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ABSTRACT

North-South technology transfer in unionised multinationals

We study how incentives for North-South technology transfers in multinational enterprises are affected by labour market institutions. If workers are collectively organised, incentives for technology transfers are partly governed by firms' desire to curb trade union power. This will affect not only the extent but also the type of technology transfer. While skill upgrading of southern workers benefits these workers at the expense of northern worker welfare, quality upgrading of products produced in the South may harm not only northern but also southern workers. A minimum wage policy to raise the wage levels of southern workers may spur technology transfer, possibly to the extent that the utility of northern workers decline. These conclusions are reached in a setting where a unionised multinational multiproduct firm produces two vertically differentiated products in northern and southern subsidiaries, respectively.

JEL Classification: F23, J51 and O33
Keywords: minimum wages, multinationals, north-south technology transfer and trade unions

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1 Introduction

The theme of this paper is the potential role played by different labour market institutions in determining the incentives for North-South technology transfer through multinational enterprises. It has long been recognised that multinationals play a ubiquitous role in technology transfers between the developed and the developing world. We develop a theoretical model where multinationals may determine how much and what type of knowledge which is transferred to subsidiaries in the South. A starting point assumption is that the workforce in the North is unionised. Will multinational corporations transfer technology to subsidiaries in the South as part of a power struggle with northern workforces? How will labour market institutions in the North and the South interact, and what does this in turn imply for technology transfer? Can the power struggle with unionised workers also help explain why multinationals seem to install rather advanced technologies even in countries where unskilled labour is available in abundance? Indeed, Caves (2007) cites many studies which argue that multinationals tend to install rather similar technologies in the South as the ones already being employed in the North, even though the relative factor abundance of different types of labour can be very different. This could possibly provide a part-answer to the question why globalisation and foreign direct investment seem to be accompanied with rising inequalities also in the South. While it is easy to grasp that globalisation can lead to more wage inequality in the North, we should perhaps expect the reverse to happen in the South. However, if the export sector in developing countries uses quite advanced technology, the employees in this sector will stand out as highly productive and well paid in their local environment. Those southern workers who outcompete the less skilled northern workers may be the more skilled workers in their home economy, and inequality may increase both in the North and in the South.

Zhu and Trefler (2005) develop a theoretical model precisely with this angle. Key features are endowments-based comparative advantages and technological catch-up in the South. Southern catch-up causes production of the least skill-intensive northern goods to migrate to the South – where they become the most skill-intensive goods, and wage inequality increases both there and in the North. Their empirical analysis reveals that among developing and newly industrialised

countries, the sharpest increase in inequality can be found where export shares have shifted towards more skill-intensive goods. Several empirical studies seem to suggest that globalisation indeed leads to rising inequalities also in the South. A famous example is Mexico. Harrison and Hanson (1999) point out that Mexico experienced a dramatic increase in the skilled-unskilled wage gap during a period of trade liberalisation.[1] Verhoogen (2008) argues that a perhaps unexpected widening of wage differentials following trade liberalisation is rooted in technological change. More trade led to quality upgrading in Mexican production, benefitting the relatively more skilled workers in that economy.

In the present paper we develop a theoretical model where multinationals may determine not only the amount of technology transfer, but also the type of knowledge which is transferred to subsidiaries in the South. More specifically, we model a multinational company which chooses its product line (one or two vertically differentiated products), the location of its production (in the North or in the South, or in both places), and the quality and quantity of its products. We identify and concentrate our attention on the equilibrium where the firm is multiproduct and produces the high-quality product in the North, where labour is unionised, and the low-quality product in the South, where labour is cheaper but also less productive. Our model therefore allows us to consider two different types of North-South technology transfer. Firstly, a firm can upgrade the quality of the product produced in the South, making it more similar to what the multinational produces in the North. Secondly, the firm can also transfer knowledge that upgrades the skills and productivity of southern labour. Decisions on technology transfers will impact wage bargaining, which in turn influences the incentives for technology transfer in a North-South framework.[2]

Many empirical observations are in line with the main features of the model we propose. There is compelling evidence that product quality varies considerably across countries and that

[1] See Goldberg and Pavcnik (2007) for a comprehensive review of empirical evidence showing similar results. Pavcnik (2003) studies technology transfer, skill upgrading and inequality in Chile. More recentcly, Rattsø and Stokke (2010) have drawn attention to the increasing wage inequality in South Africa following the fall of Apartheid and the subsequent increase in trade openness.

[2] Dowrick and Spencer (1994), Lommerud, Meland and Straume (2006) and Lommerud and Straume (2012) consider trade unions that can veto technological change, but in these models the firms are single-product, there is no North-South dimension, and new technology arrives exogenously.

richer countries tend to produce and export higher quality goods.[3] Khandewal (2010) emphasizes that the quality span between high-end and low-end variants vary among products and finds, interestingly, that markets characterized by relatively shorter 'quality ladders' are associated with larger employment and output declines in high-wage countries resulting from low-wage competition. Another empirical fact is that world trade is dominated by multinational corporations in both developed and developing economies alike.[4] Multinationals are typically multiproduct firms[5], and they will probably have quite some leeway as to where which quality variant should be produced. Several authors[6] stress that trade liberalisation can lead to a boost in economic performance, not only because new export markets become available, but also due to cheaper imports of intermediate and capital goods that earlier had been too expensive. The contribution of the present paper is to investigate theoretically if these interlinked choices a multinational must make – regarding where which quality variant is to be produced and to which degree intermediate goods and capital equipment and other forms of technology transfer should be made available for various daughter companies – can have a strategic motivation that is connected with the labour market. Are multinationals and their northern and southern workforces locked in a three-way power battle?

In the main version of our model, where northern workers are unionised while southern workers face an exogenous wage level, we find that increased bargaining power of northern workers lead to more technology transfers, both in the form of product quality upgrading and skill upgrading. Thus, technology transfer clearly is a weapon that a multinational can use against its northern workforce. A higher southern wage level, on the other hand, will discourage incentives to upgrade product quality in the South, but incentives for skill upgrading can in fact be increased.[7] Thus, a higher wage level in the South will tend to shift incentives from product quality upgrading to skill upgrading. Interestingly, when technology choices are endogenous,

[3] Schott (2004), Hallak (2006) and Hallak and Schott (2011).

[4] Dunning (1993) estimates that multinationals account for 75% of the world's commodity trade. Bernard, Jensen and Schott (2009) document that US trade flows are dominated by firms that both export to and import from 'related parties'. Manova, Wei and Zhang (2009) highlight credit constraints as one reason why foreign-owned affiliates and joint ventures in China seem to peform better than Chinese-owned firms.

[5] Bernard, Redding and Schott (2011) and Goldberg et al. (2012a).

[6] Goldberg et al. (2012b), Kugler and Verhoogen (2009) and Topalova and Khandelwal (2010).

[7] This is related to earlier results that minimum wages can encourage skill formation (Agell and Lommerud (1997) and Acemoglu and Pischke (1999)), although the context is very different.

improved labour conditions in the South may actually harm northern workers if incentives for skill upgrading are stimulated to a sufficient extent. Furthermore, we identify quality upgrading and skill upgrading as complementary strategies for the firm: a higher skill level in the South will increase incentives for quality upgrading, and *vice versa*. In the equilibrium of the full game (which is analysed by numerical simulations), we also identify a negative relationship between bargaining power and equilibrium wages for northern workers. This may seem counterintuitive, but is explained by the fact that increased union power in the North triggers technology transfer, which in turn dampens the wage claims of northern workers, possibly to the extent that the overall effect of increased bargaining power on equilibrium wages is negative. This result highlights the potential value of credible commitments with respect to trade union wage policies. If the trade union in the North were able to credibly commit itself to a policy of wage moderation, this would curtail incentives for North-South technology transfer, possibly resulting in higher union utility.

In an extended version of the model, where both northern as well as southern workers are represented by trade unions, we find that unions in the North and the South have opposite interests when it comes to *skill* upgrading. However, while northern workers lose from product *quality* upgrading, their southern counterparts will gain in some circumstances and lose in others. Since quality upgrading implies that competition between workers in the North and the South is intensified, this particular type of technology transfer might actually worsen the situation not only for northern workers, but also for their southern counterparts. Thus, although both types of technology transfers are generally profitable for the firm, technology transfer in the form of product quality upgrading might be a particularly effective instruments for multinationals in order to extract rents from workers. The effects of policies that raises the reservation wage of southern workers (e.g., minimum wage increases) are similar with and without unionised labour in the South.

If this theory is to make sense, trade unions must still be a force to be reckoned with, particularly in the northern home countries of multinationals. The role of trade unions has evolved dramatically differently in the rich part of the world. While the UK probably is a

prime example of deunionisation, and the US always had weaker unions than Europe, union membership remains rather high in most of Continental Europe and Scandinavia – and in these latter countries union coverage is almost unchanged.[8,9] This means that trade unions still stand strong when it comes to industrial production in important home countries for multinationals, such as Germany, the Netherlands and Sweden. Turning to the developing world, the situation varies enormously from country to country. Some developing countries have even more flexible labor markets than the US, while others have strong trade unions and a very regulated labor market.[10] Martin and Brady (2007) report union membership rates for 39 developing countries. There are very large variations, but average union density comes out at around 15%, which certainly is much lower than in most Western European countries. Anecdotal evidence suggests that the ability of multinationals to shift production between plants in different countries is a source of worry for many trade unions. One example that fits our theoretical model, with multinationals producing high-quality variants in the North and low-quality variants in the South, is the market for cross-country skis. All European producers of skis tend to produce top-of-the-range skis in their original home country, while skis for the mass market are produced at low-cost locations in Eastern Europe or China. The Norwegian ski producer Madshus is now a subsidiary of the US firm K2 Sports. Their mass-market skis are produced at K2 plants in China, while high-quality skis are produced in Norway. They report that the exact cut-off between which types of skis to be produced in Norway and which brands to be produced in China is currently an issue for discussion between Madshus and K2 headquarters.[11] Naturally, this choice influences the bargaining situation for a home country trade union.

As trade unions are not as prevalent in all northern economies as they are in some, several authors have sought to study labour market rigidities and globalisation in other frameworks than the unionised one. Firstly, there is a literature on spillover effects among countries from national

[8] Union coverage refers to the fraction of the workforce which has its pay and work conditions regulated by a union contract, while union density (membership) refer to the fraction of the labor force which actually pays union dues.

