Trade Liberalization, Export Quality and Three Dimensions of Wage Inequality

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Abstract

For a small open economy with diverse export pattern and segmented labour market, we show that reduction of tariff on import of a homogeneous good as an indirect export promotion strategy will upgrade export quality if higher quality varieties require more intensive use capital than skilled labour. But, quality variation, regardless of being upgraded or downgraded, accentuates wage inequality in all its three dimensions through greater informalization of the economy, when capital is immobile across formal and informal sectors. When capital is homogeneous and mobile, the initial level of export quality and relative labour intensity of informal sector matter. The result holds regardless of whether the quality-differentiated export good is domestically consumed or not.

Keywords: Trade Liberalization, Export Quality, Wage Inequality, Informalisation

JEL Codes: F16, J31, J42

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1. Introduction

This paper explores how export quality variation induced by a tariff reduction affects wage inequality, in its three different dimensions (defined later), through displacement of unskilled workers from the formal to the informal sectors.

This concern assumes relevance in the following context. Export baskets of countries like China, Brazil, India and South Africa display goods ranging from unskilled labour intensive goods to skill intensive ones. Availability of specific types of skilled labour has made these countries exporters of products like chemicals, software, office equipment, transport equipment, and scientific instruments, alongside low-skill or unskilled-intensive products like agricultural goods, cotton textiles, leather manufacture etc. But, despite such diverse export pattern, low quality of skilled based goods in particular is severely constraining their export prospects in the advanced richer countries due to change in preference of buyers there towards higher quality goods than cheaper low quality varieties, and thus weakening export-led growth process as a consequence (Sutton [2001], Hallak [2006], Rodrik (2006), Hausman et al. [2007], Baldwin and Harrigan [2011], Manova and Zhang [2012]).[1] This quality constraint on export growth has induced a recent shift in policy focus from promoting exports of cheaper low quality products to incentivizing domestic firms to export higher quality varieties. That is, instead of realising gains in the intensive margin through a rise in volume of exports, realizing gains at the extensive margin through quality upgrading and product innovation through export promotion strategies have become all the more important. This paradigm shift in export promoting strategy has, however, some far reaching implications for wage inequality in particular and income inequality in general. With a handful of recent studies convincingly arguing that recent inequality trends are related to the rising inequality of labor income (ECLAC [2012], Francese and Mulas-Granados [2015], Acemoglu and Robinson [2015], Dabla-Norris et al. [2015], Mare [2016], Greenwood et al. [2012]), containing wage inequality appears to be a major policy challenge for many developing countries. In such a context, since higher quality varieties require more intensive use of skill and

[1] Recent evidences on export-led growth suggest that what matters is not how much a country exports but what it exports.

capital, if such varieties induced by export promotion strategies cause other sectors to squeeze in face of scarce resources, the demand for unskilled labour would fall in the process, lowering the unskilled wage and thereby accentuating wage inequality. Thus, a policy conflict between quality upgrading and containing wage-inequality may be apparent, making it difficult for the policy makers to pursue quality-upgrading export promotion strategies. It is, therefore, worthwhile to explore implications of trade policy induced quality variations for wage inequality, and the policy conflict therefrom. This is what this paper is concerned with. Since tariff reductions acts as an indirect export promotion strategy by shifting scarce resources from the import competing sectors to the export sectors, we consider this as our policy instrument.

In analyzing such potential policy conflict, we take into account segmented labour markets prevalent in most of the developing countries including the countries referred to as our point of focus. As the Indian and Latin American experiences suggest, with coexistence of formal and informal labour markets, import liberalization has further contributed to rise in wage inequality through displacement of workers from the formal to the informal segments, a phenomenon known as informalization, (Bogliaccini [2013], Marjit [2000], Marjit [2003], Marjit, Kar and Beladi [2007]). In view of this, we examine whether policy-induced quality variation further contributes to informalization. In particular, we analyze three dimensions of wage inequality: wage inequality between skilled and informal unskilled workers; between skilled and formal unskilled workers; and, among unskilled workers themselves, that is, between formal and informal unskilled workers, which follows from displacement of workers from the formal to the informal sectors, the so-called process of informalization.

The other of focal point of our analysis is consideration of intensive use of domestic inputs like skilled labour and/or capital in producing higher quality export goods, in contrast to quality upgrading requiring higher intensive use of high-quality imported input. This is consistent with recent empirical observations that have found robust evidence on more intensive use of such domestic inputs in producing higher quality

export goods (Brambilla et al. [2012], Brambilla et al. [2014], Brambilla and Porto [2016]).[2]

Our paper also contributes to the large literature on trade and wage inequality that grew in leaps and bounds following the observed rising trends in wage inequality almost universally across the globe since 1980s (Davis [1996], Feenstra and Hansen [1996], Zhu and Trefler [2001], Marjit and Acharyya [2003], Xu [2003], Marjit and Kar [2005], Chakraborty and Sarkar [2007, 2009], Yabuuchi and Chaudhuri [2008], Anwar [2009], Acharyya [2011]). None of these analyses, however, have accounted for quality variations of skill-based exports as plausible source and cause of the observed rise in wage inequality. But, skill based exports do display a lot of quality variations across countries for variety of reasons including technology and, given the recent evidences cited above, on costs of capital and skill required to produce higher quality varieties. Moreover, in the above context of paradigm shift in export promotion strategy, implications of policy-induced quality variations of skill-based exports on wage inequality cannot be ignored.

Ma and Dei (2009) had also analyzed implications of quality upgrading on wage inequality.[3] But, in contrast to their study of implications of quality upgrading of a domestically produced non-traded good, our focal point is *diverse export pattern*[4] – export of a skill-based quality differentiated good, alongside export of an unskilled-labour produced good – keeping in line with diversified export baskets of China, Brazil, India and South Africa, alongside import of a distinctly different good. Consequently the objective and nature of tariff policy analysis become significantly different as we focus on the potential policy conflict between upgrading export quality and containing wage inequality. Analyzing wage inequality among unskilled workers through informalisation is another major point of departure.

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[2] Schott (2004), on the other hand, found higher unit values of imports of the United States comes from capital- and skill-abundant countries. This also suggests that higher quality export goods may require intensive use of both capital and skilled labour.

[3] The other relevant paper is that of Das (2003) who demonstrated that trade among similar countries increases relative wage in *all* trading nations by improving product quality.

[4] Diverse trade pattern of some of the developing countries as a plausible explanation of wage inequality was put forward by Marjit and Beladi (1998). But, they considered both the skill-based and unskilled-labour produced export goods as homogeneous goods and focused on the complementarity between these goods.

