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Abstract

Using a Heckscher-Ohlin-Samuelson type general equilibrium framework with segmented factor markets, we show that uniform technological progress in either the unorganized or the fixed-wage organized sector can improve the real income of a small, open developing economy. However, uniform productivity improvement in the unorganized sector turns out to be relatively more egalitarian since it helps the marginalized informal workers in terms of wage-earnings and employment whereas productivity take-off in the organized sector hurts them.

Keywords: Technological progress; general equilibrium, segmented factor markets; welfare.

JEL Classification Numbers: F11; F16; J46; O17.

1 Introduction

The purpose of our theoretical exercise is to explore the implications of different types of technological progress on real income of a small open developing economy with distortions in factor markets. It is well-known that in a developing economy 'informal sector' hosts substantial part of the workforce in unregistered activities, primarily characterised by ease of entry and unregulated markets. As suggested in many references (Agenor 1996; Schneider and Enste 2000 and the references therein) more than 70% of the workforce are engaged in the informal sectors of a less developed country (LDC), such as 80% in Zambia, 83% in Myanmar and more than 90% in most of the South Asian countries such as India, Pakistan, Bangladesh and Nepal (except Sri Lanka). Here we define 'informal' sector as one where minimum wage laws are not maintained, in order to focus on the economic conditions of the majority of the workforce in a typical developing economy. As showed in different papers (Chaudhuri 2001; Koizumi and Kopecky 1977, 1980; Findlay 1978) liberalising a developing economy may result technological progress as a peer-effect (such as an inflow of foreign capital usually leads to transfer of technology from the foreign producers to the destination sector of the recipient country). But such a technological change should have some impact on informal activities, wages and employment. The way production is organized between the formal and informal segments should also be affected. Although empirical evidence on the interaction between the formal and informal sectors is quite limited and scattered there are a growing theoretical works dealing with the informal sector of a relatively open, deregulated LDC. However as will be argued below, there are caveats which we shall try to address in this paper.

There has been a pertinent debate on the desirability of various types of technological progress among labor economists and trade-theorists (Jones 1996, 2003, 2006; Krugman 2000; Ethier 2005). Trade-theorists, emphasising the importance of relative factor intensities in different sectors (Jones 1965; Oladi and Beladi 2007 and Beladi et al. 2008), argue that a labor-augmenting type technological change in the labor-intensive sector will push the wages up. This result is in contradiction to the usual predictions of labor economists. Findlay and Jones (2000) argued that trade and labor theory outcomes will be merged for a major modification of production structure consequent upon such a technological progress. The most recent attempt has been made by Beladi et al. (2012) in terms of a simple two-sector general equilibrium model

with segmented labor markets to show that technological progress leads to opposite wage movement independent of relative factor-intensity ranking between organized (formal) and non-organized (informal) labor sectors.

However a typical developing country also suffers from capital market segmentation among the organized formal and non-organized informal sectors. The dominant feature of dualism in the capital market is the fragmented interest rate structure, featuring fewer allocation of loanable capital to the informal sector at a higher relative interest rate. The informal producers do not have access to credit from formal institutions and therefore, have to depend on the informal credit market, where rate of interest is exorbitantly high. We are going to incorporate this issue in our paper. Similar like Beladi et al. (2012), we consider a two-sector full-employment general equilibrium framework there is also an 'organized' (formal) sector where wage is pegged at a higher level by prior negotiations with labor unions through collective bargaining. Those unable to get a job in this high-wage sector would be absorbed in the 'unorganized' informal sector, which is the largest employer of relatively unskilled workers. This description, albeit simplistic, fits well for a typical developing economy with sizable informal sector (such as India, Pakistan and so on). Therefore our model is different from the standard Harris-Todaro (1970) type structure, featuring rural-urban migration with the existence of urban unemployment. But unlike Beladi et al. (2012) in our model, the formal sector faces a perfect capital market whereas the unorganized sector has the imperfect capital market but competitive labor market. It is also evident in our model that both sectors use the same two inputs viz., capital and labor in the production process and hence the general equilibrium framework is of the standard Heckscher-Ohlin-Samuelson (HOS) type.

