Trade and relative wages: The role of supervisory function by skilled workers

Satya P. Das*

Indian Statistical Institute, 7 S.J.S. Sansanwal Marg, New Delhi 110 016, India

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Abstract

The effect of trade on relative wages is examined taking into consideration some aspects of internal organization of firms, namely, the twin function of production and supervision by skilled workers. When trade is based on endowment differences, the effect of trade is greater than is predicted by the Stolper–Samuelson theorem. When trade is based on technological differences, freer trade tends to reduce the relative wages in each country in a two-country world economy.

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1. Introduction

It is well established by now that in most developed countries there has been a large increase in the relative wage – the average wage of skilled workers relative to that of unskilled workers – over the last 25 to 30 years (e.g. Davis, 1992). Two major explanatory factors are commonly advanced: (a) unskilled-labor saving technological progress and (b) increasing trade with unskilled labor abundant, low-wage, developing economies. There is not much disagreement regarding the first factor. The effect of trade is however controversial. Some empirical studies (Katz and Murphy, 1992; Krugman and Lawrence, 1993 and many others) and the study by Bhagwati and Kosters (1994) find that trade has played only a minor role in explaining the relative wage movement. However, the empirical exercises have been criticized by some proponents of this view as well as the critics. For example, the presumption that the relative domestic price of unskilled-labor intensive goods has fallen in the North over the sample period is questioned by Bhagwati and Dehejia (1994). The critics vehemently question the other maintained hypotheses in these empirical works to argue the opposite. It is also pointed out that technical progress itself is partly a function of international trade. Models of trade and endogenous growth (e.g. Grossman and Helpman, 1991) certainly imply this. Works by Bergstrand et al. (1994) and Wood (1994) find a greater role of trade in explaining wage or earnings inequalities than do other studies.

However, an unfortunate side effect of this controversy is the presumption in the profession that the issue is largely empirical and there is little to be gained in terms of theoretical understanding (although Bhagwati and Dehejia (1994) suggest some research avenues). The factor-endowment theory and the Stolper–Samuelson theorem remain at the core. Clearly, there is no serious contemplation of an alternative to this theory or significant modifications of it in understanding the issue.[1] The benchmark notion is the prediction of the theorem in terms of both direction and magnitude. As demonstrated by Jones (1997), the factor endowment theory is however rich enough to generate different predictions also, when more than two goods or factors are taken into consideration.

All this may still be inadequate in understanding the general issue of the effect of trade on relative wages. There are at least two a priori reasons to think so. First, factor endowment differences are surely *not* the only factor – and may not be even a major factor – that explains patterns and volumes of 'North–South' trade. A reminder of Leontief paradox can undermine any comfortable reliance on this theory. Technological difference is another well-known *raison d'être* of trade. One would then think that different bases of trade may very well imply different predictions or at least different mechanism of how trade may affect the wage differential.

Second, even within the confines of the endowment theory, the internal organizational behavior of firms plays very little role. More specifically – and

[1] Burless (1995) provides a nice summary of how some empirical studies closely appeal to this theory, while some are more distant. At the worst, as he writes, 'Some do not describe any clear theoretical framework at all'.

pertinent to the relative wage issue – the treatment of skilled and unskilled workers is quite naive. Their roles are capsuled in the production function, which neglects a variety of functions performed by skilled workers in particular. For example, these workers, besides contributing to the production process directly as do unskilled workers, 'manage'. Technical schools provide courses and training in management too. This is obviously related to the concept of supervision. In the internal-organization theory, management or supervision is being increasingly recognized as an important function of skilled workers. It may very well be that different functions of skilled workers may imply different implications of trade policy changes on the wage differential.

This brings us to this paper, the objective of which is to theoretically reopen the issue by incorporating some aspects of firm-organization relating to what functions are performed by skilled and unskilled workers. As the title suggests, it develops a theory of the firm in which skilled workers produce as well as supervise (while unskilled workers only produce). The firm behavior is then integrated into models of international trade based on differences in technology and endowment.

As alluded to above, different conclusions do emerge. (1) In a two-country Ricardian model free trade tends to *lower* the wage differential in *both* trading countries. In terms of North–South trade, this means that free trade lowers the wage differential in both 'Northern' and 'Southern' countries. This is in sharp contrast to the prediction of the factor endowment theory. (2) In the factor endowment theory itself, the effect of free trade on this differential is greater than predicted by the Stolper–Samuelson theorem. Thus the general point made here is that the issue is not theoretically closed. Different bases of trade and different roles performed by skilled and unskilled workers can yield different predictions.

To keep matters in their proper perspectives, it should however be mentioned that there is no prior in this paper as to how free trade may or may not widen the wage differential – upon which the modelling has been tailored: the aim is to obtain a better theoretical understanding of this issue in general. In this sense, the paper is not directly applicable to the ongoing debate. More appropriately, it explores some new channels of the causal link.

We now turn to formal analysis. The intutions behind our results will be developed as we go along.

2. Theory of the firm with skilled workers supervising and contributing to production

In constrast to the standard theory of the firm, models of firm hierarchy typically assume the other extreme: that production is carried out by unskilled workers only, together with capital and other non-human inputs, while skilled workers perform other tasks such as supervision (Calvo and Wellisz, 1978; Qian,

1994) and reduction of delays (Keren and Levhari, 1983). In what follows, a firm model is developed which is less extreme than the standard theory or the theory of hierarchy in that it allows for both functions by the skilled workers. From the perspective of trade theory, it is of course the supervising role of skilled workers that is new.

Skill, in general, can be classified into two categories: technical and managerial. In reality, some skilled workers have only technical skill, some managerial skill and some both. Skill acquisition either through previous training or on-the-job experience is however outside the scope of the model. Furthermore, our focus is on the skilled–unskilled differential, not the differential among skilled workers. We therefore assume that all skilled workers are 'endowed' or 'born' with both skills and with equal efficiency in both.

Consider a firm in sector i. The owner's contract to a skilled worker specifies his/her duty as well. The production function is: $Q_i = Q_i[e_{ui}L_{ui}, (1-\mu_i)e_{si}L_{si}]$, where L_{ui} (L_{si}) is the number of unskilled (skilled) workers employed, μ_i the proportion of skilled workers used in supervision and e_{ui} and e_{si} are the respective effort levels. Q_i is linearly homogeneous in the two arguments, with positive and diminishing returns. Also, $Q_i(0,\cdot) = Q_i(\cdot,0) = 0$, i.e., both inputs are essential for production.

