HUMAN CAPITAL, QUALITY AND TRADE

by
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1. *Introduction*

The standard theory of international trade, the "two goods-two factors" Heckscher-Ohlin-Samuelson model (henceforth HOS), is the most used tool to describe the effects of increased trade on goods and labor markets. This theory provides very clear and straightforward predictions. Assume that the two goods are *X* and *Y* and that the two factors of production are unskilled and skilled labor, denoted *L* and *H* respectively. Assume also that *X* is relatively unskilled labor intensive compared with good *Y* and that industrialized countries are relatively abundant in skilled labor compared with developing countries. The HOS model predictions for the industrialized countries, following the increased competition from unskilled-abundant developing economies, are the following:

i) the relative "world" price of *X* will fall;
ii) the production of good *X* will fall and an inter-sectoral substitution of production towards the less unskilled intensive good *Y* will occur;
iii) as good *X* is relatively intensive in unskilled labor, imports from developing countries will reduce the demand for unskilled workers in the industrialized countries. This would result in a fall in relative earnings for the unskilled workers according to the Stolper-Samuelson theorem;
iv) the rise in the real wages of skilled workers and the reduction of the real wages of unskilled ones will be accompanied by an increase in the relative employment of unskilled workers in all sectors.

Is the empirical evidence in accordance with these theoretical predictions? Although recent trends in the patterns of trade seem to confirm points (i) and (ii), there is no consensus concerning their empirical relevance, with some authors (e.g. Lawrence - Slaughter (1993)) finding almost no evidence of relative price changes and intersectoral shifts in production, and with others (e.g. Sachs-Shatz (1994) and Wood (1994)) considering these phenomena more relevant.

A large amount of evidence concerning point (iii) is also available for almost all the industrialized countries, showing a deteriorated position for unskilled workers. There is, however, a large debate over the impact of trade on the labor market.[1] Some studies have reached the conclusion that the labor market effects of trade are small and that technological change biased against the use of unskilled labor is the cause of the fall in relative wages of unskilled workers and/or of the increased unemployment of these workers. Other studies, however, have found evidence of a strong link between trade and labor markets. Finally, no evidence has so far been provided in favor of point (iv).

The aim of this paper is to build a theoretical model that provides new links between international trade and the labor market that are not explained by the traditional theory and in particular to explain why globalization has brought about only a limited intersectoral reallocation of production. The model is based on two main ideas. First, it is assumed that the effects of globalization could be described by looking at intra-industry trade (IIT) instead of inter-industry trade. There is an increasing evidence showing that, while intra-industry trade among similar countries is largely based on product differentiation and is a phenomenon of horizontal specialization, IIT among countries with a very different factor endowment is based on goods with different qualities.[2]

If differences in qualities are associated with differences in the skill content, so that higher quality products are associated with a higher content of skilled labor, countries will specialize along different parts of the spectrum, depending on their ratios of skilled to unskilled wages. Since the skill intensity of all production processes will be lower in skill-scarce than in skill-abundant countries, the factor intensity explanation of trade continues to hold and a country's trade will embody a net outflow of its abundant factor. Increased competition from low-skill-abundant countries will lead an industrialized (skill-abundant) country to upgrade

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[1] For a survey of the labor market effects of globalization see Freeman (1995), Slaughter-Swagel (1997) and OECD (1997).

[2] See, for example, Greenaway – Hine – Milner (1995), Annicchiarico – Quintieri (1999), Aturupane - Djankov - Hoekman B. (1999).

the quality of its product without necessarily raising any inter-sectoral specialization. These intra-industry effects will generate an increase in the relative demand for skilled workers that will affect relative wages and/or unemployment. Vertical product differentiation is then modeled along the HOS tradition, without resorting to the usual assumption of monopolistic competition.

The second idea on which the model is based is that skilled workers are not fully mobile among sectors as assumed by the HOS theory. In our view (much) of the skill "embodied" in each worker is specific to the sectors in which the worker is employed, being the result of the experience accumulated "on the job". This implies that moving from one sector to another is "costly" to the worker, as part of his skill is lost and with it part of his earning capability. This idea is incorporated into model by making the assumption that human capital is a semi-specific factor.

