THEORIZING WAGE INEQUALITY IN THE LIGHT OF GLOBALIZATION AND TRADE

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To

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Dr. Brati Sankar Chakraborty

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Chapter 1

Introduction

Trade theory is the branch of economics that analyzes and aims to explain the interactions behind goods and services flows across national boundaries. Thus trade theory seeks to study the determinants and pattern of commodity exchanges across national borders, the consequences of such movements on the factors associated with the production of these commodities and the effects of various institutional interventions on these exchanges.

The fast rate of growth of international trade (around 6 percent per annum for the past two decades (source: WTO)) and faster still, foreign direct investment and the progressive integration of economies at a formidable pace, calls for a deeper understanding of the subject to gain insightful knowledge about the causes and more significantly, the effects of these globalizing forces.

1.1 Determinants and Pattern of Trade

One of the first theories that seek to answer the causes and pattern of trade flows is by David Ricardo. In his theory of comparative advantage, Ricardo posits the differences in relative factor productivities across countries as the driving force behind international trade. This theory predicts that a country that is relatively productive in manufacturing a commodity would specialize in the production of the commodity and export it. In this way this model explains the causation of trade in different products as caused by exogenously given differences in production costs across countries.

The framework developed by Eli Heckscher and Bertil Ohlin (hereafter referred to as HOS) and supplemented by Paul Samuelson, Jaroslav Vanek and Ronald Jones among others, assumes away relative technological differences across countries but instead advances on differences in relative factor abundance to explain trade across economies. According to this formulation, when the production technologies of the manufactures exhibit differences in the relative factor intensities, a country that is relatively abundant in a particular factor will have, at autarky, a lower relative price for the good intensive in the use of the factor. Thus differences in relative endowments across countries generate price differences – an incentive to trade. According to this theory the country that is relatively more abundant in a factor will specialize and export those commodities that use the factor more intensively.

As it turns out empirically, the theory of relative factor abundance explains a significant part of world trade and a wide array of observed verities did fit fairly well. But several empirical studies of trade conducted in the 1970's and 80's suggest that along with the forces of comparative advantage, intra – industry trade, defined as the exports and imports of characteristically similar goods, constitutes a large share of world trade (Grubel and Lloyd (1975)). Of the total volume of intra – industry trade, 80 percent consists of trade in vertical intra – industry trade while the rest is horizontal intra – industry trade (chapter 2 Rivera-Batiz and Oliva (2003)). Vertical intra – industry trade is defined as trade in similar but quality differentiated products that technologically differs with respect to the factor intensities whereas horizontal intra – industry trade refers to trade in differentiated products that have similar production technologies, are identical in quality and thus have same prices. It is in this realm where the standard neo – classical models employing a competitive market structure with constant returns to scale technology (hereafter referred to as CRS) fails to give us the cause of trade. Krugman (1979), (1981) and Ethier (1979), (1982) proposed the first formal models that could provide an explanation to the cause of intra – industry trade.

Krugman's (1979), (1981) line of argument rests on scale economies and consumers' taste for a diversity of products. According to this approach, on one hand, consumers satisfy their love for variety by consuming each and every variety that are available in the market and on the other hand increasing returns to scale technology (hereafter referred to as IRS) ensures a unique relationship between product variety and the manufacturing firm. Thus at trade, countries that are identical with respect to production technologies and factor endowments trade in similar goods (that are variety differentiated) as the firms of one country finds market for their goods in the other country while still reaping the benefits of scale economies by producing their commodity in one location – the country of their origin. One limitation of these models of monopolistic competition is that though these models predict a greater variety of export for the relatively larger country (in terms of endowments), which country produces and exports a specific variety is indeterminate in these models. This indeterminacy can be resolved with the incorporation of transport costs (Masahisa, Mori, and Krugman (1999), Neary (2001)) or in combination with the standard HOS relative factor abundance models (Helpman and Krugman (1987)).

Likewise, the argument forwarded by Ethier (1982) replaces the love for variety in the demand structure of the consumers' with international economies of scale and gains from specialization. In his model, the production of one of the final goods is organized with the help of differentiated intermediate goods that are produced under internal IRS. In addition to this the assembling technology used to manufacture the final produced good from the differentiated intermediates also exhibits scale effects in the number of the differentiated intermediates. This feature termed as international economies of scale, opens up gainful trade in intermediates even when the trading countries are perfectly similar. Ethier has also shown that with free trade in the intermediates, and the strength of the scale economies being not too strong, the pattern of trade as predicted by a standard HOS structure holds well.

