

**SUBCONTRACTING, R&D AND LABOUR PRODUCTIVITY:  
A THEORETICAL EXPLANATION**

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While a large body of researches discusses the effects of international subcontracting on firm dynamics, the present work deals with the similar issues of a domestic firm who subcontracts to the informal sector in a typical developing world. Theoretically, we develop a model that if the formal sector wage is higher than that of informal sector, the choice of informal sector subcontracting and in-house R&D investment appears to be alternative options to the firm to bypass expensive labour in the formal sector. We argue that the R&D and labour productivity in formal sector are highly influenced by the informal wage but not the formal sector one. Since the subcontracting can raise both supply and demand for informal workers due to a rise of formal sector wage, the movement of informal sector wage is uncertain and thereby, the formal sector R&D and labour-productivity are also ambiguous. Thus, countries with a vast segment of lowly-paid informal workers exhibit lowly-productive formal workers.

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1. INTRODUCTION

The pace and pattern of subcontracting or outsourcing not only across borders but also within the boarder have been growing evidences in the present day world. To the best of our knowledge, the existing research has largely discussed the effect of international outsourcing and ignored the similar effects within a domestic country. A growing body of literature has narrated the experiences of emerging trend of subcontracting largely in the developing world and some of those are available at

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WTO-ILO report (2009). It has been observed that a producer often subcontracts a part of the production process to outside agents for various reasons (Maiti, 2008). What could be the resultant effect of this subcontracting on in-house R&D and labour productivity of a typical formal firm within the country has not been discussed seriously and the present study would like to explore this issue in this paper.

It is understood that the ability of firms to avoid minimum wage laws, certain types of taxes, and livelihood needs, for a vast majority of the population leads to the formation of the unorganized/informal sector, whose significance can hardly be undermined if one is seriously interested in understanding the working condition of a typical developing economy. The other important reason for the informal sector to be thrived is a variety of low cost non-traded goods and services which require little investment but provide employment to a large number of uneducated and otherwise jobless people. The developing world captures 60-90 % workforce in the informal manufacturing sector which has direct or indirect production linkages to the formal producer (WTO-ILO, 2009).<sup>1</sup> Several papers in Guha-Khasnobis and Kanbur (2006) edited volume and WTO-ILO (2009) report analyse the state of informal enterprises in the developing world. It is more or less recognized that the informal sector often survives through subcontracting by the formal sector in various ways.<sup>2</sup> Having this inter-sectoral linkage, it appears that R&D and labour productivity of the subcontracted firm would no longer be unaffected in a typical dual economy.

Moreover, it is also well recognized that formal sector jobs receive higher wage than what is usually offered to informal workers. Agenor (1996) corroborates such claims. Marcouiller *et al.* (1997) have contradictory evidence for Mexico while reconfirming the wage gap for El Salvador and Peru. Earlier, the theoretical model of Carruth and Oswald (1981) and later by Esfahani and Salehi-Isfahani (1989) provide justifications of economic dualism between a unionized and non-unionized sector. The later paper uses effort observability and worker productivity as possible reasons behind wage-premium in the formal sector. Many recent theoretical and empirical evidences support this observation.

We start from a set up with a given wage premium in the formal sector due to either more active unionism or government intervention. Since the formal sector activities are abided by a set of rules it gives a room to those workers for the formation union and its

<sup>1</sup> It absorbs almost 90 % of the workforce in India (Marjit and Maiti, 2009).

<sup>2</sup> One particular issue of concern in recent times has been that how informal workers can face up to the challenge of globalization as liberal policies of a reforming economy. Goldberg and Pavnick (2003) and Marjit *et al.* (2007a) argue that liberal trade and investment policies may expand or contract output and employment in the informal sector. If liberal trade policies lead to increased profitability, more output is likely to be produced in the formal segment. Marjit (2003) and Marjit *et al.* (2007) show that even if workers are laid off in the formal sector and move to casual jobs, the informal wage and employment can still go up provided capital can be relocated easily from the formal to the informal sector.

interventions. Under such circumstances, the wage in the formal labour market is assumed to be determined exogenously by the external institutions. Formal-informal division easily occurs along the line of high-low wage. Typically, a firm faced with organized union and stringent labour laws looks for workers who can be hired at lower than minimum wages without the promise of other fringe benefits. Such casual contracts are illegal, but firms can avoid punishment by increasing cost to influence the monitors. Such a system survives because poor people need jobs and the governance system turns out to be corrupt and reasonably weak.<sup>3</sup>

The existence of an informal sector allows some degree of labour market flexibility, even at the cost of encouraging an environment where people are employed at low wage and under poor working conditions. Social concern for workers having to tolerate a disgraceful work environment cannot deny the fact that without jobs they would be definitely worse off. However, the existence of a low wage sector acts as if the firms have access to a low cost technology, when they have to pay a higher wage to the formal workers. This reduces the incentive to search a low cost alternative in the formal sector and eventually leads to a lower amount of productivity augmenting R&D expenditure. This, in turn, affects average labour productivity in the formal sector. If our conjecture is right, *ceteris paribus*, lower informal wages should imply lower productivity of formal sector workers. Since the phenomenon of lower wage in the informal sector generally reflects low labour productivity in the informal sector, improving labour condition in the informal sector should lead to an improvement in the formal sector productivity as well.

Given this backdrop, we develop a theoretical framework of a typical firm in a developing economy which has two alternative options to avoid expensive formal workers. It can either subcontract to the informal sector at cheaper labour cost and/or go for in-house R&D to innovate labour saving technology in the in-house production. The formal wage is determined by exogenous factors, but the informal wage is endogenously determined by the market. However, it is assumed that the informal sector wage does not adjust quickly in the short run. Through a rise in the formal wage, if the government allows informal activities to be thrived, a formal producer would take advantage of this and would be reluctant to go for in-house R&D investment. Therefore, the firm prefers to subcontract to the informal sector and this acts as a binding condition of productivity improvement of formal workers. As a result, the demand for informal labour would rise leading to an increase in the wage. Now in the short-run, if the resultant informal wage rises, the firm effectively cuts back the subcontracting and goes for in-house R&D initiative which eventually leads to a rise in the labour productivity of formal workers. Therefore, the informal wage and formal sector labour productivity would be highly correlated.

<sup>3</sup> Dasgupta and Marjit (2006) and Marjit *et al.* (2007a) argue that the informal sector may be the outcome of a deliberate strategy of the government in a poor country, either to exert pressure on trade unions and/or to avoid social unrest in the absence of a well designed and funded social welfare programme for the poor.

But in the long-run, the informal wage is adjusted by the market. A rise in the formal sector wage leads to a rise of demand for informal production, and resultant employment, and also the firm releases some labour to the informal sector. This increases supply of workers in the informal sector. The net effect of these two forces determines the level of employment and wage in the sector. Now, if the resultant informal wage rises in response to these interactions, the formal R&D and labour productivity might improve, otherwise not.