The unskilled workers may shirk. If he/she shirks, $e_{ui} = 0$; otherwise, $e_{ui} = 1$. Skilled workers do not shirk, i.e., $e_{si} = 1$ (to be relaxed later). If found shirking and caught, a worker is fired, and there is a loss of social prestige. Skilled workers are presumably highly prestige conscious and hence do not shirk at all. Alternatively, the firm owner supervises skilled workers and he/she does it perfectly, so that the skilled workers prefer not to shirk.

The individual utility function is given by $a\tilde{\phi}(\boldsymbol{p})y - ze \equiv \phi(\boldsymbol{p})y - ze$, where a is a shift parameter of the 'indirect utility', $\boldsymbol{p} \equiv (p_1, \ldots, p_n)$ is the goods' price vector, $\tilde{\phi}'(\cdot) < 0$, y is income, e the effort level and $z > 0$ is the coefficient of disutility from effort. We assume that a is 'high enough' relative to z, that is, the weight on consumption is sufficiently high relative to that on disutility from effort. The role of this assumption will be discussed later. From now on, we normalize z to 1. The above specification implies that an individual's utility from consumption satisfies risk neutrality.

Denoting the unskilled wage as w_u, an unskilled worker's net utility is: $\phi w_u - 1$ if he does not shirk. If he shirks and is not caught, his net utility is ϕw_u. If he shirks and is caught, he is unemployed and receives zero utility (as in Qian, 1994). It is a one-period model and the labor markets open only once.[2]

[2] Unlike in the standard efficiency wage model there is no residual absorbing sector here. In equilibrium, no one is fired; but the incentive to shirk and threat of being fired have real effects. This assumption serves to focus on the problem of resource allocation between the exportable and the importable sectors. Allowing an absorbing sector would not however change the analysis in any major way.

Let π_{ui} be the probability of inspection, equal to the ratio of skilled workers engaged in supervision to the number of unskilled workers ($\mu_i L_{si}/L_{ui}$). An unskilled worker treats π_{ui} as a parameter. The expected utility from shirking is equal to $(1-\pi_{ui})\phi w_u$. There is no shirking if $\phi w_u - 1 \geq (1-\pi_{ui})\phi w_u$, or $w_u \geq 1/(\phi \pi_{ui})$. The firm is a price taker in the labor markets (but it can control π_{ui}). The firm cannot afford to choose π_{ui} such that the last inequality is violated, since in that case all unskilled workers will shirk and the output will be zero. The firm also would not choose π_{ui} such that $w_u > 1/(\phi \pi_{ui})$. Thus

$$w_u = 1/\phi \pi_{ui}. \tag{1}$$

This is the efficiency wage. Supervision being imperfect ($\pi_{ui} < 1$), the wage rate offered exceeds the disutility of effort in terms of income. In the 'standard' efficiency-wage story, the firm is a wage-setter and supervision intensity is given; here it is the opposite. Substituting $\pi_{ui} = \mu_i L_{si}/L_{ui}$ into (1), we have

$$L_{si} = L_{ui}/\phi w_u \mu_i, \tag{2}$$

$$V_i(\text{profit}) = p_i Q_i\left[L_{ui}, \frac{(1-\mu_i)L_{ui}}{\mu_i \phi w_u}\right] - \left(w_u + \frac{w_s}{\mu_i \phi w_u}\right) L_{ui}. \tag{3}$$

There are two independent choice variables: L_{ui} and μ_i. The first-order conditions are

$$p_i Q_{iu} = w_u + \frac{w_s}{\phi w_u}, \qquad p_i Q_{is} = w_s, \tag{4}$$

where Q_{iu} and Q_{is} are the derivatives with respect to the first and the second argument respectively. The term $w_u + w_s/(\phi w_u) \equiv \bar{w}_u$ is the effective marginal cost of hiring an unskilled worker. Because of the moral hazard problem, it exceeds w_u.

The firm essentially faces factor prices $\bar{w}_u$ and w_s. The respective employments for production are L_{ui} and $(1-\mu_i)L_{si}$. Indeed, V_i can be rewritten as $V_i = p_i Q_i[L_{ui}, (1-\mu_i)L_{si}] - \bar{w}_u L_u - w_s\,(1-\mu_i)L_{si}$, which is homogeneous of degree one in L_{ui} and $(1-\mu_i)L_{si}$ for any given value of μ_i. We can define the cost function, $C_i = \bar{c}_i(\bar{w}_u, w_s)Q_i$, with its usual envelope properties, $\partial C_i/\partial \bar{w}_u = L_{ui}$ and $\partial C_i/\partial w_s = (1-\mu_i)L_{si}$. We will also get

$$\frac{(1-\mu_i)L_{si}}{L_{ui}} = h\left(\frac{\bar{w}_u}{w_s}\right) \equiv h(\omega). \tag{5}$$

The analysis of the firm behavior is complete. However, as we move on to examine the effects of international trade, to gain tractability, we will assume

Cobb–Douglas technology (and hence a Cobb–Douglas cost function). Let

$$Q_i = L_{ui}^{\beta}[(1-\mu_i)L_{si}]^{1-\beta}, \quad 0 < \beta < 1/2. \tag{6}$$

$\beta < 1/2$ ensures that skilled workers are more productive than the unskilled workers.

In relation to the existing literature, it may be noted that our production model has some similarity with but is quite different from the efficiency-wage model of trade by Copeland (1989).[3] There are other, less related, efficiency wage models of trade such as Matusz (1994).

3. Difference in technology as the basis of trade

We first examine the effect of trade on the relative wage when trade is based on technological differences as in the Ricardian model.

3.1. The model and the autarky equilibrium

Consider a two-country world consisting of country h and country f. In each country, there are two sectors (1 and 2). The technology is the same across the two sectors except for a Hicks-neutral parameter.[4] This can be introduced through the cost function. Let

$$C_i^j = b_i^j c(\bar{w}_u^j, w_s^j) Q_i^j, \quad i = 1,2, \ j = \mathrm{h}, \mathrm{f}. \tag{7}$$

We will continue to use, in terms of algebraic notation, the general cost function until it is 'required' to use the Cobb–Douglas assumption.