Apart from the use of IRS, models that rely on market segmentation in an oligopolistic framework also explain two way trade in identical products. This is coined as reciprocal dumping in the trade theoretic literature (Brander (1981), Brander and Krugman (1983)).

Models explaining vertical intra – industry trade were developed by Kierzkowski and Falvey (1987) and Flam and Helpman (1987). In these models, demand for vertically differentiated products results from consumers' preference for varied qualities depending on their level of incomes. Thus trade in quality differentiated intra – industry products arise when countries produce quality differentiated products and exchange them owing to the differences in levels of incomes of the individuals within the countries.

Trade can also result from an uneven distribution of skill across countries. In this setting Grossman and Maggi (2000) have shown that when the production technology consists of tasks which for one good exhibits substitutability and complementarity for the other, then the country that is relatively homogeneous in its distribution of skill, exports the good having complementarity in the tasks and the other country exports the good whose tasks are substitutes. Complementarities in the tasks of a production process in presence of quality matching can alone account for trade as shown by Antràs, Garicano and Rossi-Hansberg (2006) in the presence of an uneven distribution of skill across the trading countries.

1.2 Trade and income distribution

When the markets are competitive, as in the Ricardian or the HOS models, trade necessarily leads to an increase in the global (i.e. the total welfare of the trading countries compared to autarky) welfare and does not 'hurt' any one of the trading partners. These results follow from gains from specialization and are robust to the extent of absence in any market distortions and externalities. In the presence of 'love for variety' effects in preferences, an additional gain that results from trade arises as the consumers spread their consumption over a larger number of varieties compared to autarky. Under imperfect competition, trade also leads to an increase in the market competitiveness as the market is opened to a larger number of producers. In the presence of scale economies, trade confers an additional source of gain. Falling average costs implied by scale economies increases the overall market efficiency with a fall in the number of participating firms. But this raises the monopoly power vested with any individual firm thus lowering the welfare. By increasing the number of firms operating globally while lowering the number of firms operating in a country, trade churns out an additional welfare gain. The natural question that arises next is how the gains are distributed amongst the factors and as such the effect of trade on the factor payments has been a topic of some serious research owing to the importance of trade and its distributive impacts on economy and society.

The HOS model of trade has been extensively analyzed for the comparative effects relating factor and product prices (holding the endowments fixed) and between endowments and output levels. The first theorem due to Wolfgang Stolper and Paul Samuelson (1941) can be stated as: in a 2x2 framework, if the relative price of a good rises, the factor that is used more intensively in the production of the good (compared to the other good) experiences an increase in its factor price while the price of the other factor decreases. This theorem establishes a one to one relationship between commodity and factor prices. The second one states that if the endowment of a factor rises then the relative supply of the good that uses the factor more intensively rises as well (Rybczynski (1955)). From these theorems, one can deduce that in a HOS model when two countries, not differing 'too much' in their relative factor endowments, engage in trade in commodities, their factor prices get equalized, and the relatively scarce factor of either countries loses as a result of trade. The Stolper and Samuelson theorem can be generalized (Jones (1965), (1979)) to give a theorem known as the 'price magnification effect' which states that with free trade, the factor used intensively in the production of the exportables experiences a raise in its real return while the real return of the factor used intensively in the manufacture of the imports is reduced. Versions of these theorems though not quite as strong as can be obtained in the 2x2 case, continue to hold in a multifactor – multi commodity world where the number of goods and factors is the same, the so-called 'even' case (Feenstra (2002)).

In the framework of IRS and other variants of the HOS framework with IRS, the validity of the Stolper and Samuelson theorem has been discussed. For example Ethier (1982) has shown that Stolper Samuelson theorem remains valid even with IRS if the scale effect is not significant enough.

Given the above results, as trade leads to an increase in the relative price of the relatively abundant factor, it seems to have an asymmetric effect on the relative factor prices for the participating countries. For the developed nations, trade with the developing countries implies an increase in the skilled labor wages compared to wages of unskilled labor as skilled labor is the abundant factor in these economies. For the developing countries endowed with a relatively huge supply of unskilled labor (vis – a – vis skilled labor), though trade with the developed nations implies a fall in the income inequality, all the empirical evidences collected so far indicates otherwise.