A standard result of the literature on “job displacement”[3] shows that displaced workers typically earned more in their previous job than they could have earned from other employers. One candidate to explain these wage losses is the “specificity” of human capital. Workers acquire specific skills through “on-the-job training” and the stock of these skills rises with tenure with the firm. If specific skills are an important determinant of earnings, those workers displaced from their jobs are likely to experience large earning losses.[4]

While studies on displaced workers are in general (too narrowly) focused on firm specific factors, some studies have also revealed that industry may be an important dimension across which skills are transferable. A number of papers find that the post-displacement earnings of individuals who change industry are lower than the earnings

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[3] For a survey of this literature, see Kletzer (1998)

[4] In many firms industry-specific skills constitute an important component of the typical worker’s human capital stock. Firms in a given manufacturing industry may value a common set of skills that are important to the production process in that industry. However these same skills may not be valued by firms producing different products.

of otherwise comparable individuals who stay in the same industry.[5] Neal (1995) shows that wages, in part, reflect compensation for industry specific skills: "… although most displaced workers suffer wage losses, workers who switch industries following displacement usually suffer greater losses than observationally similar workers who find new jobs in their predisplacement industry. Furthermore, among switchers, wage losses are strongly correlated with predisplacement measures of work experience and job tenure". Neal interprets these results as evidence that workers receive compensation for some skills that are neither completely general nor firm-specific but rather specific to a set of firms that produce similar products.

The model is capable of explaining, through the endogeneity of quality and the semi-specificity of human capital, some stylized facts that cannot be explained by the HOS theory. In particular our setup seems particularly suitable to explain the evolution of the international specialization observed for some countries (e.g. Italy) in which unskilled intensive sectors have not been retrenched by the increased competition from developing countries.

At the same time, the model is consistent with the Stolper-Samuelson effects and is able to show why empirical evidence does not give support to the above mentioned point iv), according to which the rise in the real wages of skilled workers and the reduction of the real wages of unskilled ones should be accompanied by an increase in the relative employment of unskilled workers in all sectors.

The paper is organized as follows. Section 2 develops a simple general equilibrium model with an endogenous quality choice and imperfect sectoral mobility of human capital between sectors, and discusses its basic features. Section 3 analyzes the consequences of globalization, paying special attention to the role of different degrees of human capital mobility. Section 4 summarizes the main findings of the analysis.

2. *The model*

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[5] See, for example, Kim (1992), Carrington (1993), and Neal (1995).

Consider a small open economy that produces two commodities, a vertically differentiated good and a homogeneous good, by using three factors of production, namely unskilled labor, which is perfectly mobile between sectors, and two industry semi-specific types of human capital. Perfect competition is assumed to prevail in all markets.[6] The model is static and the context deterministic.

The production function of the quality good, called X, is given by

$$XQ = \min[A(Q)L_X, H_X] \qquad A(1) = \overline{A},\ A'(Q) > 0 \tag{1}$$

where X represents physical units of the good, Q is a quality index, XQ is the amount of "quality units", L_X e H_x are respectively the unskilled labor, H_X is the employed sector semi-specific human capital employed in sector X and $A(Q)$ is a technical coefficient, representing the marginal product of labor. We assume that the unskilled labor requirement per unit of quality good, i.e. $A(Q)^{-1}$, decreases with quality.

Production function (1) assumes that there is no technical substitution between adjusted labor (i.e. expressed in efficiency units), $A(Q)L_X$, and human capital, but at the same time it implies that the human capital-"raw" labor ratio depends positively on quality. The basic idea incorporated into equation (1) is that higher quality can be obtained only through an increase in human capital intensity, according to the following technological relationship

$$\frac{H_X}{L_X} = A(Q) \tag{2}$$

The representative firm maximizes its profit by choosing the quantity of inputs employed and the quality index. Given the assumption of perfect competition in output and factor markets, the first-order conditions for profit maximization are[7]

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[6] For the interactions between product quality and trade within a perfectly competitive environment see Rodriguez (1979), Falvey-Kierzkowski (1987), Flam-Helpman (1987) and Djajic-Kierzkowski (1989). Examples of models that consider vertical product differentiation in the more natural environment of imperfect competition are given, among others, by Grossman-Helpman (1991).

[7] The second-order condition for the maximum profit concerning quality, i.e.

$$\left[\frac{w}{A(Q)}+v_X\right]Q = p_X \tag{3a}$$

$$p_X\,\frac{A(Q)}{Q^2}\left[\frac{QA'(Q)}{A(Q)}-1\right]=v_X\,A'(Q) \tag{3b}$$

where w is the wage rate of unskilled labor, v_X is the price of human capital in the X sector and the p_X is the price of one physical unit of good X of a given quality.

