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Input Trade Liberalisation and Wage-inequality with Non-traded Goods

by

Soumyatanu Mukherjee

Abstract

This paper develops a multi-sector full-employment general equilibrium model with internationally non-traded goods and international fragmentation in skill-intensive production, to understand the mechanism how trade-induced growth in the skill-intensive sector is mediated to informal sector wages and employment through the existence of finished non-tradable and the corresponding domestic demand-supply forces. The underlying developing economy is characterised by dual unskilled labour market with unionised formal and non-unionised informal sectors, consistent with the empirical literature on developing economies India. Numerical analysis has also been performed to simulate how the changes in elasticities of factor substitution in production in different sectors account for the movement in informal wage and therefore the movement in skilled–unskilled wage gap. This paper challenges the view that the relative wage-inequality in a DC like India with rigid organised sector labour market has unequivocally been governed only by the increase in the skilled wages. An extension with involuntary unemployment of skilled labour using the fair wage hypothesis has also been presented that effectively demonstrates the robustness of the results obtained under full-employment model.

JEL Classification: Input trade liberalisation; non-traded goods; informal wage; skilled labour unemployment; wage-inequality.

Keywords: F13; J31.

Centre for Research in Economic Development and International Trade, University of Nottingham

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1. Introduction

The idea that trade liberalization could be the reason for the rising skill premium documented in many developing countries (DCs) is often dismissed from the perspective of the Stolper-Samuelson (SS hereafter) theorem. Let us assume that in a two country, two commodity framework the home country (a small, open developing economy) exports good X, that is, it has a comparative advantage in good X, indicated by the lower relative price of good X. Whatever may be the reason of such comparative advantage or price differences, through arbitrage (buying cheap and selling dear) and consequent physical movements of goods across national borders, the domestic prices (net of trade costs) will eventually be equalised when demand and supply are equated. Therefore, the relative price of good X rises in the home country, while falls in the foreign country. Let us also assume that the home exportable goods are relatively unskilled labour-intensive. As the relative price of exportables increases, the production of the import-competing good Y contracts and that of the exportable good X increases. The consequent resource reallocation leads to an excess demand for unskilled labour and an excess supply of skilled labour because the expanding X sector requires more unskilled labour and can absorb fewer skilled labourers than are released by the contracting Y sector. Hence, the unskilled money wage increases whereas the skilled money wage declines. However, we can expect something more than just these changes in the absolute prices. An appeal to the SS theorem indicates that free trade leads the real wage to increase and the real return to capital falls (Caves et al., 2004). Therefore, in the home country, unskilled workers gain through trade.

However, in practice, the welfare implication of trade liberalisation on the poor unskilled workers is ambiguous. This is because, as pointed out by Sharma and Morrissey (2006), in order to be competitive in the world market, the exportable producers in developing countries often seek efficient and relatively high skilled labour. The poor households capable of supplying most unskilled labour cannot get direct benefit from trade liberalisation or global integration of a particular sector. The benefit, if any, tends to be indirect, through backward linkages in production and consequent demand. To establish this theoretically one needs to explore an appropriate general equilibrium model that matches with the empirical regularity

and considers explicitly all associated aspects in organisation of production and factor distribution issues for the particular type of economy under consideration.

One problem is labour-market rigidity as observed typically in the formal industrial sectors of India (Topalova, 2010; Besley and Burgess, 2004) that hinders free mobility of unskilled and skilled labourers across sectors. Robbins (1996), Sanchez-Paramo and Schady (2003), Attanasio, Goldberg, Pavcnik (2004) on DCs like Argentina, Brazil, Mexico, Chile and Colombia, and Topalova (2010) for Indian districts, provide grounds for the proponents of specific-factor model of Ron Jones (1971) by concluding that the skilled labour-intensive sectors do not substitute away skilled labour for the unskilled labour. In the specific factor model of trade where the number of factors of production is greater than the number of traded goods, the endowment base of the economy has direct influence on wages. It may appear obvious then to presuppose better applicability of such a model on the basis of the findings of Robbins (1996) for Columbia of strong domestic supply impact on relative wages. But the specific factor model too, unless modified, cannot explain the symmetric changes in the wage gap in the trading nations.

Along with this, one should never neglect the role of the informal sector, which is the unregulated part of the economy where minimum wage laws and labour regulations are either totally absent or weakly implemented. Since DCs are generally deficient in effective employment insurance schemes, the displaced workers from the sector experiencing decline in relative price can hardly afford to remain unemployed. Absorption of labour retrenched from the more regulated sectors by this sector is, therefore, likely to be a major reason behind the concurrent increase in inequality and informalisation, as well as the relatively jobless patterns of growth observed in many DCs in the recent years, including India (Razmi, 2009). The share of the informal sector in total employment is typically quite high in DCs (Razmi, 2009). Agenor (1996) cites an average figure of more than 70% for DCs. The share of the informal sector in total output can also be quite high. For example, Nagaraj (2004) reports a figure of 40% for India. Unfortunately, most of the relevant literature in this context has neglected the special nature of the informal sector in developing countries' labour markets.

As already documented in Chapter 2, existence of the internationally non-traded goods with the domestic market clearing condition, significantly changes many standard results of the trade theory models. Since most of the non-traded production in the DCs like India uses unskilled labour intensively, any discussion of widening wage gap in the unskilled labour-

abundant developing countries like India through trade liberalisation cannot be complete without such non-traded goods being taken into account.

The main problem with these standard theories is their failure to capture the diverse trade pattern that the developing nations exhibit in their export baskets recently and the institutional characteristics specific to them. Peculiarities such as exporting both skill-intensive manufacturing and unskilled labour intensive agricultural products, coexistence of organised and informal labour markets and the production of internationally non-tradable, are capable of explaining the relationship between openness and wage-gap in the DCs like India.

As defined in Feenstra and Hanson (1996), Jones and Kierzkowski (2001) and others, a sharp decline in transportation and communication costs during liberalisation makes it easier for the DCs to specialise in part of the production chain and outsource other parts of the production process to countries where factor prices and intensities are appropriate for that particular fragment. This gives birth to the input trade where this particular input gets exchanged in the world market for another exportable input produced in the home country. Das (2012) found that in developing countries such as India, China, South-East Asia and Latin America higher percentage of trade has been attributed to production-sharing in hi-technology products, service(s) and capital goods. As found in Goldberg et al. (2009), trade liberalisation in India also involves reduction in barriers to trade on imported inputs and thereby providing access to more and newer varieties of cheaper inputs from the other countries. Goldberg et al. (2010) estimated that input tariffs declined on average by 24 percentage points during 1989-1997. Arora and Chakrabarti (2004) provide empirical evidence of the significant impact of outsourcing of skill-intensive production on widening skilled-unskilled wage gap in Indian context. Therefore, an important agenda of research becomes to examine the implications of input trade liberalisation on wage-inequality, stepping out of the standard 2×2 HO structure, using a more convincing and encompassing theoretical structure that incorporates all these specific features mentioned above relevant for a small, open developing dual economy like India.

Liberalised economic policies generally shift resources away from the non-traded sectors to the traded sectors of the economy. Since the non-traded production by definition must match its domestic demand, trade liberalisation induced expansion of activities in the traded sectors will be possible only through a fall in the demand for non-tradeables. Therefore, as pointed out by Marjit and Acharyya (2000, 2003) whether non-traded production is organised in the

informal or in the formal sector[1] should be crucial to determine the impact on wage-inequality. Typically, the formal non-traded sector produces internationally non-tradable including all public services, hotel accommodation, real estate, construction, hair-cut and commodities produced to meet special customs or conditions of the country. Similarly, the non-tradable produced in the unorganised informal sectors include items such as small domestic industries, services provided by petty traders or street-side vendors and so on. If the non-tradable is produced in a formal sector with unionised wage, the non-traded price may be determined solely by the cost of production independent of the demand for non-tradable. In such a case demand variation consequent upon trade liberalization induced real income changes alters only the non-traded production. Accordingly any change in the wage- gap is triggered by the consequent resource reallocation across the non-traded and traded sectors. But if the non-traded sector is an informal sector, variations in the demand for non-tradable are followed by the changes in both production and price of the non-tradable. Accordingly, trade liberalization will have quite different implications on the wage-gap between skilled and unskilled workers.