1.2.1 Trade and wage inequality empirics and theory

With respect to wage earnings, the relative position of the unskilled workers compared to their skilled counterparts, deteriorated in most countries of the world since 1970's (Wood (1997)). Except for the countries of East Asia, most countries with unregulated labor markets experienced an increase in the ratio of skilled to unskilled wage. In economies where national institutions regulated the labor markets, rising unemployment of the relatively unskilled workers revealed the fall in the relative position of the unskilled workers.

In the U.S. since 1980 onwards, relative wages became more unequal based on the attributes of education, experience and occupation. See Bound and Johnson (1992) and Leamer (2000) for a detailed study. In the case of Europe, the strong influence of national institutions on the wage settings, subdued wage adjustments and instead resulted in rising unemployment. For example, the OECD Employment Outlook (1993) pointed out that the disparity in income from the highest to lowest percentiles in the U.K. increased substantially. Similar results were reported by Katz, Loveman and Blanchflower (1993). For the Latin American countries, studies by Robbins (1995) on Argentina, Chile, Colombia, Costa Rica, Mexico and Uruguay, revealed a widening of wage differentials based on educational quality. Pedersen (1998) substantiated the findings of Robbins for Chile. For East Asia though, the empirical findings do not point towards a strict rise in the wage inequality. For countries like Korea, Taiwan and Singapore, the wage gap declined during 1960's and 70's. While Robbins (1994) attributes the phenomena to a relative growth of highly educated workers, according to Wood (1997) changes in trade regimes were also partially responsible. For China, concerns have been raised in the compilation by the Department of Organization Research Group of the Communist Party Central Committee in the China Investigation Report (2001) which reveals a growing income inequality with the emergence of a very rich population. Also for the South Asian countries including India, empirical findings, though hard to find, points to a widening wage gap (Dev (2000)). For India as an example, there was a general increase in inequality among wage earners of different skills during the period of economic reforms and trade liberalization (Acharyya (2006)).

Though the phenomenon of a rise in wage inequality has been well established in empirical literature, trade theorists have not yet settled on whether trade or rather technology is the underlying cause. On one hand, the works of labor economists Murphy and Welch (1991) and Reich (1992) found the growing trend in the volume of international trade as the primary cause of the then wage changes in the U.S economy, on the other, a number of studies have concluded that skill – biased technological change seems to be the main driving force behind the development (e.g. Berman, Bound, and Griliches (1994), Desjonqueres, Machin, and Van Reenen (1999), Krugman (2000)). Such skepticism has arisen from two facts. First are the major technological changes that occurred in the industrialized countries particularly in the U.S in the last two decades of the 20th century. Second is the low volume of trade prevalent between the OECD and the low wage countries. As an example, Lawrence (1994) points that 70 percent of

America's manufacturing imports in 1990 came from OECD countries that had similar wage levels. Such stances are not uncontested though, for example several trade theorists tend to argue that the conclusion of non – involvement of trade in aggravating wage inequality is erroneous. Since the methodology used to isolate the effects of trade and technology on factor prices rests on factor content approach: an approach that directly links volume of trade to factor prices and is not valid in general equilibrium trade theory (as the volume of trade has no direct impact on factor prices). According to Sachs and Shatz (1996) for the U.S., "trade is likely to be playing a role comparable in importance to the other factors". Feenstra and Hanson (2001) argue that the conjecture of technological progress being the sole driving force of wage inequality is often based on observations that emphasize on merchandise trade, while the service sector whose role in trade and GDP is ever increasing is largely ignored. Thus it may be incorrect to say that trade has not had any significant role in the increasing wage inequality.

The cornerstone of trade theory: the HOS model of trade together with its celebrated propositions one of which is the Stolper – Samuelson theorem or its generalization (Jones (1965), (1979)) does not provide a cause for a bilateral rise in wage inequality for the trading countries (though it does provide an explanation for wage inequality for one trading country in a two country setup). Neither do the specific factor variants of the HOS structure where the number of traded goods is lesser than the number of factors of production and the endowment base of an economy has direct impact on the wages, give us an explanation for the result.