Suppose that $b_1^{\mathrm{h}}/b_2^{\mathrm{h}} < b_1^{\mathrm{f}}/b_2^{\mathrm{f}}$, so that the home country has relative technological superiority in good 1 and the foreign country in good 2. Let country j ($j = \mathrm{h}, \mathrm{f}$) be endowed with $\bar{L}_u^j$ and $\bar{L}_s^j$ of unskilled and skilled workers.

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[3] In Copeland's model in any sector there are two jobs: one that is costly to monitor and hence there is scope for shirking (called job 1) and the other that is costless to monitor and there is no scope for shirking (job 2). Both jobs are performed by the same type of labor. Monitoring intensity or the probability of detection is exogenous. In our model there are two types of jobs also but the basis of classification is different and they are performed by two types of labor in a partially overlapping way. Also, monitoring intensity is endogenous. Furthermore, it is awkward to interpret the wages in Copeland's paper as skilled and unskilled wages since the model is not designed for that purpose. If one interpretes the wage associated with job 1 as the unskilled wage and that the with job 2 as the skilled wage, then unskilled wage is greater in equilibrium. If it were the vice versa, it would imply that shirking is associated with skilled workers and unskilled workers do not shirk – something that seems rather implausible.

[4] Here again there is a major difference with Copeland's Ricardian model which assumes that technology is different between the two sectors. Unlike his, this model does not exhibit Heckscher–Ohlin characteristics.

In the demand side we assume homothetic preferences over the two goods and that goods are 'essential', that is, at any $\boldsymbol{p}^j > 0$, $D_i^j > 0$ for $i = 1,2$. Moreover, such preferences are alike across the two countries. Homotheticity implies that the ratio of quantities consumed depends only on the product price ratio, not on income. Let

$$D_1^j / D_2^j = g(p^j), \tag{8}$$

where p is the relative price of Good 2. Good 1 is the numeraire good.[5]

We now begin to characterize the autarky equilibrium. Given 'essentiality', there is a positive demand for each good. Hence both goods will be produced in equilibrium (in any country). Perfect competition and free entry and exit are assumed. Profit-maximizing conditions (2) and (5) and the zero-profit conditions give

$$\mu_1^j = \mu_2^j = \mu^j, \quad L_{s1}^j / L_{u1}^j = L_{s2}^j / L_{u2}^j, \tag{9}$$

$$b_1^j c(\bar{w}_u^j, w_s^j) = 1, \tag{10}$$

$$b_2^j c(\bar{w}_u^j, w_s^j) = p^j. \tag{11}$$

The proportion of skilled workers between the two tasks and the overall ratio of skilled to unskilled workers are the same across the two sectors. Given (9), we have

$$\frac{(1-\mu^j)\bar{L}_s^j}{\bar{L}_u^j} = h(\omega^j), \quad \frac{\mu^j \bar{L}_s^j}{\bar{L}_u^j} = \frac{1}{\phi(p^j) w_u^j}. \tag{12}$$

Eqs. (10)–(12) determine four variables: w_u^j, w_s^j, p^j and μ^j. As usual, Eqs. (10) and (11) alone imply $p^j = b_2^j / b_1^j$.

From now on, for notational simplicity, we ignore the superscript j. The autarky equilibrium can be exhibited in the (n, π_u) plane where $n \equiv w_u / w_s$ and recall that $\pi_u = 1/[\phi w_u]$ is the probability of inspection. First, note that, from $\bar{w}_u = w_u + w_s/(\phi w_u)$, we get

$$\bar{w}_u / w_s = \omega = n + \pi_u. \tag{13}$$

Given the Cobb–Douglas technology, we have $h(\omega) = (1-\beta)\bar{w}_u/(\beta w_s) = (1-\beta)(n + \pi_u)/\beta$. Using this and eliminating μ from (12),

$$(1-\beta)n + \pi_u = \beta \bar{L}_s / L_u. \tag{14}$$

[5] The function $\phi(\cdot)$, implicit in $\bar{w}_u$, is related to the function $g(\cdot)$ by $g(\cdot) = -\phi'/(\phi + p\phi')$.

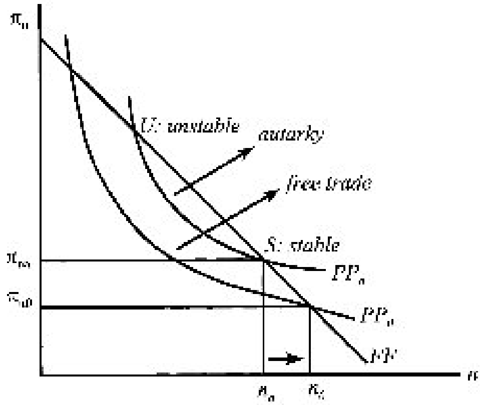

Fig. 1. Autarky and free-trade equilibria.

This is the first relationship between n and π_u, which is negative and stems from the profit-maximizing conditions essentially. It defines the FF schedule in Fig. 1. Observe that as long as $\bar{L}_s/\bar{L}_u < 1$ and $\beta < 1/2$, we have $n < \beta/(1-\beta) < 1$, that is, the unskilled–skilled wage ratio is less than one.

The second relationship between n and π_u is obtained from (10). We can write $c(\bar{w}_u, w_s) = w_s c(\omega,1) \equiv w_s \bar{c}(\omega) = w_s \bar{c}(n + \pi_u)$. Thus, using Cobb–Douglas assumption, (10) is expressed as

$$n\pi_u/(n + \pi_u)^{\beta} = b_1/\phi(p). \tag{15}$$

The left-hand side is an increasing function of n and π_u,[6] and, as shown in Appendix A, it is strictly quasi-concave in n and π_u. Thus (15) defines a downward schedule convex to the origin such as PP_a as in Fig. 1 (a denoting autarky). Moreover, it is asymptotic to both axes. This schedule reflects basically the zero-profit condition.[7]

The autarky equilibrium is at the intersection between the FF and PP_a schedules (ignore PP_0 for now). There may not exist any equilibrium and this is true when the PP_a curve lies entirely to the right of the FF line. Otherwise, there may be one equilibrium (if the PP_a curve happens to be tangent to the FF line – a razor edge, highly unlikely case) or two equilibria (if the PP_a curve intersects

[6] More generally, concavity of $c(\cdot)$ implies that $\bar{c}(n + \pi_u)$ is also concave. Thus $(n + \pi_u)\bar{c}'(n + \pi_u) \le \bar{c}(n + \pi_u) - \bar{c}(0)$, or, $(n + \pi_u)\bar{c}' \le \bar{c}$ since $\bar{c}(0) = 0$. This implies $\bar{c} - n\bar{c}'$ and $\bar{c} - \pi_u\bar{c}'$ are both positive. Hence $\partial[n\pi_u/\bar{c}(n + \pi_u)]/\partial n = \pi_u(\bar{c} - n\bar{c}')/\bar{c}^2 > 0$; similarly, $\partial[n\pi_u/\bar{c}(n + \pi_u)]/\partial\pi_u > 0$.