We shall use this framework to explore implications of uniform technological progress (all the factors of production become equally more productive in the particular sector experiencing technological progress) in organized and unorganized sectors on the real income of a small, open economy[1]. To the best of our knowledge no such effort has been made yet in the general equilibrium setting with segmented factor markets. This exercise should be regarded as a novel

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[1] We are not showing implications for labor or capital saving technological progress for each sector separately since either of them would fetch the same results we obtain with uniform technological progress.

extension of Beladi et al. (2012) and it would be informative to judge the welfare implications of such technological improvement just by answering two major questions:

(a) What are the implications of such policies on the real income of a small, open economy?

(b) How the competitive wages and employment of the relatively marginalized workers are affected in the unorganized sector?

The next sections will describe the model and the comparative static exercises while the last section briefly describes the concluding remarks and some possible extensions of our work.

2 The model

In this general equilibrium model, production functions follow constant returns to scale (CRS) technology. The following notations are used:

W = competitive informal wage rate for labor;

W^* = Institutionally given wage rate in organized/formal sector of the economy;

R = rental return in the informal credit market;

r = rental return in the formal credit market;

a_{ji} = amount of the jth factor used to produce 1 unit of the ith good $(j = L, K; i = 1,2)$;

$\overline{K}$ = total stock of capital in the economy;

K_1 = available credit in informal sector;

P_i = internationally given prices of good $i(i = 1,2)$;

θ_{ji} = cost-share of factor j in the production of good i;

λ_{ji} = share of sector i in the total employment of factor j;

$\wedge$ = proportional change.

Our simple 2×2 general equilibrium framework is described by the following set of equations:

$$Wa_{L1} + Ra_{K1} = P_1 \tag{1}$$

$$W^* a_{L2} + r a_{K2} = P_2 \tag{2}$$

We do not model the issues of wage-fixation explicitly[2]. We just assume, like Beladi et al. (2012), the wage in sector 2 is institutionally given and fixed (or rigid) at a higher rate $W^* > W$.

We assume the following functional relationship between R and r

$$R = \rho r; \ \rho > 1 \tag{3}$$

Here ρ denotes the degree of imperfection of the informal credit market. $\rho > 1$ implies that $R > r$. This is because the informal moneylenders generally borrow funds from the formal sector at the market rate of return r, re-lend it to the informal borrowers and by this way maximises net interest income[3]. Therefore it is realistic to assume that informal interest rate is positively related to and steeply higher than the formal interest rate. The lower the number of alternative sources of credit to the borrowers in the informal sector, the higher is the degree of imperfection in the informal credit market and thereby the power of the informal sector lenders to mark up interest rate in the informal credit market over the one in formal capital market (i.e., greater value of ρ)[4]. However we treat ρ here as a policy-parameter.

Substituting R from Equation (3) into Equation (1) we obtain:

$$Wa_{L1} + \rho r a_{K1} = P_1 \tag{1.1}$$

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[2] One can see Mukherjee (2012, 2014) for similar treatment.

[3] So r could also be interpreted as the opportunity cost of lending credit to the moneylender.

[4] Our story is consistent with the ideas developed in existing literature where informal credit markets have been modelled either as monopolies (see for example Bhaduri, 1977; Rudra, 1982; and Basu, 1984, 1998; Chaudhuri and Gupta, 2014) or as fragmented oligopolies (Basu and Bell, 1991; Mishra, 1994). Our assumption is also consistent with lender's risk hypothesis (Bottomley, 1975). For details, see Chaudhuri (2003). We are not going to formally analyze the behavior of the informal moneylenders here given the focus of this paper. However, one can see Chaudhuri and Gupta (2014) for a formal analysis of the behaviour of a monopolistic moneylender as the only source of credit in the informal credit market.