We find supportive results to establish our relationship from a country study. In India, it clearly defines the boundary of formal and informal sector.<sup>4</sup> Marjit and Maiti (2009) gathered information from secondary sources of Indian database and ran some regressions to study the relationship between wages and productivity. The study considers annual emoluments for hired workers in Non-Directory Manufacturing Establishments (NDME)<sup>5</sup> of the informal sector, reported by National Sample Survey Organisation, Government of India, as informal wage and annual emoluments of factory workers, reported by Annual Survey of Industries, Government of India, as the formal wage, and finds that the formal wage of an ASI worker is, on an average, 2 to 6 times higher than the informal wage and this gap varies across regions and over time. The study separately ran pooled OLS regression with state and time dummies and panel GLS regressions to estimate the relationship between informal wage-formal productivity and formal wage-formal productivity controlling other variables. The regression results clearly suggest that the correlation between formal wage and formal productivity is not significant enough, while it is highly significant between formal labour productivity and informal wage. GLS panel regression results are much superior to the OLS results. These results essentially reveal that formal productivity is highly influenced by the informal wage, but not necessarily by the formal wage. However, the study does not discuss about R&D investment of the formal firm due to lack of information in the database.

<sup>4</sup> As per Indian the Factory Act 1948, the firms which use more than 10 workers with power and more than 20 without power come under organized or formal sector. The Annual Survey of Industries (ASI), Government of India, compiles detailed information of those firms on a regular basis. The firms, which are not covered by ASI, fall under the unorganized or informal sector and are free from the Factory Act 1948. The information about those firms is procured by the National Sample Survey Organization (NSSO), Government of India through the stratified random sample survey in every five year since 1978-79. Those reports documented the extent of informality and it is noticeable that maintenance of registration, accounts, and payments to labour hardly follow the industrial and labour laws. However, information on wage output and other factors of production is covered since 1989-90 and they compile this information for three discrete time periods i.e., 1989-90, 1994-95 and 2000-01 (Marjit and Maiti, 2009).

<sup>5</sup> The firms, hiring more than five workers, are defined as directory manufacturing establishment (DME). Non-directory manufacturing establishments (NDME) and own-account manufacturing establishments (OAME) are those who hire 1-5 workers and do not hire workers, respectively.

This apart, the formal wage does not necessarily promote the condition of the informal sector workers in the long run. For example, if the formal wage increases, the firm substitutes production activities from formal to informal sector and that has two counteracting effects on informal wage. On the one hand, a typical substitution effect would raise the demand for informal workers. The released workers from formal sector, due to fall of formal production, on the other hand, would also supply more labour in the sector. The net effect is ambiguous. If the informal sector faces a net positive demand for workers as a result of change in the formal wage, it would raise employment, not wage, in the informal sector when the economy is not under full-employment, and it would raise informal wage when the economy is full-employment. But, if the net demand is negative, under certain situations, it would reduce informal wage. This may not only distort the efficiency gain of formal workers but also deteriorate the condition of the informal sector. Thus, a poor economy, or an economy with a substantial number of poor people, will also be an economy where the formal sector workers will be less productive. This shows that when a society has a lot of poor informal workers, those who are fortunate enough to land up with relatively high-wage jobs may not be as productive as they would be in a society where access to the low wage informal segment is banned or severely restricted. This also means that if two firms in two different countries face different institutional climates, that is, one may not have any access to the informal workers either because there are none or because it is too costly to access extra legal means, and the other faces a much more lustre environment, the institutionally more constrained one will have more productive workers. The next sections are organized as follows. Section 2 and 3 respectively propose a brief account of literature review and the model. The section 4 ends up with concluding observations.

## 2. LITERATURE REVIEW

The literature on endogenous growth has illustrated how R&D plays an instrumental role in accelerating long-run growth of a country (Romer, 1990). Many works have discussed the role of endogenous factors on the R&D and long-run growth in the later period, based on country experiences. Some scholars also looked at the role of external factors like infrastructure and transportation costs on R&D and long-run growth of the country, based on foundation of modern growth theory. For example, Goo (2011) showed that the larger are the transportation costs of R&D technology, the higher is the price of R&D technology and the slower is endogenous economic growth. Lee (2005) empirically shows a direct and stronger effect of information networks on international R&D. In an interesting paper, Orlov and Roufagalas (2008) investigated the role of stabilization policies on R&D production and long-run growth in presence of economic slowdowns.

The contemporary research has shown enough interests to investigate the strategic interactions of firms on their implication of R&D of firms and the performances. For

example, Grossman and Helpman (2002, 2003), Egger and Egger (2003), Shy and Stenbacka (2003), and Antràs and Helpman (2004) establish the advantages of strategic outsourcing over other organizational structures such as vertical integration and foreign direct investment.<sup>6</sup> Feenstra and Hanson (1999) and Jones (2005) respectively investigate the impact of outsourcing on the relative wage within the US market and compares immigration and local wage. On similar issue, Glass and Saggi (2001) assume that both outsourcing and R&D provide avenues for cost reduction and see the effect of complementarity and substitutability between them on employment and wage. If outsourcing and R&D are complements, outsourcing increases R&D, thus reducing the negative impact of outsourcing on wages and employment in the outsourced countries. Using almost similar framework, Marjit and Mukherjee (2008) argue that outsourcing increases the R&D investment in small markets and in highly competitive product markets, whereas it decreases the R&D investment in large markets. If the outsourced firm can be technologically very efficient under exporting, outsourcing can make the consumers worse off by reducing the R&D investment.

Such analysis of subcontracting within the domestic economy in the context of developing world is under-researched. Usually the efficiency wage models, which talk about the positive effect of higher wages (Shapiro and Stiglitz, 1984; Banerji and Gupta, 1998), have shown a direct nutritional and/or incentive effect on labour productivity of higher wages. Hence, a decline in wage does mean declining productivity and the entrepreneurs might be reluctant to reduce the wage, even in the face of unemployment. That is the key argument explaining unemployment and rigid wage at the same time. These studies have completely ignored the subcontracting part of a typical firm to the informal sector where the wage is predominantly lower than that in the formal sector. The works have ignored the possibility that the lower wages in the informal segment could act as a disincentive to go for productivity improvement efforts on the part of the formal sector entrepreneurs.