[7] Since $p = b_2/b_1$, the zero-profit condition in Sector 2 would also yield the same schedule.

the FF line). Turning now to Eqs. (14) and (15), it is seen that two equilibria will emerge as long as $\phi(\boldsymbol{p})$ is large enough. Recall that $\phi(\boldsymbol{p}) \equiv a\tilde{\phi}(\boldsymbol{p})$. Thus, our assumption that the weight on consumption is sufficiently high relative to that on disutility from effort ensures the existence of autarky equilibria (and, as we will see, the free trade equilibrium).

Out of the two equilibria, one is stable (denoted by S) and the other unstable (denoted by U), in the following sense. Suppose there is an increase in the relative endowment of unskilled workers (which shifts in the FF line). It is expected that $w_u/w_s \equiv n$ should fall. But if U (S) were the original equilibrium point, then n will increase (decrease). In the light of Samuelson's well-known correspondence principle, it follows that S and U are respectively the stable and the unstable equilibrium points. (Appendix B discusses the dynamic adjustment process.) We will therefore refer to S as the autarky equilibrium point.

The worker moral hazard problem gives rise to the element of instability. Suppose there is an increase in the supply of unskilled workers. This, ceteris paribus, would tend to lower the ratio of supervising skilled workers to unskilled workers, hence lower the supervision intensity and raise the unskilled wage. This is a destabilizing factor. At the unstable equilibrium point U, it dominates the standard stabilizing element of diminishing returns in production. Just the opposite holds at the stable equilibrium point, S.

In our model with two countries, each country will have an autarky equilibrium point like S, say, S_a^h and S_a^f for the home country and the foreign country, respectively. Given our assumption that $b_1^h/b_2^h < b_1^f/b_2^f$, clearly $p_a^h > p_a^f$, p_a^j denoting the autarky relative price of Good 2 in country j.

3.2. Free trade

We now introduce international trade. Let p_0 be the relative price of Good 2 at the free-trade equilibrium. For reasons well-known, p_0 lies inbetween p_a^h and p_a^f and at least one country specializes. We will assume however that the difference between $\bar{L}_u^h + \bar{L}_s^h$ and $\bar{L}_u^f + \bar{L}_s^f$ is not too large, so that both countries specialize according to their comparative advantage: home country in Good 1 and foreign country in Good 2.

For the moment, concentrate on the home country. The FF line, based on Eq. (14), remains the same as in autarky. Since only Good 1 is produced, Eq. (10) holds and Eq. (11) does not. Thus Eq. (15), derived from (10) and which defines the PP schedule, holds, except that in place of p_a^h, we have p_0. Since $p_0 < p_a^h$ and $\phi' < 0$, it follows that $\phi(p_0) > \phi(p_a^h)$. Thus, as in Fig. 1, the PP curve in free trade, denoted PP_0, lies to the left of the PP_a schedule.

We are now ready to derive the implications of international trade. Although Fig. 1 is drawn for the home country, symmetry implies that the implications are qualitatively the same for the foreign country. It is seen that $n_0 > n_a$ and $\pi_{u0} < \pi_{ua}$. Recalling the definitions of n and π_u, it follows that the relative wage is *lower* and the real income or welfare of unskilled workers is higher in *both countries*. Note that for the foreign country, Eq. (10) *does not* hold in free trade, but Eq. (11) does, which can be written as $n\pi/\bar{c}(\cdot) = b_2/[p\phi(p)]$. Roy's identity implies that the elasticity of ϕ with respect to p is equal to the expenditure share of Good 2 and hence is less than one. As p increases in the foreign country, $p\phi(p)$ increases, the PP curve shifts in and the relative wage declines.

There are two sources of change in workers' welfare: the direct trade effect (as in the standard Ricardian model) and the induced shift in the relative wage. The direct effect is that, if there were no shirking/supervision problems, trade would not affect the relative wage, and both factor prices would remain unchanged in terms of the exportable good and increase (proportionately) in terms of the importable good. Thereby, both types of workers would gain. The relative wage effect on welfare is redistributive: unskilled workers gain and skilled workers lose. Hence the net effect is that unskilled workers unambiguously benefit from trade, whereas skilled workers may gain or lose. This happens in both countries.

More concretely, consider for example the home country and the welfare of unskilled workers. Writing (10) as $\phi(p)w_s = \phi(p)/[b_1\bar{c}(\omega)]$, it can be expressed as

$$\phi(p)w_u = \phi(p)\,\frac{n}{b_1\bar{c}(\omega)} - 1 = \phi(p)\,\frac{n^{1-\beta}}{b_1(1+\pi_u/n)^{\beta}} - 1. \tag{16}$$

The increase in $\phi(p)$ (as p decreases) in the right-hand side of (16) is the direct trade effect. The coefficient of this term (the ratio) is the relative wage effect. It is seen from Fig. 1 that while n increases, π_u/n decreases. Hence the ratio increases, i.e., the relative wage effect on an unskilled worker's welfare is also positive.

Turning to the welfare of skilled workers, note first that Eq. (14) can be written as $n + \pi_u - \beta n = \beta\bar{L}_s/\bar{L}_u$. Thus an increase in n implies an increase in $n + \pi_u = \omega$. That is, from a firm's perspective, the relative cost of unskilled workers is higher due to international trade. Now, using (10) again, we can write skilled workers' welfare as $\phi(p)w_s - 1 = \phi(p)[1/(b_1\bar{c}(\omega))] - 1$. In the home country for example, the increase in $\phi(p)$ is the standard trade effect. However, since ω increases, $\bar{c}$ is higher and hence $1/\bar{c}$ is smaller. This is the negative relative wage effect. The net effect may be thus positive or negative.