Thus arose the challenge to construct theoretical models to explain the symmetric movements of relative wages for all the trading nations as a consequence of trade. Feenstra and Hanson (1996) show that, when a single manufacturing good is produced from a continuum of intermediate inputs, a growth of the relative stock of capital in the relatively capital scarce South, raises the skill intensity of production for both North and South and thus symmetrically widens the wage gap. Markusen and Venables (1997), feature the role of multinationals as they alter the nature of trade from trade in final goods to trade in the skill intensive intermediate producer services and in such a setting, a significant difference in the relative endowments of the two trading nations may lead to a rising wage gap for both the countries. From the standard 2x2 HOS structure the desirable result can be obtained by incorporating factor intensity reversals in the production function (Marjit and Acharya (2003)). Also as illustrated in Jones (2002) and Marjit and Acharya (2003), in a generalized HOS model, when there are fewer factors of production than the number of traded goods, a trading pattern yielding the desired result can be obtained where both the countries completely specialize in goods that are at the two ends of the intensity ranking and produce a common middle good. Glazer and Ranjan (2003) consider individuals who value product variety, and who can be skilled or unskilled as workers. Skilled people prefer to consume skill-intensive goods. In such a framework, they show that after opening up to trade, a country abundant in unskilled labor experiences an increase in the relative wage of skilled labor even when that country is a net exporter of goods intensive in unskilled labor. In Feenstra and Hanson (2003), trade in intermediate inputs is shown to raise the demand of skilled labor and thus affect wage inequality in the presence of heterogeneous activities in the manufacturing final goods sector. This paper also links up trade in intermediate inputs to skill biased technological progress in terms of their impacts on factor demands. Another group of models puts forward the integration of product markets brought about by trade to explain trade induced rise in wage inequality. In Neary (2002), the author argues that increased foreign competition can affect technical choice and skill differentials even when actual imports do not rise significantly. An oligopolistic model is presented in which a reduction in import barriers (whether technological or policy imposed) encourages more strategic investment by incumbent firms leading to higher ratios of skilled to unskilled workers employed in all sectors and throughout the economy and consequent rise in wage inequality. Ekholm and Midelfart (2005) show that with trade liberalization, firms get access to a larger market, the relative profitability of different technologies changes in favor of the more skill-intensive technology which in turn raises the relative return to skilled labor. Antràs, Garicano, and Rossi – Hansberg (2006) considers how an assignment of heterogeneous agents into hierarchical teams, of less skilled agents specializing in production and more skilled agents specializing in problem solving can raise wage inequality in a two-country model where the two countries (North and South), differ in their skill distributions.

It is in this area of trade induced wage inequality, that this thesis plans to contribute some additional causes that may be pertinent in the present day scenario. While the following chapter focuses on the role of preferences in yielding the result, the latter chapters discusses cases which deal with the supply/technology side of an economy.

1.3 Plan of the Thesis

This thesis is dissevered into five chapters. Chapter 2 focuses on the issue of trade induced wage inequality that arises due to non homotheticity in the preference structure of the individuals. This chapter incorporates Engel's law in preference structure which introduces non – homotheticity in the demand side. Due to this non – homotheticity, trade and its associated gains is shown to increase the relative demand of the relatively skill intensive commodity consequently raising the relative demand for skilled labor and thereby increasing the skilled – unskilled wage ratio in the presence of factor price equalization. Thus this work shows how Stolper Samuelson argument gets invalidated in a non – homothetic framework and also analyzes the validity of the HOS pattern of trade in such an environment.

In chapter 3, a model of trade with monopolistic competition is set up that seeks to explain the trade induced unidirectional movements in skilled – unskilled wage differential observed in most parts of the world, from the supply side of the economy. In this chapter a monopolistically competitive scenario is set up where with trade, an individual firm faces a higher number of competitors. This rise in the number of market participants requires each firm to spend higher amount of a skill intensive resource to survive in the global market. Thus opening up to trade consequently raises the relative demand for skilled labor and thereby increases the skilled – unskilled wage ratio.

Chapter 4 extends the notion of trade induced wage inequality to the broader perspective of globalization defined as free movement of manufacturing plants throughout the trading economies. In this chapter, it is shown how factor market integration induced through globalization and trade, can lead to rising wage inequality amongst the trading nations when the production technology consists of a series of complementary tasks and exhibits super modularity in the skill levels of these tasks. Factor market integration can lead to a hike in the productivity of the skilled workers, in the presence of quality matching. This translates to a higher relative skilled – unskilled wage premium in presence of non – unitary elasticity of substitution in preferences. This model also explains an increased segregation of workers based on their skill levels. This chapter also opens up a new explanation of trade in intermediates in a case where the trading countries are identical with respect to their volume and distribution of endowments and thus posits a new cause of intra – industry trade in vertically differentiated goods within similar countries.