[9] Relevant facts about union density and union coverage in several countries can be found in EEAG (2004) and OECD (1997).

[10] World Economic Forum (2008) summarises evidence on the flexibility of wage determination and other labour market relations for a wide number of countries. This is both based on 'hard facts' and on opinion surveys among business executives.

[11] DN (Dagens Næringsliv), 28 October 2011.

minimum wages.[12] Closer to the trade union literature are models of matching frictions, possibly with individual wage bargaining.[13] Finally, we should also mention models where workers have fair-wage preferences and this influences wage structures.[14] This could mean that results from trade union models have some approximate relevance also for countries with individual rather than collective bargaining. The most important difference between our paper and this whole body of literature is that we study wage formation within multinational firms. The interlinkages among workers in the same firm but in different countries then become pressing – and the question of within-firm technology transfer arises.

This paper is a contribution to the economics of technology transfer within multinational firms from rich to poor countries. This literature is truly vast. An important focus is that FDI and technology transfers can have important spillovers: workers learn new ways of producing by working in the multinationals; host country firms can be able to copy products and/or production technology from multinational subsidiaries in their vicinity. Spillovers can reduce the incentives of multinationals for FDI and technology transfer, but can also explain why host governments often are so eager to capture such investments. Theoretical work on technology transfer focusing on contractual incompleteness/spillovers include Ethier and Markusen (1996), Glass and Saggi (1998, 2002), Konrad and Lommerud (2001), Pack and Saggi (2001), Olsen and Osmundsen (2003), Antràs (2005). Müller and Schnitzer (2005) and Blalock and Gertler (2008).[15] But even if this literature is large, we have found no discussion on how technology transfers impact the strategic position of the home country workforce, and how this in turn helps determining the scale and type of technology transfer.

Our paper clearly also relates to the large literature on unionised international oligopoly.[16] The central question in that literature is how unionised workers fare when they are exposed to

[12] See, e.g., Davis (1998) and Egger, Egger and Markusen (2009).

[13] Examples of this literature include Davidson, Matusz and Shevchenko (2008), Helpman and Itskhoki (2010), Boulhol (2011) and Decreuse and Maarek (2010).

[14] See, e.g., Agell and Lundborg (1995) and Egger and Kreickemeier (2009). An empirical investigation of the fair-wage hypothesis can be found in Verhoogen, Burks and Carpenter (2007).

[15] Empirical work on technology transfer and spillovers include Haddad and Harrison (1993), Kokko (1994), Blomström and Sjöholm (1999), Aitken and Harrison (1999), Xu (2000), and Liu (2002).

[16] See, e.g., Naylor (1998, 1999), Lommerud, Meland and Sørgard (2003), Lommerud, Straume and Sørgard (2006), Eckel and Egger (2009), Bastos and Kreickemeier (2009), Ishida and Matsushima (2009) and Kreickemeier and Meland (2011).

harsher international competition. Within this literature, those papers that study globalisation in a North-South context typically portray the labour market in the South as being competitive, and the fate of southern workers is not given attention. A partial exception is Grieben and Sener (2009), who use a North-South product cycle model, with unionised workers in the North, and study the effects on innovation by trade liberalisation both in the North and the South. Nevertheless, they also use the assumption that the labour market in the South is competitive.

The remainder of this paper is organised as follows. The main model with wage bargaining in the North and an exogenous wage in the South is presented Section 2 and analysed in Sections 3-5. The model is then extended in Section 6 to capture the case where also workers in the South have collective bargaining power. Section 7 concludes the paper.

2 Model

Consider a multinational firm that can produce two versions of a vertically differentiated product – a high-quality and a low-quality version – using labour as the only variable factor of production. In addition to labour costs, the production of each variety (or 'brand') requires a fixed cost that increases with the level of brand quality. Each brand can be produced either in 'the North', where workers are unionised, or in 'the South', where labour is cheaper. However, due to less advanced technology and skill level in the South, workers there are less productive and the cost of quality is higher.

Product demand is derived from consumer preferences that correspond to a standard vertical differentiation framework (Mussa and Rosen, 1978). The firm can supply both brands to an integrated world market where consumers are heterogeneous with respect to their willingness-to-pay. More specifically, consumers are identified by a preference parameter $\tau \sim U[0,1]$, and the utility of a consumer of type τ is given by

$$u = \begin{cases} \mu_1 \tau - p_1 & \text{if buying Brand 1} \\ \mu_2 \tau - p_2 & \text{if buying Brand 2} \end{cases}, \tag{1}$$

where p_i is the price and μ_i is the quality of Brand i. We let Brand 1 be the high-quality brand,

implying $\mu_1 > \mu_2$. We also assume unit demand, where each consumer buys either one or zero units of one of the brands, and the total consumer mass is normalised to 1.

Suppose that the firm is producing the high-quality brand in the North and the low-quality brand in the South. Let q_i be the produced quantity of Brand i, and let w_N and w_S (L_N and L_S) denote the wage (employment) levels in the North and the South, respectively. Furthermore, let $\phi \in (0,1)$ be a measure of labour productivity (or 'skill level') in the South. Assuming a linear production function, where $q_1 = L_N$ and $q_2 = \phi L_S$, the firm's variable profits are given by

$$\pi = (p_1 - w_N)\, q_1 + (p_2 - \omega_S)\, q_2, \tag{2}$$

where $\omega_S := \frac{w_S}{\phi}$ is the *effective wage* in the South.

Providing quality is costly, and the firm's profits net of quality costs are given by

$$\Pi = \pi - G\left(\mu_1, \mu_2; \phi\right), \tag{3}$$

where G is increasing, at least twice differentiable and strictly convex in μ_1 and μ_2. We assume that there is an upper limit to product quality, so G is defined over $\mu_1 \in [0, \overline{\mu}_1]$ and $\mu_2 \in [0, \overline{\mu}_2]$. In order to minimise the scope for corner solutions, we further assume that there is no fixed cost of introducing a product variety at the minimum quality level; or, more technically: $G_{\mu_1}(0, \mu_2; \phi) = G_{\mu_2}(\mu_1, 0; \phi) = 0$. We also make the following additional assumptions:

(i) $G_{\mu_1}(\mu_1, \mu_2; \phi) < G_{\mu_2}(\mu_1, \mu_2; \phi)$ for $\mu_1 > 0$ and $\mu_2 > 0$,

(ii) $\overline{\mu}_1 > \overline{\mu}_2$,

(iii) $G_{\mu_2 \phi}(\mu_1, \mu_2; \phi) < 0$ and $G_{\mu_1 \phi}(\mu_1, \mu_2; \phi) = 0$.

The first two assumptions operationalise our underlying general assumption that the less technologically advanced country (the South) is less suitable for production of high-quality products: quality costs are higher and the maximum quality level that can be produced is lower in the South. The last assumption establishes a relationship between workers' skill level and the cost of quality provision in the South. The higher the skill level of workers (in the South), the lower is the cost of providing a certain level of product quality.

In addition, we also assume that the firm can make an investment in order to increase labour productivity in the South. Suppose that the initial skill level is $\phi = \phi_0$. By paying a fixed cost c, the firm can increase worker productivity to a level $\phi_1 > \phi_0$. Thus, there are potentially two types of technology transfer in our model: *quality upgrading* and *skill upgrading*.

For the main part of the analysis, the wage level in the South, w_S, is assumed to be exogenously given. The wage level in the North, on the other hand, is subject to bargaining between the firm and a rent-maximising trade union whose utility is given by

$$U_N = (w_N - r_N) L_N, \tag{4}$$

where r_N is the reservation wage of Northern workers.

We consider the following sequence of events:

Stage 0: The firm chooses its product line and the locations of production.

Stage 1: The firm chooses the quality level of each brand it decides to produce and, given that production will take place in the South, also chooses whether or not to upgrade the skill level of Southern workers.

Stage 2: The firm and its trade union bargain over the wage level in the North.

Stage 3: The firm chooses how much to produce of each brand.

Notice that, by placing the product line and technology transfer decisions prior to wage bargaining, we implicitly assume that it is impossible for the union to commit to a certain wage policy in order to influence these decisions directly.[17] We will look for an equilibrium where the firm produces both brands, and where the high-quality (low-quality) version is produced in the North (South). In the next section we derive two necessary conditions for the existence of such an equilibrium.

[17] In the literature on trade unions and offshoring (Skaksen and Sørensen (2001), Zhao (2001), Lommerud, Meland and Straume (2009) and Koskela and Stenbacka (2009)), attention is implicitly focused on Stage 0, while ignoring what we here have dubbed Stage 1.

3 Optimal output choices

Assume that both brands are produced. From the utility function, demand is given by

$$q_1 = 1 - \widehat{\tau} \text{ and } q_2 = \widehat{\tau} - \frac{p_2}{\mu_2}, \tag{5}$$

where

$$\widehat{\tau} := \frac{p_1 - p_2}{\mu_1 - \mu_2}. \tag{6}$$

Thus, consumers with high willingness-to-pay ($\tau > \widehat{\tau}$) will buy Brand 1, consumers with intermediate willingness-to-pay ($\tau \in \left(\frac{p_2}{\mu_2}, \widehat{\tau}\right)$) will buy Brand 2, while consumers will low willingness-to-pay ($\tau < \frac{p_2}{\mu_2}$) will refrain from buying.