Equation (3a) represents the zero-profit condition, stating that the average cost of a quality unit of good X is equal to the price or, equivalently, that the average cost of a physical unit of the differentiated good is equal to the price adjusted for quality (p_X/Q). Equation (3b) is the optimal condition for quality; it implies that quality must be such that the marginal revenue of quality per unskilled worker equals the marginal cost of quality per unskilled worker. The elasticity of the labor technical coefficient with respect to quality (i.e. $\frac{QA'(Q)}{A(Q)}$) must be greater than one (namely a positive effect of higher quality on total revenue occurs) to have a well-defined equilibrium. By substituting equation (3b) into (3a) for v_X, we obtain another characterization of the optimal condition for quality

$$\frac{QA'(Q)}{A(Q)}\frac{w}{A(Q)}=\frac{p_X}{Q} \tag{3b'}$$

Equation (3b') asserts that the adjusted quality price must be a proportion of the wage expressed in efficiency units, where the factor of proportionality is greater than one from condition (3b).

The production function for the homogeneous good is

$$Y = G(L_Y, H_Y) \tag{4}$$

where Y represents physical units of the homogeneous good, L_Y is the unskilled labor employed in sector Y and H_Y is the industry for semi specific human capital. The function $G(\ ,\ )$ satisfies the usual neoclassical

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$2\,\frac{A'(Q)}{Q}\left[\frac{QA'(Q)}{A(Q)}-1\right] > A''(Q)$, is assumed to be satisfied.

properties of regularity and is linearly homogeneous in the two inputs. Let Y be the *numéraire* ($P_Y=1$).

The optimal conditions for maximum profit are

$$G_{L_Y}(L_Y, H_Y) = w \tag{5a}$$

$$G_{H_Y}(L_Y, H_Y) = v_Y \tag{5b}$$

where v_Y is the price of Y-sector human capital.

Wage flexibility and perfect intersectoral mobility assure full employment of unskilled workers

$$L_X + L_Y = \overline{L} \tag{6}$$

where $\overline{L}$ is the fixed unskilled labor supply.

We assume that human capital is sector semi-specific, i.e. human capital is imperfectly mobile between the two sectors of production. The assumption of an imperfectly substitutable input according to the sector of destination has been analyzed, among others, by Mussa (1982), Grossman (1983), Hill-Mendez (1983), and Casas (1984).[8] As already noticed in the introduction, the hypothesis of factor semi-specificity is particularly adequate for human capital, since this factor can only be costly shifted among sectors, as sectoral movements imply efficiency losses in production.

The partial mobility of inputs can be introduced by considering either a convex input transformation curve (as in Mussa, 1982) or supply curves of the semi-specific factors to each industry that have a finite elasticity with respect to relative prices (as in Hill-Mendez, 1983, and Casas, 1984). We shall follow the latter approach without any implications for the final results. Therefore the measure of human capital semi-specificity is represented by the elasticity, assumed to be constant and positive, of the ratio of its supplies in the two sectors with respect to the respective relative prices:

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[8] These articles assume that at least one factor of production is imperfectly mobile between sectors -which is labor for Mussa (1982) and Casas (1984), physical capital for Grossman (1983), both labor and capital in the analysis of Hill-Mendez (1983)- mainly due to the different (in an absolute and relative sense) efficiency of factors in the industry of destination.

$$\frac{H_X}{H_Y} = k\left(\frac{v_X}{v_Y}\right)^{e} \qquad (7)$$

where k is a positive parameter, and e is the elasticity of human capital intersectoral mobility. When $0 < e < \infty$, there is an imperfect human capital mobility between sectors. If $e = 0$, equation (7) describes the complete human capital immobility case, which corresponds to the specific-factors model of Jones (1971) and Samuelson (1971) with quality. For $e \to \infty$, the case of perfect human capital mobility is obtained and the economy reduces the HOS environment with two goods and two factors of production.

The full employment condition for human capital is given by

$$H_X + H_Y = \overline{H} \qquad (8)$$

where $\overline{H}$ is the total supply of human capital.

Assuming that the preferences of consumers depend on quality units of the differentiated good (i.e. XQ) and on the quantity of the homogeneous good, and that tastes are homothetic and identical for all consumers, the supply side of the model, under the assumption of a small, perfectly competitive open economy, determines the vector of factor prices, outputs, the sectoral distribution of the factors and quality.

By postulating, without any loss of generality, that A is an isoelastic function of quality -i.e. $A(Q) = \overline{A}Q^h$, where $h > 1$ according to condition (3b)-, the general equilibrium model is obtained by combining the optimality conditions of the firms operating in the two industries together with the equilibrium conditions on the factor markets.

