{\sqrt{2Aw_1}}{\gamma_1}n\frac{\gamma_1}{2}\sqrt{\frac{A}{2w_1}}$$

$$= A^* = \frac{2nk\left[\frac{\beta(1-s)}{s} + (1-\rho)\right] + G_n + X_n - M_n}{n} \qquad 24)^4$$

This gives the total equilibrium revenue value (A) of one new good (x) industry. The equilibrium value of the total revenue generated in all n industries can be calculated as An. Now substituting this value of A^* in equation (11), which gives the equilibrium amount of output produced by each of the duopolistic firm, gives

[3] Steps available from the corresponding author on request
[4] Steps available from the corresponding author on request

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$$q_1 = q_2 = \frac{\gamma_1}{2}\sqrt{\frac{\frac{2nk}{n}\left[\frac{\beta(1-s)}{s}+(1-p)\right]+G_n+X_n-M_n}{2w_1}}$$

which implies that

$$q_I^* = \frac{\lambda_1}{2}\sqrt{\frac{nk\left[\frac{\beta(1-s)}{s}+(1-\rho)\right]+G_n+X_n-M_n}{nw_1}} \qquad 25)$$

Hence the equilibrium level of output for the new good *x* is

$$x^* = q_1 + q_2 = \gamma_1\sqrt{\frac{nk\left[\frac{\beta(1-s)}{s}+(1-\rho)\right]+G_n+X_n-M_n}{nw_1}}$$

Also upon requisite substitution in $l_{I} = (\frac{q_1}{\gamma_1})^2$ which is the amount of labour employed in each of the duopolistic firm producing the new good *x*, we get

$$l_I = \left(\frac{\gamma_1}{2}\right)^2 \frac{\sqrt{\frac{nk\left[\frac{\beta(1-s)}{s}+(1-\rho)\right]+G_n+X_n-M_n}{nw_1}}^{\,2}}{\gamma_1^2}$$

Further from the value obtained for A^* in equation (23) we can derive the equilibrium level of total labour employed in new good sector *x*, by substituting the value in $L_1 = \frac{An}{4w_1}$ derived earlier which comes out to be

$$L_1^* = \frac{1}{4w_1}\left\{2nk\left[\frac{\beta(1-s)}{s}+(1-\rho)\right]+G_n+X_n-M_n\right\} \qquad 26)$$

To see how this equilibrium value of the labour employed in the new sector responds to changes in the various parameters in the model, we carry out comparative statics and get the following results[5]

<u>Parameter β</u>

$$\frac{\partial L_1^*}{\partial \beta} = \frac{2n(1-s)k}{4sw_1} > 0$$

<u>Result 1-</u> As the proportion of consumption out of the total wage income devoted to the new good sector increases, the labour demand in the new good sector also increases.

<u>Parameter s</u>

$$\frac{\partial L_1^*}{\partial s} = \frac{-nk\beta}{2s^2w_1} < 0$$

<u>Result 2-</u> As the consumer's marginal propensity to save increases, the labour demand in the new good sector decreases.

[5] Steps available from the corresponding author on request

Parameter n

$$\frac{\partial L_1^*}{\partial n}=\frac{1}{4w_1}\left\{2k\left[\frac{\beta(1-s)}{s}+(1-\rho)\right]\right\}>0$$

Result 3-. As the number of firms in the new good sector increases, the demand for labour in the sector increases.

Parameter w_1

$$\frac{\partial L_1^*}{\partial w_1}=\frac{-1}{4w_1^2}\left\{2nk\left[\frac{\beta(1-s)}{s}+(1-\rho)\right]+G_n+X_n-M_n\right\}<0$$

Result 4- Increase in the wages of the labour employed in the new good sector, decreases its demand for them.

Parameter k

$$\frac{\partial L_1^*}{\partial k}=\frac{1}{4w_1}\left\{2n\left[\frac{\beta(1-s)}{s}+(1-\rho)\right]\right\}>0$$

Result 5- As the capital requirement of the new good sector increases, the demand for labour and hence labour employment in the sector also increases.