For the purpose of our theoretical analysis, we adopt the small open economy structure of Acharyya and Jones (2001) with a quality-differentiated export good and a set of homogeneous traded goods displaying diverse trade pattern. But, we modify their analytical framework in several directions appropriately to address the above mentioned concerns. The small open economy under consideration produces three goods: a skill-based quality differentiated export good, an unskilled-labour intensive homogeneous export good and a capital intensive homogeneous import competing good. While the import competing good is produced in the formal sector, the homogeneous export good is produced in the informal sector. Manufacturing and agricultural goods exemplify this segmentation in developing countries. In such a set up with the quality differentiated export good not domestically consumed in the benchmark case, we establish the following results. First, tariff reduction induces upgrading of export quality only when higher quality varieties require more intensive use of capital than skilled labour. Second, when capital used in formal and informal sectors are of specific type (or, capital is immobile across formal and informal sectors), tariff reduction unambiguously raises the skilled wage and lowers the unskilled wage thus accentuating the initial wage inequality. The fall in unskilled wage, and consequently wage inequality, is further reinforced by the induced change in export quality, irrespective of whether it is upgraded or downgraded. Third, the change in quality lowers the availability of capital to the formal sector that lowers its output and thus demand for and employment of unskilled labour there. Workers displaced from the formal sector move to the informal sector, and thereby cause informalisation of the economy. Wage inequality among unskilled workers thus accentuate as well. Fourth, when capital is mobile across formal and informal sectors, tariff reduction raises both the skilled and the unskilled wage, and the initial level of quality become important in determining whether wage inequality rises or declines. These results do not change when the economy consumes the quality-differentiated good domestically.

Rest of the paper is organized as follows. In Section 2 we set out our analytical structure and examine effect of tariff reduction in the benchmark case where the quality-differentiated export good is not domestically consumed. Section 3 checks the robustness of results when this good is also domestically consumed. In Section 4 we conclude the paper.

1. Analytical Structure and Results

2.1 The Benchmark Model with Sector-specific capital

Consider a small open economy producing three goods: a homogeneous import competing manufacturing good (Y), a homogeneous agricultural export good (X) and a quality differentiated export good (Z), whose quality is observable and indexed by $Q \in [0,1]$. Goods Y and Z use the same type of capital (K) whereas good X uses a different type of capital (K_X). On the other hand, whereas X and Y use unskilled labour (L), good Z requires skilled labour (S). Production of Y is organized in the formal sector where unskilled labour is paid a fixed wage $\overline{w}$, and X is produced in the informal segment of the economy where unskilled workers are paid the competitive informal wage w. Production technologies for X and Y follows CRS, and allow per unit input requirements (a_{ij}, $i = L, K, j = X, Y$) to vary with relevant wage-rental ratios. For good Z we assume that per unit requirement of S and K, are fixed for any given Q, but increases at an increasing rate with quality upgrading reflecting diminishing returns:

$$a_{iZ} = a_{iZ}(Q), a'_{iZ}(Q) > 0, a''_{iZ}(Q) > 0, \quad i = S, K \tag{1}$$

The small country faces given world prices of all the traded goods, P_j^W, j = X, Y and Z. P_Z^W, however, is higher for higher quality varieties rises reflecting foreign buyers' willingness to pay for higher quality of Z: $P_Z^{W'}(Q) > 0$, $P_Z^{W''}(Q) > 0$.

With exchange rate normalized to unity and an ad valorem tariff at the rate 0 < t < 1 imposed on imports of Y, perfect competition in all domestic markets, which, , gives us the following zero-profit conditions:

$$P_X = P_X^W = a_{LX} w + a_{TX} r_X \tag{2}$$

$$P_Y = (1+t) P_Y^W = a_{LY} \overline{w} + a_{KY} r \tag{3}$$

$$P_Z^W(Q) = a_{KZ}(Q) r + a_{SZ}(Q) w_S \tag{4}$$

where, r (r_X) is the rate of return to capital used in Y and Z (in X), w_S is the skilled wage, and t is the ad valorem tariff rate.

Profit maximizing export quality Q_0 is given by the following marginal condition:

$$P_Z^{W'}(Q_0) = a'_{KZ}(Q_0)r + a'_{SZ}(Q_0)w_S \quad (5)$$

The model is closed by the full employment conditions that are ensured by flexibility of rates of return to different types of capital and informal wage:

$$\overline{K} - a_{KZ}(Q)Z = \widetilde{K}(Q) = a_{KY}Y \quad (6)$$

$$\overline{S} = a_{SZ}(Q)Z \quad (7)$$

$$\overline{K}_X = a_{TX}X \quad (8)$$

$$\overline{L} = a_{LX}X + a_{LY}Y \quad (9)$$

where, X, Y and Z are respectively output levels of the three traded goods.

Note that despite fixed money wage in the formal sector, those who cannot be absorbed there are employed in the informal sector producing the export good X.

Above set of eight equations in (2) – (9) determines the eight variables in our system: w_S, w, r_X, r, Q, X, Y and Z. Note that given the minimum formal money wage and the world price of the import good, by the zero-profit condition (3) the ad valorem tariff rate determines the rate of return to capital used in (Y, Z) subsystem. This, in turn, determines the skilled wage for any given level of quality Q and corresponding world price of good Z (see eq. (4)). On the other hand, for any given skilled wage and the rate of return to capital, producers choose the quality of good Z that satisfies the marginal condition (5). Since, by the zero-profit condition (4), w_S and r are inversely related[5], so profit maximizing quality is related to the cost of capital (or skill) as follows:

[5] By envelope theorem, the skilled wage will be invariant with respect to the quality variation.

$$\hat{Q} = \frac{P_Z^W}{\delta Q^2}\theta_{KZ}(\gamma_{KZ} - \gamma_{SZ})\hat{r} \qquad (10)$$

where, $\gamma_{iZ} = \frac{\partial a_{iZ}}{\partial Q}\frac{Q}{a_{iZ}}, i = S, K$, denote the quality elasticity of per unit requirements of input i, and $\delta \equiv \left[eP_Z^{W''}(Q) - w_S a''_{SZ}(Q) - ra''_{KZ}(Q) \right] < 0$ by the second order condition for profit maximization.

Thus, *at initial quality level*, a policy induced fall (rise) in r, and corresponding rise (fall) in skilled wage, will lower (raise) the marginal cost of quality and accordingly raise (lower) the quality choice, if quality upgrading requires more (less) intensive use of capital than skilled labour $(\gamma_{KZ} > \gamma_{SZ}$ or $\gamma_{KZ} < \gamma_{SZ})$. This relationship is shown in Figure 1.