Equations (1.1) and (2) are the price-unit cost equality conditions for the unorganized and the organized sectors respectively. We also assume that amount of credit allocated to the informal sector is a positive function of the return differential between the two capital markets. Therefore as long as $\rho > 1$, informal capital market exists and thus the dichotomy between the two credit markets exists.

$$K_1 = K_1(R - r) = K_1\{r(\rho - 1)\}. \text{ So when } (R - r) \geq 0, K_1'(.) \geq 0. \qquad (4)$$

So full utilisation of informal credit implies

$$a_{K1}X_1 = K_1(R - r) = K_1\{r(\rho - 1)\}; \; K_1(.) \geq 0 \text{ as long as } (R - r) \geq 0 \quad (5)$$

Note that Equation (5) *is not an independent equation since it only states that part of the available credit is allocated to the informal credit market*[5].

Similarly for formal credit:

$$a_{K2}X_2 = \overline{K} - K_1(.) \qquad (6)$$

Full-employment of labor implies (normalising economy's total labor-endowment to utility):

$$a_{L1}X_1 + a_{L2}X_2 = 1 \qquad (7)$$

National income at world prices would give us:

$$Y = W + (W^* - W)a_{L2}X_2 + r\overline{K} + (R - r)K_1(.) \qquad (8)$$

We have 5 independent equations, namely Equations (1.1), (2), (4), (6) and (7); to solve for 5 endogenous variables, namely: W, r, K_1, X_1 and X_2. The determination of endogenous variables is as follows. From Equation (2) we can determine r given the rigid formal wage (W^*). Given the policy parameter ρ, substituting r in Equation (1.1) we can find the competitive informal

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[5] For similar treatment see Chaudhuri (2003). It is worth to mention that Chaudhuri (2003) has considered the dualism in capital/credit market in the same fashion to consider the welfare implications of different liberalization policies. However, that paper considered a Harris-Todaro type economy while we have considered a full-employment model with segmentation in labor market. The justification for considering full-employment structure with segmented labor market has been discussed in the introduction.

wage W. So the factor coefficients are also known as the factor prices are already determined in terms of exogenous commodity prices and other parameters. Once r is known, given ρ, we can use Equation (4) to determine K_1. Substituting K_1 in Equation (6), we can solve for X_2. Then substituting X_2 in Equation (7), we get X_1.

3 Comparative static exercises

3.1 Uniform technological progress in sector 2

Suppose the productivity parameters are such that sector 2 undergoes uniform technological progress by $\alpha > 0$, ceteris paribus. This essentially means the same percentage reduction (i.e., here by α%) in labor and capital coefficients in sector 2. The implications on informal sector wage can be expressed as

$$\widehat{W} = -(\alpha\theta_{K1}/\theta_{L1}\theta_{K2}) < 0 \tag{9}$$

While returns to capital in both sectors will rise.

$$\hat{r} = \alpha/\theta_{K2} > 0 \tag{10}$$

Totally differentiating Equations (6) and (7) and using Cramer's rule, one obtains

$$\hat{X}_1 = -\{\alpha/(\theta_{K2}\lambda_{L1})\}[A + \lambda_{L2}\{S_{KL}^2 - (K_1'(.)/\overline{K}\lambda_{K2})r(\rho - 1)\}] \tag{11}$$

Where $S_{jk}^i = (\partial a_{ji}/\partial w_k)(w_k/a_{ji})$ is the elasticity of substitution between factors j and k in the ith sector; $j, k = L, K$ and $i = 1,2$. $S_{jk}^i > 0$ for $j \neq k$ and $S_{kk}^i < 0$ Also,

$$A = [\lambda_{L1}S_{LK}^1(1/\theta_{L1}) + \lambda_{L2}S_{LK}^2] > 0 \tag{11.1}$$

$$\hat{X}_2 = (\alpha/\theta_{K2})[S_{KL}^2 - (K_1'(.)/\overline{K}\lambda_{K2})r(\rho - 1)] \tag{12}$$

Therefore from Equations (11) and (12) it is clear that if $S_{KL}^2 > (K_1'(.)/\overline{K}\lambda_{K2})r(\rho - 1)$ holds; $\hat{X}_2 > 0, \hat{X}_1 < 0$.