Parameter ρ

$$\frac{\partial L_1^*}{\partial \rho}=\frac{-nk}{2w_1}<0$$

Result 6- As the proportion of investment devoted to the old good sector increases, the labour demand in the new good sector decreases.

$$\frac{\partial L_1^*}{\partial G_n}=\frac{1}{4w_1}>0$$

Result 7- As the proportion of government expenditure devoted to the new good sector increases, the labour demand in the new good sector also increases.

Hence we conclude that the total labour employed in the new good duopolistic industry is positively related to the number of firms in the new good sector n, the total capital required in the new good sector k,the amount of government expenditure in the new good sector and the proportion of income that the consumer devotes from his budget towards the new good β. As each of these factors increases, the total labour employment in the new good sector increases. Further this labour demand is negatively related to the savings propensity of the consumers s, the wages earned by the workers in the new good sector w_1 and the proportion of investment devoted to the old good sector.

Next substituting this equilibrium value of $L_1^* and\ \Pi_x = n\frac{3A}{4}$in equation (8) gives the equilibrium value of the labour employed in the old good sector. i.e.

$$L_2^*=\frac{1}{w_2}\left\{\frac{2nk}{s(1-t)}-\left[\frac{1}{4}\left(2nk\left(\frac{\beta(1-s)}{s}+(1-\rho)\right)+G_n+X_n-M_n\right)\right]-\Pi\right\} \qquad 27)$$ [6]

Now to see how this equilibrium value of the labour employed in the new sector responds to changes in the various parameters in the model, we carry out comparative statics and get the following results[7]

[6] Steps available from the corresponding author on request

Parameter β

$$\frac{\partial L_2^*}{\partial \beta} = -\frac{2nk(1-s)}{sw_2} < 0$$

Result 7- As the proportion of consumption out of the total wage income, devoted to the new good sector increases, the labour demand in the old good sector decreases.

Parameter *s*

$$\frac{\partial L_2^*}{\partial s} = -\frac{2nk}{w_2 s^2}\left[\frac{1}{(1-t)} - \beta\right] < 0$$

Result 8- As the saving propensity of the consumer increases, the labour demand in the old good sector decreases.

Parameter *n*

$$\frac{\partial L_2^*}{\partial n} = \frac{2k}{w_2}\left\{\frac{1}{s(1-t)} - \left[\frac{\beta(1-s)}{s} + (1-\rho)\right]\right\} > 0$$

Result 9- As the number of firms in the new good sector increases, the labour employed in the old good sector increases.

Parameter w_2

$$\frac{\partial L_2^*}{\partial w_2} = -\frac{1}{w_2^2}\left\{\frac{2nk}{s(1-t)} - \left[2nk\left(\frac{\beta(1-s)}{s} + (1-\rho)\right) + G_n + X_n - M_n\right]\right\} < 0$$

Result 10- An increase in the wages of the labour employed in the old good sector decreases its demand for them.

Parameter *k*

$$\frac{\partial L_2^*}{\partial k} = \frac{2n}{w_2}\left\{\frac{1}{s(1-t)} - \left[\frac{\beta(1-s)}{s} + (1-\rho)\right]\right\} > 0$$

Result 11- Increase in the capital requirement of the new good sector increases the labour demand in the old good sector.

Parameter *ρ*

$$\frac{\partial L_2^*}{\partial \rho} = \frac{2nk}{w_2} > 0$$

Result 12-Increase in the investment proportion towards the old good sector increases the labour demand in the old good sector.

$$\frac{\partial L_2^*}{\partial G_n} = -\frac{1}{w_2} < 0$$

Result 13-Increase in the government expenditure towards the new good sector decreases the labour demand in the old good sector.