The importance of non-traded goods in theoretical models determining the direction of skilled-unskilled wage gap has been documented by Marjit and Acharyya (2000, 2003), Chaudhuri and Yabuuchi (2008) who have used a four-sector general equilibrium model to study the consequences of import liberalization on skilled-unskilled wage gap, highlighting the significance of dualism in labour market and role of non-tradable commodities in driving the results. Gupta and Dutta (2011) incorporated involuntary unemployment of both skilled and unskilled labour in a three-sector model with non-traded goods to understand the implications of trade liberalisation-induced changes on skilled-unskilled relative wage and on the unemployment rates. This paper contributes to this research arena by sketching out the implication of input trade liberalisation on wage-inequality with dual labour market, large informal sector and non-traded goods. The purpose of such a comparative static exercise is two-fold. Firstly, the accelerated growth in Indian manufacturing and service sectors has largely been attributed to dramatic reduction in tariffs and NTBs on the imports of intermediate inputs as emanates from recent empirical evidence (Goldberg et al., 2009; 2010). Secondly, the recent empirical literature (Panagariya, 2004; Kotwal et al., 2011) suggests that the skill-intensive manufacturing and service industries such as communication

[1] Typically we shall confine ourselves in this paper characterising the informal sector as the sector with unorganised unskilled labour market in line with other theoretical papers such as Marjit and Acharyya (2000, 2003), Chaudhuri (2005), Chaudhuri and Banerjee (2010) and so on.

services, financial services and business services in India experienced significant growth in exports during the liberalised regime, where software accounted for the highest share of all service exports, at least up to the recent financial crisis (Kotwal et al., 2011). Dehejia and Panagariya (2010) argued that imports of capital-intensive foreign inputs (embodying foreign technology) by the skill-intensive service sectors (primarily software services and IT-enabled services) facilitated the growth of these sectors in India in the post-reform period. At the same instance, Hasan (2002) provided evidence from panel data on Indian manufacturing firms in favour of a significant effect of imported technology on productivity. Hence, access to newer varieties of foreign inputs owing to trade reform has fuelled such growth in India's service industries during the liberalised regime. Therefore, there should be an increased demand for skilled labour, due to the increase in demand by the skill-intensive service industries both at the extensive margin and due to the skill-biased technological change at the intensive margin owing to the increased skill content of imported inputs that are then assembled for export. Therefore, the contribution of this paper is to adopt a tractable but encompassing general equilibrium structure to trace out the implications of such productivity surges in the skill-intensive service sector, brought about by the tariff reform on the imports of capital-intensive inputs, on the non-traded sector and subsequently on the unskilled labour market and informal unskilled wage.

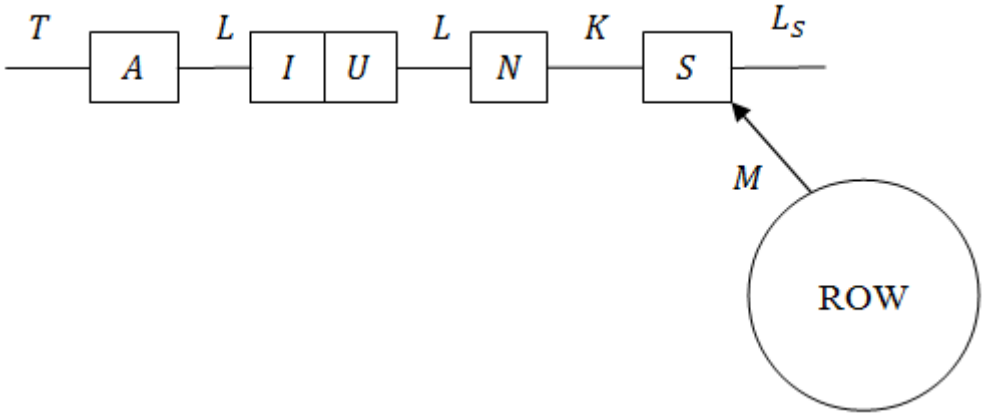
The general equilibrium framework used in this paper follows the available empirical evidence that low-skilled workers cannot afford to remain unemployed and the retrenched unskilled workers from the organised formal sectors get absorbed in the unorganised informal sectors at market-determined lower wages. Our modelling approach, closely follow Marjit and Acharyya (2003) with organised (formal) and unorganised (informal) non-traded sectors respectively to enlighten the role of non-tradable in determining the implications on unskilled informal wage and consequently on the relative wage-gap. The framework used in this paper can be viewed as a generalisation of Marjit et al. (2007) with additions of skill-intensive sector and non-traded final good producing sector.

2. The Model

2.1 Non-traded Production in Formal Sector with Contractual Money Wages

Let us consider a small, open dual economy comprising of four sectors. Sector A is the rural agricultural sector (with informal or unorganised labour market for the unskilled labourers) producing a tradable agricultural good using unskilled labour (L) and land-capital (T).[2] Sector U is an unskilled labour-intensive formal manufacturing sector (with organised labour market for unskilled workers) in the urban area, producing with unskilled labour, capital (K) and an internationally non-traded intermediate input[3], which is, in turn, produced in one segment of the formal sector U (sub-sector I) using unionised unskilled workers and capital. The skill-intensive manufacturing sector (S) uses skilled labour (L_S), capital and a hi-technology-intensive imported intermediate input produced abroad (M)[4]. Consistent with empirical evidence[5] we assume that only the relatively skill-intensive firms use imported intermediate inputs and consequently pay for foreign technology licences or foreign technical assistance. Furthermore, there is an *advalorem* tariff (t) imposed on the import of M. [6]

Figure 1: The Model Structure



Similar to Marjit and Acharyya (2000, 2003), this model also makes a simplifying assumption that a non-traded final good is produced in the urban area using only unskilled

[2] The input 'land-capital' broadly includes land and other durable assets. See Bardhan (1972), Chaudhuri (2007) and Mukherjee (2012) in this context.
[3] Examples of such non-traded intermediate input include electricity, water supply, local transportation, goods with very high transportation costs such as gravel and so on.
[4] Examples of such imported inputs include computer data storage units, automatic data processing machines and so on.
[5] See for example Alvarez and Lopez (2005), Lopez (2008, 2015) and so on.
[6] This should be interpreted here as the *advalorem* equivalence of tariff and non-tariff barriers (NTBs).

labour in a fixed proportion. We assume that this non-traded good is produced in the formal sector where unskilled labour is hired at a contracted nominal wage, as considered in Marjit and Acharyya (2000, 2003). Unskilled labourers in the unorganised labour market of the rural agricultural sector get competitive (market-determined) money wages at the rate W, while their counterparts working in the organised labour markets of the formal sectors receive contractual money wages at the rate W^*, determined owing to prior unionised negotiation[7], with $W < W^*$. Therefore, only the agricultural sector is modelled as the informal sector[8] where the unskilled labour gets a lower market-determined nominal wage. The skilled workers receive wages at the rate W_S. The rental to land-capital is denoted as R and the interest rate on capital is denoted as r. The price the non-traded intermediate input I, P_I, is determined domestically by demand-supply mechanism. However, the price of non-traded final commodity N, P_N, is determined in this case by the labour cost given W^* and therefore the production of the non-traded good N is determined by the domestic demand for N. a_{ji} denotes the amount of the j^{th} input used in per-unit production of the i^{th} good. P_i^* denotes the internationally given price of the i^{th} commodity owing to the small, open economy assumption ($i = A, U, S$). All markets, except the organised labour markets for the unskilled workers working in the formal sectors, are perfectly competitive. All production is subject to constant returns to scale. Except for the non-traded production and production in the input tier, there are diminishing returns to the variable factors in each sector. The price-unit cost equality conditions (the so-called 'zero-profit conditions') for the competitive producers are mentioned below.

$$Wa_{LA} + Ra_{TA} = P_A^* \tag{1}$$

$$W^* a_{LI} + ra_{KI} = P_I \tag{2}$$

$$W^* a_{LU} + ra_{KU} + P_I a_{IU} = P_U^* \tag{3}$$

$$W_S a_{SS} + ra_{KS} + P_M{}^*(1+t)a_{MS} = P_S{}^* \tag{4}$$

$$W^* a_{LN} = P_N \tag{5}$$

[7] We assume the organised sector wages are institutionally given and we do not explicitly model the wage-bargaining here. For a discussion on how unionised wages are determined through collective bargaining, see Chaudhuri and Mukhopadhyay (2010), Mukherjee (2014) and so on.