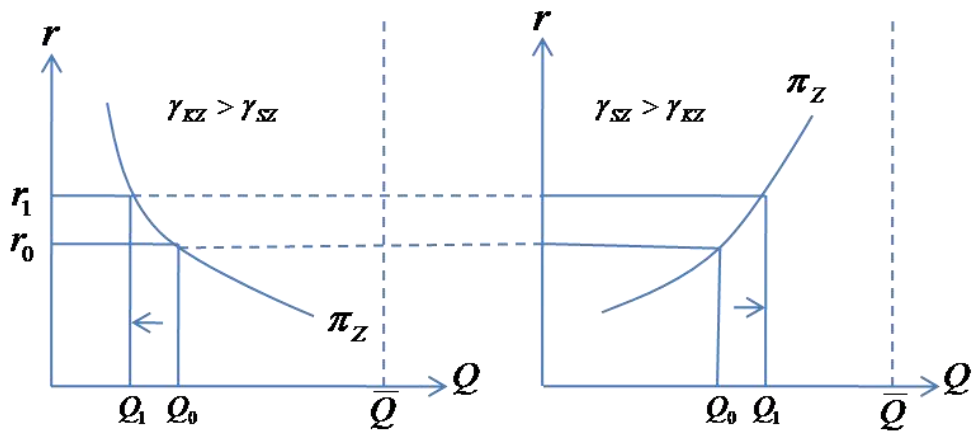

Figure 1: Choice of Equilibrium Export Quality

The subset of export baskets of developing countries like China, India and Brazil, containing high value addition quality differentiated goods, display wide variations in skill (or capital) intensities for quality upgrading. Higher quality of goods like aerospace, scientific instruments, defence equipments, household and office equipments, electrical appliances, agro based products are more capital intensive, $(\gamma_{KZ} > \gamma_{SZ})$,whereas, higher qualities of goods and services like software, jewellery, diamond cutting and polishing, ITeS, and financial services are more skill intensive, $(\gamma_{KZ} > \gamma_{SZ})$. Such asymmetry in use of skilled labour and capital for quality upgrading means that rise in cost of capital (and corresponding rise in the skilled wage) will

have altogether different incentives for different goods varying in relative skill (or capital) requirements.

Thus, once a tariff rate determines the rate of return to capital *r*, it correspondingly determines the profit maximizing quality, independent of the output levels and the informal wage. But, this choice of quality level will determine the informal wage through availability of capital for production of the import-competing good Y (see eq. (6)). Note here that the informal wage and return to the capital specific to the informal sector (r_X) cannot be determined independent of the capital and labour available for production of goods X and Y, unlike the skilled wage and the rate of return to capital used in the (Y, Z) sectors. This follows from the specific factor structure of the (X,Y) subsystem (or capital immobility across formal and informal sectors). Thus, quality variation affects wage inequality through reallocation of unskilled workers across formal and informal sectors and its consequent impact on the informal wage. Before proceeding further, note that we can define three dimensions of wage inequality. First, between skilled workers and formal unskilled workers, which is captured through the change in skilled wage; between skilled and informal unskilled workers, captured through $\hat{w}_S - \hat{w}$; and, among the unskilled workers themselves, that is, between formal and informal unskilled workers, which is captured through the change in the informal wage along with the share of the informal sector in total employment of unskilled workers.

2.2 Tariff reduction, Informalization and Wage Inequality

Now, consider a ceteris paribus reduction in the tariff rate. With fixed formal wage this lowers the rate of return to capital. Producers of Y thus substitute costlier labour with cheaper capital per unit of Y. Given the initial level of export quality and corresponding availability of capital for Y production, this causes a fall in the scale of output of Y. Some unskilled workers are thus displaced from the formal Y sector on account of less labour intensive technique being adopted as well as fall in output of Y. Thus, *at initial export quality*, tariff reduction leads to informalization of the economy measured in terms of share of employment of the informal sector X (which, under full employment, equals change in the informal employment):

$$\hat{L}_X = -\hat{L}_Y = -(\hat{a}_{LY} + \hat{Y}) > 0. \tag{11}$$

Given the specificity (or immobility) of formal and informal capital, such informalization, by diminishing marginal productivity of workers, lowers the informal wage *at initial export quality,* causing wage inequality to accentuate not only among skilled and unskilled workers, but also among formal and informal unskilled workers.

Tariff reduction also raises the skilled wage, which, in turn, accentuates wage inequality further. As tariff lowers the capital cost of production of Z at initial Q, it encourages producers to expand production, which, however, cannot be realized since skilled workers are specific to this sector and were initially fully employed. Thus, the skilled wage increases. Algebraically,

$$\hat{w}_S = -\left[\frac{\theta_{KZ}}{\theta_{SZ}\theta_{KY}}\right]\hat{T} > 0 \qquad (12)$$

where, θ_{ij} is the share of factor-i in unit production cost of good j.

Turning now to change in quality of good Z, it is immediate from the earlier discussion and Figure 1 that as tariff lowers the rate of return to capital used in production of good Z (and correspondingly raise the skilled wage) so producers will upgrade quality if $\gamma_{KZ} > \gamma_{SZ}$ (see appendix):

$$\hat{Q} = \frac{\alpha}{\delta}\frac{\theta_{KZ}}{\theta_{KY}}(\gamma_{KZ} - \gamma_{SZ})\hat{T} \qquad (13)$$

where, $\alpha \equiv \frac{eP_Z^W \theta_{KZ}\theta_{LT}}{Q^2\theta_{KT}} > 0$.

Hence, we can write Proposition 1 as follows:

Proposition 1: *Reduction of tariff on the import of good Y will incentivize producers of good Z to raise quality only if quality upgrading requires more intensive use of capital than skilled labour.*

Proof: Follows from (13).

As mentioned earlier, tariff reduction as an indirect export promotion strategy would asymmetrically incentivize producers of different types of skill-based goods that vary from each other in terms of relative requirement of capital (or skill) for quality upgrading.

Turning now to effect on wages, the quality variation though will not change the skilled wage for the reason spelled out earlier, it will affect the informal wage and consequently the wage inequality further through capital reallocation across Z and Y sectors. To see this, note that capital requirement in Z sector changes in two ways. First, if quality is upgraded, it lowers output of Z since higher quality requires more skilled labour which is specific to this sector and the extent of such output contraction is given by $\hat{Z} = -\gamma_{SZ}\hat{Q}$. Thus, on this account less capital is required. Second, capital requirement per unit of output of good Z rises if quality is upgraded, and the extent of such additional capital requirement is given by $\hat{a}_{KZ} = \gamma_{KZ}\hat{Q}$. So, if $\gamma_{SZ} < \gamma_{KZ}$, the condition for which quality is upgraded, then overall capital requirement in Z production will rise. The reverse reasoning shows that if $\gamma_{SZ} > \gamma_{KZ}$, as tariff reduction downgrades quality, larger capital requirement due to expansion of output of Z dominates smaller capital requirement per unit due to quality degradation. Thus, in either case, the overall capital requirement in Z sector rises:

$$\hat{K}_Z = \frac{\alpha}{\delta}(\gamma_{KZ} - \gamma_{SZ})^2 \hat{T} > 0 \tag{14}$$

This result is summarized in the following Lemma:

Lemma 1: *Tariff reduction causes larger capital requirement for production of Z regardless whether it induces quality upgrading or downgrading.*

Proof: Follows from (14).