### 3. THE MODEL

We start with simple set up of a developing economy where a single producer is working with the use of two forms of workers (formal and informal). If the economy consists of a firm who produces a good  $X$ , it can be either produced at in-house in the formal sector ( $X_1$ ) and subcontracted to the informal sector ( $X_2$ ), where the total output is ( $X_1 + X_2$ ). The quality of products produced is the same in both sectors or are not assumed to be substantially different, but the productivity can be higher in the formal

<sup>6</sup> Strictly speaking, there is no significant difference between subcontracting and outsourcing, but in the paper the former is largely used in the context of movement within boarder and the latter is used for across boarder movement.

sector because of its usage of advanced technology than those are available in the informal sector. For simplicity, we assume that one unit of output to be produced in the informal sector requires one unit of workers ( $X_2$ ) and one unit of output to be produced in formal sector needs  $\alpha X_1$  unit of workers. Here,  $\alpha$  is the number of labour required to produce one unit of output in the formal sector. Essentially, the inverse of  $\alpha$  (or,  $1/\alpha$ ) can be termed as the formal sector labour productivity. We further assume that  $\alpha < 1$  and this condition ensures higher productivity of workers in formal sector than those in informal sector.

Now, the question is why a firm subcontracts to the informal sector. The answer is that the firm wants to save expensive workers in the formal sector. If the output is produced by using in-house formal workers he must pay a relatively higher wage, following institutional rules fixed up by either the trade unions or the government, or both. It is mentioned in the previous section that a formal worker receives a wage rate which is on an average two to six times higher than the informal wage. If  $w_1$  and  $w_2$  are, respectively, formal and informal wage rates, where  $w_2 < w_1$ , the firm has clearly two strategies to save the cost, either subcontracting to the informal sector and/or taking up more R&D efforts for bringing labour-replacing technologies in the in-house formal production. We model this trade-off here.

While in the absence of any noticeable quality gap, the firm tends to hire only informal workers at low wages, but it must incur transaction costs for hiring such informal workers. Under this conditions, two types of transaction costs are modelled in recent literature – extra-legal cost (Marjit *et al.* 2006) and search cost (Maiti and Marjit, 2008). The former argues that hiring informal workers is not legal. Therefore, potential regulatory problems are faced by the firm and it is possible for them to avoid these problems by offering bribes to the regulators. The latter suggests that subcontracting outside involves an additional effort in searching suitable suppliers, setting mutually acceptable informal terms and conditions, and mentoring them. Simply, we assume that a positive cost, a combination of both, is present for each transaction of informal contracting. If  $X_2$  be the amount of final output produced in the informal sector,  $t(X_2)$  is defined as transaction cost where it increases at a constant rate with a rise of informal production, that is,  $t' > 0$ ,  $t'' = 0$ . Therefore, if we assume that a single unit of informal workers produces a single unit of output, the firm hires  $X_2$  and the total cost would be the wage bills for informal wages ( $w_2 X_2$ ) and the amount of transaction cost to be incurred to execute these contracts ( $t w_2 X_2$ ). In total, this is as follows:

$$C = (1 + t)w_2 X_2 = w_2 c(X_2), \quad (1)$$

where  $c(X_2) = (1+t)X_2$ . It can easily be shown that  $c' > 0$ ,  $c'' > 0$ .<sup>7</sup>

Hence, the marginal cost for informal production is  $w_2c'(X_2)$ ,  $c' > 0$ ,  $c'' > 0$ . The basic logic here is that the larger the size of the informal segment, the greater would be the costs to be incurred for such transactions.

This apart, if the firm is forced to produce in-house, for any reason, the R&D effort seeking a labour saving technology would be beneficial. We define that R&D is the level of augmenting technology which would essentially enable to save labour per unit of output. For example, upgradation of information technology with appropriate software for industrial activities can be considered as one form of R&D initiative in the firm. This reduces the requirement of labour per unit of output in the formal sector. Further, the R&D initiative is assumed to be possible only in the formal sector which can be thought of a technology that reduces the marginal cost of production in the in-house production. If one unit of  $X$  (or  $X_1$ ) in the formal sector requires  $\alpha(F)$  units of labour, the total cost of formal production is  $w_1\alpha(F)X_1$  where  $\alpha' < 0$ ,  $\alpha'' > 0$ .

On the other hand, there is another side of R&D initiative in the firm. For any level of successful R&D or technological change, the firm needs to incur certain cost. Obviously, there would be monotonic relationship between expenditure on R&D sector ( $Z$ ) and actual level of technological ( $F$ ). But, the whole expenditure should not be counted here as real R&D, because a part of the expenditure would be loss in the experimental process of successful innovation. Moreover, it engages a set of proper personnel with appropriate laboratory who would work through a trial and error process to get the desired level of technology (or, R&D) in the firm successfully. These essentially account for a cost and the result of such investment provides a certain level of technological in the firm, i.e.,  $Z(F)$ . One would also expect that higher the cost higher would be level of R&D or technology. Because, more qualified personnel with better laboratory can increase the chances of the successful technological change and higher order of R&D. Therefore,  $Z(F)$  is assumed to follow properties similar to a usual cost function, where  $Z' > 0$ ,  $Z'' > 0$ ,  $Z''' = 0$ .

Now, in order to optimize the surplus, an entrepreneur, facing large informal workers at lower wage, has a trade-off, either an increased R&D for in-house production or outsource to low paid informal workers, or both. If  $R(X)$  is the standard revenue function facing the firm, the firm's optimization problem looks as follows.

$$\text{Max}_{X_1, X_2, F} \pi = R(X) - w_1\alpha(F)X_1 - w_2c(X_2) - Z(F). \quad (2)$$

The following curvature restrictions are assumed:

<sup>7</sup>  $c' = 1+t + X_2t' > 0$ ;  $c'' = 2t' > 0$ .

$$R' > 0, R'' < 0, R''' = 0,$$

$$\alpha' < 0, \alpha'' > 0, \alpha''' = 0,$$

$$Z' > 0, Z'' > 0, Z''' = 0,$$

$$c' > 0, c'' > 0, c''' = 0,$$

$$X = X_1 + X_2.$$

The economic interpretations of these conditions have been discussed above. Taking these specifications of the model, our intention is clearly to observe the implications of a change in formal wage, an exogenous variable in the model, or a rise of subcontracting on others in the system. Definitely, a change in formal wage would affect the demand for informal labour and, thus, informal wage. The informal wage, which is assumed to be market determined, cannot move instantaneously in the short run. Moreover, in the presence of a large pool of informal workers in the economy, the wage cannot go below the certain minimum subsistence level, because the workers would physically be incapable to do work. However, in the long-run, the informal wage is adjusted according to the changes in market conditions. Let us discuss the short-run and long-run case separately.

### *Short-Run Case*

We assume sequence of the game that the decision on  $F$  is taken at first and then  $X_1$  and  $X_2$ . The model can be solved by the backward induction method.