Chapter 5 looks at the topic of trade and its effect on wage inequality from a different view point. It is found empirically that there exists an inverted – U relationship between skilled to unskilled wage differential and the relative skilled to unskilled labor endowment. This clearly violates the basic principle of economic theory, the law of supply and demand: that a lower/higher price of a good/factor relative to some other, reflects its relative abundance/scarcity. This chapter presents a model where this apparent paradox is resolved by incorporating a type of externality in the production function. This externality in the production function takes the form of a training cost that is assumed to be related to the average skill levels of the individuals of the economies. It is shown here that the presence of such an externality necessarily acts towards widening the skill to unskilled wage ratio in a trade regime that incorporates factor price equalization and incomplete specialization.

Chapter 2

Non homothetic preferences:

explaining unidirectional movements in wage differentials

2.1 Introduction

Economists are well acquainted with the Engel's law. The Engel's law concerning consumption of necessities seems to be valid not only in the developed countries but also in the developing ones. In day to day life, it is quite an observable fact that goods are consumed in a definite pattern. For example, it is impossible to find an individual who owns a car but has no access to electricity at home, while the reverse case is quite observable. To elucidate, consider the case of an individual who has to select from two bundles. The first bundle say B1 consists of two units of food and two units of entertainment e.g. a film show. The second bundle B2 consists of four units of food and no entertainment. Since food is essential for the individual, she could well choose B2 over B1. Had the amount of food in B1 and B2 been increased proportionately (a proxy for real income gains), the preference could have reversed because of the individual's satiation in food. This demand sequentiality is quite a natural phenomenon in everyday life and is captured in economics through Engel's law. One of the primary implications of Engel's law is the presence of non – homotheticity in the preference structure of the individuals. Clearly apart from food items, clothing, energy, housing, healthcare, transportation etc are also included in the basic needs and as such everyone must spend some resources on these items. Also, these basic items consumed, are often products of unskilled – labor intensive industries in comparison to other luxurious items. Noting the above factors of consumer demand, this chapter tries to account for trade induced widening of the skilled – unskilled wage differentials, that may arise out of such non – homotheticity in demand.

The empirical literature has produced a number of findings that accepts the role of non – homotheticity in trade. Examples include the wok by Hunter (1991) where they have shown that non – homothetic preferences may account for as much as one – quarter of inter – industry trade flows. Similar results ruling out homotheticity in demand were contributed by Tchamourliyski (2002). In conventional HOS trade models, income distribution does not affect the trade flows whereas empirically it has been found that income distribution has indeed a role to play in driving trade (See Dalgin, Mitra, and Vitor (2008) as an example).

The presence of non – homotheticity is captured in this chapter by a hierarchical preference structure as in Eswaran and Kotwal (1993), Puga and Venables (1999), Gollin, Parente, and Rogerson (2002). The avenue through which this discourse succeeds in achieving the result is as follows. With trade there must be some associated gains. These gains may be interpreted as some increase in the real income of the trading economies. Since it is a very well established fact, that goods that are at the top of the hierarchy, are often skill intensive compared to those lower down the rung, the increased real income translates to an increase demand of the skill – intensive luxurious goods (that are at the top of the rung). This raises the relative demand of skilled labor and affects the skilled to unskilled wage ratio. Thus this construct derives trade induced wage inequality by considering the income effect of non – homotheticity of demand: an approach that (to the author's knowledge) has not yet been explored in the trade – wage gap literature. In a majority of standard trade models that incorporates factor price equalization, the relative factor rewards monotonically decreases with the respective relative factor endowments. Any form of violation of this monotonicity implies an inherent positively sloped relative factor demand schedule. This raises issues regarding stability of the general equilibrium. This chapter shows that in the presence of non – homothetic preferences and trade induced variety gains, a standard 2x2 framework with factor price equalization can yield a symmetric rise in relative wages without any concerns regarding stability of the equilibrium (which here is shown to be Walras stable). Also, the notion of product differentiation used, is well suited for the developed OECD countries and thus this model can explain rising wage inequality amongst these developed countries even when their trade volume with the less developed countries is small (because in the trade – wage inequality debate, the low volume of trade prevalent between the OECD and the low wage countries is often cited to annul the role of trade in driving wage inequality).