[7] Steps available from the corresponding author on request

The results derived above are quite interesting. The labour employed in the old good sector is positively related to the total capital required in the new good sector k, the number of new good firms n, and the proportion of income that the consumer devotes from his budget towards the new good β as well as the investment proportion devoted towards the old good sector. Further this labour demand is negatively related to the savings propensity of the consumers s, the wages earned by the workers in the old good sector w_2 and the amount of government expenditure in the new good sector.

Hence it can be said that increasing the number of industries involved in the production of the new good increases the overall labour employment opportunities in the economy and are not just sector specific.

Equations (26) and (27) together give us the value for the total labour force, L, in the economy with $L=L_1+L_2$. Hence

$$L=\left\{2nk\left[\frac{\beta(1-s)}{s}+(1-\rho)\right]+G_n+X_n-M_n\right\}\left(\frac{1}{4w_1}-\frac{1}{w_2}\right)+\frac{2nk}{w_2 s(1-t)}-\frac{\prod}{w_2} \qquad 28)$$

Differentiating the total labour force with respect to the different parameters shows that, since by assumption $w_1 > w_2$,

$$\frac{\partial L}{\partial \beta}=\frac{2nk(1-s)}{s}\left[\frac{1}{4w_1}-\frac{1}{w_2}\right]<0$$ [8],

$$\frac{\partial L}{\partial s}=-\frac{nk}{s^2}\left[\frac{\beta}{2w_1}+\frac{2}{w_2}\left(\frac{1}{(1-t)}-\beta\right)\right]<0$$ [9],

$$\frac{\partial L}{\partial n}=2k\left[\frac{\beta(1-s)}{s}+(1-\rho)\right]\left[\frac{1}{4w_1}-\frac{1}{w_2}\right]+\frac{2k}{w_2 s(1-t)}>0$$ [10]

$$\frac{\partial L}{\partial \rho}=\frac{2nk}{w_2}-\frac{nk}{2w_1}>0$$ [11]

$$\frac{\partial L}{\partial k}=2n\left[\frac{\beta(1-s)}{s}+(1-\rho)\right]\left[\frac{1}{4w_1}-\frac{1}{w_2}\right]+\frac{2n}{w_2 s(1-t)}>0$$ [12]

$$\frac{\partial L}{\partial G_n}=\frac{1}{4w_1}-\frac{1}{w_2}<0$$

Hence we can conclude that the total labour force is positively influenced by the total number of new goods n, the proportion of investments directed towards the old goods sector ρ, and the total capital requirement in the new goods sector k. It is negatively influenced by the consumption proportion devoted towards the new goods sector β, the savings propensity of the consumers s, and the government expenditure incurred by the government on the new goods.

Moving on to the second macroeconomic equation that gives the demand and the supply side in the old good, perfectly competitive industry and substituting the values so obtained for L_1^*, Π_x, L_2^* and A^* in equation (6) gives

$$(1-\beta)(1-s)(1-t)\left\{\frac{1}{4}\boldsymbol{C}+\boldsymbol{N}-\boldsymbol{R}+\frac{3}{4}\frac{\boldsymbol{R}}{n}\right\}+2nk\rho+G_o+X_o-M_o=my \qquad 13$$

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Where $\mathbf{C}$ denotes the expression $2nk[\frac{\beta(1-s)}{s}+(1-\rho)]+G_n+X_n-M_n$

and $\mathbf{N}$ denotes the expression $\frac{2nk}{s(1-t)}$

Hence

$$y^* = \frac{(1-\beta)(1-s)(1-t)\left\{\frac{1}{4}\mathbf{C}+\mathbf{N}-\mathbf{R}+\frac{3\mathbf{R}}{4n}\right\}+2nk\rho+G_o+X_o-M_o}{m} \qquad 29)^{14}$$