Assuming that the high-quality version (Brand 1) is produced in the North and the low-quality version (Brand 2) in the South, the profit maximising prices are given by

$$p_1 \ = \frac{1}{2}\left(\mu_1 + w_N\right) \text{ and } p_2 = \frac{1}{2}\left(\mu_2 + \omega_S\right). \tag{7}$$

The corresponding quantities are

$$q_1 = \frac{\left(\mu_1 - \mu_2\right) - \left(w_N - \omega_S\right)}{2\left(\mu_1 - \mu_2\right)} \text{ and } q_2 = \frac{w_N\mu_2 - \omega_S\mu_1}{2\mu_2\left(\mu_1 - \mu_2\right)}. \tag{8}$$

The existence of an interior solution (i.e., $q_1 > 0$ and $q_2 > 0$) requires that

$$w_N - \left(\mu_1 - \mu_2\right) < \omega_S < \frac{\mu_2}{\mu_1} w_N. \tag{9}$$

Although the above condition is derived under the initial assumption that the high-quality (low-quality) version is produced in the North (South), several implications about alternative options immediately follow. Since $\mu_1 > \mu_2$, a necessary condition for an interior solution is that the effective wage level is lower in the South than in the North (i.e., $\omega_S < w_N$). This means that, for given quality levels, the firm will produce both versions only if the low-quality version can be produced with lower variable costs. This condition rules out the possibility of producing

both varieties in the same country. Since labour is assumed to be cheaper in the South than in the North, the above condition also rules out the possibility of producing the high-quality version in the South and the low-quality version in the North. Two possibilities remain; the firm can produce only one brand, either in the North or in the South. If the firm sells only one brand (with quality μ_1 and price p_1), demand is given by $1 - \frac{p_1}{\mu_1}$. Clearly, selling only one brand, and producing it in the North, is never optimal if the condition in (9) is satisfied. This follows directly from the way (9) is derived. The final option is to sell only one brand and produce it in the South, where labour is cheaper. This would allow the firm to produce the good with lower variable costs. However, locating production in the South implies higher fixed quality costs and a smaller scope for producing a high-quality product. Thus, this option is clearly not optimal if the cost of quality improvements is sufficiently lower in the North than in the South.

The following proposition summarises the above analysis:

Proposition 1 *The following two conditions are necessary for the existence of an equilibrium where a high-quality and a low-quality version are being produced in, respectively, the North and the South:*

1. *The effective wage rate must be lower in the South than in the North*
2. *The cost of quality upgrading must be sufficiently lower in the North than in the South.*

In the following we will concentrate on this particular equilibrium, which is the interesting one from the viewpoint of North-South technology transfer, and we will therefore assume that the two above-stated conditions are satisfied.

4 Wage bargaining

We assume that quality costs are sunk at the wage bargaining stage. Assuming Nash bargaining, the wage level in the North is determined as a solution to the following problem:

$$w_N = \arg\max \left(U_N - \overline{U}_N\right)^{\alpha} \left(\pi - \overline{\pi}_N\right)^{1-\alpha}, \tag{10}$$

where $\alpha \in (0,1)$ measures the relative bargaining strength of the trade union, and $\overline{U}_N$ and $\overline{\pi}_N$ are the disagreement payoffs of the union and the firm, respectively. We assume that the unionised workers do not have access to alternative employment during a bargaining conflict; i.e., $\overline{U}_N = 0$. The firm, on the other hand, is still able to produce Brand 2 in the South during a conflict in the North. We assume that, in case of a bargaining conflict, the firm optimally adjusts its production of Brand 2 to maximise profits for $q_1 = 0$. This implies that the disagreement payoff of the firm is given by

$$\overline{\pi}_N = \frac{(\mu_2 - \omega_S)^2}{4\mu_2}. \tag{11}$$

The bargained wage is then given by

$$w_N = r_N + \frac{\alpha\Theta}{2}, \tag{12}$$

where[18]

$$\Theta := \omega_S - r_N + \mu_1 - \mu_2 > 0.$$

All comparative statics results for w_N, which follow straightforwardly from (12), are qualitatively unambiguous:

Proposition 2 *The bargained wage in the North is increasing in α, r_N, ω_S and μ_1, and decreasing in μ_2.*

That the bargained wage increases with the relative bargaining power and the reservation wage of the trade union is standard and requires no further explanation. The remaining comparative statics results are the more interesting ones.

Quality upgrading has opposite effects on the bargained wage depending on whether the upgrading takes place in the North or in the South. A quality increase of the brand produced in the South enables the firm to charge a higher price for this brand without losing demand. This means that it becomes relatively more profitable for the firm to produce Brand 2 and the firm will consequently produce more of this brand and less of Brand 1, implying a drop in

[18] Notice that the condition in (9) ensures that $\Theta > 0$, since $w_N \geq r_N$.

labour demand in the North, making demand for Northern workers more elastic. In addition, a higher quality of Brand 2 increases the disagreement payoff of the firm in case of a bargaining conflict.[19] Both these effects contribute to a lower bargained wage in the North, as a result of quality upgrading in the South. A quality upgrading in the North, on the other hand, shifts production towards Brand 1 and therefore enables to union to obtain a higher wage.

A lower effective wage rate in the South has qualitatively similar effects on the bargained wage as quality upgrading in the South: Brand 2 becomes relatively more profitable to produce and the disagreement payoff of the firm also increases, leading to a lower wage in the North. Thus, skill upgrading of workers in the South, which reduces their effective wage rate, would lead to lower wages for workers in the North. On the other hand, a higher wage rate in the South, for example due to an increase in the legal minimum wage or generally better outside options for Southern workers, would have the opposite effect and ultimately lead to higher wages also for workers in the North.

For given qualities, equilibrium quantities and prices of the two brands are given by

$$q_1 = \frac{(2-\alpha)\,\Theta}{4\,(\mu_1-\mu_2)}, \qquad q_2 = \frac{2\,(\mu_2 r_N - \mu_1\omega_S) + \alpha\mu_2\Theta}{4\mu_2\,(\mu_1-\mu_2)}, \tag{13}$$

$$p_1 = \frac{2\,(r_N+\mu_1)+\alpha\Theta}{4}, \qquad p_2 = \frac{\omega_S+\mu_2}{2}. \tag{14}$$

An interior solution for any $\alpha \in (0,1)$ requires

$$r_N - (\mu_1-\mu_2) < \omega_S < r_N\frac{\mu_2}{\mu_1} \tag{15}$$

We will therefore restrict the subsequent analysis to parameter configurations which satisfy this condition.

[19] From (11), notice that

$$\frac{\partial\overline{\pi}_N}{\partial\mu_2} = \frac{(\mu_2+\omega_S)\,(\mu_2-\omega_S)}{4\mu_2^2} > 0.$$

Equilibrium union utility and variable profits, as functions of qualities, are

$$U_N = \frac{\alpha(2-\alpha)\Theta^2}{8(\mu_1-\mu_2)} \tag{16}$$

and

$$\pi = \frac{(2-\alpha)\Theta(2(\mu_1-r_N)-\alpha\Theta)}{16(\mu_1-\mu_2)} + \frac{(\mu_2-\omega_S)(2(r_N\mu_2-\omega_S\mu_1)+\alpha\mu_2\Theta)}{8\mu_2(\mu_1-\mu_2)}. \tag{17}$$

Notice that the first (second) term of (17) is the variable profits from producing and selling Brand 1 (Brand 2). Based on (16) and (17), and abstracting from the fixed costs of quality and skill upgrading, the union and the firm can be shown to have diametrically opposite incentives with respect to quality and skill upgrading in the South:[20]

Proposition 3 *(i) For given brand qualities, a higher effective wage in the South benefits the union but reduces the variable profits of the firm.*

(ii) Higher quality of the brand produced in the South increases variable profits but reduces union utility.

(iii) Higher quality of the brand produced in the North increases both variable profits and union utility.

Thus, the firm's and union's interests are perfectly aligned only with respect to the quality level of the brand produced in the North: both parties will benefit from a (costless) quality upgrading here. The intuition for these results mirrors closely the discussion of the wage effects reported in Proposition 2.

The first part of Proposition 3 implies a positive relationship between labour conditions (w_S) in the South and union utility in the North. Notice that this relationship is derived for given qualities and skill level in the South. If we endogenise the firm's quality choices and also allow the firm to invest in skill upgrading of Southern workers, an improvement of labour conditions in the South might affect the incentives for quality and skill upgrading in a way that potentially harms the unionised workers in the North. We will return to this question in the next section.

[20] The proofs of this and all subsequent propositions are given in the Appendix.

5 Quality choices and skill upgrading

The firm chooses the quality of each brand and decides whether or not to invest in skill upgrading of Southern workers, taking into the account how these choices affect wage bargaining in the North. In this section we will analyse the incentives for quality and skill upgrading separately, before solving for the subgame perfect Nash equilibrium of the full game.

5.1 Optimal quality choices for a given skill level

For a given skill level of workers in the South, the optimal quality choices are implicitly given by the following pair of first-order conditions (assuming an interior solution):

$$\frac{\partial \Pi}{\partial \mu_1} = \frac{(2-\alpha)^2 \Theta \left(\Theta + 2\left(r_N - \omega_S\right)\right)}{16\left(\mu_1 - \mu_2\right)^2} - G_{\mu_1} = 0, \tag{18}$$

$$\frac{\partial \Pi}{\partial \mu_2} = \frac{4\left(\omega_S \mu_1 - \left(2\omega_S - r_N\right)\mu_2\right)\left(r_N \mu_2 - \omega_S \mu_1\right) + \alpha\left(4-\alpha\right)\mu_2^2 \Theta\left(\Theta + 2\left(r_N - \omega_S\right)\right)}{16\mu_2^2\left(\mu_1 - \mu_2\right)^2} - G_{\mu_2} = 0. \tag{19}$$

The second-order conditions, which are satisfied if G is sufficiently convex in μ_1 and μ_2, are given by

$$\frac{\partial^2 \Pi}{\partial \mu_1^2} = \frac{(2-\alpha)^2\left(r_N - \omega_S\right)^2}{8\left(\mu_1 - \mu_2\right)^3} - G_{\mu_1\mu_1} < 0, \tag{20}$$

$$\frac{\partial^2 \Pi}{\partial \mu_2^2} = \frac{4\omega_S^2 \mu_1^3 + 4 r_N \mu_2^3\left(r_N - 2\omega_S\right) - 12\omega_S^2 \mu_1 \mu_2\left(\mu_1 - \mu_2\right) - \alpha\left(4-\alpha\right)\mu_2^3\left(r_N - \omega_S\right)^2}{8\mu_2^3\left(\mu_1 - \mu_2\right)^3} - G_{\mu_2\mu_2} < 0, \tag{21}$$

and

$$\frac{\partial^2 \Pi}{\partial \mu_1^2}\frac{\partial^2 \Pi}{\partial \mu_2^2} - \left(\frac{\partial^2 \Pi}{\partial \mu_1 \partial \mu_2}\right)^2 > 0, \tag{22}$$

where

$$\frac{\partial^2 \Pi}{\partial \mu_1 \partial \mu_2} = -\frac{(2-\alpha)^2\left(r_N - \omega_S\right)^2}{8\left(\mu_1 - \mu_2\right)^3} < 0. \tag{23}$$

For a given skill level, ϕ, equations (18)-(19) define a pair of optimal qualities: $\mu_1^*(\phi) \in (0, \overline{\mu}_1)$ and $\mu_2^*(\phi) \in (0, \overline{\mu}_2)$. Using standard comparative statics techniques, we can evaluate how marginal changes in the key parameters affect optimal quality choices. Keeping ϕ constant, we

are foremostly interested in how changes in labour market conditions affect incentives for quality upgrading.