The whole economy can be described by the following system

$$\left(\frac{w}{\overline{A}Q^{h}} + v_X\right)Q = p_X \qquad (9a)$$

$$a_{LY}w + a_{HY}v_Y = 1 \qquad (9b)$$

$$h\frac{w}{\overline{A}Q^{h}} = \frac{p_X}{Q} \qquad (9c)$$

$$\frac{XQ}{\overline{A}Q^{h}} + a_{LY}Y = \overline{L} \qquad (9d)$$

$$XQ + a_{HY}Y = \overline{H} \tag{9e}$$

$$\frac{XQ}{a_{HY}Y} = k\left(\frac{v_X}{v_Y}\right)^e \tag{9f}$$

where a_{iY} $(i=L,H)$ represents the units of factor i-th employed in the production of one unit of good Y. From cost minimization the optimal input to output ratios in sector Y depend on factors prices:

$$a_{LY} = a_{LY}(w, v_Y) \tag{9g}$$

$$a_{HY} = a_{HY}(w, v_Y) \tag{9h}$$

Model (9) determines the equilibrium values of the following endogenous variables: w, v_X, v_Y, Q, X, Y, a_{LY}, and a_{HY}. The terms of trade are exogenously given according to the small open economy assumption. The sectoral distribution of the inputs –i.e. L_X, L_Y, H_X, and H_Y- can be solved residually once the reduced forms for the endogenous variables of system (9) are obtained.

By using the Jones (1965) procedure and by eliminating a_{iY} $(i=L,H)$ through equations (9g) and (9h), the basic model of the economy can be expressed as

$$\boldsymbol{J}_{LX}\hat{w} + (1-\boldsymbol{J}_{LX}\boldsymbol{h})\hat{Q} + \boldsymbol{J}_{HX}\hat{v}_X = \hat{p}_X \qquad \boldsymbol{J}_{LX} + \boldsymbol{J}_{HX} = 1,\ \boldsymbol{J}_{LX}\boldsymbol{h} < 1 \tag{10a}$$

$$\boldsymbol{J}_{LY}\hat{w} + \boldsymbol{J}_{HY}\hat{v}_Y = 0 \tag{10b}$$

$$(\boldsymbol{h}-1)\hat{Q} - \hat{w} = -\hat{p}_X \tag{10c}$$

$$\begin{gathered}\boldsymbol{l}_{LX}(\hat{X} + \hat{Q} - \boldsymbol{h}\hat{Q}) - \boldsymbol{l}_{LY}[\boldsymbol{J}_{HY}\boldsymbol{s}(\hat{w} - \hat{v}_Y) - \hat{Y}] = 0 \\ \boldsymbol{l}_{LX} + \boldsymbol{l}_{LY} = 1,\ \boldsymbol{J}_{LY} + \boldsymbol{J}_{HY} = 1\end{gathered} \tag{10d}$$

$$\boldsymbol{l}_{HX}(\hat{X} + \hat{Q}) + \boldsymbol{l}_{HY}[\boldsymbol{J}_{LY}\boldsymbol{s}(\hat{w} - \hat{v}_Y) + \hat{Y}] = 0 \tag{10e}$$

$$\hat{X} + \hat{Q} - \boldsymbol{J}_{LY}\boldsymbol{s}(\hat{w} - \hat{v}_Y) - \hat{Y} = \boldsymbol{e}(v_X - v_Y) \tag{10f}$$

where $\hat{Z} = \frac{dZ}{Z}$, $\boldsymbol{J}_{ij}$ is the distributive share of factor i-th $(i=L, H)$ in the value of output in industry j-th $(j=X, Y)$, $\boldsymbol{l}_{ij}$ is the fraction of factor i-th $(i=L, H)$ employed in the j-th sector $(j=X, Y)$ and $\boldsymbol{s}$ is the elasticity of substitution between labor and human capital in Y industry.

According to equation (10a), higher quality exerts two contrasting effects on the autharky relative prices. On the one hand it increases relative prices, since it raises the average cost of the quality, but on the other hand it reduces them since it lowers the unskilled labor cost, once expressed in efficiency units $\left(\frac{w}{A}\right)$. With the imposed condition $\boldsymbol{J}_{LX}\boldsymbol{h} < 1$, we assume that the positive effect prevails. The "strong factor-intensity" assumption, that is worth examining, is that the differentiated good is relatively unskilled labor intensive both in the physical sense, i.e. $\boldsymbol{l}_{LX} > \boldsymbol{l}_{HX}$, and in the value sense, i.e. $\boldsymbol{J}_{LX} > \boldsymbol{J}_{LY}$. As will be clear below, the reversed assumption would reinforce the traditional results.

3. *The general equilibrium effects of a terms of trade shock*

The model developed in section 2 can be purposefully employed to investigate the implications of a change of the terms of trade. We assume that the increased world competition, will imply a reduction of p_X, namely the relative price of the unskilled labor intensive good. The comparative statics multipliers for the endogenous variables are given in the Appendix.