The relative wage change and the ambiguous effect on the welfare of skilled workers both stem from the same source. That is, international trade, by increasing production efficiency, *tends* to improve the real wage of both types of workers. In particular, the improvement of the unskilled real wage increases the opportunity cost of shirking and hence reduces the incentive to shirk. This reduces demand for skilled workers for supervisory work and tends to pull the real wage of skilled workers down (whether a skilled worker is engaged in production or supervision); this is an indirect effect. As a result, the relative wage falls and the net effect on the welfare of the skilled workers is ambiguous.[8] We have

Proposition 1. For both economies, international trade based on difference in technology improves welfare of unskilled workers while skilled workers may gain or lose. The relative wage of skilled workers however falls.

This result has three general implications. First, the existing literature and controversy on trade and relative wage, by relying solely on some version of the factor endowment theory, offers the impression that it is mostly an empirical issue, and, further theoretical investigation is unlikely to yield sufficiently different result. Proposition 1 means that this may not be so. Second, the effect of trade on the relative wage may depend on the type of the source of comparative advantage. Third, a change in the relative wage does not necessarily mean that one type of workers loses and the other type gains. It is possible that both types of workers gain. So the issue may be just positive, not normative.

3.3. Shirking by skilled workers

Our main result continues to hold even when skilled workers may shirk. Consider a hierarchy in which skilled workers supervise unskilled workers and the owner supervises skilled workers by expending effort. Assume that both types of workers choose their effort levels at 0 or 1, while the owner can choose the effort level needed for supervision on a continuous scale. This means that there is an explicit or implicit contract for workers of what is expected as 'normal' intensity of work. There is no reward for more effort than expected and hence no worker puts in more, while he/she is fired if found caught working at *any* subnormal effort level. On the other hand, the owner is her own boss and selects her effort level depending on its effect on profit and her net utility.

We first note the additional efficiency-wage constraint: $\pi_{si} = 1/[\phi(\boldsymbol{p})w_s]$, where π_s, the intensity of supervision of skilled workers, assumed is proportional to the ratio of the effort level chosen by the owner, say E, and the number of skilled workers. Thus $\pi_s = E/L_{si}$. Hence

$$E_i = L_{si}/\phi w_s = L_{ui}/\phi^2 \mu_i w_u w_s. \tag{17}$$

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[8] It might be conjectured that the above line of explanation hinges crucially on that there is no absorbing sector in the model economy: If there were such a sector, real wage, in the first round, would have increased proportionately in all sectors and therefore there is no second-round asymmetric effect. This is incorrect however. It is because the incentive to shirk would depend on the *absolute*, not relative, difference between wage to be earned in a 'regular' sector and that in the absorbing sector; the absolute wage difference *will* increase when all wages increase proportionately and reduce the incentive to shirk.

Owners have similar utility function as workers do, represented by $\phi(p)V_i - E_i$. Substituting (17) into π_i, the owner's maximand is

$$p_i Q_i\left[L_{ui}, \frac{(1-\mu_i)L_{ui}}{\mu_i \phi w_u}\right] - \left(w_u + \frac{w_s}{\mu_i \phi w_u} + \frac{1}{\phi^2 \mu_i w_u w_s}\right) L_{ui}. \tag{18}$$

The model description is complete. To save space however, its solution is given in Appendix C. The model yields that, compared to autarky, the relative wage is less in free trade. The economic reasoning remains the same.

4. The factor endowment model

We now move to this more common territory on which the issue of trade and relative wage is posed. There are two countries (h and f) and two factors as before. We return to our original assumption that only unskilled workers can shirk. There are no technological differences, but factor endowments differ. (We do not need to assume Cobb–Douglas technology.) Let Sector 2 be the relatively unskilled labor intensive sector and let the home country be relatively more skilled labor abundant, i.e., $\bar{L}_s^h/\bar{L}_u^h > \bar{L}_s^f/\bar{L}_u^f$. Further, let the preference structure be same as earlier; the parameter a is assumed 'sufficiently' high.[9]

The central result to be obtained here is that the effect of trade on the relative wage follows the Stolper–Samuelson theorem qualitatively, but in magnitude, it is stronger. The intuition is as follows. Consider the relatively skilled labor abundant country. By the Theorem, international trade tends to lower the real wage of unskilled workers and raise that of skilled workers. But the decline in the real wage of unskilled workers reduces the opportunity cost of shirking and hence encourages it. This increases the demand for skilled labor for the supervisory job and tends to increase skilled wage. The relative wage increases further. In what follows, we 'prove' this in a precise sense and obtain related results.

4.1. The two-sector model

Consider each country in isolation (autarky). The production side is represented by

$$c_1(\bar{w}_u, w_s) = 1, \quad c_2(\bar{w}_u, w_s) = p, \tag{19}$$

[9] This model is closer to Copeland's in structure, but quite distinct nevertheless. In the latter the sectors are identified on the basis of which sector is more intensive in the job in which shirking is costly. Here the sectors are different depending on whether production requires relatively more skilled or unskilled workers. Accordingly, predictive statements such as the analog of the Stolper–Samuelson theorem will have different economic contents.

$$(1-\mu_i)\,\frac{L_{si}}{L_{ui}} = h_i(\omega), \quad \frac{\mu_i L_{si}}{L_{ui}} = \frac{1}{\phi(p)w_u}, \tag{20}$$

$$a_{u1}(\omega)Q_1 + a_{u2}(\omega)Q_2 = \bar{L}_u, \tag{21}$$

$$a_{s1}(\omega)Q_1 + a_{s2}(\omega)Q_2 = \sum_1^2 (1-\mu_i)L_{si} = \bar{L}_s - \pi_u \bar{L}_u. \tag{22}$$

Eqs. (19) are the zero-profit conditions. Eqs. (20) are the profit-maximizing conditions, same as in Section 2. Finally, Eqs. (21) and (22) are the full-employment conditions, wherein Eqs. (20) are made use of and a_{ui}'s and a_{si}'s are the respective factor coefficients.

It is easy to see that, from the zero-profit conditions, $\bar{w}_u$, w_s and ω are determined by p in accordance with the Theorem. Then, from the defintion of $\bar{w}_u$, w_u is determined. Given p and w_u, π_u is known, and, given ω and π_u, the full-employment equations determines the outputs. The Rybczinski theorem also holds. However, the (general-equilibrium) price–output response is different from the standard two-sector model. It contains the standard effect – a movement along a given production possibility frontier (PPF) – and a Rybczinski effect. The latter arises from the effect of a product price change on π_u and hence on the number of skilled workers utilized in production as opposed to supervision.