Proposition 4 *For a given level of labour productivity in the South, (i) an increase in union bargaining power leads to lower quality in the North and higher quality in the South, while (ii) a higher effective wage rate in the South leads to lower quality in the South and higher quality in the North.*

Generally, if one of the brands becomes more costly to produce, the firm would like to produce less of this brand and more of the other brand. The firm then optimally upgrades (downgrades) the quality of the brand which has become cheaper (costlier) to produce. Although this explains the relationship between production costs (wages) and quality choices stated in the above proposition, it is only part of the full story. In addition, the firm has an incentive to use quality choices *strategically* in order to influence the outcome of wage bargaining. As stronger unions make the production of Brand 1 more expensive, the multinational firm can counteract this effect by upgrading the quality of Brand 2, which is produced in the South. Due to increased inter-brand competition, this worsens the union's bargaining position in the North (cf. Proposition 2) and consequently dampens its wage claims. Thus, through the particular product market linkage explored in this paper, we have identified a possible mechanism whereby the presence of powerful trade unions in the North will reinforce incentives for North-South technology transfer, in this case quality upgrading, within multinational firms.

Notice also that the negative relationship between the effective wage in the South and the quality level of Brand 2 implies a *positive* effect of skill upgrading on quality upgrading in the South. Since skill upgrading leads to a lower effective wage, it follows that skill upgrading will increase incentives also for quality upgrading in the South. This relationship holds even in the absence of any cost linkages between the two types of technology transfer. Consequently, the effect is reinforced by the assumption that skill upgrading reduces the marginal cost of quality upgrading. We will return to this point in the next subsection, where we investigate incentives for skill upgrading.

5.2 Incentives for skill upgrading

The firm can transfer technology to upgrade the skill level of Southern workers. By investing an amount of $c > 0$, the skill level is upgraded by $\Delta\phi := \phi_1 - \phi_0 > 0$. For given quality levels, the profit gain of skill upgrading is given by

$$\begin{aligned}\Delta\Pi &= \Pi(\mu_1, \mu_2; \phi_1) - \Pi(\mu_1, \mu_2; \phi_0) \\ &= \omega_S^1 \frac{4\left(2r_N - \frac{\mu_1}{\mu_2}\left(\omega_S^0 + \omega_S^1\right)\right) + \alpha(4-\alpha)(\Theta_0 + \Theta_1)}{16(\mu_1 - \mu_2)} \left(\frac{\phi_1 - \phi_0}{\phi_0}\right) \\ &\quad + [G(\mu_1, \mu_2; \phi_0) - G(\mu_1, \mu_2; \phi_1)], \end{aligned} \tag{24}$$

where $\omega_S^i := \frac{w_S}{\phi_i}$ and $\Theta_i := \omega_S^i - r_N + \mu_1 - \mu_2 > 0$, $i = 0, 1$. The firm will invest in skill upgrading if $\Delta\Pi > c$, so we can use $\Delta\Pi$ as a measure of the firm's incentive for skill upgrading.

By considering marginal changes in α and w_S, we can assess the effects of changing labour market conditions in the North and South, respectively, on incentives for skill upgrading:

Proposition 5 *For given quality levels, (i) an increase in union bargaining power increases the firm's incentive for skill upgrading in the South, while (ii) a higher wage in the South increases (reduces) the firm's incentive for skill upgrading if the effective wage rate in the South remains sufficiently low (high).*

The first part of Proposition 5 is clearly related to the first part of Proposition 4: stronger union power in the North increases the incentive for both types of technology transfer, skill upgrading as well as quality upgrading in the South, and both effects are strongly linked to the wage effects reported in Proposition 2. The multinational firm can counteract (at least partly) the union power in the North by upgrading the skill level of the workers in its Southern affiliate. By investing in skill upgrading, and thereby making Brand 2 relatively cheaper to produce, the demand for Northern labour becomes more elastic, which dampens the wage claims of the union in the North. Naturally, the stronger the relative bargaining power of the union, the stronger the firm's incentive to invest in skill upgrading.

The second part of the proposition shows that improved labour conditions in the South

have a generally ambiguous effect on the firm's incentive for skill upgrading. A marginal wage increase in the South will increase incentives for skill upgrading only if the effective wage rate in the South is sufficiently low to begin with. A contributing factor to this result is the convexity of π in ω_S: the lower the effective wage rate in the South, the higher the profit gain of a marginal reduction in the effective wage rate (through skill upgrading).[21] An implication of this result is that improved labour conditions in the South might have qualitatively different effects on the two types of technology transfer. In other words, a higher wage in the South might affect not only the extent but also the predominant *type* of technology transfer. Even though we have not yet solved for the equilibrium of the full game, Propositions 4-5 suggest that a wage increase in the South might shift incentives for technology transfer from product quality upgrading to skill upgrading, as long as the effective wage rate in the South remains sufficiently low.

The second part of Proposition 4 also suggests that, when endogenising the quality and skill level in the South, the unionised workers in the North might not necessarily benefit from improved labour market conditions in the South. Although there are positive effects of a wage increase in the South on union utility in the North, both directly (Proposition 3) and indirectly through quality adjustments (Proposition 4), the overall effect might nevertheless be negative if a higher wage in the South triggers North-South technology transfer in the form of skill upgrading. We will further explore this possibility when solving for the equilibrium of the full game below.

We can also use (24) to see how the firm's incentive for skill upgrading depend on brand qualities:

Proposition 6 *A higher product quality in the South or a lower product quality in the North increases the firm's incentive for skill upgrading.*

Since skill upgrading implies paying a fixed cost in order to reduce variable costs, the incentive for skill upgrading in the South increases, all else equal, with the production volume of Brand 2. An increase in the quality of the brand produced in the South (North) will increase (reduce) the

[21] From (17):

$$\frac{\partial^2 \pi}{\partial \omega_S^2} = \frac{4\left(\mu_1 - \alpha\mu_2\right) + \alpha^2\mu_2}{8\mu_2\left(\mu_1 - \mu_2\right)} > 0.$$

optimal output of Brand 2 and thus lead to a correspondingly higher (lower) incentive for skill upgrading. For this reason, the relationship between quality upgrading and skill upgrading in the South is positive even in the case of $G_{\mu_2\phi} = 0$. The assumed cost complementarity between the two types of technology transfer (i.e., $G_{\mu_2\phi} < 0$) will only reinforce the strength of this relationship. When seen in conjunction with the second part of Proposition 4, the above stated result allows us to reach the following conclusion:

Corollary 1 *Skill upgrading and quality upgrading in the South are complementary strategies for the firm.*

5.3 Equilibrium choices of quality and skill upgrading

In order to analyse the subgame perfect Nash equilibrium of the full game, where the multinational firm chooses brand qualities and also decides whether or not to invest in skill upgrading, we assume that the cost function G takes the following quadratic form:

$$G(\mu_1, \mu_2; \phi) = \frac{k_1}{2}\mu_1^2 + \frac{k_2}{1+\phi}\mu_2^2, \tag{25}$$

where $k_2 \geq k_1 > 0$. By simultaneously solving (18)-(19), we can define the optimal quality choices for a given skill level in the South: $\mu_1^*(\phi)$ and $\mu_2^*(\phi)$. The firm will invest in skill upgrading – which increases labour productivity in the South from ϕ_0 to ϕ_1 – if

$$\Delta\Pi(\mu_1^*, \mu_2^*) := \Pi(\mu_1^*(\phi_1), \mu_2^*(\phi_1); \phi_1) - \Pi(\mu_1^*(\phi_0), \mu_2^*(\phi_0); \phi_0) > c. \tag{26}$$

Deriving the optimal solution requires solving a fifth-degree polynomial. We must therefore resort to numerical simulations in order to characterise the equilibrium. Table 1 shows the optimal quality choices, and the corresponding levels of employment, wages, profits and union utility, for a set of parameter configurations where we vary the key labour market parameters α and w_S.[22] We assume that $\phi_0 = 0.5$ and $\phi_1 = 0.6$ and calculate the optimal quality choices with ($\phi = \phi_1$) or without ($\phi = \phi_0$) skill upgrading. The remaining parameters are chosen in order to

[22] The reported values in Table 1 are rounded to the nearest three decimals.

ensure that the optimal product line decision is to produce both brands: the high-quality version in the North and the low-quality version in the South. Given the parameter values reported in Table 1, equilibrium existence is ensured by setting the upper bounds on quality at appropriate levels, for example $\overline{\mu}_1 = 3.3$ and $\overline{\mu}_2 = 1.1$. Since we are fixing α at specific values, we choose parameters satisfying (9) rather than (15).

[Table 1 about here]

We see that the results reported in Table 1, on the relationship between labour market conditions (in the North and the South) on quality choices, are consistent with Proposition 4. A higher wage in the South leads to quality upgrading in the North and quality downgrading in the South (where the first effect is quantitatively much smaller than the second). Wages, employment and union utility in the North increase correspondingly. On the other hand, an increase in the union's relative bargaining power leads to lower quality in the North and higher quality in the South, with a corresponding reduction (increase) in employment in the North (South). Perhaps surprisingly, we see that a more powerful union also leads to a reduction in the bargained wage in the North. Since both wages and employment go down, so does union utility. *A priori*, there are two counteracting effects of increased union bargaining power on wages and union utility. For given quality levels, a stronger union is able to bargain higher wages, with a corresponding increase in union utility. However, increased union power in the North also triggers quality downgrading in the North and quality upgrading in the South, which have the opposite effect on wages and union utility in the North. For the parameter configurations reported in Table 1, it turns out that the second effect dominates, establishing (somewhat paradoxically) a negative relationship between union bargaining power and union utility.