From (2), the first order conditions are

$$R' = w_1 \alpha(F), \tag{3}$$

$$R' = w_2 c'(X_2). \tag{4}$$

While solving for  $(X_1, X_2)$ ,  $F$  is taken as given. From (3) and (4),

$$w_1 \alpha(F) = w_2 c'(X_2). \tag{5}$$

$$\text{Let } \tilde{X} = c'^{-1}(w_1 \alpha(F) / w_2) = f(w_1 \alpha(F) / w_2), \quad f' > 0 \text{ as } c'' > 0. \tag{6}$$

Check that for  $X < \tilde{X}$ , the firm does not employ any formal workers as  $w_1 \alpha(F) > w_2 c'(X_2)$ . If  $X > \tilde{X}$ ,  $X - \tilde{X}$  must be produced in the formal sector as

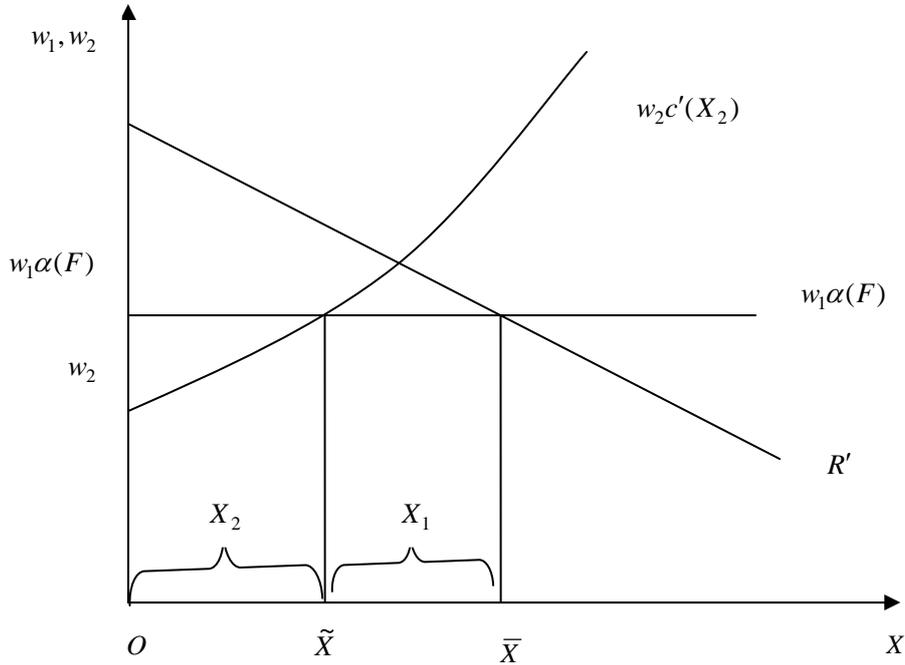
$w_1 \alpha(F) < w_2 c'(X_2)$  for  $X > \tilde{X}$ . We assume that the size of the market is large enough to accommodate both in-house production as well as subcontracting (Figure 1). From the first order condition (4), we find that  $R'(\bar{X}) = w_1 \alpha(F)$ . We can easily derive  $\bar{X}$  from this relation taking inverse of it.

$$\bar{X} = \phi(w_1 \alpha(F)), \quad \phi' < 0 \quad \text{as} \quad R'' < 0. \quad (7)$$

Technically, this is assumed a  $\bar{X}$  such that the equilibrium prevails with  $\bar{X} > \tilde{X}$ .

This also implies that if the market size is not large enough, only informal workers are hired. Therefore, the firm outsources  $\tilde{X} = X_2$  units to the informal sector and produce  $(\bar{X} - \tilde{X})$  in-house. Note that these solutions are derived for a given value of  $F$ . We are following a backward induction method by which  $\bar{X}$  and  $\tilde{X}$  are solved as functions of  $F$ , then  $(\bar{X} - \tilde{X}) = X_1$  is substituted in (7) to solve for  $F$ .

$$X_1 = \bar{X} - \tilde{X}_2 = \phi(w_1 \alpha) - f\left(\frac{w_1 \alpha}{w_2}\right). \quad (8)$$



**Figure 1.** Allocation of Formal-informal Production (given  $F$ )

Internalizing Equations (5) and (6) and using the envelope theorem we find the following condition to determine optimal  $F$ :

$$-w_1\alpha'X_1 = Z'. \quad (9)$$

Since  $\alpha(F)$  denotes the inverse of labour productivity in the formal sector, our task is to check how  $F$  responds to changes in  $w_1$  and  $w_2$  – the formal and informal wage rate. Rewriting and assuming  $F^*$  is the optimal R&D to start with we have, therefore,

$$\frac{dF^*}{dw_1} = \frac{1}{\Delta} \left[ \alpha'(\bar{X} - \tilde{X}) + w_1\alpha' \frac{d(\bar{X} - \tilde{X})}{dw_1} \right], \quad (10)$$

$$\text{and } \frac{dF^*}{dw_2} = \frac{1}{\Delta} \left[ w_1\alpha' \frac{d(\bar{X} - \tilde{X})}{dw_2} \right], \quad (11)$$

where  $\Delta = -w_1\alpha''X_1 - Z'' < 0$  (by the second order condition guaranteeing the optimality of  $F^*$ ).

Since the formal output is the difference of total output and informal output, the derivate of the formal output with respect to the formal and informal wage would be:

$$\frac{d(\bar{X} - \tilde{X})}{dw_1} = \phi'\alpha - f' \frac{\alpha}{w_2} < 0, \quad (12)$$

$$\text{and } \frac{d(\bar{X} - \tilde{X})}{dw_2} = f' \frac{w_1\alpha(F)}{w_2^2} > 0. \quad (13)$$

The above two equations suggest that the formal output is inversely related to the formal wage and positively related to the informal wage. Hence, from (10) and (11), we can write

$$\frac{dF^*}{dw_1} = \frac{1}{\Delta} \left[ \alpha'(\phi - f) + \alpha w_1\alpha' \left( \phi' - \frac{f'}{w_2} \right) \right] \begin{matrix} \geq 0, \\ < \end{matrix} \quad (14)$$

$$\frac{dF^*}{dw_2} = \frac{1}{\Delta} \left[ w_1\alpha' \left( f' \frac{w_1\alpha}{w_2^2} \right) \right] > 0. \quad (15)$$

The above-two expressions reveal the effect of change in the wages on the level of R&D in the short-run. Now, we can write down the following proposition.

**Proposition 1:** In the short-run, a rise of informal wage, but not formal wage, must improve R&D and labour-productivity in formal sector.

**Proof:** From (14), we find that  $\frac{dF^*}{dw_1}$  could be positive or negative depending on the conditions of the right-hand side of the expression. Therefore, the labour productivity change in the formal sector is given by

$$\frac{d\left(\frac{1}{\alpha(F)}\right)}{dw_1} = -\frac{1}{\alpha^2} \alpha'(F^*) \frac{dF^*}{dw_1} < 0. \blacksquare$$

So, the formal wage is not highly correlated with the labour productivity in the sector. A rise of formal wage has two counteracting effects on  $F$ . It directly cuts down total production of the firm and, accordingly, reduces  $F$  (that is, scale effect). On the other hand, two substitution effects can be observed. One, a rise in the formal wage directly substitutes formal workers by  $F$  within the sector and raises demand for  $F$ . Second, it pushes up informal subcontracting, cutting down in-house production, and  $F$ . The net effects of a rise in formal wage on  $F$  and the resultant productivity of formal sector workers are ambiguous.