Morever, there are two equilibria as in the Ricardian model (with respect to w_u and hence π_u and the outputs). By definition, $\bar{w}_u = w_u + w_s/[\phi(p)w_u]$ which is not monotonic in w_u. Given $\bar{w}_u$ and w_s (determined by p), it defines a quadratic equation in w_u:

$$(\bar{w}_u - w_u)w_u = w_s/\phi(p). \tag{23}$$

The left-hand side is represented by the UU curve in Fig. 2. There are two solutions of w_u such as points A and B. Recall that $\phi(p) \equiv a\tilde{\phi}(p)$, and our assumption that a is large enough ensures that $w_s/\phi(p)$ line cuts the UU curve and hence there exists a solution.

It is proven in Appendix D that, given a is large enough, the solution of w_u along the falling part of UU (i.e. such as B) is consistent with stability in the factor markets (and point A is not). Hence we assume that w_u is determined along the falling portion of UU. This is where $w_u > \bar{w}_u/2$, i.e., $2n > \omega$. (By definition, $\omega > n$; so we can write $2n > \omega > n$.) π_u and the two output levels are determined accordingly. (A sufficiently large value of a also implies $\pi_u < 1$.)

Let θ_{ui} and θ_{si} be the respective factor shares, $|\theta| = \theta_{u2}\theta_{s1} - \theta_{u1}\theta_{s2}$, λ_{ui} and λ_{si} the respective sectoral employment shares, $|\lambda| = \lambda_{u2}\lambda_{s1} - \lambda_{u1}\lambda_{s2}$ and σ_i the elasticity of substitution in production. $|\theta|$ and $|\lambda|$ are both positive when Sector 2 is unskilled labor intensive. Also define η_i as the share of expenditure on Good i. We now derive the equations of change by differentiating the production side equaitons. Denoting proportional changes by carets and using

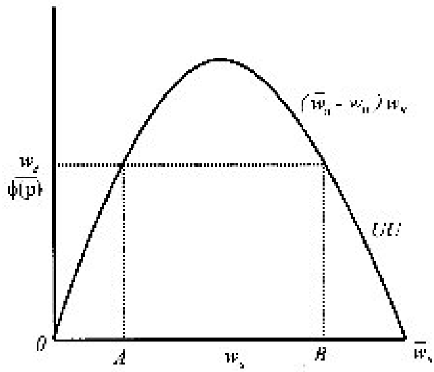

Fig. 2. Multiple equilibria.

$\hat{a}_{ui} = -\theta_{si}\sigma_i\hat{\omega}$ and $\hat{a}_{si} = \theta_{ui}\sigma_i\hat{\omega}$,

$$\hat{w}_u = \frac{\theta_{s1}}{|\theta|}\hat{p}, \quad \hat{w}_s = -\frac{\theta_{u1}}{|\theta|}\hat{p},$$

$$\hat{w}_u = \frac{\hat{p}}{2n-\omega}\left[\frac{\omega\theta_{s1}}{|\theta|} + (\omega - n)\left(\frac{\theta_{u1}}{|\theta|} - \eta_2\right)\right], \tag{24}$$

$$\hat{n} = \hat{w}_u - \hat{w}_s = \frac{\hat{p}}{|\theta|}\left[1 + \frac{\omega - n}{2n - \omega}(1 + \eta_1\theta_{s1} + \eta_2\theta_{s2})\right], \tag{25}$$

$$\hat{\pi}_u = \frac{2(\omega - n) + \omega\eta_1\theta_{s1} + \omega\eta_2\theta_{s2}}{2n - \omega}\hat{p}, \tag{26}$$

$$\hat{Q}_2 - \hat{Q}_1 = \frac{\lambda_{u1}\theta_{s1}\sigma_1 + \lambda_{u2}\theta_{s2}\sigma_2 + \lambda_{s1}\theta_{u1}\sigma_1 + \lambda_{s2}\theta_{u2}\sigma_2}{|\lambda||\theta|}\hat{p} - m\frac{\hat{\pi}_u}{|\lambda||\theta|}, \tag{27}$$

where $m \equiv \pi_u\bar{L}_u/(\bar{L}_s - \pi_u\bar{L}_u)$. Eqs. (24) are the Stolper–Samuelson effects. The next two expressions are obtained by using (24). The last one is price–output response; the first term is the standard effect of movement along a given PPF, while the second term is a Rybczinski effect as discussed earlier.

Finally, the demand side is represented by (8) as before. This completes the description of the autarkic economy. Our focus is on how the wage differential is affected via Eq. (25).

4.2. Comparative advantage and free trade

Given that the autarky equilibrium is stable, the model is qualitatively similar to the standard model in many respects. The home country being relatively more skilled labor abundant, $p_a^h > p_a^f$ and $n_a^h > n_a^f$. This country exports the skilled labor intensive good and the foreign country exports the other good.

To ensure comparability with the prediction of the Stolper–Samuelson theorem, assume further that $\bar{L}_s^h/\bar{L}_u^h - \bar{L}_s^f/\bar{L}_u^f$ is not so large and hence there is incomplete specialization in each country. The effect of trade on the relative wage is contained in (25) where $2n > \omega > n$. The first term in the square bracket ('1') is the Stolper–Samuelson expression. The second term is new and positive. It arises because of the shirking problem. Hence

Proposition 2. As long as endowment differences are the basis of trade, international trade causes the change in the relative wage in the direction predicted by the Stolper–Samuelson theorem. However, for the same amount of price change brought about by international trade, the magnitude of the effect on the relative wage is greater than what is predicted by the Theorem.

Propositions 1 and 2 together underscore that the qualitative or quantitative effects of international trade on the relative wage may be sensitive to the source of comparative advantage and different functions performed by skilled and unskilled workers.

The welfare effects follow in the direction of the Theorem. The welfare change for skilled workers is evident from the sign of $\hat{w}_s$ in (24). That for the unskilled workers is obtained from the change in $\phi(p)w_u$. By the definition of $\bar{w}_u$, we have $\omega = n + 1/[\phi w_u]$. Thus $\hat{\omega}/\hat{p} = n\hat{n}/[\omega\hat{p}] - (1 - n/\omega)\widehat{\phi w_u}/\hat{p}$. We already have the expressions for $\hat{\omega}/\hat{p}$ and $\hat{n}/\hat{p}$. Substituting those, it is easy to see that $\widehat{\phi w_u}/\hat{p} \gtrless 0$ as Sector 2 is unskilled or skilled labor intensive.