[8] See footnote 1 in this context.

We assume that the per-unit requirement of the non-traded intermediate input in the production of sector U (a_{IU}) and per-unit requirement of the imported input in sector S (a_{MS}) are constant. Although these two assumptions are simplified assumptions, they are not without any basis. If we think of sector U as an automobile industry that always uses four tyres as the intermediate input to build one car and sector S as a software industry that always has a fixed requirement of automatic data processing machine or computer data storage units in the production process, then these assumptions are perfectly legitimate.

Full-employment in the factor market suggests

$$a_{TA}A = \bar{T} \tag{6}$$

$$a_{KI}I + a_{KU}U + a_{KS}S = \bar{K} \tag{7}$$

$$a_{SS}S = \overline{L_S} \tag{8}$$

Domestic demand-supply equality condition in the market for non-traded intermediate input implies

$$a_{IU}U = I \tag{9}$$

Or,

$$\hat{U} = \hat{I} \tag{9.1}$$

Where the ^ indicates proportional change. The unskilled labour-endowment equation is

$$a_{LA}A + a_{LU}U + a_{LI}I + a_{LN}N = \bar{L} \tag{10}$$

Following Marjit and Acharyya (2003) and Marjit et al. (2011) let us make a simplifying assumption that α-proportion of the total urban income is spent on the non-traded good N. Thus, the domestic market clearing of non-traded good (assuming rural population cannot avail of N)

$$\alpha({P_U}^*U + {P_S}^*S) = (1-\alpha)P_N N \tag{11}$$

Once the domestic market for N is cleared the overall trade is balanced.

The above equation system consists of eleven unknowns or endogenous variables of the system (W, W_S, R, r, P_I, P_N, A, U, S, I, N) and eleven equations. The input-coefficients, a_{ji}s, except the per-unit requirements of the imported and non-traded intermediate inputs (a_{IU} and a_{MS}) and the unit labour coefficient in the production of non-traded final good N (a_{LN}), are determined once the factor prices are known.

The model is solved as follows: Equations (2) and (3) simultaneously solve for r and P_I for exogenously given W^* and P_U^*. Once r is determined, zero-profit condition for the skilled labour-intensive manufacturing sector determines W_S given P_S^*, P_M^* and the ad-valorem rate of tariff imposed on the import of M, t. On the other hand, the price of the non-traded good is given by the labour cost, which is the product of fixed input-coefficient and the contracted unskilled-wage, independent of the demand for non-traded good. Once the nominal skilled wage and the rate of return to capital are determined, total skilled labour force determines the skill-intensive manufacturing production and this together with the total domestic capital stock yields the production of the unskilled labour-intensive manufacturing good and consequently the production of the non-traded intermediate input, I, by dint of the complementarity in production process between these two sectors as given by Equation (9). The non-traded output, on the other hand, is demand-determined given the equilibrium values of W_S,r and U (and I), as evident from the market-clearing condition in Equation (11). Therefore, the formal sectors form an independent subsystem of the economy under consideration.

The output and prices of the factors used in production of U,I, S and N are all determined independent of the informal agricultural sector in this set-up. But the informal wage rate, the rental to land-capital and production in sector A are determined once the equilibrium values in the formal sectors of the economy are obtained. In this set-up, the production activities in sector A will be constrained by the outputs and hence by the demand for unskilled labour in the formal sectors. This depicts the importance of the non-traded good N. Because of the presence of the non-traded final good N, production of agricultural exports and the consequent demand for unskilled labour are constrained by the demand for N, which otherwise could have been satisfied through imports. Finally, given such an output level of the agricultural exports, informal competitive wage and the return to the specific factor, land-capital, must satisfy the zero-profit condition given by Equation (1) and full employment condition for land in Equation (6).

2.1.1 Comparative Static Exercise – Tariff Reduction on Imported Intermediate Input[9]

The key comparative static exercise in this paper is to consider a reduction in the *ad valorem* rate of tariff (t) on the import of the intermediate input M.

Since interest rate on capital in the formal sector, r, is already determined by solving the zero-profit conditions given in Equations (2) and (3) simultaneously, r does not change and hence skilled wage goes up as an immediate impact of the reduction in tariff on the imported input, as evident from the zero-profit condition for the skill-intensive sector described in Equation (4). Therefore, denoting the proportional change by '^' (i.e. $\hat{X} = dX/X$), the expression for change in skilled wage is:

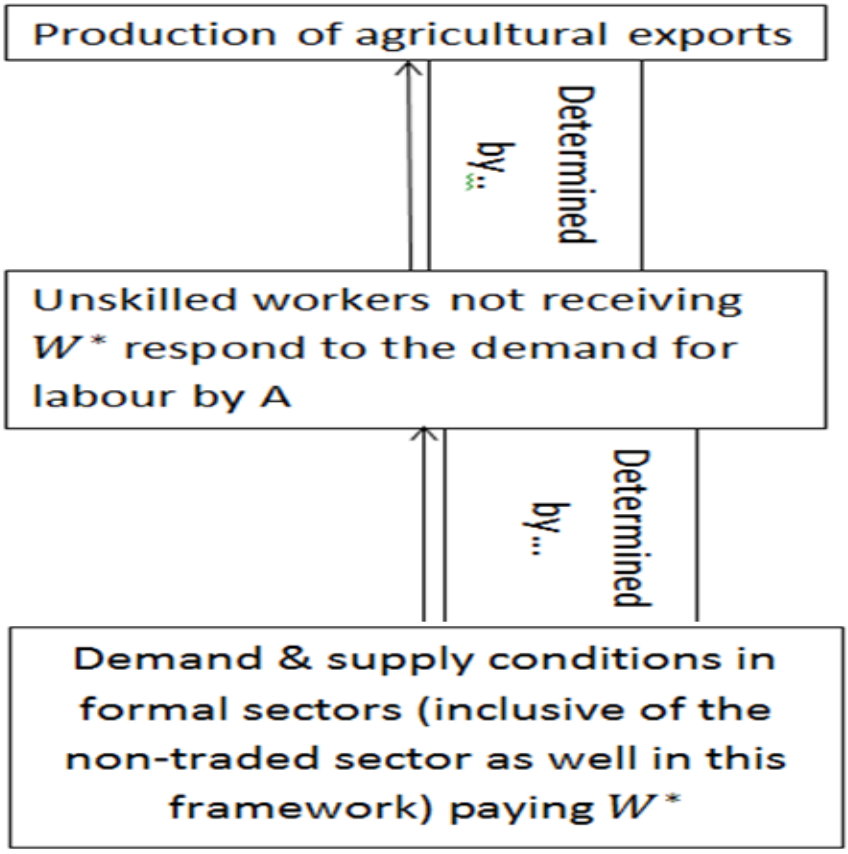
$$\widehat{W_S} = -(\theta_{MS} T \hat{t}/\theta_{SS}) > 0, \text{ since } \hat{t} < 0 \qquad (12)$$

Where θ_{ji} denotes cost-share of the j^{th} input in the production of the i^{th} good (for example, $\theta_{SS} = (W_S a_{SS}/P_S^*)$) and $T = t/(1+t)$.

How does W change? The agricultural sector with an informal labour market employs only those unskilled labourers that are not employed in the formal sectors of the economy (that is not employed in sectors *U* and *N*). Therefore, it is obvious that production activities in the agricultural sector (*A*) will be constrained by the demand for unskilled labour in the formal sectors and hence by the outputs in the formal sectors. So the effect on W depends on whether the organised sectors using unskilled labour contracts or not.

[9] Detailed derivations of key algebraic expressions will be available upon request.