From (17), we find that  $\frac{dF^*}{dw_2} > 0$ . Therefore, the labour productivity change in the formal sector is given by,

$$\frac{d\left(\frac{1}{\alpha(F)}\right)}{dw_2} = -\frac{1}{\alpha^2} \alpha'(F^*) \frac{dF^*}{dw_2} > 0. \blacksquare$$

A rise in informal wage has only one substitution effect but no scale effect. Because, it only affects the inter-sectoral distribution of production and does not affect total production. A higher  $w_2$  raises in-house production and R&D investment in the formal sector.  $F$  increases and  $\alpha(F)$  drops making labour more productive in formal sector.

### ***Long-Run Case***

The informal wage would no longer be an exogenous in the long run, because any

change in the formal sector would definitely retaliate and affect the wage in the informal labour market through subcontracting linkages. In this case, the structure of the game will be a bit of different from the earlier one. At stage 1,  $F$  will be determined by the firm and the informal wage will be solved in stage 2. Sectoral outputs will be determined in the stage 3. Accordingly, the profit is realised by the firm. The objective function of a formal producer is as in Equation (1) and as per backward induction method the sectoral outputs, wages and R&D would be solved, respectively.

Since the objective function is same, the optimum outputs in formal and informal sector are as earlier, i.e.,

$$X_2 = \tilde{X} = f\left(\frac{w_1\alpha}{w_2}\right), \text{ and } X_1 = X - \tilde{X}_2 = \phi(w_1\alpha) - f\left(\frac{w_1\alpha}{w_2}\right).$$

The formal wage is exogenously determined by the institutions at  $w_1$ . On the other hand, the informal wage will be determined by labour market conditions. Given a formal wage, the demand for informal labour is  $L_2 = f\left(\frac{w_1\alpha}{w_2}\right)$ , where the demand is inversely related to the informal wage and positively related to the formal wage. Also, given the same wage, the demand for formal labour will be

$$L_1 = \alpha X_1 = \alpha \left[ \phi(w_1\alpha) - f\left(\frac{w_1\alpha}{w_2}\right) \right]. \quad (16)$$

Therefore, the total demand for labour by the firm, combining both formal and informal workers in the economy, is  $L^d = \alpha X_1 + X_2$ . It can be written as follows:

$$L^d = \alpha\phi(w_1\alpha) + (1-\alpha)f\left(\frac{w_1\alpha}{w_2}\right). \quad (17)$$

It should be noted that the demand for total labour depends on the informal wage,  $w_2$ . Taking partial derivative of (17) with respect to  $w_2$ , we find that

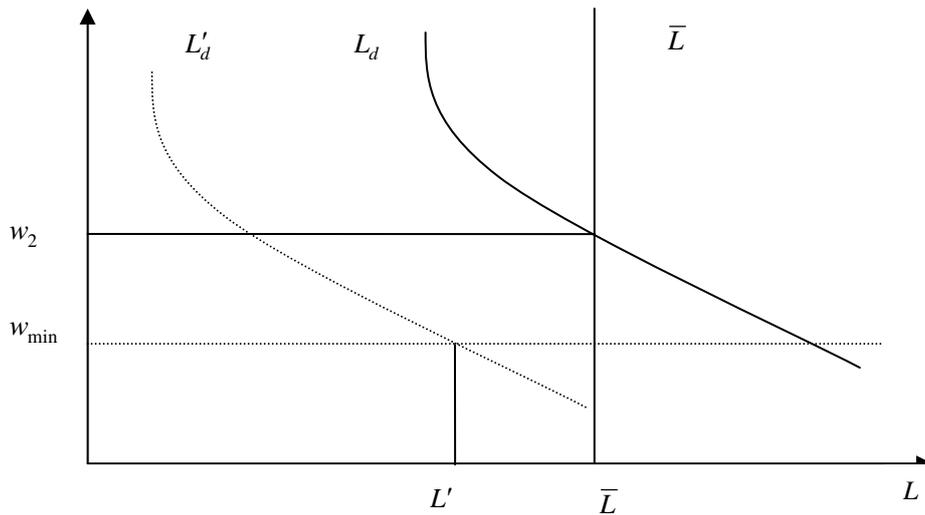
$$\frac{\partial L^d}{\partial w_2} = -(1-\alpha)\frac{w_1\alpha}{w_2^2} f' < 0, \text{ as } f' > 0.$$

So, it confirms that the demand function is negatively sloped. The basic logic is that for a decline in informal wage, the firm substitutes formal labour by subcontracting to the informal sector. But, the demand for informal labour would be higher than that in the formal sector for the same production. Thus, this raises the subcontracting to the informal sector.

If the total working labour force in the economy is fixed at  $\bar{L}$ , we can derive a unique equilibrium informal wage from the following condition.

$$\bar{L} = \alpha\phi(w_1\alpha) + (1-\alpha)f\left(\frac{w_1\alpha}{w_2}\right). \quad (18)$$

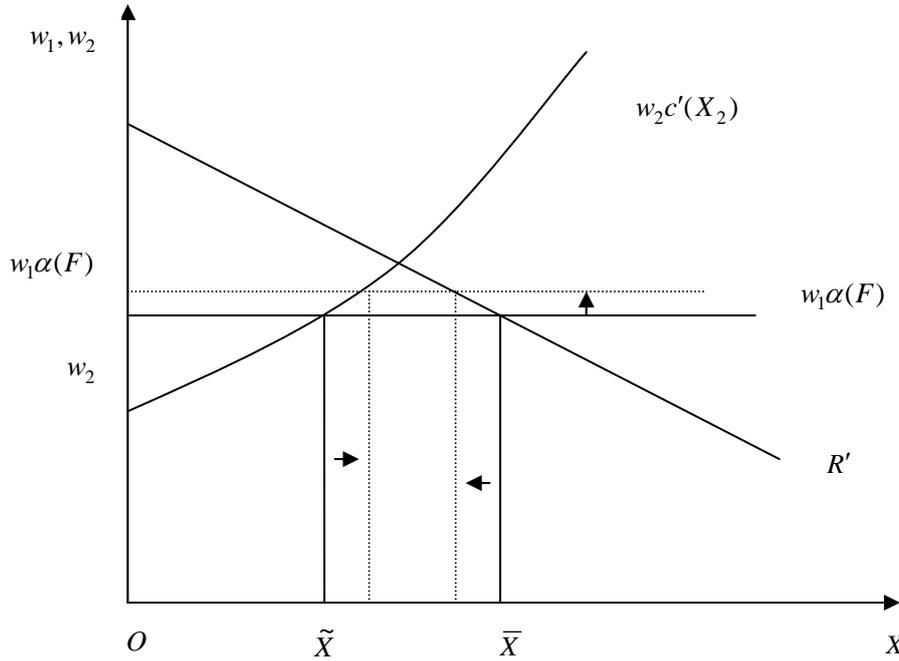
It is clear from above expression that one may not always find the full-employment equilibrium conditions in a developing economy. The informal wage moves freely to clear labour markets and to restore full-employment equilibrium. However, even at excess supply situation, we assume that the informal wage cannot go below the minimum level to absorb them in the informal sector. It suggests that (i)  $w_2 = w_{\min}$  if  $\alpha X_1 + X_2 \leq \bar{L}$ , and (ii),  $w_2 \geq w_{\min}$  if  $\alpha X_1 + X_2 = \bar{L}$ . In case (i),  $\bar{L} - (\alpha X_1 + X_2)$  is unemployed worker and gives downward pressure on the informal wage to accommodate them within the sector. But the wage cannot go further down if the level is already at minimum. In case (ii), the workers, who do not find employment in the formal sector, crowd in the informal sector and the labour market conditions would set a new equilibrium at separate informal wage with no unemployment in the economy. This has been demonstrated in Figure 2. If  $L_d$  be the demand for total labour by the firm, it cuts the supply curve  $\bar{L}$  at  $w_2$ . The full-employment condition prevails in the labour market. If the demand function is laid at below, i.e.,  $L'_d$ , it cannot cut the supply curve at higher than the minimum informal wage, i.e.,  $w_{\min}$ . Hence, the full employment equilibrium cannot be reached.