A novel prediction of this model concerns the allocation of skilled workers between the two tasks. Substituting (9) into (20) and eliminating L_{si}/L_{ui}, $1/\mu_i = 1 + h_i(\omega)[\phi(p)w_u]$. Both $h(\omega)$ and $\phi(p)w_u$ increase or decrease with p and thus $\hat{\mu}_i/\hat{p} \lesseqgtr 0$ as Sector 2 is skilled or unskilled labor intensive. Hence

Proposition 3. As trade opens up, there is an increase (a decrease) in the proportion of skilled workers used for supervision in both sectors in the skilled-labor (unskilled-labor) abundant country.

For example, consider the skilled labor abundant, home, country. As trade opens up, the real wage of unskilled workers falls which lowers the opportunity cost of shirking. There is an increase in the incentive to shirk. Firms in both sectors respond to this by diverting some skilled workers from production to supervision.

5. Other patterns of specialization

It has been assumed that the difference in country sizes in the Ricardian model or the difference in country endowment ratios in the factor endowment model is not large, so that both countries completely specialize in the former and incompletely specialize in the latter. Allowing for other possibilities weaken the results somewhat but do not overturn them in any major way.

Consider the Ricardian model. If one country is sufficiently large relative to the other, the world price ratio is same as the autarky price ratio and hence there is no change in the relative wage in this country. But it decreases in the other country. Thus trade lowers the wage differential in at least one country and neither country experiences an increase in the same.

In the factor endowment model, suppose that at the free-trade equilibrium there is complete specialization in one country (or in both). Denoting the free-trade relative price of Good 2 by p_0, let us decompose the overall price difference, $|p_a^j, p_0|$, into the two intervals: $|p_a^j, \tilde{p}^j|$ and $|\tilde{p}^j, p_0|$, where $\tilde{p}^j$ is the borderline price at which complete specialization occurs in the good country j has comparative advantage in. The effect of price change on the wage differential over the first interval is governed by Eq. (25). Over the second the relevant equations are analogous to those in the Ricardian model that defines the FF and PP schedules in Fig. 1. The implication is that *because of a price change from* $\tilde{p}^j$ *to* p_0*, there is a fall in the wage differential whether it is a skilled labor or an unskilled labor abundant country*. If it is the latter, then the overall effect of trade on the differential is stronger than if the country were incompletely specializing. For the skilled labor abundant country, the effect of price change over the complete specialization interval runs counter to that over the incomplete specialization interval. Unless the former (specialization) interval is very large (a highly unusual situation), the overall effect on the relative wage will still be positive.

6. Summary

One purpose of this paper is to convey a message that the issue of international trade and relative wages is as much theoretical as it is empirical. A simple production function does not summarize all important functions performed within a firm. Allowing for multiple functions by skilled workers in particular, namely, production and supervision, it is shown that as long as factor endowment differences explain international trade, the effect of trade on the relative wage is stronger than what is predicted by the Stolper–Samuelson theorem (assuming that trade does not lead to complete specialization). If international trade results from technological differences and both countries specialize (in a two-country world), the implication of trade for relative wages is quite different: (a) it falls and (b) the effect is symmetric – it falls in both trading countries.

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Appendix A

We show that the function $(xy)/(x+y)^{\beta}$ is strictly quasi-concave in x and y (where $x \equiv n$ and $y \equiv \pi_{\mathrm{u}}$). In general, if a function $g(x,y)$ is quasi-concave, then $\exp(g(x,y))$ is quasi-concave in x and y. Thus it is sufficient to show that the function $j(x,y) \equiv \ln x + \ln y - \beta \ln(x+y)$ is strictly quasi-concave. Its first and the second partials are: $j_x = 1/x - \beta/(x+y)$; $j_y = 1/y - \beta/(x+y)$; $j_{xy} = \beta/(x+y)^2$; $j_{xx} = -1/x^2 + \beta/(x+y)^2$; $j_{yy} = -1/y^2 + \beta/(x+y)^2$. The bordered Hessian of function $j(\cdot)$ can be computed to be equal to

$$\left(\frac{1}{x} - \frac{\beta}{x+y}\right)\frac{(1-\beta)x^2 + (1-\beta)y^2 + 2xy}{xy^2(x+y)^2}$$

$$+\left(\frac{1}{y} - \frac{\beta}{x+y}\right)\left[\frac{(x+y)^2 - \beta x^2}{x^2 y(x+y)^2} + \frac{xy}{x^2(x+y)^2}\right] > 0.$$

This proves that $j(\cdot)$ is quasi-concave in x and y.

Appendix B

We discuss here the stability of autarky equilibrium in the Ricardian model. The corresponding out-of-equilibrium, dynamic adjustment process is a Marshallian one based on the difference between the relative supply price and demand price of either kind of labor.

Suppose that the Marshallian auctioneer, at time t, fixes the quantity $L_{\mathrm{u}}/L_{\mathrm{s}}$. Let the adjustment mechanism be: increase, leave unchange and decrease $L_{\mathrm{u}}/L_{\mathrm{s}}$ as the demand price exceeds, is equal to or falls short of the supply price. Since the endowments are given, the supply price function of this is

$$\begin{cases} -\infty & \text{if } L_{\mathrm{u}}/L_{\mathrm{s}} < \bar{L}_{\mathrm{u}}/\bar{L}_{\mathrm{s}}, \\ \text{indeterminate} & \text{if } L_{\mathrm{u}}/L_{\mathrm{s}} = \bar{L}_{\mathrm{u}}/\bar{L}_{\mathrm{s}}, \\ +\infty & \text{if } L_{\mathrm{u}}/L_{\mathrm{s}} > \bar{L}_{\mathrm{u}}/\bar{L}_{\mathrm{s}}. \end{cases}$$

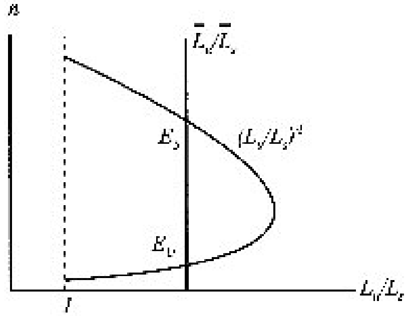

Fig. 3. Stability of autarky equilibrium in the Ricardian model.