This gives the equilibrium value of the amount of old good produced. Next to see how this equilibrium value responds to changes in the various parameters, we again resort to comparative exercise which gives the following results

$$\frac{\partial y^*}{\partial n} = \frac{(1-\beta)(1-t)(1-s)\left\{\frac{2k}{s(1-t)}+\frac{3}{4}\left[2k\left(\frac{\beta(1-s)}{s}+(1-\rho)\right)\right]\right\}+2k\rho}{m} > 0$$

$$\frac{\partial y^*}{\partial k} = \frac{(1-\beta)(1-s)(1-t)2n\mathbf{Q}+2n\rho}{m} > 0^{15}$$

$$\frac{\partial y^*}{\partial m} = \frac{(1-\beta)(1-s)(1-t)\left[\mathbf{N}+\frac{3}{4}\mathbf{R}+2nk\rho+G_o+X_o-M_o\right]}{m^2} < 0^{16}$$

$$\frac{\partial y^*}{\partial \beta} = \frac{(1-t)(1-s)2nk\{\left[\frac{1-s}{s}\right](1-\beta)-\mathbf{Q}\}}{m} \; ^{17}$$

$$\frac{\partial y^*}{\partial s} = \frac{(1-\beta)(1-t)2nk\left\{(1-s)\left[\frac{\beta}{s^2}+\frac{1}{(1-t)}-\mathbf{Q}\right]\right\}}{m} < 0^{18}$$

$$\frac{\partial y^*}{\partial \rho} = \frac{-(1-\beta)(1-t)(1-s)2nk+2nk}{m} = \frac{2nk\left[1-(1-\beta)(1-t)(1-s)\right]}{m} > 0$$

The results derived above show that the total production of the old good is positively related to the number of firms in the new good industry. Further as the capital requirement of the new good industry increases, the production of the old good also increases. An increase in the proportion of income that the consumer devotes to the new good decreases the production of the old good. Interestingly, as the number of firms in the old good industry increases, the production of the old good decreases. Alternatively we can say that as the production of the old good increases, the number of firms in the old good sector decreases as a result of economies of scale or 'scale effects'. Further an increase in the savings propensity of the consumers, decreases the production of the old good and an increases in the proportion of investment devoted to the old good sector increases the production of the old good.

SUMMARY OF RESULTS AND CONCLUSIONS

The paper makes an attempt to find out if theoretically any relationship could be established between product innovation and employment in an open economy. Our model has concluded that when a new innovative good enters the market, it leads to increased employment opportunities in the economy. While Solow (1956,1957) in his model asserted on the importance of

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improvement in technology or what can be called as Process innovation, the present model shows that when a new technology is introduced or what can be termed as Product innovation, the economy experiences an increases in employment.

The main conclusion that can be drawn from the model is that when a new good industry expands, it increases the labour demand not only in the new good sector but also in the sector that is involved in the production of the old good. An increase in the number of firms engaged in the new good sector, the total capital requirement of the new good sector and an increase in the proportion of budget that the consumer allocates to the new good, all increase the labour employment in the entire economy.

In our model we assumed the existence of surplus labour. Hence for the labour surplus economies innovation can be considered a boon. The development of industries producing new goods promotes consumerism. Also increased employment opportunities increase the purchasing power that leads to the growth of both the new and the old good sector. This is the main macroeconomic impact of product innovation. Hence we can conclude that the development of the new good industry and therefor product innovation leads to an overall development of the economy.

If however the total labour force in the economy were assumed fixed, unlike as assumed in the present model, and there were no existence of surplus labour, then an increases in the number of new good industries would lead to an increase in the labour employed in the new good sector and consequently a decrease in the labour employed in the old good sector. Assuming a mature old good sector with increasing returns to scale and existing capital structure, the production would increase but the old sector would shrink resulting in the consolidation of the old goods sector. As such the structure of the economy would change.

The model presented is thus a significant contributor to the already existing literature on the importance of innovation, especially product innovation, in the economic development of any country, especially the less developed or developing countries with abundant labour, like India. It is precisely the reason why the government of India has initiated programs like ‘Start Up India’ that aims to promote innovation in the country and create employment opportunities.

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