Figure 2: Role of Non-traded Good



In algebraic terms,

$$\frac{\sigma_A \lambda_{LA}}{\theta_{TA}} \widehat{W} = (1 - \lambda_{LA} - \lambda_{LN})\widehat{U} + \lambda_{LN}\widehat{N} \qquad (13)$$

Where λ_{ji} denotes share of the j^{th} input in the production of the i^{th} good (for example, $\lambda_{LA} = (Aa_{LA}/\bar{L})$). LHS measures change in labour demand in sector A due to input substitution effect in sector A, but induced by change in W, which in turn, depends on how demand for unskilled labour by the rest of the economy changes; or in other words, how productions of U (consequent upon change in I) and N change. However, as sector S expands, producers in sector S demand more capital that must come from the vertically integrated sectors U and I, leading to contraction of both sectors.

$$\widehat{U} = \hat{I} = [\sigma_S \lambda_{KS}/\theta_{SS}(1 - \lambda_{KS})]\theta_{MS} T\hat{t} < 0 \qquad (14)$$

Hence, $(1 - \lambda_{LA} - \lambda_{LN})\widehat{U} < 0$ implying fall in labour demand due to contraction of U and I. Therefore, the changes in urban income and consequently the demand for the non-tradable

can be in either direction. W falls unequivocally only if N contracts. Here lies the significance of the role of non-tradables. When the non-tradable is produced under contractual wages, the variation in demand for non-tradables only affects the production of non-tradables.

Totally differentiating domestic market-clearing condition for the non-traded good and simplifying

$$\widehat{N} = \mu\widehat{U} - \theta_{MS}T\hat{t}\frac{\sigma_S(1-\mu)\theta_{KS}}{\theta_{SS}} \qquad (15)$$

Where $\mu = \{\alpha P_U^* U/(1-\alpha)P_N N\}$ and $(1-\mu) = \{\alpha P_S^* S/(1-\alpha)P_N N\}$. It intuitively follows that higher (lower) value of μ means people in the urban areas earning from sector U (sector S) spend relatively more on the good N. Equation (14) suggests direction of change in the demand for non-traded good and consequently on its production is ambiguous. The ambiguity stems from two alternative forces: one is increased demand by the skilled workers due to rise in their real earnings, another is reduced demand by the unskilled workforce in the urban area due to reduction in their real income owing to contraction of sector U.

Figure 3 quantifies in the two panels respectively the changes in the production of non-tradable N and the consequent movement in informal wage for different values of σ_S (the elasticity of substitution between skilled labour and capital in the skill-intensive sector S) in two different scenarios: $\mu = 0.3$ and $\mu = 0.7$, owing to a reduction in tariff on the imported input by 24 percentage points (as estimated by Goldberg et al., 2010 during 1989-1997 in India).[10] When skilled wage increases owing to a tariff cut of 24% on the import of input M, with increase in the elasticity of substitution between skilled labour and capital, producers in sector S would be more tempted to substitute capital for skilled labour and sector S would expand even more and consequent contractionary impact on the vertically integrated sector U would be higher as well since additional units of capital sector S demands must come from sectors I and U, thereby both direct and indirect capital usage by sector U would decline at higher rate. Therefore income from sector S (sector U) increases (decreases) at an increasing rate with increase in σ_S.

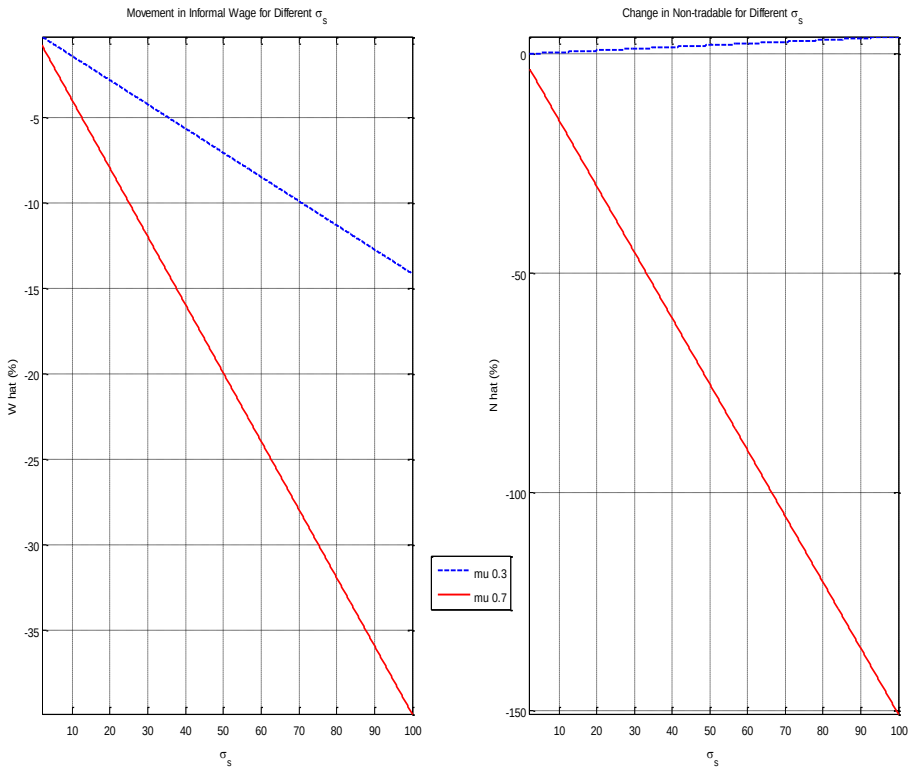
When μ =0.3, we have the scenario when urban population earning from sector S would spend relatively larger share of their income on the non-tradable, N, compared to the urban population earning from the vertically integrated sector U. Sector S expands more with the

[10] The benchmark parameter values used for the sensitivity analysis are presented in Table A1.1 in Appendix.

increase in σ_S; when the share of urban income from sector S spent on the non-tradable N is relatively higher, the decrease in the demand for N by the urban people earning from the vertically integrated sector U would be outweighed by the increase in demand for N by the people receiving income from sector S and consequently we observe a modest increase in the production of sector N with increase in σ_S for μ =0.3. Therefore, for μ =0.3, there would be two forces operating on the demand for unskilled workers in the formal sectors and consequently on the informal wage: one is decrease in demand for the unskilled workers at a higher rate by sector U with the increase in σ_S and another is the increased demand by the non-traded sector N, which is however, modest. Therefore, demand for unskilled workers in the formal sectors is not increased as a net effect and informal wage would decline, but the rate of decrease in informal wage is quite modest.

However, when μ =0.7, share of urban income from the vertically integrated sector U spent on N is much higher compared to the people earning from sector S. So the contractionary impact on the vertically integrated sector U would now be much more pronounced in determining the demand for N by the urban population with the increase in σ_S. Therefore, demand for non-tradable N would now decline as a net effect with the increase in σ_S. Consequently, demand for unskilled workers in the formal sectors would unambiguously fall and the informal wage would fall at a much higher rate compared to the case with μ =0.3.

Figure 3: Movements in Non-traded Production (N) & Informal Wage (W) following 24% Tariff-cut on Imports of M, for Different σ_S at $\mu = 0.3$ & $\mu = 0.7$, under Contractual Wage in Sector N



Totally differentiating the full-employment condition in the unskilled labour market and substituting values we obtain

$$\widehat{L_A} = \hat{a}_{LA} + \hat{A} = -\frac{\sigma_A}{\theta_{TA}}\widehat{W} \qquad (16)$$

Since informal unskilled wage falls, total employment of unskilled workers in sector A rises in this scenario with unionised wage in sector N. This is because, the reduction in flexible unskilled wage does not have any impact on determining the production in sector N (due to the unionised unskilled labour market in sector N) and thus all the retrenched workers from sectors U, I and N will now be joining sector A.