**Figure 2.** The Determination of Informal Wage and Employment

**Lemma 1:** In the long run, (i)  $w_2$  depends on  $w_1$ ; (ii)  $\frac{\partial w_2}{\partial w_1} = 0$  if  $\bar{L} > (\alpha X_1 + X_2)$  and  $\frac{\partial w_2}{\partial w_1} > 0$  if  $\bar{L} = (\alpha X_1 + X_2)$ .

**Proof:** (i) From (6) and (16), it is observed that the formal wage affects the demand for formal workers negatively, and informal workers positively. Since the labour required in the informal sector for the same amount of production would be higher than that in the formal sector, the net demand for labour in the informal sector would be positive. On the other hand, total scale of production comes down in response to a rise in the formal wage. This would further release workers from the formal sector and the total supply of workers to the informal sector may exceed the net demand for workers. If the demand effect is still stronger, the informal employment would, as a result, rise until the excess labour is exhausted, when  $\bar{L} > (\alpha X_1 + X_2)$  and the higher demand for informal workers will be met up by adjusting the informal wage when  $\bar{L} = (\alpha X_1 + X_2)$  (see Figure 3). The second case is discussed in the next at length.



**Figure 3.** Effect of a Rise Formal Wage on Outputs (Given Informal Wage and  $F$ )

(ii) If  $\bar{L} = (\alpha X_1 + X_2)$ , from (18), we can derive  $w_2$ :

$$w_2 = \frac{w_1 \alpha}{h}, \quad (19)$$

where  $h = h\left(\frac{\bar{L} - \alpha\phi(w_1\alpha)}{1 - \alpha}\right)$ , and  $h' > 0$ , and  $f' > 0$ .

Differentiating (18) with respect to  $w_1$ , we find

$$\frac{\partial w_2}{\partial w_1} = \frac{\alpha(1 - \alpha)h + w_1 \alpha^3 h' \phi'}{(1 - \alpha)h^2} > 0. \quad (20)$$

Since  $\phi' < 0$  and  $h' > 0$ , we find that  $\frac{\partial w_2}{\partial w_1}$  is ambiguous. As is mentioned above,

the basic intuition is that, for a rise of formal wage, the firm would substitute formal workers by more subcontracting to workers in the informal sector. Again, the demand for informal workers would be greater than the number of workers supplied by the formal sector. The net demand for informal workers would be positive. On the other hand, overall production and, particularly, the formal production will decline due to a rise of the formal wage, and these further increases the supply of workers to the informal sector. At the full employment equilibrium (i.e., when  $\bar{L} = (\alpha X_1 + X_2)$ ), the net demand would be adjusted by raising the informal wage, if the demand dominates the supply. Therefore, we can safely conclude that a rise of formal wage does not necessarily pushes up the informal wage. ■

Now, we can derive sectoral outputs by substituting informal wage.

**Lemma 2:** If  $w_2 = w_2(w_1)$ , then (i)  $X_1 = X_1(F; w_1); X_2 = X_2(F; w_1)$  and  $X = X(F; w_1)$ , (ii)  $\frac{\partial X_1}{\partial F} > 0$ ,  $\frac{\partial X_2}{\partial F} < 0$ ,  $\frac{\partial X}{\partial F} > 0$  and  $\frac{\partial w_2}{\partial F} > 0$ .

**Proof:** We find in the expression (19) that  $w_2$  depends on  $w_1$ . Now substituting (19) into (8), we derive  $X_1$  as follows:<sup>8</sup>

$$X_1 = \frac{\phi - \bar{L}}{(1 - \alpha)}. \quad (20a)$$

<sup>8</sup> Note that if  $y = f(x)$  and  $h = f^{-1}$ , then  $f(h(y)) = y$ .

The formal output will be positive if  $\phi > \bar{L}$ . It means that total output produced in the economy must be greater than the amount to be produced by employing fully in the informal sector. Similarly, we find that

$$X_2 = \frac{\bar{L} - \alpha\phi}{1 - \alpha}. \quad (20b)$$

In other words, the total workforce in the economy must be greater than the amount required to produce in the formal sector. And

$$X = \phi. \quad (20c)$$

Now, taking partial derivative of (20a) with respect to  $F$ , we find

$$\frac{\partial X_1}{\partial F} = \frac{\alpha'}{(1 - \alpha)^2} [(1 - \alpha)\phi'w_1 + (\phi - \bar{L})] \begin{matrix} > \\ < \end{matrix} 0. \quad (21a)$$

The sign of the derivative is ambiguous, because the first term within the third bracket is negative and the last term is positive. If  $F$  rises, it increases output raising the productivity of workers, given same number of workers. On the other hand,  $F$  replaces some formal workers and, hence, reduces output. Therefore, the net effect is uncertain.

Similarly, taking the partial derivative of (20b) with respect to  $F$ , we find

$$\frac{\partial X_2}{\partial F} = \frac{-\alpha'[(\phi - \bar{L}) + (1 - \alpha)\alpha\phi'w_1]}{(1 - \alpha)^2} \begin{matrix} > \\ < \end{matrix} 0. \quad (21b)$$

The sign of the derivative also shows an ambiguity. If  $F$  increases, the productivity of formal workers will be higher and, also, the output to be produced in the informal sector will be higher as a result of this. On the other hand,  $F$  also substitutes a few formal workers and they will crowd in the informal sector. Therefore, the directional change of informal output is ambiguous.