In order to properly understand how the model works, we firstly focus on the extreme cases obtained by setting $\boldsymbol{e} = 0$ and alternatively by letting $\boldsymbol{e} \to \infty$.

When human capital is completely sector-specific, i.e. $\boldsymbol{e} = 0$, the model's response to the international price disturbance can be described as follows. The exogenous shock first has an impact on the allocation of unskilled labor and then feeds back to the other variables of the economy. The distribution of unskilled labor can be easily grasped by using the specific-factors textbook diagram that combines labor demands (2) and (5a) as well as the allocation constraint (6). Since the labor demand in the X sector depends on quality according to the production function (1), we can use equation (3b') to eliminate Q from equation (2) and obtain the following relationship between w and L_X, that can be considered as a sort of labor demand equation

$$w = \frac{\overline{A} p_X}{\boldsymbol{h}} \left(\frac{\overline{H}_X}{\overline{A} L_X} \right)^{\frac{h-1}{h}} \qquad (11)$$

where $\overline{H}_X$ is the inelastic supply of X sector human capital. The above equation represents a pseudo-demand curve. Function (11) is downward-sloping in the L_X-w space and is shifted on the left by a reduction in p_X (see fig.1). For sector Y we have a rather conventional labor demand curve represented by equation (5a) with an inelastic supply of human capital. The distribution of labor is determined by the intersection of the two labor demand schedules, which simultaneously gives employment in both sectors and the wage rate measured in terms of the *numéraire*. As the labor demand curve in the X sector shrinks for a given labor demand in the Y industry, a fall of w occurs as a result of an excess of supply in the unskilled labor market. The lower unskilled workers' real wage in terms of good Y lowers the cost of labor for firms operating in the Y sector and therefore raises the amount of unskilled labor employed in that sector. Since the total labor supply is given, employment of workers in the quality good sector is reduced.[9] As the supply of human capital in sector X is inelastic, human capital intensity increases, implying higher quality for the differentiated good.

The price of H diminishes as well according to the zero-profit condition (10a) and by a greater amount than w. The price of H_X also falls when expressed in terms of the quality good. As the demand for human capital in the Y sector is increased by the exogenous shock, given the Edgeworth complementarity between unskilled labor and human capital in such a sector, v_Y is pulled up. Notice that the price of skilled workers in terms of the homogeneous good is reduced in the differentiated sector and increased in the Y sector. Finally, the physical quantity of the quality good falls, as $XQ = \overline{H}_X$ and Q is increased, while the amount of the homogeneous good augments due to the larger volume of unskilled labor employed.

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[9] The introduction of quality in a simple two sector-three factors model with no substitutability between inputs in one sector completely alters the effects of the exogenous change in the terms of trade. In the model with homogeneous goods, the relative price changes exert no effects on the sectoral composition of unskilled labor and henceforth on the wage. Since L_X is given by the technological condition and the assumption of a given supply of human capital in the X sector, the change in p_X does not affect sectoral employment, the wage rate and the price of human capital in the Y sector. The only consequence of this shock we observe is the change of the specific human capital price, that moves in the same direction as p_X but to a greater extent. When vertical differentiation is introduced into the model, employment of unskilled workers in the X sector depends (negatively) on quality. Quality in turn depends on the wage through the quality equation, so that an indirect relationship between unskilled labor and the real wage is introduced. Therefore through quality we restore the basic features of the specific-factors model, even in the case of the Leontief production function, allowing for an endogenous change in sectoral employment.

When $\boldsymbol{e} \to \infty$, the HOS version of the model with endogenous quality is obtained. Since now $v_X = v_Y$, equations (10a)-(10c) represent a closed sub-system autonomously determining factors prices and quality. As the main features of the HOS model are maintained, we observe that the shock reduces w as well as $\frac{w}{p_X}$, since the *magnification effect* is at work, and increases v. The reduction of the real wage implies that firms find optimal to reduce quality of the differentiated good. Notice that human capital intensities decline in both sectors. In sector X we have a decline of H_X and L_X, while in sector Y there is an increase of H_Y and L_Y. The production of the quality good is reduced, while that of the homogeneous good is increased.

The intermediate case of human capital mobility, that is $0 < \boldsymbol{e} < \infty$, can be analyzed as a mixed situation between the two extreme ones just described. Despite the fact that there is no substitutability between unskilled labor, expressed in efficiency units, and human capital in the production of the quality good, the endogeneity of quality generates a well-defined relative demand of human capital. If we combine equations (2) and (3b') –substituting out quality- we obtain a negative relationship between human capital-labor ratio and real wage expressed in terms of the X commodity. This equation represents a relative demand for factors in sector X. It follows that the consequences of the change in the terms of trade on capital intensity of the differentiated sector and quality depend on the effect on real wage.