Thus, by Lemma 1, quality variation lowers capital availability for production of Y and lowers its output. This causes larger informalization, which pushes down the informal wage *further*. Algebraically, the fall in the informal wage is given by,

$$\hat{w} = \frac{1}{A}\frac{\lambda_{KY}\sigma_Y}{\theta_{KY}}\hat{T} - \frac{1}{A}\lambda_{KZ}(\gamma_{KZ} - \gamma_{SZ})\hat{Q} \tag{15}$$

$$where, A = \lambda_{KY}\sigma_Y + \lambda_{KY}\frac{\lambda_{LX}}{\lambda_{LY}}\frac{\sigma_X}{\theta_{KX}} > 0$$

The first term in the parenthesis is the initial effect of tariff reduction, whereas the second term captures the induced effect through quality variation.

Thus, wage inequality worsens even more on all counts: between skilled and informal unskilled workers ($\hat{w}_S - \hat{w} > 0$); between skilled and formal unskilled workers; and between formal and informal unskilled workers, the latter due to informalization.

Therefore,

Proposition 2: *A tariff reduction (a) worsens wage inequality both at initial level of quality, and through quality variation regardless of whether quality is upgraded or downgraded; (b) larger informalisation through quality variation.*

Proof: Part (a) follows from (12) and (15). For part (b), it is sufficient to note that $\hat{L}_X = -\hat{L}_Y = -(\hat{a}_{LY} + \hat{Y}) > 0$, where L_X is the total informal employment of unskilled workers.[6]

Proposition 2 implies that when we account for quality variation of skill-based exports, wage inequality worsens to a greater extent than when such quality variations are not accounted for, as the case in the existing literature. The interesting point to note is that quality variation per se accentuates wage inequality further regardless of whether quality is upgraded and downgraded. This brings out the relevance of accounting for quality variations induced by export promotion strategies like tariff reduction.

On the other hand, from Propositions 1 and 2 it follows that the policy conflict that we mentioned earlier arises when $\gamma_{KZ} > \gamma_{SZ}$. Mitigating wage inequality would require a tariff hike, but that would, on the other hand, downgrade quality of the skill-based exports. Of course, for skill-based export goods for which $\gamma_{KZ} < \gamma_{SZ}$, tariff reduction as an indirect export promotion strategy does not work. A tariff hike would then incentivize upgrading of quality. That would also lower wage inequality. These two observations are more precisely stated in the following two corollaries:

Corollary 1: For tariff as a policy instrument, the policy conflict between upgrading export quality and mitigating wage inequality arises when $\gamma_{KZ} > \gamma_{SZ}$.

Corollary 2: When $\gamma_{KZ} < \gamma_{SZ}$, there would be no policy conflict if the tariff rate is increased as it would raise quality of the skill-based exports and also mitigate wage inequality in all its three dimensions.

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[6] See appendix for details.

1.3. Homogeneous and Mobile Capital

Suppose capital is homogeneous, and mobile across formal and informal sectors. With $r = r_X$, (X, Y) sectors now display HOS production structure, so that *w* and *r* are now determined solely by world prices of X and Y, and thus are *independent of the quality variations*. Tariff reduction will now unambiguously *raise* the informal wage. With the skilled wage rising as well, now the wage inequality may or may not rise:

$$\hat{w}_S - \hat{w} = \frac{1}{\theta_{KY}}\left[\frac{\theta_{KX}}{\theta_{LX}} - \frac{\theta_{KZ}}{\theta_{SZ}}\right]\hat{T} > 0 \text{ if } \frac{\theta_{KX}}{\theta_{LX}} < \frac{\theta_{KZ}}{\theta_{SZ}}$$

Validity of this condition, however, depends on the initial level of export quality, Q_0, because by the technology conditions defined earlier, $\frac{\theta_{KZ}}{\theta_{SZ}}$ is larger (smaller) for a higher initial quality level if quality upgrading requires relatively more capital (skill) than skilled labour (capital). More precisely,

Lemma 2: Define $\mu(Q) \equiv \frac{\theta_{KZ}(Q)}{\theta_{SZ}(Q)}$. Then, $\mu'(Q) < 0 \; \forall \, Q \in [0,1]$ if $\gamma_{KZ} < \gamma_{SZ}$, and $\mu'(Q) > 0 \; \forall \, Q \in [0,1]$ otherwise.

Proof: See appendix.

Thus,

Proposition 3: *When capital is homogeneous and mobile, tariff reduction widens wage inequality between skilled and informal unskilled workers, (a) unambiguously if* $\frac{\theta_{KX}}{\theta_{LX}} < \min[\mu(0), \mu(1)]$*; (b) for all* $Q_0 > \tilde{Q}$ *when* $\gamma_{KZ} > \gamma_{SZ}$*, and for all* $Q_0 < \tilde{Q}$ *when* $\gamma_{KZ} < \gamma_{SZ}$*, if* $\max[\mu(0), \mu(1)] > \frac{\theta_{KX}}{\theta_{LX}} > \min[\mu(0), \mu(1)]$*, where* $\mu(\tilde{Q}) = \frac{\theta_{KX}}{\theta_{LX}}$.

Proof: See appendix.

Figures 2(a) and 2(b) illustrates the alternative cases stated in Proposition 3.