Now, the partial derivative of (20c) with respect to  $F$  shows a positive sign. In other words, the total effect of R&D on overall production is always positive. It also suggests that the productivity of  $F$  must be substantially higher than that of workers' substitution. Therefore, the effect of  $F$  on either  $X_1$  or  $X_2$  will be always positive so that net effect of total output gets positive.

$$\frac{\partial X}{\partial F} = \phi'w_1\alpha' > 0. \quad (21c)$$

Moreover, since the mobility of workers takes place freely across sectors as an indirect effect of an increase in  $F$ , it might affect the informal wage. Taking partial derivative of (19) with respect to  $F$ , we get

$$\frac{\partial w_2}{\partial F} = \frac{w_1 \alpha'}{h^2 (1-\alpha)^2} \left[ h(1-\alpha)^2 + \alpha h' \{ (\phi - \bar{L}) + \alpha(1-\alpha) \phi' w_1 \} \right] \begin{matrix} > \\ < \end{matrix} 0. \quad (22)$$

■

For an increase of  $F$ , the scale of formal production would rise and, hence, an increase in demand for workers in the formal sector is observed. On the other hand,  $F$  would also substitute some formal workers and they would come to the informal sector. Hence, these two forces will work on informal wage in opposite directions and the net effect is uncertain.

**Lemma 3:** If  $w_2 = w_2(w_1)$ , then  $\frac{\partial X_1}{\partial w_1} < 0$ ,  $\frac{\partial X_2}{\partial w_1} > 0$  and  $\frac{\partial X}{\partial w_1} < 0$ ; and (iii)  $\frac{\partial X_1}{\partial F} > 0$ .

We have already assumed that the formal wage is exogenously fixed. Now, for any deliberate increase in formal wage, we want to see what the impact on sectoral outputs is. Taking partial derivatives of 20(a), 20(b) and 20(c), we get

$$\frac{\partial X_1}{\partial w_1} = \frac{\phi' \alpha}{(1-\alpha)} < 0, \quad (23a)$$

$$\frac{\partial X_2}{\partial w_1} = -\frac{\alpha^2 \phi'}{(1-\alpha)} > 0, \quad (23b)$$

$$\frac{\partial X}{\partial w_1} = \phi' \alpha < 0. \quad (23c)$$

For a rise in formal wage, output in the concerned sector drops and informal output increases, and the net effect of total output will be negative. This is clear from the earlier discussions.

Given these results, we can now write the following proposition.

**Proposition 2:** A rise in formal wage (i) raises subcontracting to the informal sector and (ii) does not necessarily promote R&D and labour productivity in the formal sector firm even in the long-run.

**Proof:** (i) From (23b) we find that  $\frac{\partial X_2}{\partial w_1} > 0$ . Since, the cost of production in the formal sector rises with an increase of formal wage, the firm offers more subcontracting to the informal sector.

(ii) Substituting the value of  $X_1$ ,  $X_2$  and  $w_2$  in Equation (2), we find that the profit function depends only on  $F$ . Then solving  $F$ , we get (see appendix)

$$\frac{dF^*}{dw_1} = \frac{-\alpha'D}{\Delta}, \text{ where } D \begin{matrix} \geq \\ \leq \end{matrix} 0.$$

So, the resultant effect of  $w_1$  on  $F^*$  is also ambiguous, i.e.,  $\frac{dF^*}{dw_1} \begin{matrix} \geq \\ < \end{matrix} 0$ . We can also

write that the effect of  $w_1$  on labour productivity as follows:

$$\frac{d\left(\frac{1}{\alpha(F)}\right)}{dw_1} = -\frac{1}{\alpha^2} \alpha'(F^*) \frac{dF^*}{dw_1} \begin{matrix} < \\ > \end{matrix} 0. \blacksquare$$

The basic intuition is as follows: If the formal wage rises, the production will take place more in the relatively cheaper informal sector as a substitution effect. This must raise the demand for informal workers. At the same time, whoever has lost a job in the formal sector come to the informal sector. If we add these factors, we may still find net positive demand for informal workers, because the demand for informal workers for same amount of production would be higher than the number of productive workers released from the formal sector. But, on the other hand, overall production falls, particularly in the formal sector, as a scale effect, and adds more to the supply of workers to the informal sector. Now, taking into account all these factors, movement of the informal wage is uncertain. If the demand effect is stronger, the informal wage goes up and if not, the wage comes down. If the informal wage rises, the share of formal production goes up through investing more on labour-saving R&D and thus promotes labour productivity of the sector. On the other hand, if the informal wage declines, the relative share of production in the formal sector also goes down. As a result, R&D and labour productivity in the formal sector definitely falls. Looking at these results, one can argue that if the formal wage pushes up informal wage, both R&D and labour productivity in the formal sector must rise and the rise of formal wage alone does not ensure an improvement in R&D and labour productivity of the sector. Therefore, we come to a conclusion that a rise in informal subcontracting, for any reason, may adversely affect in-house R&D and labour productivity in the formal sector even if the economy is fully employed.

#### 4. CONCLUDING REMARKS

While the existing studies largely discuss the effect of international outsourcing on firm dynamics and welfare of an economy, but we study the effect of domestic subcontracting on in-house R&D investment and labour productivity of a typical firm in a developing economy. This paper develops a new framework to establish a production link between outputs produced in two segments, that is, the formal and informal sectors, where a share of the production is being subcontracted to the informal enterprises, a common practice in the developing economies. Therefore, the firm, in order to bypass expensive labour in in-house production, has a clear trade off, either spending more on labour saving R&D in the formal sector or subcontracting to the informal sector at a cheaper cost. The formal wage is determined by the government and/or by the labour market institution, whereas the informal wage is determined by the market. We argue that in response to a rise in wage of formal workers, the firm subcontracts to the informal sector at lower wage and does not have enough incentive for more in-house R&D. And, this acts as a binding condition of productivity improvement of formal workers.

The study finds that in a typical developing economy the formal sector R&D and labour productivity are highly influenced by informal wage, but not by formal wage in the short run. *Second*, the informal wage is endogenously adjusted in response to a change in formal wage (i.e., exogenous factor) in the long run due to the changes in the supply and demand conditions of informal workers. Even in this case, a rise of formal wage does not necessarily influence R&D and labour productivity in the formal sector until and unless it raises the informal wage. *Third*, a relatively low informal wage hurts the R&D and resultant productivity in formal sector. In other words, the higher the difference of wages between two segments, the greater will be the subcontracting to the informal sector and lower would be the chances of improving R&D and labour productivity in the formal sector. *Fourth*, a relatively prosperous informal sector raises the amount of output to be produced in-house and expands the size of formal sector in the economy. It supports one justification for promoting economic condition of informal sector workers. *Fourth*, the government periodically revises the wage of workers in the formal sector for their incentive and welfare. This cannot confirm the improvement of labour productivity of the concerned workers, if the informal wage is not patronised simultaneously. *Fifth*, the informal wage is very low in some countries and even below the minimum level. But the enforcement of minimum wage and social securities has been one of the growing concerns in those countries for the benefits those poor and low income earners. Such measure could essentially be beneficial for them but also for the growth of labour productivity in the formal sector and overall industrial growth in the economy.