When the degree of human capital mobility is relatively low, we can expect that the features of the specific-factors model prevail leading to an increase of $\frac{w}{p_X}$ when p_X is reduced.[10] This implies that firms raise human capital intensity since labor has become more expensive. However in the case of a high degree of human capital mobility we can expect to observe the usual Stolper-Samuelson results, namely a drop in the real wage following the reduction of the relative prices. Under the present

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[10] Notice that this also implies that human capital is less expensive in terms of the X good, since we have: $\hat{w} - \hat{p}_X = -(\boldsymbol{h} - 1)(\hat{v}_X - \hat{p}_X)$.

circumstance, the fall in relative prices leads to higher unskilled labor intensity (since its cost has been reduced) and lower quality. Human capital intensity in the homogeneous sector is lowered for any value of $\boldsymbol{e}$.

In between the two extreme cases, there must be a critical value of the elasticity of human capital mobility that accounts for the change of the sign in the human capital intensity of sector X and the quality multipliers. This critical value, labelled $\boldsymbol{e}^*$,[11] satisfies the following relationship

$$\mathrm{sgn}\left(\frac{\hat{H}_X - \hat{L}_X}{\hat{p}_X}\right) = \mathrm{sgn}\left(\frac{\hat{Q}}{\hat{p}_X}\right) = \mathrm{sgn}(\boldsymbol{e} - \boldsymbol{e}^*)$$

where $\boldsymbol{e}^* = \dfrac{\boldsymbol{l}_{LY}\boldsymbol{s}}{\Lambda} > 0$ and $\Lambda = \boldsymbol{l}_{LX} - \boldsymbol{l}_{HX} > 0$. It is not surprising that the critical value of the elasticity of sectoral substitution for human capital also discriminates between either a positive or a negative multiplier for the real wage (see the Appendix). Therefore according to the different effect on $\dfrac{H_X}{L_X}$ and quality, we can distinguish between the case of a relatively low or high degree of human capital mobility depending on whether $\boldsymbol{e} < \boldsymbol{e}^*$ or $\boldsymbol{e} > \boldsymbol{e}^*$ (see fig. 2).

Human capital intensity in the *Y* sector is always reduced by the shock under investigation, while human capital intensity in the quality good sector can be either increased when *H* is scarcely mobile between sectors or reduced when *H* is highly mobile between sectors in relative terms. Finally, notice that the multiplier for v_X has an ambiguous sign according to the value of $\boldsymbol{e}$. The critical value of that accounts for $\boldsymbol{e}$ for

[11] Notice that for $\boldsymbol{e} = \boldsymbol{e}^*$ the human capital in the *X* sector and the quality multipliers are equal to zero.

the change of sign of $\frac{\hat{v}_X}{\hat{p}_X}$ is bigger than the critical value of e that accounts for the change of the sign of $\frac{\hat{H}_X - \hat{L}_X}{\hat{p}_X}$ and $\frac{\hat{Q}_X}{\hat{p}_X}$.

Finally, consider the consequences of the terms of trade shock on income distribution.

The share of income of human capital employed in the homogenous sector over national income is increased by the reduction of p_X, with no ambiguity and independently of the degree of human capital mobility. The response of income earned by human capital employed in the vertically differentiated sector to the national income ratio depends on the value of e. If this elasticity is relatively low, $\frac{v_X H_X}{p_X X + Y}$ is reduced by the price shock, otherwise an increase of this income's share is observed. Regarding the share of unskilled labor income over total income, a clear reduction will take place when such mobility is relatively high, while sign ambiguity is observed in the case of low mobility of human capital.

Notice that if there is some degree of specificity, it is not necessarily true that the reward of human capital always increases after a terms of trade shock. The more specific human capital is, the more likely is the reduction of its reward in the differentiated sector, i.e. the sector hit by the shock. In the case of perfect human capital mobility, we have the Stolper-Samuelson theorem, otherwise the model exhibits a sort of "modified" Stolper-Samuelson effect as a result of human capital semi-specificity.

Relative to the reward of H_Y, we observe the usual HOS effects for any degree of intersectoral mobility of human capital.

The degree of sectoral mobility matters for the impact of a terms of trade shock for the wage differentials.