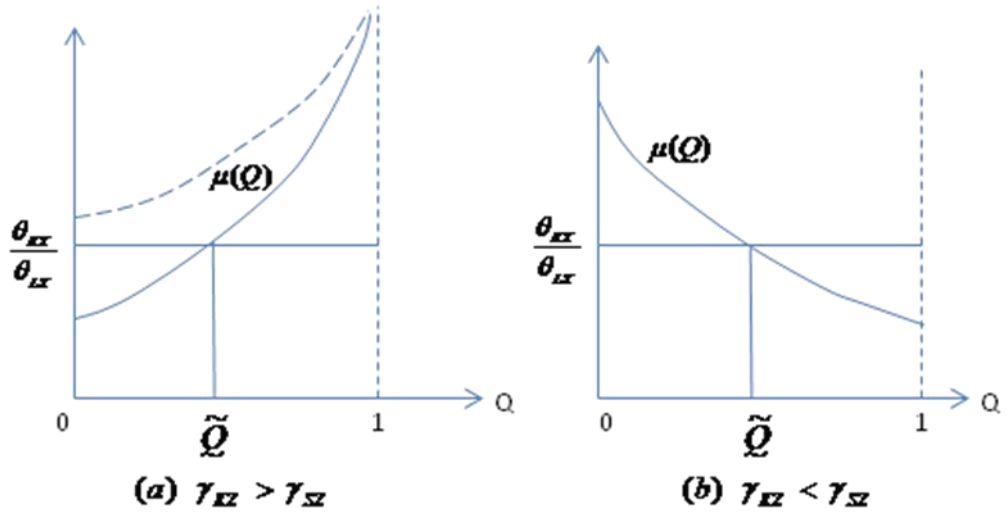

Figure 2: Initial Choice of Quality and Wage Inequality

Let us now turn to informalization. Since now the same capital is used in both X and Y and capital is mobile, so *both* formal and informal sectors adopt more capital intensive techniques as tariff reduction lowers the rate of return to capital. This, at initial export quality, appears in essence as a fall in supply of capital so that similar to the output magnification effect a la Jones (1965), informal sector will expand if it is labour intensive relative to the formal sector, which is more likely. In addition, by Lemma 1, quality variation induced by tariff reduction will lead to further informalization under the same factor intensity condition. Displacement of unskilled labour from formal sector due to technique effect will thus be reinforced by these scale effects causing accentuation of wage inequality among unskilled workers employed in formal and informal sectors *despite a rise in the informal wage*. Hence, we can write the following Proposition:

Proposition 4: *When capital is homogeneous and mobile across formal and informal sectors, tariff reduction induced quality variation causes further informalization if the informal production of export good X labour intensive relative to the formal sector production of the import-competing good Y.*

Proof: See appendix.

Note that in this case wage inequality *among* unskilled workers is ambiguous. As the informal wage now rises, those who were employed in the informal sector before the tariff reduction gains relative to the formal unskilled workers, both still employed there and those displaced therefrom. But those workers who are now displaced from

the formal sector and move to the informal sector are now worse off as they now earn lower wage than the formal wage that they were earning before the tariff reduction.

3. Domestic Demand for commodity Z

Consider now the domestic consumption of the quality differentiated good. Our discussion in Section 2.2 has made it clear that any parametric change can influence quality choice *only* through changes in the factor prices - the rate of return to capital and the skilled wage. Accordingly, domestic consumers now demanding Z will affect quality only if it can affect the rate of return to capital used in Z sector and skilled wage, and correspondingly the marginal cost of quality. But given the rigid unskilled wage in Y sector and the given world price of Y determined in the world market, r and correspondingly w_S are solely determined by the tariff policy. Thus, changes in domestic demand for good Z does not generate any direct change in the factor prices and thereby export quality remains unchanged. Possibility of an *indirect* effect on factor prices through influencing the world market output prices also gets ruled out since we assume our economy to be an insignificant player in the world market. If it was a large country, local demand for Z would have lowered export volumes which, through change in output prices in world market could have changed factor prices and then quality choice. So effect of a tariff cut on choice of export quality is thus invariant with respect to assuming domestic demand for Z.

Turning to the effect on informal wage, note that how change in quality on account of a tariff reduction affects the informal wage depends on the availability of capital to the rest of the economy post quality selection and the changes in output of X and Y that it causes. But neither of these will be affected by our assumption of domestic demand for Z. To verify recall that change in capital availability to the rest of the economy due to change in export quality (which always falls irrespective of whether quality is upgraded or lowered) is determined by relative skill intensities of higher qualities of Z. And finally, irrespective of how this changes the composition of output of X and Y, it is imperative that since both X and Y are traded goods, their output levels will always be at full employment thus giving us the competitive value of informal wage that clears the unskilled labour market as a whole. Z being the export good, full capacity output of Z, (permissible by the availability of skilled labour and level of quality), in excess of domestic demand will constitute the volume of export of

Z. Therefore, introducing domestic demand for Z and variations therein caused by the tariff cut will *only* affect the level of its excess supply or the volume of Z being exported.

4. Conclusion

We have shown that when formal and informal sectors use different capital, or capital is immobile across these sectors, tariff induced quality variation, regardless of its direction, causes both larger fall in the informal wage and greater degree of informalization. Thus, wage inequality in all its three dimensions accentuates due to quality variation. When capital is homogeneous and mobile across formal and informal sectors, the informal wage rises, but still wage inequality between skilled labour and informal unskilled labour may increase depending on the level of pre tariff reduction quality level. On the other hand, if informal sector is relatively labour intensive, quality variation causes further informalisation. The wage inequality between formal and informal unskilled workers is bit ambiguous since informalisation takes place with a rise in the informal wage. Finally, these results remain the same when the quality-differentiated export good is domestically consumed.

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Appendix

A.1: Relation between quality and cost of capital.

Total differentiation of the marginal condition (5) for quality choice as given in text yields,

$$P_Z^{W\,''}(Q)dQ = a''_{SZ}(Q)dQw_S + a'_{SZ}(Q)dw_S + ra''_{KZ}(Q)dQ + a'_{KZ}(Q)dr \qquad \text{(A1.1)}$$

$$\Rightarrow \left[P_Z^{W\,''}(Q) - ra''_{KZ}(Q) - w_S a''_{SZ}(Q)\right]dQ = ra'_{KZ}(Q)\hat{r} + w_S a'_{SZ}(Q)\hat{w}_S$$

$$\Rightarrow \delta\hat{Q}Q = \frac{a_{KZ}(Q)r}{P_Z^W}\frac{P_Z^W}{Q}\left[\frac{Qa'_{KZ}(Q)}{a_{KZ}(Q)}\right]\hat{r} + \frac{a_{SZ}(Q)w_S}{P_Z^W}\frac{P_Z^W}{Q}\left[\frac{Qa'_{SZ}(Q)}{a_{SZ}(Q)}\right]\hat{w}_S$$

$$\Rightarrow \delta\hat{Q}Q = \frac{P_Z^W}{Q}\left[\theta_{KZ}\gamma_{KZ}\hat{r} + \theta_{SZ}\gamma_{SZ}\hat{w}_S\right] \qquad \text{(A1.2)}$$

From the zero profit condition in Z sector given by (4), at initial Q, proportional change in skilled wage is given by, $\hat{w}_S = -\frac{\theta_{KZ}}{\theta_{SZ}}\hat{r}$. Substituting this in (A1.2) yields,

$$\Rightarrow \delta\hat{Q}Q = \frac{P_Z^W}{Q}\left[\theta_{KZ}\gamma_{KZ}\hat{r} + \theta_{SZ}\gamma_{SZ}\left(-\frac{\theta_{KZ}}{\theta_{SZ}}\right)\hat{r}\right]$$

$$\Rightarrow \hat{Q} = \frac{P_Z^W}{\delta Q^2}\theta_{KZ}(\gamma_{KZ} - \gamma_{SZ})\hat{r} \qquad \text{(A1.3)}$$

$$\Rightarrow \frac{dQ}{dr} > 0, when, \gamma_{KZ} < \gamma_{SZ}$$

A.2: Determination of change in quality.