These results are based on optimal quality adjustments for a given skill level in the South. However, the firm also decides whether or not to invest in skill upgrading of Southern workers. From Table 1 we see that higher labour productivity in the South leads to quality upgrading of Brand 2, which triggers a wage reduction in the North.[23] The incentives for skill upgrading are

[23] Higher labour productivity in the South also leads to quality downgrading of Brand 1, but this effect is quantitatively so small that it is not noticeable (in most cases) when rounding the numbers to the nearest three decimals.

given by Table 2, where we report the values of $\Delta\Pi$, i.e., the profit gain of skill upgrading, for all parameter configurations considered in Table 1.[24] For each parameter configuration, the firm will invest in skill upgrading if the reported value of $\Delta\Pi$ is higher than the cost of technology transfer, c.

[Table 2 about here]

Consistent with Proposition 5, we see that the firm has stronger incentives for skill upgrading when the relative bargaining power of the union is higher.[25] Thus, the more powerful the union is, the more likely it is that the firm will transfer technology to upgrade the skill of Southern workers in equilibrium. If an increase in the union's relative bargaining power triggers skill upgrading, this will only reinforce the previously discussed negative relationship between union bargaining power and union utility. One implication of this result is that it would potentially be highly valuable for the union in the North to be able to credibly commit itself to a policy of wage moderation in order to curtail North-South technology transfer.

For the parameter configurations considered in this numerical example, a higher wage in the South also increases incentives for skill upgrading. This opens up for the possibility, as mentioned in Section 5.2, that improved labour market conditions in the South could eventually be harmful for Northern workers, if it leads to skill upgrading of Southern workers. A comparison of Tables 1 and 2 reveals that this possibility is actually present for all parameter configurations. Consider, for example, the parameter configuration ($\phi = 0.5, w_S = 0.03, \alpha = 0.5$), where equilibrium union utility is given by $U_N = 0.180$. Suppose that $c = 0.005$, which implies that the firm will not invest in skill upgrading in equilibrium (since $\Delta\Pi < c$). However, it only takes a wage increase in the South from 0.03 to 0.04 to trigger skill upgrading. This will, in turn, trigger quality upgrading in the South and union utility drops from 0.180 to 0.176 in equilibrium.

[24] The reported values of $\Delta\Pi$ were calculated before rounding the figures in Table 1 to the nearest three decimals.

[25] However, notice that the results in Proposition 5 are derived for fixed quality levels, while the profit gain of skill upgrading reported in Table 2 takes into account that qualities are optimally adjusted when labour productivity in the South goes up.

6 Wage bargaining in the South

In this section we endogenise w_S by assuming that also workers in the South are unionised. As in the North, they are represented by a rent-maximising trade union whose utility is given by

$$U_S = (w_S - r_S)L_S. \tag{27}$$

Along the lines of our previous analysis, we start out by characterising the labour market equilibrium and analysing how wages and union utility (in the North *and* the South) are affected by quality and skill upgrading. Subsequently, we solve (numerically) for the equilibrium of the full game and investigate how minimum wage policies in the South affect incentives for technology transfer and, in turn, worker welfare in the North and the South. We also compare the solution with the one derived in the previous section in order to analyse the effects of unionisation in the South.

6.1 Equilibrium wages

Wages in the North and the South are now both determined in multi-unit bargaining between the multinational firm and the two trade unions. In order to enhance tractability, we assume that the firm and its workers have equal bargaining power (i.e., $\alpha = \frac{1}{2}$). Applying the multi-unit bargaining model developed by Davidson (1988), the bargained wages in the North and the South are given by the simultaneous solution to the following pair of Nash bargaining problems:

$$w_N = \arg\max \left(U_N - \overline{U}_N\right)(\pi - \overline{\pi}_N), \tag{28}$$

$$w_S = \arg\max \left(U_S - \overline{U}_S\right)(\pi - \overline{\pi}_S), \tag{29}$$

where $\overline{\pi}_N$ and $\overline{\pi}_S$ are the profits of the firm in case of a bargaining conflict between the firm and the union in, respectively, the North and the South. As before, we assume $\overline{U}_N = \overline{U}_S = 0$, and we assume that the firm optimally adjusts its production of the other brand to maximise

profits during a bargaining conflict with one of the unions. $\overline{\pi}_N$ is still given by (11), while

$$\overline{\pi}_S = \frac{(\mu_1 - w_N)^2}{4\mu_1}. \tag{30}$$

Simultaneously solving the two maximisation problems, the bargained wages are found to be

$$w_N = \frac{\mu_1 \left(3r_N + \frac{3}{4}\varpi_S + \mu_1 - \mu_2\right)}{4\mu_1 - \frac{1}{4}\mu_2}, \tag{31}$$

$$w_S = \frac{\phi \left(3\mu_1 \varpi_S + \frac{1}{4}\mu_2 \left(3r_N + \mu_1 - \mu_2\right)\right)}{4\mu_1 - \frac{1}{4}\mu_2}, \tag{32}$$

where $\varpi_S := \frac{r_S}{\phi}$ is the 'effective reservation wage' in the South. The optimal output of each brand is found by substituting (31)-(32) into (8), yielding

$$q_1 = \frac{3\left(2\mu_1 \left(\varpi_S - r_N + \mu_1 - \mu_2\right) + \frac{1}{2}\left(r_N\mu_2 - \varpi_S\mu_1\right)\right)}{4\left(4\mu_1 - \frac{1}{4}\mu_2\right)\left(\mu_1 - \mu_2\right)}, \tag{33}$$

$$q_2 = \frac{3\mu_1 \left(\frac{1}{2}\mu_2 \left(\varpi_S - r_N + \mu_1 - \mu_2\right) + 2\left(r_N\mu_2 - \varpi_S\mu_1\right)\right)}{4\left(4\mu_1 - \frac{1}{4}\mu_2\right)\left(\mu_1 - \mu_2\right)\mu_2}. \tag{34}$$

Equilibrium existence requires that the condition in (9) is satisfied. In this case, with $\alpha = \frac{1}{2}$ and wages given by (31)-(32), (9) becomes

$$\frac{r_N\left(4\mu_1 - \mu_2\right) - 4\mu_1\left(\mu_1 - \mu_2\right)}{3\mu_1} < \varpi_S < \frac{\left(3r_N + \mu_1 - \mu_2\right)\mu_2}{4\mu_1 - \mu_2}, \tag{35}$$

Notice that the above condition implies $w_N > \omega_S$, making labour more expensive in the North than in the South. From (31)-(32), we derive:

Proposition 7 *(i) The bargained wage in the North is increasing in μ_1, r_N and r_S, and decreasing in ϕ and μ_2. (ii) The bargained wage in the South is increasing in r_S, r_N and ϕ. If the qualities are sufficiently low to begin with, the wage in the South is decreasing in μ_1 and increasing in μ_2. For higher quality levels, this may however be overturned if either the good produced in the South has sufficiently high quality (making w_S increasing in μ_1), or the quality difference between the goods is sufficiently low (making w_S decreasing in μ_2).*

The first part of the proposition shows that the comparative statics properties of the wage in the North are qualitatively unchanged by endogenising the wage in the South (cf. Proposition 2), with the additional result that the wage is increasing in the effective reservation wage of Southern workers. This is intuitive and follows from the strategic complementarity of the two unions' wage claims. Similarly, the bargained wage in the South is increasing in the reservation wage of Northern workers.

Notice that skill upgrading has an asymmetric impact on wages in the South and the North. For a given wage level in the South, skill upgrading reduces the effective wage rate and makes Brand 2 cheaper to produce. When workers in the South are unionised, they are able to capture part of this gain through a wage increase. As before, the drop in the effective wage rate in the South has two direct effects that contribute to a drop in the bargained wage in the North. First, the firm's incentive to produce more of the cheaper Brand 2 and less of the more expensive Brand 1 makes labour demand more elastic in the North. Second, the disagreement payoff of the firm in case of a bargaining conflict in the North increases.[26]

The relationship between qualities and wages is slightly more involved. Quality upgrading in the South implies that some demand is shifted from Brand 1 to Brand 2. All else equal, this contributes to a lower wage in the North and a higher wage in the South. Obviously, a quality upgrading in the North has the opposite effect. However, this is only part of the story. Notice that quality upgrading in the South increases the implicit competition between workers in the North and the South, since the two brands become less differentiated.[27] The increased intensity of competition between the two unions has a dampening effect on wages. This reinforces the wage drop in the North while it makes the direction of the wage response in the South ambiguous for high quality levels. The inter-union competition effect dominates, implying that quality upgrading in the South leads to a wage drop in both countries, if the quality difference between the two brands is sufficiently small to begin with. Similarly, a quality increase in the North will lead to a wage increase both in the North and in the South, if the quality of the good produced

[26] Since workers in the North and the South are implicitly Bertrand competitors, there are also second-order feedback effects.

[27] This can be seen from (6), where a change in relative prices leads to a larger shift in demand when the quality difference $(\mu_1 - \mu_2)$ is smaller.

in the South is sufficiently high.

For given qualities and skill level, union utility in the North and the South are given by

$$U_N = \frac{3\left(\mu_1\left(3\varpi_S + 4\left(\mu_1 - \mu_2\right)\right) - r_N\left(4\mu_1 - \mu_2\right)\right)^2}{2\left(\mu_1 - \mu_2\right)\left(16\mu_1 - \mu_2\right)^2}, \tag{36}$$

$$U_S = \frac{3\mu_1\left(\mu_2\left(3r_N + \mu_1 - \mu_2\right) - \varpi_S\left(4\mu_1 - \mu_2\right)\right)^2}{2\left(\mu_1 - \mu_2\right)\mu_2\left(16\mu_1 - \mu_2\right)^2}, \tag{37}$$

Using (36)-(37), we are interested in assessing how North-South technology transfer – either skill upgrading or quality upgrading in the South – affects worker welfare both in the North and in the South.

Proposition 8 *(i) Skill upgrading in the South leads to higher union utility in the South and lower union utility in the North.*

(ii) Quality upgrading in the South always leads to lower union utility in the North, while union utility in the South increases if the quality difference remains sufficiently large. If the quality difference is small to begin with, and if the effective reservation wage in the South is sufficiently high relative to the one in the North, then quality upgrading in the South reduces union utility also in the South.

As for the case of an exogenous wage rate in the South, both types of technology transfer have a negative impact on workers in the North. This comes as no surprise, as either type of technology transfer shifts demand from Brand 1 to Brand 2, with a corresponding loss of employment and wage drop for Northern workers (cf. Proposition 7). However, while workers in the South benefit from skill upgrading, they might not benefit from product quality upgrading. Once more, this is explained by the wage responses to quality upgrading discussed above (Proposition 7). Thus, with wage bargaining in the North and the South, it might be the case that a particular type of technology transfer – product quality upgrading – makes workers in *both* countries worse off. As previously discussed, the reason is that, for certain parameter configurations, product quality upgrading can be used as an effective instrument to increase the degree of competition between the two unions, causing wages to fall in both countries.