This chapter is organized as follows. Section 2.2 of this chapter sets up the basic model which is solved for the endogenous variables in section 2.3. This section also characterizes the nature of the equilibrium obtained thus and deduces the pattern of trade flows and the effect of income distribution on the pattern of trade. Section 2.4 shows how the result of trade induced rising wage inequality is guaranteed in this model and tries to extract the economic rationale behind it. Also it is reasoned in this section that even in the presence of elastic factor supplies, the efficacy of this model is guaranteed. The last section offers conclusions, highlighting some key aspects of this model.

2.2 The Model

The model comprises of two countries: Home and Foreign, producing two commodities with two factors. The countries have identical demand and production structures. They possibly differ with respect to the endowments of the factors and its distribution amongst the individuals. In the following section I set up the economic structure of the home economy.

2.2.1 Preferences

The economy consumes two goods: X and Y. The representative individual of the economy has two consumption patterns: a 'basic' pattern and an 'affluent' pattern. The 'basic' pattern yields utility up to a certain threshold: T. The 'affluent' pattern yields utility only if the 'basic' pattern is already providing with T amount of utility. The 'basic' pattern and the 'affluent' pattern, have different intensity rankings for the goods. I assume that, in going from the 'basic' to the 'affluent' pattern, consumption of Y rises relative to X. The utility function representing the preference structure of the representative individual is of the form:

$$U = \text{Min}\left\{X_b^{\beta} Y_b^{1-\beta}, T\right\} + \mathfrak{I} X_a^{\alpha} Y_a^{1-\alpha} \text{ with } \mathfrak{I} = \begin{cases} 1 \text{ if } X_b^{\beta} Y_b^{1-\beta} \geq T \\ 0 \text{ if } X_b^{\beta} Y_b^{1-\beta} < T \end{cases} \text{ and } \alpha, \beta \in (0,1)$$

The 'b' in the subscript denotes the amounts of the goods, consumed following the 'basic' pattern and the 'a' in the subscript denotes the amounts of the goods, consumed following the 'affluent' pattern. This is a mere generalization of the preference structure as adopted by

Eswaran and Kotwal (1993), Puga and Venables (1999) and Gollin, Parente, and Rogerson (2002). In these papers, they assumed non – substitutability across the goods consumed whereas here I have allowed for different degree of substitution amongst the two goods. To accommodate for the differences in the intensity of consumption of the goods across the patterns, I take $\beta > \alpha$. To incorporate the gains from trade – effect in the model, I assume that the X and Y goods are variety differentiated composites as in Dixit and Stiglitz (1977) that is formed using the function:

$$X = \left[\sum_{1=1}^{n_x} x(i)^{\rho_x}\right]^{1/\rho_x}, Y = \left[\sum_{1=1}^{n_y} y(i)^{\rho_y}\right]^{1/\rho_y}$$

Here $x(i)$ is the i^{th} variety of good X and n_x is the number of varieties of the good available in the market and similarly $y(i)$ is the i^{th} variety of good Y and n_y is the number of varieties of the good available in the market.

2.2.2 Production and market organization

Next I describe the production side of the economy. The production of the X good is organized with the help of unskilled labor (l_u), while that of Y is organized with the help of skilled labor (l_s). This assumption introduces the notion of higher skill intensity of the 'affluent' good Y (i.e. the good whose relative demand increases in going from the 'basic' to the 'affluent' consumption pattern)[1]. The choice of units is such that one unit unskilled labor yields one unit of any variety of good X and likewise a unit of skilled labor yields a unit of a variety of good Y. In addition to this, production of a variety of the goods requires an overhead expenditure in the form of f_x units of unskilled labor for good X and f_y units of skilled labor for good Y. These expenditures can be thought of as the infrastructural requirements to set up the production of a variety of goods X and Y. The economy is assumed to be endowed with a fixed amount of unskilled labor: L_u and skilled labor: L_s which is inelastically supplied to the industries.

The factor markets are assumed to be perfectly competitive while monopolistic competition is assumed to prevail in the market for commodities X and Y. The factors of production are freely mobile between the firms.