2.2 Non-traded Production in Unorganised Informal Sector

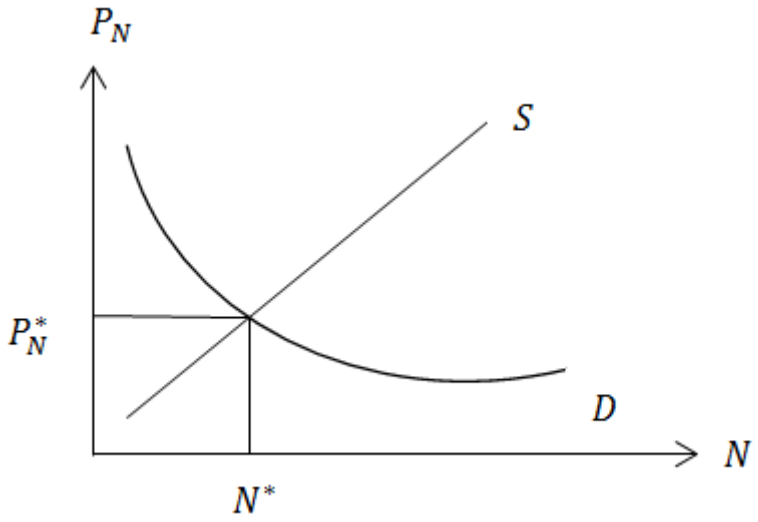
In case of contractual wages in the formal non-traded sector N, non-traded price was held fixed by the unionised unskilled money wage. But in case of non-traded good being produced in the informal sector with unorganised labour market where unskilled labour receives market-determined (flexible) nominal wage, production of N is no longer demand-determined. Consequently, P_N is not just cost-determined. We continue to assume a_{LN} is fixed (simplifying assumption). Therefore, the zero-profit condition for sector N in Equation (5) can now be re-written as

$$W a_{LN} = P_N \qquad (5.1)$$

The prices and output levels in the formal sectors (U, I, S) can still be determined independent of the informal sectors (A, N). The remaining variables can be determined as follows. For a given P_N, Equation (5.1) determines the unskilled wage, W, which then solves for the return to land-capital, R, from the zero-profit condition in Equation (1). Given these values of W, R and the consequent input choices, the output levels of the agricultural exports (A) and non-tradable N, are determined from Equations (6) and (10) respectively. This yields a supply curve for the non-tradable, N as $N^S = S(P_N)$. An increase in P_N raises W and lowers R. The subsequent increase in intensity of land-capital usage lowers the agricultural output, which, along with the less intensive use of unskilled labour due to the higher unskilled-wage, releases some unskilled labour; accordingly the non-traded output increases. We, therefore, have a positive association between P_N and N^S. So the supply curve is positively sloped.

On the other hand, the demand relationship for the non-traded good N in Equation (11) now becomes a rectangular hyperbola in this case.

Figure 4: Equilibrium in the Market for N



2.2.1 Comparative Static Exercise – Decline in Tariff on Imports of M under Flexible Wage Production in Non-traded Sector

This interaction of demand for and supply of non-tradable N in determining its price and output levels has important implications on the wage-gap between skilled and unskilled labour. Given (5.1), i.e., proportionality between P_N and W, it is immediate that whether the wage-gap widens or declines following tariff cut on imports of M depends crucially on the movement of P_N. In the earlier case of the production of N with contractual unskilled money wage, it was only the demand-determined production of N, which was crucial. But now with the price of N no longer determined by the contracted unskilled nominal wage, supply of N is of no less importance in determining the movement in unskilled-wage.

Equation (15) now changes to

$$\theta_{LN}\widehat{W} + \widehat{N} = \mu\widehat{U} - \theta_{MS}T\hat{t}\,\frac{\sigma_S(1-\mu)\theta_{KS}}{\theta_{SS}} \qquad (15.1)$$

Therefore, when non-tradable is produced in the unorganised informal sector, we can get expression for $\widehat{W}$ under tariff reduction on the imported input M by solving Equations (13), (14) and (15.1) simultaneously.

From Equation (15.1) it can be inferred that given supply, the demand for non-tradable N is ambiguous for the same reason mentioned before while discussing Equation (15). Therefore, the price of the non-traded good now may move in either direction. On the other hand, the supply effect depresses the non-traded price: At the initial P_N and hence at the initial W and A, unskilled labour released from the contracting sectors U and I relaxes the (net) labour constraint for the non-traded sector and thereby raises its supply. This additional supply effect imposes a downward pressure on unskilled wage and therefore reduces P_N. Figure 5 demonstrates the possibility where both demand for and supply of non-traded good increase but since supply increases by more than the increase in demand, price of the non-tradable falls from P_N^1 to P_N^2 while production of non-tradable rises from N_1 to N_2.

Figure 5: Comparative Static Response in the Domestic Market for N under Flexible Unskilled Wage

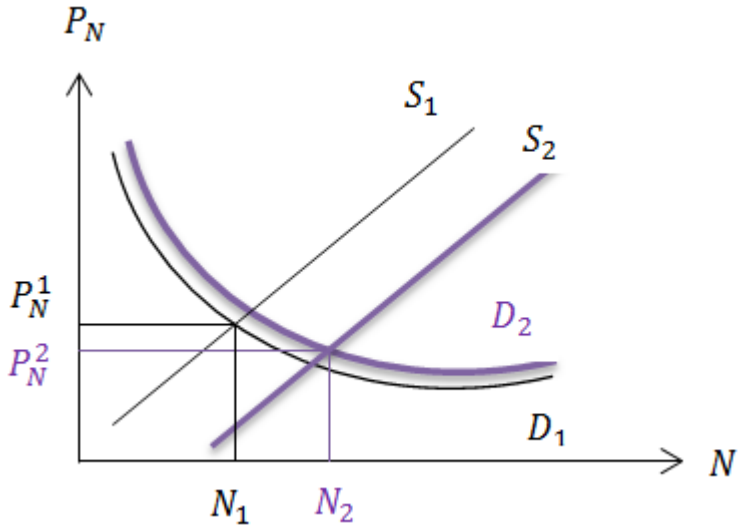


Figure 6 represents similar kind of sensitivity analysis as performed in Figure 2, however now under the assumption of flexible unskilled wage in the non-tradable sector. When μ =0.3, share of total urban income from sector S spent on non-traded good N is relatively high and hence there is a net increase in the demand for N (since sector S expands at the expense of sector U) at initial P_N. However, the increases in the supply of unskilled labour to sectors A and N depress W and therefore price of non-tradable. This yields the same scenario as the one depicted in Figure 5. Hence, as σ_S rises, expansion of sector S and consequent contraction of sectors U and I induce increase in non-traded production by dint of higher supply of unskilled labour, but reduction in W.

However, when μ =0.7, share of urban income from the contracting vertically integrated sector U spent on non-tradable is relatively higher. Therefore, there is a net decline in the demand for and supply of non-tradable at initial P_N. But this dominant supply effect leads to an increase in P_N (supply curve shifts upwards by more than the downward shift in demand curve, as shown in Figure 7 below). Given the proportional relationship between competitive unskilled wage and P_N, as laid in Equation (5.1), this latter effect outweighs the former impact on W and we observe a net increase in W but a decline in non-traded production in Figure 3 for μ =0.7.

Figure 6: Movements in Non-traded Production (N) & Informal Wage (W) following 24% Tariff-cut on Imports of M, for Different σ_S at μ=0.3 & μ=0.7, under Flexible Wage in Sector N