## APPENDIX

Substituting the value of  $X_1, X_2$  and  $w_2$  in Equation (2), we find that the profit function depends only on  $F$ . Taking partial derivatives with respect to  $F$ , we find

$$\frac{\partial \pi}{\partial F} = R' \frac{\partial X}{\partial F} - (w_1 \alpha' X_1 + w_1 \alpha \frac{\partial X_1}{\partial F}) - (w_2 c' \frac{\partial X_2}{\partial F} + c \frac{\partial w_2}{\partial F}) - Z' = 0. \quad (\text{A1})$$

Substituting (21) and (22), we rewrite it as follows:

$$\begin{aligned} & R' \phi' w_1 \alpha' - \left[ \frac{w_1 \alpha' (\phi - \bar{L})}{(1 - \alpha)} + \frac{w_1 \alpha \alpha'}{(1 - \alpha)^2} \{ (1 - \alpha) \phi' w_1 + (\phi - \bar{L}) \} \right] \\ & - \left[ - \frac{w_1 \alpha c' \alpha'}{h(1 - \alpha)^2} \{ (\phi - \bar{L}) + (1 - \alpha) \alpha \phi' w_1 \} \right. \\ & \left. + \frac{c w_1 \alpha'}{h^2 (1 - \alpha)^2} \{ h(1 - \alpha)^2 + \alpha h' \{ (\phi - \bar{L}) + \alpha (1 - \alpha) \phi' w_1 \} \} \right] - Z' = 0. \end{aligned} \quad (\text{A2})$$

There is a critical value of  $F$ , that is,  $F^*$ , for which above condition will hold. In order to confirm it, the second order condition will be satisfied. Differentiating (A2) with respect to  $F$ , we find the following condition

$$\begin{aligned} \frac{\partial^2 \pi}{\partial F^2} = \Delta = & R'' (\phi' \alpha' w_1)^2 + R' \phi' \alpha' w_1 - \frac{w_1 \alpha' \{ (\phi - \bar{L}) + \alpha \phi' w_1 \} + 3(w_1 \alpha')^2 \phi'}{(1 - \alpha)} \\ & - \frac{\alpha'^2 w_1 \{ (\phi - \bar{L}) + \alpha \phi' w_1 \} + w_1 \alpha'^2 c' \{ (\phi - \bar{L}) + \alpha (1 - \alpha) \phi' w_1 \} - w_1 \alpha \alpha' c'' \{ (\phi - \bar{L}) + \alpha (1 - \alpha) \phi' w_1 \}^2}{(1 - \alpha)^2} \\ & + \frac{w_1^2 \alpha \alpha'^2 c' \phi'}{h(1 - \alpha)^2} + \frac{w_1^2 \alpha \alpha'^2 c' \phi'}{h(1 - \alpha)} - \frac{(w_1 \alpha \alpha')^2 c' \phi'}{h(1 - \alpha)^2} + \frac{2w_1 \alpha \alpha'^2 c'}{h(1 - \alpha)^3} \\ & + \frac{w_1 \alpha \alpha' c' h' \{ (\phi - \bar{L}) + \alpha (1 - \alpha) \phi' w_1 \} \{ \alpha' (\phi - \bar{L}) - (1 - \alpha) (\alpha' \phi + \alpha \phi' \alpha' w_1) \}}{h^2 (1 - \alpha)^4} \\ & - \frac{w_1 \alpha'' c [h(1 - \alpha)^2 + \alpha h' \{ (\phi - \bar{L}) + \alpha (1 - \alpha) \phi' w_1 \}]}{h^2 (1 - \alpha)^2} \\ & + \frac{w_1 \alpha'^2 c' \{ (\phi - \bar{L}) + \alpha (1 - \alpha) \phi' w_1 \} [h(1 - \alpha)^2 + \alpha h' \{ (\phi - \bar{L}) + \alpha (1 - \alpha) \phi' w_1 \}]}{h^2 (1 - \alpha)^4} + \frac{2w_1 \alpha'^2 c}{h(1 - \alpha)} \\ & - \frac{w_1^2 \alpha' c (1 - \alpha)^2 h' \{ \alpha' (\bar{L} - \alpha \phi) - (1 - \alpha) (\alpha' \phi + \alpha \phi' \alpha' w_1) \}}{h^2 (1 - \alpha)^2} + \frac{2w_1 \alpha' c'}{h^2 (1 - \alpha)^3} \\ & - \frac{2w_1 \alpha' c h' \{ h(1 - \alpha)^2 + \alpha h' \{ (\phi - \bar{L}) + \alpha (1 - \alpha) \phi' w_1 \} \} \{ \alpha' (\bar{L} - \alpha \phi) - (\alpha' \phi + \alpha \phi' \alpha' w_1) \}}{h^3 (1 - \alpha)^3}. \end{aligned}$$

If  $\Delta < 0$ , then  $F^*$  is maximum. Since our interest is to see the effect of  $w_1$  on  $F^*$ , now totally differentiating (A2) with respect to  $w_1$  and rearranging the terms, we find

$$\begin{aligned} \frac{dF^*}{dw_1} &= \frac{-\alpha'D}{\Delta}, \\ D &= R''\alpha\phi'^2w_1 + R'\phi' - \frac{\phi - \bar{L} + 3\alpha\phi'w_1}{(1-\alpha)^2} \\ &+ \frac{\alpha c'\{(\phi - \bar{L}) + 2\alpha(1-\alpha)\phi'w_1\} + \alpha^2c'\phi'w_1}{h(1-\alpha)^2} - \frac{w_1\alpha^3c''\phi'\{(\phi - \bar{L}) + \alpha(1-\alpha)\phi'w_1\}}{h(1-\alpha)^3} \\ &- \frac{c'\{(1-\alpha) + w_1\alpha^2\phi'\}\{h(1-\alpha)^2 + \alpha h'\{(\phi - \bar{L}) + \alpha(1-\alpha)\phi'w_1\}\}}{h^2(1-\alpha)^3} \\ &- \frac{w_1\alpha^3h'c'\phi'\{(\phi - \bar{L}) + \alpha(1-\alpha)\phi'w_1\}}{h^2(1-\alpha)^3} - \frac{w_1c\alpha^2h'\phi' + w_1c'\alpha'(1-\alpha)h'\phi'}{h^2(1-\alpha)^2} \\ &+ \frac{2\alpha^2w_1h'c'\phi'\{h(1-\alpha)^2 + \alpha h'\{(\phi - \bar{L}) + \alpha(1-\alpha)\phi'w_1\}\}}{h^3(1-\alpha)^3}. \end{aligned}$$

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