[1] Here I have assumed non – substitutability of the factors across the two goods. While the same may be incorporated in this model without any substantial gains, the analysis and implications that follows still goes through.

2.3 The solution

This section derives the general solution of the endogenous variables of the home's economy. From it, one can deduce the equilibrium of the foreign country at autarky by simply plugging in the respective exogenous variables of the foreign country.

2.3.1 The commodity and factor markets

For the industry of good X, each variety differentiated firm 'i' faces a profit function (keeping in mind that one unit of any variety of good X requires a unit of unskilled labor as variable cost):

$$\pi_x(i) = p_x(i)x^d(i) - x^d(i)w_u - f_x w_u$$

where $x^d(i)$ is the demand for the i^{th} variety and is given by:

$$x^d(i) = \frac{p_x(i)^{\frac{1}{\rho_x - 1}} I_x}{\sum_{j=1}^{n_x} p_x(j)^{\frac{\rho_x}{\rho_x - 1}}}$$

In the above equation, I_x is the amount of income of the economy, spend behind the composite good X and the factor payments of unskilled labor and skilled labor for the economy are respectively denoted by w_u and w_s.

Profit maximization on part of the producers of good X yields the relation:

$$\rho_x p_x(i) = w_u \qquad \text{… (2.1)}$$

Equation (2.1) implies equal prices for all the varieties of good X (from now on denoted by p_x) which together with the demand for the varieties, entails equal demand for each variety of the good. Thus from now onwards the index of the firm 'i' is omitted. Since free entry/exit prevails in the industry, the profits over and above the variable cost of the firms (the LHS of the following equation), gets equated to the fixed costs (the RHS of the following equation), ensuring the relation:

$$(1 - \rho_x)p_x x = f_x w_u \qquad \text{… (2.2)}$$

In the above equation production of each variety of good X is denoted by 'x'.

The unskilled labor market clearing condition can be written as:

$$n_x x + n_x f_x = L_u \qquad \text{… (2.3)}$$

From equations (2.1) and (2.2), we can derive the optimal of each variety of good X (i.e. x) as:

$$x = \frac{f_x \rho_x}{1 - \rho_x} \qquad \text{… (2.4)}$$

This when incorporated in equation (2.3), yields the optimal degree of differentiation of good *X* (i.e. n_x) as:

$$n_x = \frac{L_u(1-\rho_x)}{f_x} \qquad \dots (2.5)$$

For the industry of good *Y* identical arguments yields the following relations:

$$\rho_y p_y = w_s \qquad \dots (2.6)$$

$$(1-\rho_y)p_y y = f_y w_s \qquad \dots (2.7)$$

$$n_y y + n_y f_y = L_s \qquad \dots (2.8)$$

$$y = \frac{f_y \rho_y}{1-\rho_y} \qquad \dots (2.9)$$

$$n_y = \frac{L_s(1-\rho_y)}{f_y} \qquad \dots (2.10)$$

2.3.2 The general equilibrium

At this moment, I define the critical income: I_c, as the income which is just sufficient for an individual with the given form of utility, to attain the threshold level with the 'basic' pattern of consumption. That is I_c is the level of income that solves (the RHS of the following equation is the indirect utility function of the 'basic' pattern of consumption):

$$T = \left(\frac{\beta I_c}{P_X}\right)^{\beta} \left(\frac{(1-\beta)I_c}{P_Y}\right)^{1-\beta}$$

where P_X and P_Y are the composite prices of goods *X* and *Y* which takes the form:

$$P_X = \left[\sum_{1=1}^{n_x} p_x(i)^{\frac{\rho_x}{\rho_x - 1}}\right]^{\frac{\rho_x - 1}{\rho_x}} = n_x^{\frac{\rho_x - 1}{\rho_x}} p_x \qquad \dots (2.11)$$

$$P_Y = \left[\sum_{1=1}^{n_y} p_y(i)^{\frac{\rho_y}{\rho_y - 1}}\right]^{\frac{\rho_y - 1}{\rho_y}} = n_y^{\frac{\rho_y - 1}{\rho_y}} p_y \qquad \dots (2.12)$$