Dividing (A1.1) throughout by $\frac{P_Z^W}{Q}$ gives,

$$\Rightarrow \frac{Q^2}{P_Z^W}\delta\hat{Q} = \frac{a_{KZ}(Q)r}{P_Z^W}\left[\frac{Qa'_{KZ}(Q)}{a_{KZ}(Q)}\right]\hat{r} + \frac{a_{SZ}(Q)w_S}{P_Z^W}\left[\frac{Qa'_{SZ}(Q)}{a_{SZ}(Q)}\right]\hat{w}_S$$

$$\Rightarrow \frac{Q^2}{P_Z^W}\delta\hat{Q} = \theta_{KZ}\gamma_{KZ}\hat{r} + \theta_{SZ}\gamma_{SZ}\hat{w}_S$$

Substituting $\hat{r} = \frac{1}{\theta_{KY}}\hat{T}$ and $\hat{w}_S = -\frac{\theta_{KZ}}{\theta_{SZ}\theta_{KY}}\hat{T}$ in the above we get,

$$\begin{aligned} &\Rightarrow \frac{Q^2}{P_Z^W}\delta\hat{Q} = \theta_{KZ}\gamma_{KZ}\frac{\hat{T}}{\theta_{KY}} + \theta_{SZ}\gamma_{SZ}\left(-\frac{\theta_{KZ}\hat{T}}{\theta_{KY}\theta_{SZ}}\right) \\ &\Rightarrow \hat{Q} = \frac{\alpha}{\delta}\frac{\theta_{KZ}}{\theta_{KY}}(\gamma_{KZ} - \gamma_{SZ})\hat{T} \end{aligned} \qquad \text{(A1.4)}$$

A.3: Effect of tariff reduction on informal wage.

Total differentiation of (6), (8) and (9) yields,

$$\hat{\bar{K}} = 0 = \lambda_{KY}(\hat{Y} + \hat{a}_{KY}) + \lambda_{KZ}(\hat{Z} + \gamma_{KZ}\hat{Q}) \qquad \text{(A1.5)}$$

$$\hat{X} = -\hat{a}_{KX} \qquad \text{(A1.6)}$$

$$\hat{\bar{L}} = 0 = \lambda_{LX}(\hat{X} + \hat{a}_{LX}) + \lambda_{LY}(\hat{Y} + \hat{a}_{LY}) \qquad \text{(A1.7)}$$

Substituting (A1.6) in (A1.7) we get:

$$\begin{aligned} &\hat{\bar{L}} = 0 = \lambda_{LX}(\hat{a}_{LX} - \hat{a}_{KX}) + \lambda_{LY}(\hat{Y} + \hat{a}_{LY}) \\ &\Rightarrow \hat{Y} = -\hat{a}_{LY} - \frac{\lambda_{LX}}{\lambda_{LY}}\sigma_X(\hat{r}_X - \hat{w}) \end{aligned} \qquad \text{(A1.8)}$$

where $\sigma_j = \frac{\hat{a}_{Kj} - \hat{a}_{Lj}}{\hat{w} - \hat{r}_j}$. Note that by the condition for least-cost choice of inputs we have (see Jones [1965]):

$$\hat{a}_{KX} = \hat{a}_{KX} - \theta_{KX}\hat{a}_{KX} - \theta_{LX}\hat{a}_{LX}$$
$$\Rightarrow \hat{a}_{KX} = \theta_{LX}(\hat{a}_{KX} - \hat{a}_{LX})$$
$$\Rightarrow \hat{a}_{KX} = \sigma_X\theta_{LX}(\hat{w} - \hat{r}_X)$$

$\hat{a}_{LX}$ and $\hat{a}_{LY}$ can be expressed similarly.

Now total differentiation of (7) yields,

$$\hat{Z} = -\gamma_{SZ}\hat{Q} \tag{A1.9}$$

Substituting (A1.8) and (A1.9) in (A1.5) gives us:

$$0 = \lambda_{KY}(\hat{a}_{KY} - \hat{a}_{LY}) - \lambda_{KY}\frac{\lambda_{LX}}{\lambda_{LY}}\sigma_X(\hat{r}_X - \hat{w}) + \lambda_{KZ}(\gamma_{KZ} - \gamma_{SZ})\hat{Q}$$

$$0 = \lambda_{KY}\sigma_Y(\hat{w} - \hat{r}) + \lambda_{KY}\frac{\lambda_{LX}}{\lambda_{LY}}\frac{\sigma_X}{\theta_{KX}}\hat{w} + \lambda_{KZ}(\gamma_{KZ} - \gamma_{SZ})\hat{Q}$$

$$\Rightarrow \left[\lambda_{KY}\sigma_Y + \lambda_{KY}\frac{\lambda_{LX}}{\lambda_{LY}}\frac{\sigma_X}{\theta_{KX}}\right]\hat{w} = \frac{\lambda_{KY}\sigma_Y}{\theta_{KY}}\hat{T} - \lambda_{KZ}(\gamma_{KZ} - \gamma_{SZ})\hat{Q}$$

$$\Rightarrow \hat{w} = \frac{1}{A}\frac{\lambda_{KY}\sigma_Y}{\theta_{KY}}\hat{T} - \frac{1}{A}\lambda_{KZ}(\gamma_{KZ} - \gamma_{SZ})\hat{Q} \tag{A1.10}$$

$$where, A = \lambda_{KY}\sigma_Y + \lambda_{KY}\frac{\lambda_{LX}}{\lambda_{LY}}\frac{\sigma_X}{\theta_{KX}} > 0$$

Note the first term in RHS of (A1.10) is the direct effect of tariff cut on informal wage and the second term is the quality induced effect.

Substituting the expression for quality change from (A1.4) in (A1.10) we get the final expression for proportional change in informal wage as,

$$\hat{w} = \frac{1}{A}\frac{\lambda_{KY}\sigma_Y}{\theta_{KY}}\hat{T} - \frac{1}{A}\frac{\alpha}{\delta}\frac{\lambda_{KZ}\theta_{KZ}}{\theta_{KY}}(\gamma_{KZ} - \gamma_{SZ})^2\hat{T}$$

$$\Rightarrow \hat{w} = \frac{1}{A\theta_{KY}}\left[\lambda_{KY}\sigma_Y - \frac{\alpha}{\delta}\lambda_{KZ}\theta_{KZ}(\gamma_{KZ} - \gamma_{SZ})^2\right]\hat{T} \tag{A1.11}$$

Note that the term within third bracket in the above expression is positive since $\delta < 0$.

A.4: Proof of Proposition 2(b).

Equation (9) from the text can be rewritten as,

$$\bar{L} = L_e = L_X + L_Y$$

Total differentiating the above yields,

$$\hat{L}_X = -\hat{L}_Y = -(\hat{Y} + \hat{a}_{LY}) \tag{A1.12}$$

The above gives the rate of informalisation of unskilled workers on account of tariff cut.