We observe that $\frac{v_Y}{w}$, i.e. the skilled to unskilled wage ratio, is increased by the terms of trade shock as predicted by the conventional theory, while the effects on $\frac{v_X}{w}$ are ambiguous since they depend on the relative degree of human capital mobility. When this elasticity is relatively high, this ratio is reduced as unskilled wage diminishes while v_X is raised. If e is relatively low, this ratio is increased as the price of human capital is reduced more in absolute value than w. Comparing the two previous wage differentials , we see that $\frac{v_Y}{v_X}$ is unambiguously increased and the rise will be larger the lower the degree of mobility of these workers between sectors.

4. *Concluding remarks*

This paper has developed a simple model of international trade with vertical product differentiation and human capital imperfect mobility between sectors with the aim of investigating the general equilibrium effects of globalization. The model incorporates the hypothesis that higher quality products are associated with a higher content of skilled labor. If differences in qualities are associated with differences in skill content, countries will specialize in different parts of the quality spectrum, depending on the relative factors prices.

When the degree of human capital mobility is relatively low, the reduction of the relative price of the quality sector, which is labor-intensive, generates an increase in the real wage of unskilled workers and a fall in the price of human capital implying that firms have an incentive to produce differentiated goods with higher quality through an increase of human capital intensity. At the same time the terms of trade shock diminishes the relative price of unskilled workers compared to the human capital price leading to a reduction of human capital intensity in this sector. Notice that since the skill intensity of all production processes will be less in skill-scarce than in skill-abundant countries, the factor endowment explanation of trade continues to hold and a country's trade will embody a net outflow of its abundant factor. Therefore increased competition from low-skill abundant countries will lead an industrialized (skill-abundant) country to upgrade the quality of its product without this necessarily implying inter-sectoral specialization.

The model describes a possible reaction to the increased world competition not considered in the traditional theory: a country can continue producing in the sector whose price is reduced by raising the quality of output.

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Appendix

Effects of a terms of trade change

Factors prices

$$\frac{\hat{w}}{\hat{p}_X} = \frac{\boldsymbol{hJ}_{HY}(\Lambda\boldsymbol{e}+\boldsymbol{l}_{LX})}{\overline{\Delta}} > 0;\quad \frac{\hat{w}-\hat{p}_X}{\hat{p}_X} = \frac{(\boldsymbol{h}-1)(\Lambda\boldsymbol{e}-\boldsymbol{l}_{LY}\boldsymbol{s})}{\overline{\Delta}} ?;$$

$$\frac{\hat{v}_X}{\hat{p}_X} = \frac{\boldsymbol{h}(\boldsymbol{l}_{LY}\boldsymbol{s}+\boldsymbol{J}_{HY}\boldsymbol{l}_{LX}-\boldsymbol{J}_{LY}\Lambda\boldsymbol{e})}{\overline{\Delta}} ?;\quad \frac{\hat{v}_X-\hat{p}_X}{\hat{p}_X} = \frac{(\boldsymbol{l}_{LY}\boldsymbol{s}-\Lambda\boldsymbol{e})}{\overline{\Delta}} ?;$$

$$\frac{\hat{w}-\hat{v}_X}{\hat{p}_X} = \frac{\boldsymbol{h}(\Lambda\boldsymbol{e}-\boldsymbol{l}_{LY}\boldsymbol{s})}{\overline{\Delta}} ?;$$

$$\frac{\hat{v}_Y}{\hat{p}_X} = -\frac{\boldsymbol{hJ}_{LY}(\boldsymbol{l}_{LX}+\Lambda\boldsymbol{e})}{\overline{\Delta}} < 0;$$

$$\frac{\hat{v}_Y-\hat{p}_X}{\hat{p}_X} = -\frac{[\boldsymbol{l}_{LX}\boldsymbol{h}+(\boldsymbol{h}-1)\boldsymbol{l}_{LY}\boldsymbol{s}+\Lambda\boldsymbol{e}]}{\overline{\Delta}} < 0;$$

$$\frac{\hat{w}-\hat{v}_Y}{\hat{p}_X} = \frac{\boldsymbol{h}(\Lambda\boldsymbol{e}+\boldsymbol{l}_{LX})}{\overline{\Delta}} > 0;\quad \frac{\hat{v}_Y-\hat{v}_Y}{\hat{p}_X} = \frac{\boldsymbol{h}(\boldsymbol{l}_{LY}\boldsymbol{s}+\boldsymbol{l}_{LX})}{\overline{\Delta}} > 0;$$