The demand price function of L_u/L_s is obtained from Fig. 1. At very high values of this ratio (i.e. at very low values of L_s/L_u), there is no solution of n. As L_u/L_s is gradually lowered, there is a critical value which yields a unique solution of n and below which there are two solutions. Fig. 3 depicts this as the $(L_u/L_s)^d$ curve. Along this curve, n is analogous to a competitive auction price.

Given the nature of the supply price function, it follows that the dynamic process is stable if the demand price is negatively related to quantity. This rules out the rising portion of the $(L_u/L_s)^d$ curve. E_S is the stable equilibrium point, which corresponds to point S in Fig. 1.

This adjustment mechanism has some similarities as well as differences with that in the well-known study by Neary (1978) which deals with sluggishness of factor movement across two sectors of a small open economy. Both analyses are Marshallian in that some kind of quantity adjustment is assumed. But they relate to different quantities. Here the movement of the two factors of production across the two sectors is presumed to be instantaneous. The auctioneer announces total quantities of the two factors for the entire economy (and, by implication, their ratio), observes the difference between the supply and demand prices and adjusts (economy-wide) quantities accordingly. In Neary's, the auctioneer is interested in the allocation of one of the factors between the two sectors while regarding the total endowment of this (sluggish) factor as given. She annouces an allocation, observes the difference in the quasi-rents and adjusts allocation accordingly.

The two approaches yields similar outcomes however. Our analysis, in effect, implies a downward sloping relative demand curve for either factor, whereas Neary's gives a positive price–output response and removes many paradoxical outcomes that were being previously attributed to factor market distortions.

Appendix C

The hierarchy model is solved here. From the expression of the owner's maximand, the first-order conditions are

$$p_i Q_{is} = w_s + 1/\phi^2 w_s \equiv \bar{w}_s; \quad p_i Q_{iu} = w_u + \bar{w}_s/\phi w_u \equiv \bar{w}_u. \tag{C.1}$$

Note that the effective marginal costs of hiring both types of workers are higher than their market wages. Moreover, in equilibrium, there is zero net utility for the owner, i.e. the expression (18) is zero. She earns 'normal' profits equal to the value of her effort.

Given (C.1), the structure of this model is however similar to that of the basic model. Analogous to $n\,(\equiv w_u/w_s)$, define $N \equiv w_u/\bar{w}_s$. The autarky equilibrium is then expressed in the (N, π_u) space. The analogs of Eqs. (14) and (15) hold except for N substituting n.

As before, the existence of autarky equilibria is assured by a sufficiently large value of a. However, unlike in the previous model, $w_s/w_u > 1$ is not assured by only the existence of equilibria. We have

$$\frac{1}{N} = \frac{w_s}{w_u} + \frac{1}{\phi^2 w_u w_s} = \frac{1}{n} + n\pi_u^2. \tag{C.2}$$

Given $\beta < 0.5$, the analog of Eq. (14) implies $N < 1$ (and $\pi_u < 1$). From the above equation, $n < 1$ if and only if π_u is sufficiently small. This is ensured if the stable equilibrium (point S) is sufficiently down the FF line, which in turn is implied by a large enough value of a. Thus a 'well-behaved' autarky equilibrium, that is stable and where $n < 1$, exists with a more restricted range of the values for a – which we assume.

Similar to the previous analysis, free trade compared to autarky involves a higher N and a lower value of π_u. Thus unskilled workers benefit. We now show that the relative wage declines. From the analog of (14), $\mathrm{d}\pi_u/\mathrm{d}N = -(1-\beta)$. Using this and totally differentiating (C.2),

$$\frac{1}{N^2}\mathrm{d}N = \left(\frac{1}{n^2} - \pi_u^2\right)\mathrm{d}n - 2n\pi_u\,\mathrm{d}\pi_u,$$

or

$$\left(\frac{1}{n^2} - \frac{\pi_u^2}{n}\right)\frac{\mathrm{d}n}{\mathrm{d}N} = \frac{1}{N^2} - 2(1-\beta)n\pi_u = \frac{1 - 2(1-\beta)N^2 n\pi_u}{N^2}.$$

From the analog of (14) and given $\beta < 0.5$, $2(1-\beta)N < 1$. Since N, n and π, each, are less than one, it follows that $2(1-\beta)N^2 n\pi_u < Nn\pi_u < 1$ and thus $\mathrm{d}n/\mathrm{d}N > 0$. Hence free trade reduces the relative wage.

Appendix D

We consider here the factor market stability in the factor endowment model. As in the Ricardian model (see Appendix B), assuming Marshallian adjustment process, it is sufficient to consider how an increase in $\bar{L}_u/\bar{L}_s$ affects n, the unskill–skill wage ratio. (This is again different from Neary's (1978) stability analysis.) It will be shown that, if the parameter a is large enough, determination of w_u along the falling (rising) arm of the UU curve implies that an increase in $\bar{L}_u/\bar{L}_s$ lowers (raises) n. Thus, the solution of w_u on the falling arm of UU curve is consistent with factor market stability.

It will be convenient to begin with the price–output response given in (27). The solution of w_u being along the falling part of UU, i.e. $2n > \omega$, implies that $\hat{\pi}_u/\hat{p} > 0$. Also, for any given p, a higher value of a implies a higher value of w_u, a lower value of $\pi_u = 1/[a\tilde{\phi}w_u]$ and hence a lower value of m. It follows then that a high enough value of a together with $2n > \omega$ implies a low enough value of $m\hat{\pi}_u/\hat{p}$ such that either $(\hat{Q}_2 - \hat{Q}_1)/\hat{p} > 0$, or, if negative, smaller in magnitude than the elasticity of substitution in consumption; in other words, the relative supply function is either positively sloped, or, if negatively sloped, steeper than the relative demand curve. The implication is of this is that an exogenous shift in the relative supply function to the right or left implies a higher or lower value of p.

We now turn to examine how an increase in $\bar{L}_u/\bar{L}_s$ would affect n. Recall that Sector 2 is assumed unskilled labor intensive. Hence, by the Rybczynski effect, an increase in $\bar{L}_u/\bar{L}_s$ increases Q_2/Q_1 at any given p. It is already established that this would lower p. Turning to (25), we see that n decreases as long as $2n > \omega$.

The same line of argument implies that the solution of w_u along the upward sloping part of the UU curve implies that an increase in $\bar{L}_u/\bar{L}_s$ would be associated with an increase in w_u. Thus the factor market is stable as long as the solution of w_u is along the downward sloping part of the UU curve and a is large enough.

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