Substituting $\hat{Y}$ from (A1.8), $\hat{r}_X = -\frac{\theta_{LX}}{\theta_{KX}}\hat{w}$ and $\hat{w}$ from (A1.11) in (A1.12) gives,

$$\hat{L}_X = -(\hat{a}_{LY} + \hat{Y}) = -\left(\hat{a}_{LY} - \hat{a}_{LY} - \frac{\lambda_{LX}}{\lambda_{LY}} \sigma_X (\hat{r}_X - \hat{w}) \right)$$

$$\Rightarrow \hat{L}_X = -\frac{\lambda_{LX}}{\lambda_{LY}} \sigma_X \frac{\hat{w}}{\theta_{KX}} \tag{A1.13}$$

$$\Rightarrow \hat{L}_X = -\frac{\lambda_{LX}\sigma_X}{\lambda_{LY}\theta_{KX}} \frac{1}{A\theta_{KY}} \left[\lambda_{KY}\sigma_Y - \frac{\alpha}{\delta} \lambda_{KZ}\theta_{KZ}(\gamma_{KZ} - \gamma_{SZ})^2 \right] \hat{T} > 0$$

A.5: Proof of Lemma 2.

Given the definition of cost share of capital in Z production, we can write θ_{KZ} as,

$P_Z^W(Q)\theta_{KZ} = a_{KZ}(Q)r$

Differentiating the above for a given r,

$$P_Z^{W'}(Q)\theta_{KZ}dQ + P_Z^W(Q)d\theta_{KZ} = a'_{KZ}(Q)rdQ$$

$$\Rightarrow P_Z^W(Q)\left(\frac{P_Z^{W'}(Q)Q}{P_Z^W(Q)} \right)\theta_{KZ}\hat{Q} + P_Z^W(Q)d\theta_{KZ} = ra_{KZ}(Q)\left(\frac{a'_{KZ}(Q)Q}{a_{KZ}(Q)} \right)\hat{Q}$$

$$\Rightarrow P_Z^W(Q)d\theta_{KZ} = (ra_{KZ}(Q)\gamma_{KZ} - P_Z^W(Q)\gamma_Z\theta_{KZ})\hat{Q}$$

$$\Rightarrow P_Z^W(Q)d\theta_{KZ} = P_Z^W(Q)\theta_{KZ}(\gamma_{KZ} - \gamma_Z)\hat{Q}$$

$$\Rightarrow d\theta_{KZ} = \theta_{KZ}(\gamma_{KZ} - \gamma_Z)\hat{Q} \tag{A1.14}$$

Similarly, $d\theta_{SZ} = \theta_{SZ}(\gamma_{SZ} - \gamma_Z)\hat{Q}$

Now by definition, $\mu(Q) \equiv \frac{\theta_{KZ}(Q)}{\theta_{SZ}(Q)}$, that is, $\mu(Q)\theta_{SZ}(Q) = \theta_{KZ}(Q)$

Total differentiation gives us,

$$d\mu(Q)\theta_{SZ}(Q) + \mu(Q)d\theta_{SZ}(Q) = d\theta_{KZ}(Q)$$

$$\Rightarrow \frac{d\mu(Q)}{dQ}\theta_{SZ}(Q) + \mu(Q)\frac{d\theta_{SZ}(Q)}{dQ} = \frac{d\theta_{KZ}(Q)}{dQ}$$

$$\Rightarrow \frac{d\mu(Q)}{dQ}\theta_{SZ}(Q) = \frac{d\theta_{KZ}(Q)}{dQ} - \mu(Q)\frac{d\theta_{SZ}(Q)}{dQ}$$

Substituting expression for $d\theta_{KZ}$ from (A1.14) in the above gives,

$$\Rightarrow \frac{d\mu(Q)}{dQ}\theta_{SZ}(Q) = \frac{\theta_{KZ}(\gamma_{KZ} - \gamma_Z)}{Q} - \mu(Q)\frac{\theta_{SZ}(\gamma_{SZ} - \gamma_Z)}{Q}$$

$$\Rightarrow \frac{d\mu(Q)}{dQ}\theta_{SZ}(Q) = \frac{\theta_{KZ}(\gamma_{KZ} - \gamma_Z)}{Q} - \frac{\theta_{KZ}(\gamma_{SZ} - \gamma_Z)}{Q}$$

$$\Rightarrow \frac{d\mu(Q)}{dQ}\theta_{SZ}(Q) = \frac{\theta_{KZ}(\gamma_{KZ} - \gamma_{SZ})}{Q} \Rightarrow \mu'(Q) = \frac{\theta_{KZ}}{\theta_{SZ}}\frac{(\gamma_{KZ} - \gamma_{SZ})}{Q}$$

So $\mu'(Q) < 0$ when, $\gamma_{KZ} < \gamma_{SZ}$.

A.6: Proof of Proposition 3.

(a) Suppose, $\gamma_{KZ} > \gamma_{SZ}$. Then, by Lemma 2, $\mu(0) < \mu(1)$ and thus, given monotonicity of $\mu(Q)$, $\hat{w}_S > \hat{w}$ $\forall Q \in [0,1]$ if $\frac{\theta_{KX}}{\theta_{LX}} < \mu(0)$.

Similarly, when $\gamma_{KZ} < \gamma_{SZ}$. Then, by Lemma 2, $\mu(1) < \mu(0)$ and thus, $\hat{w}_S > \hat{w}$ $\forall Q \in [0,1]$ if $\frac{\theta_{KX}}{\theta_{LX}} < \mu(1)$. (b) Note that by monotonicity of $\mu(Q)$, $\widetilde{Q} \in [0,1]$ will exist only if $\max[\mu(0), \mu(1)] > \frac{\theta_{KX}}{\theta_{LX}} > \min[\mu(0), \mu(1)]$. Rest of the proof follows from Lemma 2.

A.7: Proof of Proposition 4.