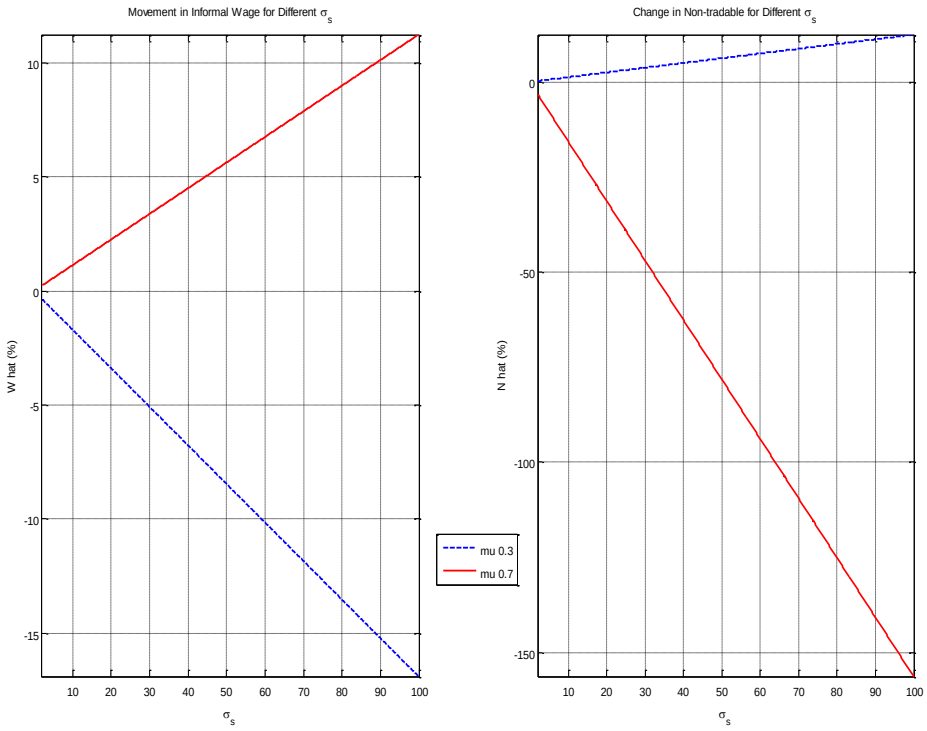
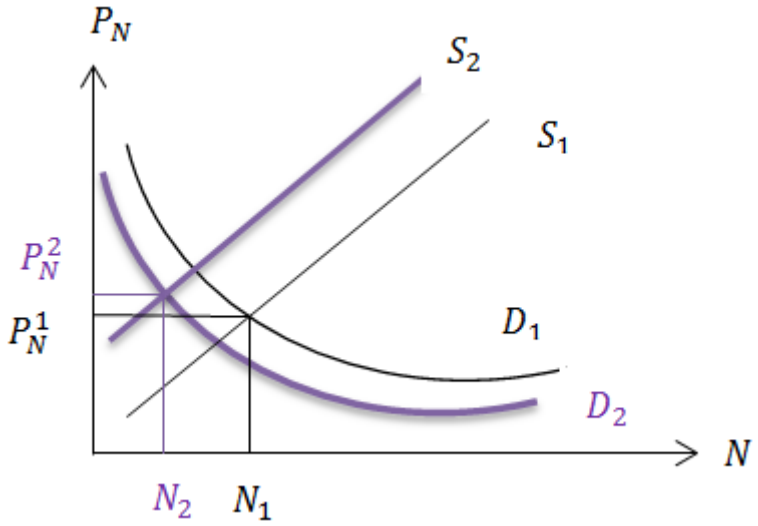


Figure 7: Comparative Static Response in the Domestic Market for N under Flexible Unskilled Wage with μ =0.7



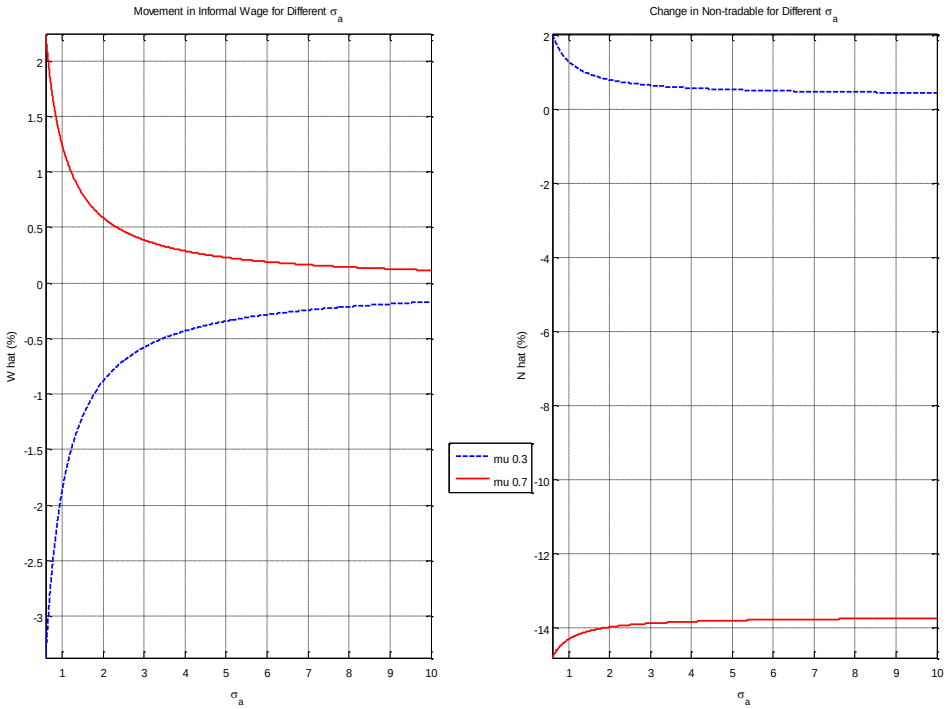
Another interesting exercise has been tracing out the movements of production of N and resulting movement of W under flexible wage in the non-traded sector owing to a 24% tariff reduction on the imports of M by changing σ_A, the elasticity of substitution between unskilled labour and land-capital in the agricultural sector, from 0.6 to 3. This analysis has been motivated by an interesting observation in Golder et al. (2014) who have reported that σ_A can either be less than (but closer to) or more than unity, with preferred estimated value as 1.2 (obtained by direct estimation of CES production function using non-linear least squares approach) that has been taken as the benchmark value in the earlier analyses for varying σ_S. For the sake of brevity this paper only examines this under flexible W assumption in sector N, since that renders seemingly counter-intuitive results.

Although the retrenched unskilled workers from sectors U and I flow to sectors A and N, when μ =0.3, producers in sectors N demand more of the unskilled workers. This will raise the demand for unskilled workers in sector N, imposing an upward pressure on informal wage ($\widehat{W}$ starts becoming less negative in Figure 8). Given Equation (5.1), this leads to an increase in non-traded price and subsequent reduction in the supply of N. This additional supply effect induces sector N to release some unskilled labour to sector A. For low values of σ_A, even with the increase in W producers in sector A would be relatively less willing to substitute unskilled labour by land-capital and continue to demand unskilled labour for the expansion of sector A. Thus, W continues to go up for low values of σ_A, but after a certain level, for relatively higher values of σ_A, producers in sector A substitute land-capital for relatively costlier unskilled labour that imposes a downward pull on W and consequently on

P_N. These retrenched unskilled workers from sector A will now migrate to sector N and that exerts an upward push on non-traded production. Therefore, the resultant trajectory of $\widehat{N}$ takes a convex (to the origin) pattern while that of $\widehat{W}$ takes a concave (from the origin) pattern from lower to higher values of σ_A for μ =0.3.

For μ =0.7, demand for N falls by the urban consumers as a net effect whereas retrenchment of unskilled workers from sectors U and I leads to an excess supply of unskilled labour in the competitive unskilled labour market of sector N and thereby reducing W. However, with the increase in σ_A, producers in sector A are going to substitute land-capital by labour in production that imposes a consequent upward pressure on W, which, in turn, would increase P_N, implying a subsequent reduction in supply of N. Therefore, we observe exactly mirror images to those for μ =0.3 in the trajectories of $\widehat{N}$ and $\widehat{W}$ (i.e. concave from the origin for $\widehat{N}$ and convex to the origin for $\widehat{W}$) from lower to higher values of σ_A for μ =0.7.

Figure 8: Movements in Non-traded Production (N) & Informal Wage (W) following 24% Tariff-cut on Imports of M, for Different σ_A at μ=0.3 & μ=0.7, under Flexible Wage in Sector N



Employment of Unskilled Workers in the Informal Sector

Note that, now we have two sectors with 'informal' labour market: one is sector A and another is sector N. The total employment of unskilled workers in the informal sectors is therefore, given by

$$\widehat{L_A} + \widehat{L_N} = \left(\theta_{LN} - \frac{\sigma_A}{\theta_{TA}}\right)\widehat{W} \qquad (16.1)$$

Therefore, if unskilled labour and land-capital are less than perfect substitutes in sector A (i.e. $\sigma_A < 1$), informal employment changes in the same direction of change in W if $\theta_{LN}\theta_{TA} > \sigma_A$. However, if $\sigma_A > 1$, direction of change in informal employment would be opposite to that in W. This is because, when W falls P_N falls and that reduces demand for the non-tradable, which, in turn, affects non-traded production; while if $\sigma_A > 1$, producers in sector A would be quite willing to minimise production cost by substituting retrenched unskilled labour for capital and that can boost employment of unskilled workers in the informal labour market of sector A. However, for low values of σ_A sector A producers would also be unwilling to employ additional units of retrenched worker for capital. Therefore total employment in the informal sector will also fall in that case.