If the organized sector experiences uniform technological progress, r will go up since wages are fixed in the organized sector and therefore from the zero-profit condition of the informal sector, it is clear that competitive informal wages will fall. Note that alike Beladi et al. (2012) here also we do not need any assumption about relative factor-intensities between the sectors to yield the implications on factor returns. So producers in both the sectors will switch to more labor-intensive techniques of production and hence capital-output rations, a_{Ki}s will fall in both the sectors. Now since r rises, $(R - r) = r(\rho - 1)$ goes up as well. This will lower the supply of capital to the formal credit market. Therefore two opposite effects are operating on X_2: given the supply of credit to the organized formal sector $(\overline{K} - K_1(.))$, the fall in a_{K2} will increase X_2; while for given a_{K2}, lower supply of capital to the formal credit market will affect adversely the formal sector. However under the sufficient condition $S_{KL}^2 > (K_1'(.)/\overline{K}\lambda_{K2})r(\rho - 1)$[6], the formal sector will expand and will attract more workers from the informal sector. As a result informal sector producers will have to depend on the relatively more costly capital for the production and hence the effective price of commodity 1 net of capital-cost will fall in the informal sector. Therefore informal sector will contract both in terms of output and employment since relatively productive workers will now join the formal sector. This leads to the following proposition.

Proposition 1a: *If only the organized sector undergoes uniform technological progress by $\alpha > 0$, ceteris paribus, returns to capital rise in both the sectors while competitive wage falls unambiguously. However if $S_{KL}^2 > (K_1'(.)/\overline{K}\lambda_{K2})r(\rho - 1)$ holds; formal sector will expand while informal sector will contract both in terms of output and employment.*

Subsequently it follows from the expression of national income at world prices

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[6] This condition states that elasticity of substitution between capital and labour in sector 2 should be sufficiently high, so that when capital (credit) availability in formal sector falls, sector 2 can still expand by switching towards more labor-intensive techniques of production.

$$Y\hat{Y} = (\alpha/\theta_{K2})[(W^* - W)\lambda_{L2}\{S_{LK}^2 + S_{KL}^2 - (K_1'(.)/\overline{K}\lambda_{K2})r(\rho - 1)\}] + (r\alpha/\theta_{K2})[(\overline{K} - K_1) + (\rho - 1)\{K_1(.) + r(\rho - 1)K_1'(.)\}]$$

$$(13)$$

Assumption: *Without any loss of generality we assume that sector 2 is relatively capital-intensive vis-à-vis sector 1 in physical and value terms.*

Above assumption just restates that the formal sector is the most capital-intensive sector of the economy. And sector 1 uses more labor-intensive techniques in the production process than the other sector in value terms, i.e., $(Wa_{L1}/a_{K1}) > (W^*a_{L2}/a_{K2})$; which trivially implies sector 1 is relatively more labor-intensive in physical terms.

Therefore a productivity improvement in the formal sector will produce two different impacts on the aggregate wage-income: (a) direct negative effect on W given X_is; (b) if $S_{KL}^2 > (K_1'(.)/\overline{K}\lambda_{K2})r(\rho - 1)$, the higher wage-paying formal sector expands at the expense of the lower wage-paying informal sector (positive 'output effect') leading to labor reallocation between the sectors of the economy, which will affect the aggregate wage income of the workers positively. Also note that aggregate rental income of the economy will increase unequivocally. So there will be two different effects on the economy's per capita income:

(a) Changes in aggregate factor-income given the labor-reallocation effect, captured by $(r\alpha/\theta_{K2})[(\overline{K} - K_1) + (\rho - 1)\{K_1(.) + r(\rho - 1)K_1'(.)\}]$. Here $(\overline{K} - K_1)$ denotes the net supply of domestic credit to the formal sector, in the absence of any foreign capital in the economy's aggregate capital endowment. And therefore given that the formal sector is the most capital-intensive sector in this set-up, $(\overline{K} - K_1)$ is unambiguously positive in our model. Hence $(r\alpha/\theta_{K2})[(\overline{K} - K_1) + (\rho - 1)\{K_1(.) + r(\rho - 1)K_1'(.)\}]$ is always positive in our set-up when r rises. However if we would take into account the presence of foreign capital in this set-up, then the rental income of the economy from domestic capital employed would become $\{rK_D + (R - r)K_1(.)\}$ in the expression for national income in world prices (Equation (8)), with K_D being the stock of domestic capital. In that case we would require $(K_D - K_1)$ to be non-negative in order for $(r\alpha/\theta_{K2})[(\overline{K} - K_1) + (\rho - 1)\{K_1(.) + r(\rho - 1)K_1'(.)\}] > 0$. And that would almost always be true if the stock

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of foreign capital in the aggregate capital endowment of the economy is not exorbitantly high.

And,

(b) Changes in aggregate wage-income following the output effect in the organized sector, which is positive if $S_{KL}^2 > (K_1'(.)/\overline{K}\lambda_{K2})r(\rho - 1)$ is satisfied.

Thus there is a clear possibility for the economy-wide per capita income to rise following a uniform technological progress in the formal sector under the sufficient condition mentioned in (b). This enables us to state the following proposition:

Proposition 1b: *Real income of the economy will rise following a policy of uniform technological progress in the formal sector if $S_{KL}^2 > (K_1'(.)/\overline{K}\lambda_{K2})r(\rho - 1)$ is satisfied.*

This policy of uniform technological improvement in the formal sector, although could be welfare ameliorating, the benefit of expansion of economy-wide per capita income would not 'trickle down' to the economically marginalized people in the informal sector. This is because the workers attached to the informal sector would become worse off in terms of wage-earnings and employment.

3.2 Uniform technological progress in sector 1

Let us assume only sector 1 would undergo uniform productivity improvement by $\alpha > 0$, ceteris paribus. It is easy to verify from Equations (1) and (2) that

$$\hat{r} = 0 \tag{14}$$

And

$$\widehat{W} = (\alpha/\theta_{L1}) > 0 \tag{15}$$

Since r is not changing, no credit-reallocation takes place between different capital markets. So substituting (5) into (6) we can write for full utilisation of capital between the two markets:

$$a_{K1}X_1 + a_{K2}X_2 = \bar{K} \tag{6.1}$$

Totally differentiating (5.1) and (7) and using the Cramer's rule one can obtain[7]:

$$\hat{X}_1 = (B_1/|\lambda|)(\alpha/\theta_{L1}) \tag{16}$$

And

$$\hat{X}_2 = -(B_2/|\lambda|)(\alpha/\theta_{L1}) \tag{17}$$

Where $|\lambda| = (\lambda_{L1}\lambda_{K2} - \lambda_{K1}\lambda_{L2}) > 0$ under the assumption that the formal sector is relatively capital-intensive vis-à-vis the informal sector in physical and value terms.

$$B_1 = (\lambda_{L1}S_{LK}^1\lambda_{K2} + \lambda_{K1}S_{KL}^1\lambda_{L2}) > 0 \tag{16.1}$$

$$B_2 = \lambda_{L1}\lambda_{K1}(S_{LK}^1 + S_{KL}^1) > 0 \tag{17.1}$$

So from (16) and (17) it follows that $\hat{X}_1 > 0$ and $\hat{X}_2 < 0$ following a uniform technological improvement in sector 1.