6.2 Technology transfer in equilibrium

As previously explained, deriving the equilibrium solution for the full game necessitates the use of numerical simulations. We apply the same cost function as before, given by (25), and we use the same parameter configurations as in Section 5.3. This enables us to analyse the effect of unionisation of Southern workers on optimal quality choices and incentives for skill upgrading. Within the regime of wage bargaining in both countries, we are also interested in analysing the effects of minimum wage policies in the South. Here we assume that the introduction of a legal minimum wage (or an increase in the existing minimum wage) affects the bargained wage in the South indirectly through an increase in the reservation wage r_S. This is a reasonable interpretation, since the reservation wage reflects outside options and is therefore likely to be affected by a legal minimum wage that also applies to the labour market outside the firm in question.

[Table 3 about here]

Table 3 reports the optimal quality choices, with the corresponding levels of employment, wages, profits and union utility, for $\phi_0 = 0.5$ and $\phi_1 = 0.6$, and three different values of r_S. The chosen values of r_S correspond exactly to the chosen values of w_S in the case where there is no wage bargaining in the South. Thus, a direct comparison of the cases with and without wage bargaining in the South can be made by comparing Table 3 with Table 1 (for the parameter configurations with $\alpha = 0.5$). The incentives for skill upgrading (for the parameter configurations used in Table 3) are reported in Table 4. In order to ease the comparison with the case without wage bargaining in the South, we have included in Table 4 the relevant figures from Table 2.

[Table 4 about here]

Let us first compare the cases with and without wage bargaining in the South. Comparing Table 1 and Table 3, we see that, for a given skill level, the presence of a trade union in the South induces the firm to choose lower qualities of both brands, and the quality reduction is larger in the South. There are two effects at work. First, wage bargaining yields higher wages

in the South, and Proposition 4 tells us that this should reduce (increase) quality in the South (North). Additionally, since Southern unionised workers are able to capture parts of the gains from quality investments, wage bargaining in and by itself should lead to lower investments in quality in the South. Thus, both effects contribute to lower incentives for quality investments in the South. However, regarding quality incentives in the North, wage bargaining in the South implies a reversal of the positive effect of an exogenous wage increase in the South on quality in the North, as stated in Proposition 4. The reason is the strategic complementarity between wages in the South and the North. With wage bargaining both places, a quality upgrade in the North, spurring wage increases there, will soften competition and spill over into wage increases in the South (with additional feedback effects on Northern wages). As it turns out, this quality-driven wage effect dominates here, and the incentives for quality improvements in the North are then reduced by the presence of wage bargaining in the South. Also, union utility in the North is higher with unionisation in the South.[28] From Table 4 we see that wage bargaining in the South reduces the profit gain of skill upgrading.[29] Thus, unionisation of Southern workers dampens the firm's incentives for both types of technology transfer – quality upgrading as well as skill upgrading.

In the scenario with wage bargaining in both countries, the effects of minimum wage policies in the South (as measured by an increase in the reservation wage of Southern workers), are similar to the effects of Southern wage increases in the absence of wage bargaining. Such policies are detrimental to product quality in the South, but stimulate incentives for skill upgrading. Once more, Northern workers stand to lose from improved labour market conditions in the South, if such improvements (a higher reservation wage) trigger North-South technology transfer in the form of skill upgrading.

[28] Notice that in the second row of Table 3, the southern wage is, incidentally, 0.05 (approximately). Comparing with union utility in the corresponding 8^{th} line of Table 1, we see that union utility in the North is increased by the presence of southern wage bargaining also when we take away the wage increase.

[29] Since Table 2 shows that the incentives for skill upgrading are increasing in southern wages, this result comes from wage bargaining and not from the imbedded increase in wages.

7 Concluding remarks

How do labour market conditions affect North-South technology transfer in multinational firms? In contrast to previous literature, we focus on internal labour market externalities caused by the power struggle between the multinational firm and trade unions representing workers in different subsidiaries (in the North and the South). In this context, North-South technology transfer – whether skill upgrading or product quality upgrading in the South – is partly motivated by the multinational firm's desire to curb trade union power. It is therefore no surprise that northern workers stand to suffer from such transfer of technology. A more striking finding is that a particular type of technology transfer, namely product quality upgrading, may hurt not only northern but also southern workers.

Policies (e.g., minimum wage policies) that lift the wage level of the poorer southern workers may affect worker welfare in unexpected ways through changes in technology transfer incentives. We find that higher wages in the South can actually increase incentives for skill upgrading and may even hurt northern workers as an end result, if the incentives for skill upgrading are triggered to a sufficient degree.

Does our analysis suggest that technology transfer is excessive? One should perhaps refrain from bold policy statements. We have identified one externality at play stemming from multinationals' desire to gain power over northern (and sometimes even southern) workers. However, in a fuller picture there might be many other externalities and market imperfections at play, so in the end technology use in a developing country might be too small. As mentioned in the introduction, technology transfer typically involve spillovers, so too strong incentives to transfer technology due to firm-internal externalities can simply help to counteract too weak incentives for such transfer arising from the various forms of hold-up risk and technology leakage out of the company.[30] We would also like to point out that multinationals may install 'western' technologies in developing countries for a good reason. Acemoglu and Zilibotti (2001) adapt the theory of directed technological change to a North-South setting. In northern countries, technological development will naturally complement skills and contribute towards increased wage dispersion.

[30] Ghatak and Jiang (2002) point to credit market imperfections as a reason for a too large informal sector in the developing world.

If southern countries simply rely on technological catch-up by copying technology developed in the North, also they will eventually implement these new technologies, even though they do not sit well with the composition of their labour forces. But this is not necessarily a market failure – copying a technology which does not perfectly fit one's needs might be far better than having no technological development at all.

All this said, we think it is somewhat paradoxical that power struggle in the North can lead multinationals not only to produce in the South at a very high technological level, but that technology transfers could take the form of producing products in the South that can almost match product quality in the North, rather than investing in upgrading the skills of the host country labour force. Our analysis also shows that a potential remedy for directing investments away from product quality upgrading and towards skill upgrading is a minimum wage policy that lifts the reservation wage level of workers in developing countries. In a well-known study Xu (2000) points out that US multinationals seem to be sources of technological spillovers only in countries which already have achieved some level of development. The least developed countries fail to take advantage of such transfers and spillovers because they lack the minimum human capital threshold level that is necessary in order to do this. In such a light, skill upgrading may be paramount for a country's successful economic development.

Appendix: Proofs of Propositions 3-8

Proof of Proposition 3. From (16) and (17) we derive

$$\frac{\partial U_N}{\partial \omega_S} = \frac{\alpha (2-\alpha) \Theta}{4 (\mu_1 - \mu_2)} > 0, \tag{A1}$$

$$\frac{\partial U_N}{\partial \mu_1} = -\frac{\partial U_N}{\partial \mu_2} = \frac{\alpha (2-\alpha) \Theta (\Theta + 2 (r_N - \omega_S))}{8 (\mu_1 - \mu_2)^2} > 0, \tag{A2}$$

$$\frac{\partial \pi}{\partial \omega_S} = -\left(\frac{4 (r_N \mu_2 - \omega_S \mu_1) + \alpha (4-\alpha) \mu_2 \Theta}{8 (\mu_1 - \mu_2) \mu_2} \right) < 0, \tag{A3}$$

$$\frac{\partial \pi}{\partial \mu_1} = \frac{(2-\alpha)^2 \Theta (\Theta + 2 (r_N - \omega_S))}{16 (\mu_1 - \mu_2)^2} > 0, \tag{A4}$$

$$\frac{\partial \pi}{\partial \mu_2} = \frac{4\left(\omega_S \mu_1 + \left(r_N - 2\omega_S\right)\mu_2\right)\left(r_N \mu_2 - \omega_S \mu_1\right) + \alpha\left(4-\alpha\right)\mu_2^2 \Theta\left(\Theta + 2\left(r_N - \omega_S\right)\right)}{16\mu_2^2\left(\mu_1 - \mu_2\right)^2} > 0. \quad \text{(A5)}$$

The negative sign of (A3) and the positive sign of (A5) are confirmed by noticing that $r_N\mu_2 - \omega_S\mu_1 > 0$ and $\omega_S\mu_1 + \left(r_N - 2\omega_S\right)\mu_2 > 0$ for all parameter configurations where the equilibrium condition given in (15) is satisfied. *Q.E.D.*

Proof of Proposition 4. (i) Total differentiation of (18)-(19) yields

$$\begin{bmatrix} \frac{\partial^2 \Pi}{\partial \mu_1^2} & \frac{\partial^2 \Pi}{\partial \mu_1 \partial \mu_2} \\ \frac{\partial^2 \Pi}{\partial \mu_1 \partial \mu_2} & \frac{\partial^2 \Pi}{\partial \mu_2^2} \end{bmatrix} \begin{bmatrix} d\mu_1 \\ d\mu_2 \end{bmatrix} + \begin{bmatrix} \frac{\partial^2 \Pi}{\partial \alpha \partial \mu_1} \\ \frac{\partial^2 \Pi}{\partial \alpha \partial \mu_2} \end{bmatrix} d\alpha = 0, \quad \text{(A6)}$$

where

$$\frac{\partial^2 \Pi}{\partial \alpha \partial \mu_1} = -\frac{\partial^2 \Pi}{\partial \alpha \partial \mu_2} = -\frac{\left(2-\alpha\right)\Theta\left(\Theta + 2\left(r_N - \omega_S\right)\right)}{8\left(\mu_1 - \mu_2\right)^2} < 0. \quad \text{(A7)}$$

Using Cramer's rule:

$$\frac{\partial \mu_1}{\partial \alpha} = \frac{\begin{vmatrix} -\frac{\partial^2 \Pi}{\partial \alpha \partial \mu_1} & \frac{\partial^2 \Pi}{\partial \mu_1 \partial \mu_2} \\ -\frac{\partial^2 \Pi}{\partial \alpha \partial \mu_2} & \frac{\partial^2 \Pi}{\partial \mu_2^2} \end{vmatrix}}{|J|} < 0, \quad \text{(A8)}$$

$$\frac{\partial \mu_2}{\partial \alpha} = \frac{\begin{vmatrix} \frac{\partial^2 \Pi}{\partial \mu_1^2} & -\frac{\partial^2 \Pi}{\partial \alpha \partial \mu_1} \\ \frac{\partial^2 \Pi}{\partial \mu_1 \partial \mu_2} & -\frac{\partial^2 \Pi}{\partial \alpha \partial \mu_2} \end{vmatrix}}{|J|} > 0, \quad \text{(A9)}$$

where the signs are unambiguously given by the fact that $\frac{\partial^2 \Pi}{\partial \alpha \partial \mu_1} < 0$, $\frac{\partial^2 \Pi}{\partial \alpha \partial \mu_2} > 0$ and $\frac{\partial^2 \Pi}{\partial \mu_1 \partial \mu_2} < 0$, while $\frac{\partial^2 \Pi}{\partial \mu_i^2} < 0$, $i = 1, 2$, and $|J| := \frac{\partial^2 \Pi}{\partial \mu_1^2}\frac{\partial^2 \Pi}{\partial \mu_2^2} - \left(\frac{\partial^2 \Pi}{\partial \mu_1 \partial \mu_2}\right)^2 > 0$ by assumption.