2.3 Expression for Relative Wage-inequality

Since the unskilled labourers are entitled to receive either the flexible wage in the informal unorganised sector or the fixed wage in the organised sector, we can define an average unskilled wage of the economy and can consequently define the ratio of skilled wage over the average unskilled wage of the economy as the expression for relative wage-gap in the economy under consideration.

(a) Non-tradable Production under Contractual Wage

With flexible wage in sector A but unionised wage in sectors U, I and N the expression for the average unskilled wage in the economy becomes the weighted average of total money wage paid in respective sectors, when the weights are employment shares of respective sectors.

$$W_A = W\lambda_{LA} + W^*(\lambda_{LI} + \lambda_{LU} + \lambda_{LN})$$

$$\text{Or, } W_A = W^* - (W^* - W)\lambda_{LA}$$

Since $\sum_i \lambda_{Li} = 1$, where $i = A, I, U, N$.

Therefore,

$$dW_A = dW\lambda_{LA} - Wd\lambda_{LA}$$

Or,

$$\widehat{W_A} = (W\lambda_{LA}/W_A)\widehat{W} - (W\lambda_{LA}/W_A)\left(\hat{a}_{LA} + \hat{A}\right)$$

Since $\lambda_{LA} = (a_{LA}A/\bar{L})$. Therefore,

$$\widehat{W_A} = (W\lambda_{LA}/W_A)\left(1 + \frac{\sigma_A}{\theta_{TA}}\right)\widehat{W} \qquad (17)$$

Therefore, $\widehat{W_A} < 0$ if W falls owing to tariff-cut on the imports of M.

(b) Non-tradable Production in the Informal Sector with Flexible Wages

Just like (a), it can be shown that

$$\widehat{W_A} = (W/W_A)\widehat{W}(\lambda_{LA} + \lambda_{LN}) + \{(W^* - W)/W_A\}(1 - \lambda_{LA} - \lambda_{LN})\widehat{U} \qquad (18)$$

Since $\widehat{U} < 0$, $\widehat{W_A} < 0$ if W falls as a consequence of tariff reduction on the imports of M.

Therefore, the expression for wage-inequality in both (a) and (b) would be

$$\Omega = W_S/W_A$$

Or,

$$\widehat{\Omega} = \widehat{W_S} - \widehat{W_A} \qquad (19)$$

Wherein an increase (decrease) in Ω means a deterioration (improvement) in wage-inequality. As evident from the above discussions, the degree of substitutability between skilled labour

and capital is of utmost importance to determine the fate of sector N and the consequent implication for the unskilled informal wage. Therefore, let us summarise the implications of liberalisation of input trade and the consequent demand-driven rise in skill-premium on the relative wage-inequality for different σ_S in the following table, on the basis of the observations from Figure 3 and Figure 5:

Table 1: Tariff-cut on Imports of M and Directions of Relative Wage-inequality for Rising σ_S

	Case I (Unionised Unskilled Wage in Sector N)	Case II (Flexible Unskilled Wage in Sector N)
μ =0.3	$\hat{\Omega} > 0$	$\hat{\Omega} > 0$ and getting magnified σ_S rises
μ =0.7	$\hat{\Omega} > 0$ and getting magnified	$\hat{\Omega} > 0$ or < 0, $\hat{\Omega}$ gets smaller even if >0

3. An Extension – Tariff Reduction on Imports of M with Unemployment of Skilled Labour

This section considers a more realistic scenario with full employment of unskilled labour but unemployment of skilled labour. We have incorporated unemployment of skilled labour using efficiency wage hypothesis, in a similar fashion of Gupta and Dutta (2011) where efficiency of a skilled labourer varies positively with its wage rate and the unemployment rate in the skilled labour market.[11] A higher wage rate motivates the skilled worker to work hard; and a higher unemployment rate accentuates the disutility in the presence of a threat of firing and subsequently makes the skilled worker more disciplined.

[11] In this context, one may also see works of Agell and Lundborg (1992, 1995), Gupta (2000), Chaudhuri and Banerjee (2010) and so on.

Zero-profit condition for sector *S* changes in the following way

$$(W_S/h)a_{SS} + ra_{KS} + P_M{}^*(1+t)a_{MS} = P_S{}^* \qquad (4.1)$$

Where (W_S/h) is the effective unit cost employing skilled labour, or nominal skilled wage paid *per efficiency unit*, with $h = h(W_S, v)$ being the efficiency of the skilled worker with $h_1 > 0, h_2 > 0, h_{11} < 0, h_{22} < 0$ (i.e. positive and concave in terms of every argument).

Interestingly, the presence of non-traded final good implies in this framework that the skilled wage *per efficiency unit*, unemployment rate of skilled labour and competitive unskilled wage should simultaneously be affected by any perturbation in non-traded production and equilibrium price of the non-traded final good.

Micro foundations of such an efficiency function are available in several well-known works including Shapiro and Stiglitz (1984), Pisauro (1991), Gupta and Gupta (2001) etc. Minimising (W_S/h) with respect to W_S the following first-order condition of minimisation can be obtained as

$$(\partial h/\partial W_S)(W_S/h) = 1 \qquad (20)$$

This is the modified Solow (1979) condition implying that wage elasticity of efficiency is equal to unity in market for skilled labour.

Also we have

$$\widehat{W_S} - \hat{h} = -\varepsilon_v \hat{v} \qquad (21)$$

Where $\varepsilon_v = (\partial h/\partial v)(v/h) > 0$ is the elasticity of $h(.)$ with respect to v.

However, totally differentiating the new zero-profit condition for sector *S*, for $\hat{t} < 0$

$$\widehat{W_S} - \hat{h} = -(\theta_{MS}/\theta_{SS})T\hat{t} > 0 \qquad (22)$$

Therefore, using Equations (21) – (22) it is straightforward to obtain

$$\hat{v} = (\theta_{MS}/\varepsilon_v\theta_{SS})T\hat{t} < 0 \qquad (23)$$

While differentiating the modified Solow condition and performing a little algebraic manipulation yields (note that $h_{11} < 0$ by the concavity of efficiency function)

$$\widehat{W_S} = [\varepsilon_v h/h_{11}(W_S)^2]\hat{v} > 0 \qquad (24)$$

Therefore, skilled wage increases while unemployment rate of skilled labour falls.

The skilled labour endowment equation will now be modified as (with fixed economy-wide physical endowment of skilled labour, $\overline{L_S}$)

$$a_{SS}S = \overline{L_S}(1-v)h \qquad (8.1)$$

Totally differentiating Equation (8.1) with Equation (7) one can obtain by simple algebraic manipulations and substituting values (note that now $a_{jS} = a_{jS}\left(\frac{W_S}{h}, r\right)$, where $j = S, K$)

$$\widehat{U} = \hat{I} = \{\lambda_{KS}/(1-\lambda_{KS})\}\left[\left\{\left(\frac{v}{1-v}\right) + (\sigma_S - 1)\varepsilon_v\right\}\hat{v} - \widehat{W_S}\right] \qquad (25)$$

And

$$\hat{S} = \widehat{W_S} + \left[-\left(\frac{v}{1-v}\right) - (\sigma_S\theta_{KS} - 1)\varepsilon_v\right]\hat{v} \qquad (26)$$

Therefore, if $\sigma_S \geq (1/\theta_{KS})$, $\hat{S} > 0$ and $\widehat{U}\left(= \hat{I}\right) < 0$ as $\widehat{W_S} > 0, \hat{v} < 0$. That is, for a sufficiently higher degree of elasticity of substitution between skilled labour and capital in sector *S*, sector *U* contracts while sector *S* expands.