As r is pegged by the exogenous commodity price in sector 2 and the unionised wage, any productivity improvement in the informal sector is going to increase the competitive wage and as a result the producers in sector 1 will adopt more capital-intensive techniques than before. So a_{K1} rises while a_{L1} falls. Given X_is, this will generate relative shortage of capital and thereby a 'Rybczynski-type' effect[8] due to which the relatively capital-intensive formal sector will contract while the relatively labor-intensive unorganized sector would expand.

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[7] Note that $\widehat{a_{j2}} = 0$, for $j = L, K$ since $\hat{r} = 0$ and $\widehat{W^*} = 0$.

[8] This is slightly different from the usual 'Rybczynski effect'. Whenever technologies of production are of variable-coefficient type, any change in factor returns will lead to changes in unit factor-coefficients and subsequent changes in output-compositions.

It follows from the expression of national income at world prices

$$Y\hat{Y} = (\alpha/\theta_{L1})\left[\underbrace{W\lambda_{L1}}_{>0} + \underbrace{(W - W^*)\lambda_{L2}(B_2/|\lambda|)}_{<0}\right] \qquad (18)$$

Or assuming that production function in each sector is of Cobb-Douglas type[9], substituting B_2 from (17.1) into Equation (18), one can easily obtain by simple manipulation:

$$Y\hat{Y} = (\alpha\lambda_{L1}/|\lambda|\theta_{L1})[(Wa_{L1}/a_{K1}) - (W^*a_{L2}/a_{K2})] \qquad (18.1)$$

From Equation (18) it is clear that aggregate wage income is affected by:

(a) Direct positive effect on W and thereby increase in wage-income of the informal workers, captured by $(\alpha/\theta_{L1})W\lambda_{L1} > 0$.

And,

(b) Negative 'output effect' due to the contraction of formal sector, captured by $\{-(\alpha/\theta_{L1})(W^* - W)\lambda_{L2}(B_2/|\lambda|)\} < 0$, for which some of the laborers will be reallocated to the informal sector.

However as long as sector 1 is more labor-intensive vis-à-vis sector 2 in value and physical terms, we have

$$(Wa_{L1}/a_{K1}) > (W^*a_{L2}/a_{K2}) \text{ and } |\lambda| > 0.$$

Therefore from Equation (18.1) we see that the aggregate wage-income of the economy will go up in this case and since aggregate rental income is not changing (as r does not change) impact on the real income of the economy will also be positive. There the following proposition can be established.

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[9] This is a simplifying assumption. It implies that elasticity of substitution between capital and labor in each sector is unity.

Proposition 2: *If the informal sector undergoes uniform technological progress, ceteris paribus, informal wage will rise and if the informal sector is more labor-intensive than the formal sector in physical and value terms, the former will expand in terms of both output and employment while the latter will contract but real income of the economy will go up.*

4   Concluding remarks

This paper has made a novel attempt to analyze the welfare implications of sector-specific uniform technological progress for a small, open developing economy in a two-sector full employment general equilibrium structure with distortions in both labor and capital markets. We have found that when the organized sector undergoes uniform productivity improvement, the per capita income of the economy may increase but the workers attached to the informal sector could be worse off in terms of wages and employment. However, if the unorganized sector goes through a uniform technological improvement, laborers in the relatively labor-intensive informal sector could benefit in terms of wages and employment and the per capita income of the economy would go up as well. Therefore from the policy perspective, productivity improvement in the unorganized informal sector will be more egalitarian in this set-up.

We suggest the following future directions of our research. One possible extension of our framework could be to incorporate the informal sectors producing non-tradable items (final commodities and/or intermediate inputs) in order to examine the possible implications of technological progress in the traded sectors. Another interesting direction could be to investigate the same research question using an oligopolistic Heckscher-Ohlin framework (like the framework of Lahiri and Ono 2011) where one of the two sectors is oligopolistic.

Acknowledgement

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