(ii) Total differentiation of (18)-(19) yields

$$\begin{bmatrix} \frac{\partial^2 \Pi}{\partial \mu_1^2} & \frac{\partial^2 \Pi}{\partial \mu_1 \partial \mu_2} \\ \frac{\partial^2 \Pi}{\partial \mu_1 \partial \mu_2} & \frac{\partial^2 \Pi}{\partial \mu_2^2} \end{bmatrix} \begin{bmatrix} d\mu_1 \\ d\mu_2 \end{bmatrix} + \begin{bmatrix} \frac{\partial^2 \Pi}{\partial \omega_S \partial \mu_1} \\ \frac{\partial^2 \Pi}{\partial \omega_S \partial \mu_2} \end{bmatrix} d\omega_S = 0, \quad \text{(A10)}$$

where

$$\frac{\partial^2 \Pi}{\partial \omega_S \partial \mu_1} = \frac{\left(2-\alpha\right)^2\left(r_N - \omega_S\right)}{8\left(\mu_1 - \mu_2\right)^2} > 0, \quad \text{(A11)}$$

$$\frac{\partial^2 \Pi}{\partial \omega_S \partial \mu_2} = -\left(\frac{4\omega_S \mu_1 (\mu_1 - 2\mu_2) + \mu_2^2 (4r_N - \alpha(4-\alpha)(r_N - \omega_S))}{8\mu_2^2 (\mu_1 - \mu_2)^2} \right) < 0. \tag{A12}$$

The sign of (A12) is determined by noticing that the numerator is monotonically decreasing in α and monotonically increasing in r_N. Thus, the numerator is least likely to be positive if α is at the highest possible level, while r_N is at the lowest possible level. From (15) we know that $\omega_S < \frac{\mu_2}{\mu_1} r_N$, implying that the lowest permissible level of r_N is $\frac{\mu_1}{\mu_2}\omega_S$. Setting $\alpha = 1$ and $r_N = \frac{\mu_1}{\mu_2}\omega_S$, the numerator reduces to $\omega_S(\mu_1 - \mu_2)(4\mu_1 - 3\mu_2) > 0$, which implies that (A12) is negative for all valid parameter configurations. Using Cramer's rule, we obtain

$$\frac{\partial \mu_1}{\partial \omega_S} = \frac{\begin{vmatrix} -\frac{\partial^2 \Pi}{\partial \omega_S \partial \mu_1} & \frac{\partial^2 \Pi}{\partial \mu_1 \partial \mu_2} \\ -\frac{\partial^2 \Pi}{\partial \omega_S \partial \mu_2} & \frac{\partial^2 \Pi}{\partial \mu_2^2} \end{vmatrix}}{|J|} > 0, \tag{A13}$$

$$\frac{\partial \mu_2}{\partial \omega_S} = \frac{\begin{vmatrix} \frac{\partial^2 \Pi}{\partial \mu_1^2} & -\frac{\partial^2 \Pi}{\partial \omega_S \partial \mu_1} \\ \frac{\partial^2 \Pi}{\partial \mu_1 \partial \mu_2} & -\frac{\partial^2 \Pi}{\partial \omega_S \partial \mu_2} \end{vmatrix}}{|J|} < 0, \tag{A14}$$

where the signs are unambiguously given by the fact that $\frac{\partial^2 \Pi}{\partial \omega_S \partial \mu_1} > 0$ and $\frac{\partial^2 \Pi}{\partial \omega_S \partial \mu_2} < 0$. *Q.E.D.*

Proof of Proposition 5. (i) From (24):

$$\frac{\partial(\Delta\Pi)}{\partial \alpha} = \frac{(2-\alpha)\omega_S^1 (\Theta_0 + \Theta_1)}{8(\mu_1 - \mu_2)} \left(\frac{\phi_1 - \phi_0}{\phi_0} \right) > 0. \tag{A15}$$

(ii) From (24):

$$\frac{\partial(\Delta\Pi)}{\partial w_S} = \frac{4\left(r_N - \frac{\mu_1}{\mu_2}\left(\omega_S^0 + \omega_S^1\right)\right) + \alpha(4-\alpha)\left(\Theta_1 + \omega_S^0\right)}{8\phi_1(\mu_1 - \mu_2)} \left(\frac{\phi_1 - \phi_0}{\phi_0} \right). \tag{A16}$$

The sign of this expression is ambiguous. However, since the numerator is monotonically decreasing in ω_S^0, as shown by

$$\frac{\partial\left(4\left(r_N - \frac{\mu_1}{\mu_2}\left(\omega_S^0 + \omega_S^1\right)\right) + \alpha(4-\alpha)\left(\Theta_1 + \omega_S^0\right)\right)}{\partial \omega_S^0} = -\frac{4(\mu_1 - \alpha\mu_2) + \alpha^2\mu_2}{\mu_2} < 0,$$

it follows that

$$\frac{\partial(\Delta\Pi)}{\partial w_S} > (<)\, 0 \; if \; \omega_S^0 < (>) \, \frac{4\left(r_N - \frac{\mu_1}{\mu_2}\omega_S^1\right) + \alpha(4-\alpha)\Theta_1}{4\frac{\mu_1}{\mu_2} - \alpha(4-\alpha)} > 0.$$

Q.E.D.

Proof of Proposition 6. From (24):

$$\frac{\partial(\Delta\Pi)}{\partial \mu_1} = -\frac{(2-\alpha)^2 \omega_S^1 \left(2r_N - \omega_S^1 - \omega_S^0\right)}{16(\mu_1 - \mu_2)^2}\left(\frac{\phi_1 - \phi_0}{\phi_0}\right) < 0, \tag{A17}$$

(where we have used the assumption that $G_{\mu_1\phi}(\mu_1, \mu_2; \phi) = 0$)

$$\frac{\partial(\Delta\Pi)}{\partial \mu_2} = \frac{\omega_S^1\left(\frac{\phi_1-\phi_0}{\phi_0}\right)F}{16\mu_2^2(\mu_1-\mu_2)^2} + [G_{\mu_2}(\phi_0, \mu_1, \mu_2) - G_{\mu_2}(\phi_1, \mu_1, \mu_2)] > 0, \tag{A18}$$

where

$$F := 4\left(\omega_S^0 + \omega_S^1\right)\mu_1(\mu_1 - 2\mu_2) + \mu_2^2\left(2r_N(2-\alpha)^2 + \alpha(4-\alpha)\left(\omega_S^0 + \omega_S^1\right)\right). \tag{A19}$$

The sign of (A18) is confirmed by showing that $F > 0$. Notice that F is monotonically decreasing in α :

$$\frac{\partial F}{\partial \alpha} = -2\mu_2^2(2-\alpha)\left(2r_N - \left(\omega_S^0 + \omega_S^1\right)\right) < 0.$$

Setting $\alpha = 1$ yields $F = \mu_2^2\left(2r_N - \left(\omega_S^0 + \omega_S^1\right)\right) + \left(4\mu_1^2 + 4\mu_2^2 - 8\mu_1\mu_2\right)\left(\omega_S^0 + \omega_S^1\right) > 0$ for all $r_N > \omega_S^i$ and $\mu_1 > \mu_2$. Thus, $F > 0$ for all $\alpha \in (0,1)$, implying that (A18) is positive for all valid parameter configurations. *Q.E.D.*

Proof of Proposition 7. (i) From (31):

$$\frac{\partial w_N}{\partial \mu_1} = \frac{64\mu_1^2 - 3\varpi_S\mu_2 - 12r_N\mu_2 - 8\mu_1\mu_2 + 4\mu_2^2}{(16\mu_1 - \mu_2)^2} > 0, \tag{A20}$$

$$\frac{\partial w_N}{\partial \mu_2} = -\frac{3\mu_1 \left(20\mu_1 - \varpi_S - 4r_N\right)}{\left(16\mu_1 - \mu_2\right)^2} < 0, \tag{A21}$$

$$\frac{\partial w_N}{\partial r_S} = \frac{3\mu_1}{\phi\left(16\mu_1 - \mu_2\right)} > 0, \tag{A22}$$

$$\frac{\partial w_N}{\partial r_N} = \frac{12\mu_1}{16\mu_1 - \mu_2} > 0, \tag{A23}$$

$$\frac{\partial w_N}{\partial \phi} = \frac{-3\mu_1 \varpi_S}{\phi\left(16\mu_1 - \mu_2\right)} < 0. \tag{A24}$$

The signs of (A20) and (A21) are easily established by noticing that $\mu_1 > \mu_2$, $\mu_1 > w_N > r_N$ and $\mu_2 > \omega_S > \varpi_S$.