In this case, it will be appropriate to consider a Gini index of wage-inequality,[12] derived as $\Delta = (W_S/W_A)$, as before:

$$G = \frac{\overline{L_S}v\{\overline{L_U}+\overline{L_S}(1-v)\Delta\}+(\overline{L_S})(\overline{L_U})(1-v)(\Delta-1)}{(\overline{L_S}+\overline{L_U}-1)\{\overline{L_U}+\overline{L_S}(1-v)\Delta\}} \qquad (27)$$

The intuitions are fairly straightforward. A decline in tariff on the imported input *M* encourage sector *S* producers to expand by hiring more skilled labour, since skilled labour is specific input used in sector *S*. This raises wage received by every skilled worker *per efficiency unit*. Consequently, effective rate of unemployment of skilled labour also falls. Thus, there are two effects operating on the efficiency of each skilled worker employed: one is the positive impact of higher money wage received; the other is a negative effect due to

[12] In the full-employment case considered before, $G = \frac{(\overline{L_S})(\overline{L_U})(\Delta-1)}{(\overline{L_S}+\overline{L_U}-1)(\overline{L_U}+\overline{L_S}\Delta)}$. This can be verified by putting $v = 0$. It can be shown that $(dG/d\Delta) > 0$ in a full-employment model (one can see Gupta and Dutta, 2011), where $\Delta = (W_S/W_A)$, as considered in the earlier scenario. So without any loss of generality, one can take skilled wage relative to the average unskilled wage of the economy as the measure of wage-gap in a full-employment model.

decline in the effective rate of unemployment. Therefore, the producers in sector S can now economise production costs by paying higher money wages only to the efficient skilled workers and replacing the relatively less efficient workers by cheaper capital. However, this is possible only if the substitutability between capital and skilled labour is sufficiently high. In that case, sector S will expand but sector U and I contract by releasing additional units of capital to sector S.

Likewise the full-employment scenario, in case of production under unionised wage, the expression in Equation (15) changes to

$$\widehat{N} = \left(1 - \left({}^{\mu}/_{1-\lambda_{KS}}\right)\right)\begin{bmatrix} \{h/h_{11}(W_S)^2\} - \\ \left({}^{v}/_{1-v}\right) \\ \left({}^{\lambda_{KS}}/_{1-\lambda_{KS}}\right)\sigma_S(1-\theta_{KS}) \end{bmatrix}\varepsilon_v(\theta_{MS}/\varepsilon_v\theta_{SS})T\hat{t} \qquad (28)$$

Since $h_{11} < 0$, the bracketed expression is negative. So Equation (28) yields $\widehat{N} \lesseqgtr 0$ when $\hat{t} < 0$ iff $\mu \gtreqless (1-\lambda_{KS})$. Therefore, as in the full-employment case, under contractual wage in the finished non-tradable producing sector (N), the resultant impact on the production of N depends on the magnitude of μ (and/or equivalently, on $(1-\mu)$), or in other words, on the relative domestic demand for the non-tradable by urban population working in vertically integrated sector U (and sector I) and/or sector S. As discussed above, tariff cut on imports of M creates more job-opportunities for the skilled workforce, at higher wages per efficiency units, but only to the relatively more productive workers from the unemployment pool. Thus, Equation (28) states that if the relative share of urban income from the vertically integrated sector U spent on N is sufficiently small ($\mu < (1-\lambda_{KS})$), the resultant demand for the finished non-tradable will be guided by the increase in demand for the urban population working in the skill-intensive sector at higher effective wages.

Substituting $\widehat{N}$ in Equation (13), one can solve for $\widehat{W}$ under the scenario when the production in sector N is organised in a unionised unskilled labour market. Assigning λ_{KS} the benchmark value of 0.4 as before,[13] μ =0.3 and μ =0.7 mimic exactly the similar trajectories for the changes in non-traded production and informal wage as in Figure 3 (however non-linearity would be observed due to the presence of quadratic terms in the expressions under consideration).

[13] See Table A1.1 in Appendix.

In case of non-traded production with flexible unskilled wage, Equation (28) is changed to

$$\theta_{LN}\widehat{W} + \widehat{N} = \left(1 - \left({}^{\mu}/_{1-\lambda_{KS}}\right)\right)\begin{bmatrix} \{h/h_{11}(W_S)^2\} - \\ \left({}^{v}/_{1-v}\right) \\ \left({}^{\lambda_{KS}}/_{1-\lambda_{KS}}\right)\sigma_S(1-\theta_{KS}) \end{bmatrix}\varepsilon_v(\theta_{MS}/\varepsilon_v\theta_{SS})T\hat{t} \qquad (29)$$

Solving this equation together with Equation (13), one can solve for $\widehat{W}$ under the scenario when the production in sector N is organised in informal (non-unionised) unskilled labour market. As in the full-employment scenario, there is an additional supply-effect that depresses informal unskilled wage and thereby P_N and thus adds to the ambiguity in non-traded production as well.

Therefore, as before, the effect on real income of the urban population and the demand for the non-tradable will be ambiguous. Consequently, the direction of change in competitive informal wage (W) and thereby the direction of change in Gini will also be ambiguous in this extended model as well for either of the scenarios – with unionised unskilled labour market in sector N and with flexible unskilled wage in sector N. Therefore, in qualitative terms, the resultant implications on unskilled informal wage and the relative income-inequality are very similar to the results obtained under the full-employment model considered in Section 2, which demonstrates the robustness of the results obtained under the full-employment model.

4. Concluding Remarks

Growth acceleration in skill-intensive sectors has been one of the most prominent features of the liberalisation experience in India. On the other hand, liberalisation has facilitated import of capital goods and thus skill-intensive foreign technology that leads to increased demand for skilled workforce driving their wages up. This paper explores the general equilibrium impact of such trade-induced growth in the skill-intensive sector on informal sector wages and employment and most importantly, how this impact is mediated through the existence of finished non-tradable and the corresponding domestic demand-supply forces. This paper re-establishes the claim put forward by Marjit and Acharyya (2003) that the organisation of

production of the non-traded final good is indeed important – in particular, whether the production cost of the non-tradable is market determined or not. The numerical analysis explores this point further, with varying elasticities of factor substitution in skill-intensive and agricultural production respectively. Therefore, this paper challenges the view that the relative wage-inequality in a DC like India with rigid organised sector labour market has unequivocally been governed only by the increase in the skilled wages. The sector-level general equilibrium approach adopted in this paper has not only been able to enlighten the role of various degrees of factor substitutability in production organised in different sectors, but also to highlight the role of non-traded consumption goods in determining the supply of unskilled labour to the informal (unorganised) sector and consequently the implication on competitive unskilled wage and subsequently, the direction of the relative wage-gap. Finally an extended framework with unemployment of skilled labour has also been presented that effectively yields similar conclusions obtained under full-employment model and thus demonstrates the robustness of the full-employment results. Therefore, the relationships and results are indeed important to formulate policies aiming at betterment of the position of the unskilled poor workers. However one future extension of this exercise could be introducing skill-formation and capital-adjustment costs into the basic full-employment static general equilibrium model under consideration.[14]

[14] This is now work in progress.

Appendix

Table A1.1: Parameter Values for Sensitivity Analyses

Parameters	Description	Values
θ_{LN}	Cost-share of labour in sector N	0.5
θ_{LA}	Cost-share of labour in sector A	0.6
θ_{TA}	Cost-share of land-capital in sector A	$0.4= (1-\theta_{LA})$
θ_{SS}	Cost-share of skilled-labour in sector S	0.6
θ_{MS}	Cost-share of imported input in sector S	0.1 (constant)
θ_{KS}	Cost-share of capital in sector S	0.3
λ_{KS}	Share of capital used in sector S	0.4
λ_{LN}	Share of unskilled labour employed in sector N	0.3
λ_{LA}	Share of unskilled labour employed in sector A	0.5
σ_S	Elasticity of substitution between skilled labour and capital in sector S	[1.5,3.7,100]
σ_A	Elasticity of substitution between labour and land-capital in sector A	$[0.6, 1.2, 3]$

Source: Abraham 2010, Berman et al. 2005, Marjit and Kar 2008, Marjit et al. 2011, Seker & Rodriguez-Delgado (2011), Broda et al. (2006) (for the ranges of σ_S) and Golder et al. (2014) (for ranges of σ_A).

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