Quality and production

$$\frac{\hat{Q}}{\hat{p}_X} = \frac{(\Lambda\boldsymbol{e}-\boldsymbol{l}_{LY}\boldsymbol{s})}{\overline{\Delta}} ?;$$

$$\frac{\hat{Y}}{\hat{p}_X} = -\frac{[\boldsymbol{hJ}_{LY}\Lambda\boldsymbol{es}+\boldsymbol{hel}_{HX}\boldsymbol{l}_{LX}+\boldsymbol{hs}(\boldsymbol{l}_{LX}\boldsymbol{J}_{LY}+\boldsymbol{el}_{HX}\boldsymbol{l}_{LY})]}{\overline{\Delta}} < 0;$$

$$\frac{\hat{X}+\hat{Q}}{\hat{p}_X} = \frac{\boldsymbol{hel}_{HY}(\boldsymbol{l}_{LY}\boldsymbol{s}+\boldsymbol{l}_{LX})}{\overline{\Delta}} > 0;$$

$$\frac{\hat{X}}{\hat{p}_X} = \frac{\boldsymbol{l}_{LY}\boldsymbol{s}+\boldsymbol{e}[(\boldsymbol{h}-1)\boldsymbol{l}_{HY}\boldsymbol{l}_{LX}+\boldsymbol{hl}_{LY}\boldsymbol{s}+\boldsymbol{l}_{HX}\boldsymbol{l}_{LY}]}{\overline{\Delta}} > 0;$$

$$\frac{\hat{X}+\hat{Q}-\boldsymbol{h}\hat{Q}}{\hat{p}_X} = \frac{\boldsymbol{eh}(\boldsymbol{l}_{LY}\boldsymbol{s}+\boldsymbol{l}_{HX}\boldsymbol{l}_{LY})+\boldsymbol{hl}_{LY}\boldsymbol{s}}{\overline{\Delta}} > 0;$$

Allocation of inputs

$$\frac{\hat{L}_X}{\hat{p}_X} = \frac{\hat{X} + \hat{Q} - \boldsymbol{h}\hat{Q}}{\hat{p}_X} > 0;$$

$$\frac{\hat{L}_Y}{\hat{p}_X} = -\frac{\boldsymbol{l}_{LX}}{\boldsymbol{l}_{LY}}\frac{\hat{L}_X}{\hat{p}_X} < 0; \quad \frac{\hat{H}_X}{\hat{p}_X} = \frac{\hat{X} + \hat{Q}}{\hat{p}_X} > 0; \quad \frac{\hat{H}_Y}{\hat{p}_X} = -\frac{\boldsymbol{l}_{HX}}{\boldsymbol{l}_{HY}}\frac{\hat{H}_X}{\hat{p}_X} < 0;$$

$$\frac{\hat{H}_X - \hat{L}_X}{\hat{p}_X} = \boldsymbol{h}\frac{(\Lambda\boldsymbol{e} - \boldsymbol{l}_{LY}\boldsymbol{s})}{\overline{\Delta}} ?; \quad \frac{\hat{H}_Y - \hat{L}_Y}{\hat{p}_X} = \frac{\boldsymbol{hs}(\Lambda\boldsymbol{e} + \boldsymbol{l}_{LX})}{\overline{\Delta}} > 0;$$

where $\Lambda = \boldsymbol{l}_{LX} - \boldsymbol{l}_{HX} > 0$,

$\overline{\Delta} = \Lambda\boldsymbol{e}(1 - \boldsymbol{hJ}_{LY}) + \boldsymbol{l}_{LY}\boldsymbol{s}(\boldsymbol{h} - 1) + \boldsymbol{hJ}_{HY}\boldsymbol{l}_{LX} > 0$ and $\boldsymbol{hJ}_{LY} < 1$.

Figure 1

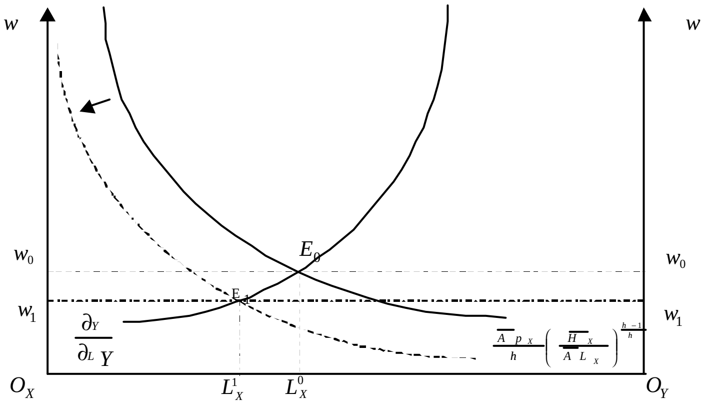

Figure 2