From (A1.6), $\hat{Y}$ can be written as,

$$\hat{Y} = -\frac{\lambda_{LX}}{\lambda_{LY}}(\hat{X} + \hat{a}_{LX}) - \hat{a}_{LY} \qquad \text{(A1.15)}$$

With homogenous and mobile capital, full employment condition for capital will be,

$$\overline{K} - a_{KZ}(Q)Z = \widetilde{K}(Q) = a_{KY}Y + a_{KX}X$$

Total differentiating yields, $\hat{\overline{K}} = 0 = \lambda_{KY}(\hat{Y} + \hat{a}_{KY}) + \lambda_{KX}(\hat{X} + \hat{a}_{KX}) + \lambda_{KZ}(\hat{Z} + \gamma_{KZ}\hat{Q})$

Substituting $\hat{Y}$ from (A1.15) and $\hat{Z}$ from (A1.9) in the above we get,

$$0 = \lambda_{KY}\left(-\frac{\lambda_{LX}}{\lambda_{LY}}(\hat{X} + \hat{a}_{LX}) - \hat{a}_{LY} + \hat{a}_{KY}\right) + \lambda_{KX}(\hat{X} + \hat{a}_{KX}) + \lambda_{KZ}(\gamma_{KZ} - \gamma_{SZ})\hat{Q}$$

$$0 = \left(\lambda_{KX} - \lambda_{KY}\frac{\lambda_{LX}}{\lambda_{LY}}\right)\hat{X} - \lambda_{KY}\frac{\lambda_{LX}}{\lambda_{LY}}\hat{a}_{LX} + \lambda_{KY}(\hat{a}_{KY} - \hat{a}_{LY}) + \lambda_{KX}\hat{a}_{KX} + \lambda_{KZ}(\gamma_{KZ} - \gamma_{SZ})\hat{Q}$$

Rewriting the input coefficients as,

$\hat{a}_{KX} = \sigma_X\theta_{LX}(\hat{w} - \hat{r}), \hat{a}_{LX} = -\sigma_X\theta_{KX}(\hat{w} - \hat{r}), \hat{a}_{KY} = -\sigma_Y\theta_{LY}\hat{r}, \hat{a}_{LY} = \sigma_Y\theta_{KY}\hat{r}$, in the above equation yields,

$$0 = -\frac{|\lambda|}{\lambda_{LY}}\hat{X} + \lambda_{KY}\frac{\lambda_{LX}}{\lambda_{LY}}\sigma_X\theta_{KX}(\hat{w}-\hat{r}) - \lambda_{KY}\sigma_Y\hat{r} + \lambda_{KX}\sigma_X\theta_{LX}(\hat{w}-\hat{r}) + \lambda_{KZ}(\gamma_{KZ}-\gamma_{SZ})\hat{Q}$$

$$0 = -\frac{|\lambda|}{\lambda_{LY}}\hat{X} - \lambda_{KY}\sigma_X\frac{\lambda_{LX}}{\lambda_{LY}}\frac{\theta_{KX}}{\theta_{LX}}\hat{r} - \lambda_{KY}\sigma_Y\hat{r} - \lambda_{KX}\sigma_X\hat{r} + \lambda_{KZ}(\gamma_{KZ}-\gamma_{SZ})\hat{Q}$$

$$0 = -\frac{|\lambda|}{\lambda_{LY}}\hat{X} - \beta\hat{r} + \lambda_{KZ}(\gamma_{KZ}-\gamma_{SZ})\hat{Q}$$

$$\Rightarrow \hat{X} = -\frac{\beta\lambda_{LY}}{|\lambda|}\hat{r} + \frac{\lambda_{KZ}\lambda_{LY}}{|\lambda|}(\gamma_{KZ}-\gamma_{SZ})\hat{Q} \qquad \text{(A1.16)}$$

$$where, \beta = \left(\lambda_{KY}\sigma_X\frac{\lambda_{LX}}{\lambda_{LY}}\frac{\theta_{KX}}{\theta_{LX}} + \lambda_{KY}\sigma_Y + \lambda_{KX}\sigma_X\right) > 0$$

Informalisation of unskilled workers is given by, $\hat{L}_X = \hat{X} + \hat{a}_{LX}$. Substituting $\hat{X}$ from (A1.16) and $\hat{a}_{LX}$ as mentioned earlier, gives,

$$\begin{aligned}\hat{L}_X &= -\frac{\beta\lambda_{LY}}{|\lambda|}\hat{r} + \frac{\lambda_{KZ}\lambda_{LY}}{|\lambda|}(\gamma_{KZ}-\gamma_{SZ})\hat{Q} - \sigma_X\theta_{KX}(\hat{w}-\hat{r}) \\ &= \left[\sigma_X\frac{\theta_{KX}}{\theta_{LX}} - \frac{\beta\lambda_{LY}}{|\lambda|}\right]\hat{r} + \frac{\lambda_{KZ}\lambda_{LY}}{|\lambda|}(\gamma_{KZ}-\gamma_{SZ})\hat{Q}\end{aligned} \qquad \text{(A1.17)}$$

Breaking down the term in third bracket gives,

$$\left[\sigma_X\frac{\theta_{KX}}{\theta_{LX}} - \frac{\beta\lambda_{LY}}{|\lambda|}\right]\hat{r} = \left[-\left(\lambda_{KY}\sigma_Y + \lambda_{KX}\sigma_X\right)\frac{\lambda_{LY}}{|\lambda|} + \sigma_X\frac{\theta_{KX}}{\theta_{LX}}\left(1 - \frac{\lambda_{KY}\lambda_{LX}}{|\lambda|}\right)\right]\hat{r}$$

$$= \left[-\left(\lambda_{KY}\sigma_Y + \lambda_{KX}\sigma_X\right)\frac{\lambda_{LY}}{|\lambda|} + \sigma_X\frac{\theta_{KX}}{\theta_{LX}}\left(\frac{\lambda_{LX}\lambda_{KY} - \lambda_{KY}\lambda_{LX} - \lambda_{KX}\lambda_{LY}}{|\lambda|}\right)\right]\hat{r}$$

$$= -\left[\left(\lambda_{KY}\sigma_Y + \lambda_{KX}\sigma_X\right) + \sigma_X\frac{\theta_{KX}\lambda_{KX}}{\theta_{LX}}\right]\frac{\lambda_{LY}}{|\lambda|}\hat{r}$$

$$= -\left[\lambda_{KY}\sigma_Y + \lambda_{KX}\sigma_X\left(1 + \frac{\theta_{KX}}{\theta_{LX}}\right)\right]\frac{\lambda_{LY}}{|\lambda|}\hat{r} = -\left[\lambda_{KY}\sigma_Y + \frac{\lambda_{KX}\sigma_X}{\theta_{LX}}\right]\frac{\lambda_{LY}}{|\lambda|}\hat{r} \qquad \text{(A1.18)}$$

The final expression derived will be positive for $|\lambda| > 0$ since $\hat{r} < 0$. Substituting (A1.18) and the expression for $\hat{r}$ and that of $\hat{Q}$ from (A1.4) in (A1.17), we finally get,

$$\hat{L}_X = \left[-\left(\lambda_{KY}\sigma_Y + \frac{\lambda_{KX}\sigma_X}{\theta_{LX}}\right)\frac{\lambda_{LY}}{|\lambda|}\frac{1}{\theta_{KY}} + \frac{\lambda_{KZ}\lambda_{LY}}{|\lambda|}(\gamma_{KZ}-\gamma_{SZ})^2\frac{\alpha}{\delta}\frac{\theta_{KZ}}{\theta_{KY}}\right]\hat{T} > 0; if, |\lambda| > 0.$$