(ii) From (32):

$$\frac{\partial w_S}{\partial r_N} = \frac{3\mu_2\phi}{16\mu_1 - \mu_2} > 0, \tag{A25}$$

$$\frac{\partial w_S}{\partial r_S} = \frac{12\mu_1}{16\mu_1 - \mu_2} > 0, \tag{A26}$$

$$\frac{\partial w_S}{\partial \phi} = \frac{\mu_2\left(\mu_1 - \mu_2 + 3r_N\right)}{16\mu_1 - \mu_2} > 0 \tag{A27}$$

$$\frac{\partial w_S}{\partial \mu_1} = -3\frac{\left(16r_N + 4\varpi_S - 5\mu_2\right)\phi\mu_2}{\left(16\mu_1 - \mu_2\right)^2} < (>)\, 0 \quad if \quad \mu_2 < (>)\, \frac{4}{5}\left(\varpi_S + 4r_N\right), \tag{A28}$$

$$\begin{aligned} \frac{\partial w_S}{\partial \mu_2} &= \frac{\left(4\mu_1\left(3\varpi_S + 4\mu_1 - 8\mu_2 + 12r_N\right) + \mu_2^2\right)\phi}{\left(16\mu_1 - \mu_2\right)^2} > (<)\, 0 \\ if \quad \mu_2 &< (>)\, 16\mu_1 - 2\sqrt{3}\sqrt{\mu_1\left(20\mu_1 - \varpi_S - 4r_N\right)}. \end{aligned} \tag{A29}$$

Notice that $16\mu_1 - 2\sqrt{3}\sqrt{\mu_1\left(20\mu_1 - \varpi_S - 4r_N\right)} > \mu_1$ when $\mu_1 < \frac{4}{5}\left(\varpi_S + 4r_N\right)$. Imposing the condition $\mu_1 > \mu_2$, it follows that $\frac{\partial w_S}{\partial \mu_2} > 0$ and $\frac{\partial w_S}{\partial \mu_1} < 0$ for $\mu_1 < \frac{4}{5}\left(\varpi_S + 4r_N\right)$. *Q.E.D.*

Proof of Proposition 8. (i) Since the productivity parameter ϕ only enters in the definition of ϖ_S in the expressions for union utility, we can evaluate the effect of skill upgrading by

considering a reduction in the effective reservation wage in the South. From (36)-(37) we have

$$\frac{\partial U_N}{\partial \varpi_S} = \frac{9\mu_1 \left(4\mu_1 \left(\mu_1 - \mu_2\right) - r_N \left(4\mu_1 - \mu_2\right) + 3\varpi_S \mu_1\right)}{\left(16\mu_1 - \mu_2\right)^2 \left(\mu_1 - \mu_2\right)}, \tag{A30}$$

$$\frac{\partial U_S}{\partial \varpi_S} = -\frac{3\left(4\mu_1 - \mu_2\right)\mu_1 \left(\mu_2 \left(\mu_1 - \mu_2\right) + 3r_N \mu_2 - \varpi_S \left(4\mu_1 - \mu_2\right)\right)}{\left(16\mu_1 - \mu_2\right)^2 \left(\mu_1 - \mu_2\right)\mu_2}. \tag{A31}$$

Notice that the numerator in (A30) is monotonically increasing in ϖ_S while the numerator in (A31) is monotonically decreasing in ϖ_S. Equation (35) gives the bounds on ϖ_2 which are necessary for equilibrium existence. Setting ϖ_S at the lower bound, $\varpi_S = \frac{r_N(4\mu_1-\mu_2)-4\mu_1(\mu_1-\mu_2)}{3\mu_1}$, the numerator in (A30) becomes zero, and setting ϖ_S at the upper bound, $\varpi_S = \frac{(3r_N+\mu_1-\mu_2)\mu_2}{4\mu_1-\mu_2}$, the numerator in (A31) also becomes zero. This means that both numerators are positive, implying $\frac{\partial U_N}{\partial \varpi_S} > 0$ and $\frac{\partial U_S}{\partial \varpi_S} < 0$, for all parameter configurations where the condition in (35) is satisfied.

(ii) From (36)-(37) we have

$$\frac{\partial U_N}{\partial \mu_2} = -\frac{3\Gamma\left(2\mu_1\left(\varpi_S - r_N + \mu_1 - \mu_2\right) + \frac{1}{2}\left(r_N\mu_2 - \varpi_S\mu_1\right)\right)}{\left(\mu_1 - \mu_2\right)^2\left(16\mu_1 - \mu_2\right)^3}, \tag{A32}$$

$$\frac{\partial U_S}{\partial \mu_2} = \frac{3\mu_1\left[\mu_2\left(3r_N + \varpi_S\right) - 4\mu_1\varpi_S + \mu_2\left(\mu_1 - \mu_2\right)\right]\Psi}{2\left(16\mu_1 - \mu_2\right)^3\left(\mu_1 - \mu_2\right)^2\mu_2^2}, \tag{A33}$$

where

$$\Gamma := 4\mu_1\left(\mu_1 - \mu_2\right)\left(14\mu_1 + \mu_2\right) + r_N\left(4\mu_1\mu_2 + 40\mu_1^2 + \mu_2^2\right) - 9\mu_1\varpi_S\left(6\mu_1 - \mu_2\right) \tag{A34}$$

and

$$\begin{aligned}\Psi \quad : \quad &= \mu_2\mu_1\left(\mu_1 - \mu_2\right)\left(16\mu_1 - 31\mu_2\right) + 3\mu_2 r_N\left(\mu_1\mu_2 + 16\mu_1^2 - 2\mu_2^2\right) \\ &-\varpi_S\left(2\mu_2^3 - 64\mu_1^3 - 17\mu_1\mu_2^2 + 124\mu_1^2\mu_2\right).\end{aligned} \tag{A35}$$

The sign of (A32) depends on the sign of Γ. Notice that Γ is monotonically decreasing in ϖ_S.

Setting ϖ_S at the upper bound, $\varpi_S = \frac{(3r_N+\mu_1-\mu_2)\mu_2}{4\mu_1-\mu_2}$, yields

$$\Gamma = (\mu_1 - \mu_2)(16\mu_1 - \mu_2)\frac{\mu_1(14\mu_1 - 5\mu_2) + r_N(10\mu_1 - \mu_2)}{4\mu_1 - \mu_2} > 0,$$

implying that $\frac{\partial U_N}{\partial \mu_2} > 0$ for all valid parameter configurations. Regarding the sign of (A33), notice first that

$$\Psi\mu_1^4 = x(1-x)(16-31x) + 3x\frac{r_N}{\mu_1}\left(x + 16 - 2x^2\right) - \frac{\varpi_S}{\mu_1}\left(2x^3 - 64 - 17x^2 + 124x\right),$$

where $x = \frac{\mu_2}{\mu_1} < 1$ is an inverse measure of quality differences. For $x < \frac{16}{31}$, $2x^3 - 64 - 17x^2 + 124x$ is negative, so Ψ is clearly positive for such high quality differences. For lower quality differences, this result may be overturned when r_N is low and – for $x > 0.56$, where $2x^3 - 64 - 17x^2 + 124x > 0$ – when ϖ_S is high. *Q.E.D.*

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Tables

Table 1: Optimal quality choices

ϕ	w_S	α	μ_1	μ_2	L_N	L_S	w_N	Π	U_N
0.5	0.03	0.4	3.199	0.660	0.394	0.122	0.600	0.245	0.197
0.5	0.03	0.5	2.811	0.810	0.368	0.191	0.590	0.203	0.180
0.5	0.03	0.6	2.448	0.949	0.341	0.255	0.538	0.172	0.149
0.5	0.04	0.4	3.200	0.646	0.397	0.082	0.607	0.242	0.201
0.5	0.04	0.5	2.812	0.802	0.371	0.158	0.598	0.199	0.185
0.5	0.04	0.6	2.450	0.943	0.345	0.224	0.546	0.168	0.154
0.5	0.05	0.4	3.200	0.627	0.400	0.041	0.615	0.240	0.206
0.5	0.05	0.5	2.813	0.790	0.375	0.123	0.606	0.196	0.190
0.5	0.05	0.6	2.450	0.935	0.350	0.193	0.556	0.164	0.159
0.6	0.03	0.4	3.199	0.711	0.392	0.121	0.588	0.248	0.191
0.6	0.03	0.5	2.811	0.869	0.365	0.176	0.573	0.207	0.173
0.6	0.03	0.6	2.447	1.016	0.338	0.229	0.514	0.179	0.140
0.6	0.04	0.4	3.199	0.702	0.395	0.096	0.593	0.246	0.194
0.6	0.04	0.5	2.812	0.863	0.369	0.155	0.579	0.204	0.176
0.6	0.04	0.6	2.449	1.012	0.342	0.209	0.521	0.175	0.144
0.6	0.05	0.4	3.200	0.691	0.397	0.071	0.598	0.244	0.198
0.6	0.05	0.5	2.812	0.856	0.372	0.133	0.585	0.201	0.180
0.6	0.05	0.6	2.450	1.006	0.346	0.188	0.528	0.171	0.148

In all simulations: $r_N = 0.1$, $k_1 = 0.05$, $k_2 = 0.1$

Table 2: Incentives for skill upgrading ($\Delta\Pi$)

	$w_S = 0.03$	$w_S = 0.04$	$w_S = 0.05$
$\alpha = 0.4$	0.00341	0.00361	0.00367
$\alpha = 0.5$	0.00486	0.00527	0.00556
$\alpha = 0.6$	0.00637	0.00694	0.00740

Table 3: Optimal quality choices with wage bargaining in the South

ϕ	r_S	μ_1	μ_2	L_N	L_S	w_N	w_S	Π	U_N	U_S
0.5	0.03	2.805	0.749	0.372	0.141	0.611	0.043	0.198	0.190	0.002
0.5	0.04	2.806	0.742	0.375	0.114	0.616	0.050	0.195	0.194	0.001
0.5	0.05	2.807	0.733	0.378	0.087	0.623	0.058	0.193	0.197	0.001
0.6	0.03	2.803	0.806	0.371	0.132	0.594	0.048	0.202	0.183	0.002
0.6	0.04	2.804	0.801	0.374	0.114	0.599	0.056	0.200	0.186	0.002
0.6	0.05	2.805	0.795	0.376	0.096	0.604	0.063	0.198	0.189	0.001
In all simulations: $\alpha = 0.5$, $r_N = 0.1$, $k_1 = 0.05$, $k_2 = 0.1$										

Table 4: Incentives for skill upgrading with wage bargaining in the South

	$r_S = 0.03$	$r_S = 0.04$	$r_S = 0.05$
No wage bargaining in the South ($w_S = r_S$)	0.00486	0.00527	0.00556
Wage bargaining in the South	0.00380	0.00407	0.00428