Noting equations (2.1) and (2.6) and the composite prices of goods *X* and *Y* i.e. equations (2.11) and (2.12), the value of I_c is derived to be:

$$I_c \equiv \frac{T w_u^{\beta} w_s^{1-\beta}}{n_x^{\frac{\beta(1-\rho_x)}{\rho_x}} n_y^{\frac{(1-\beta)(1-\rho_y)}{\rho_y}} (\beta\rho_x)^{\beta}\left((1-\beta)\rho_y\right)^{(1-\beta)}} \qquad \dots (2.13)$$

Observe that an individual with an income of 'm', spends: Max $\{m - I_c, 0\}$ of her income following the 'affluent' pattern of consumption. Since the individuals' incomes and the critical income (equation (2.13)) are continuous functions of the factor payments, the incomes of the individuals' spent following the 'affluent' pattern, are also continuous in the factor payments. Thus the aggregate income of the economy spent following the 'affluent' pattern being a sum of the individuals' income spent following the 'affluent' pattern, is also continuous in the factor payments. From now on, I coin I_a as the surplus income function of the economy. Since the utility structure revels that the affluent pattern of consumption has the form: $X_a^{\alpha} Y_a^{1-\alpha}$, I_a satisfies the relation:

$$I_a \equiv P_X X_a + P_Y Y_a$$

The rate of change of I_a with respect to any factor price (the other factor price and the product varieties being held fixed) is always lesser than that for I (noting that $I \equiv w_u L_u + w_s L_s$ is the total income of the economy) that is:

$$\frac{\Delta I_a}{\Delta w_s}\Big|_{w_u, n_x, n_y} < L_s \text{and} \frac{\Delta I_a}{\Delta w_u}\Big|_{w_s, n_x, n_y} < L_u$$

This is because if (say) the skilled wage rate rises/(falls) by Δw_s, the aggregate income of the economy rises/(falls) by $L_s \Delta w_s$ and at the most, the whole of this income rise/(fall) will be spent behind/(deducted from) the affluent pattern of consumption. But with the rise/(fall) in the unskilled wage rate, the critical income i.e. I_c of the economy also rises/(falls) (refer to equation 2.13) and thus I_a rises/(falls) by less that the rise/(fall) in I. Similar argument holds for the rate of change of I_a with respect to the unskilled wage rate.

From the utility structure, the demand for the two goods – X and Y can be obtained as (note that a 'd' in the superscript implies quantity demanded):

$$X^d = \frac{\beta(I - I_a) + \alpha I_a}{P_X} \qquad \text{… (2.14)}$$

$$Y^d = \frac{(1-\beta)(I - I_a) + (1-\alpha) I_a}{P_Y} \qquad \text{… (2.15)}$$

Now, the total demand for unskilled labor comes from the industry of good X and analogously for the skilled labor the total demand comes from industry Y. Since the firms earn zero profits, the relative demand for skilled to unskilled labor can be derived from equations (2.14) and (2.15) by observing the facts that:

$$\frac{P_X X^d}{w_u} = L_u^d \text{ and } \frac{P_Y Y^d}{w_s} = L_s^d$$

to yield:

$$\frac{L_s^d}{L_u^d} = \frac{w_u}{w_s}\left[\frac{(1-\beta)(I - I_a) + (1-\alpha) I_a}{\beta(I - I_a) + \alpha I_a}\right] \qquad \text{… (2.16)}$$

Thus the relative demand for skilled to unskilled labor when equated to the supply yields the following equation:

$$\frac{L_s}{L_u} = \frac{w_u}{w_s}\left[\frac{(1-\beta)(I-I_a)+(1-\alpha)I_a}{\beta(I-I_a)+\alpha I_a}\right]$$

Noting that $I \equiv w_u L_u + w_s L_s$, the above equation may be simplified to yield:

$$w_s = \frac{(1-\beta)w_u L_u + (\beta-\alpha)I_a}{\beta L_s} \qquad \dots (2.17)$$

To study the nature of the solution of equation (2.17), first I take the unskilled labor to be the numéraire. Then LHS and the RHS of equation (2.17) can be plotted against the skilled wage rate (since the number of varieties of goods X and Y is fixed and is given by equations (2.5) and (2.10)). This exercise is done in the figure – 1. The LHS of the equation ascribes a 45° line and the RHS of the equation translates to a line which originates (in limits) from a point with value greater than or equal to: $(1-\alpha)L_u/\beta L_s$. Also the slope of this line is strictly lesser than one. This follows from the fact derived earlier that:

$$\left(\frac{\Delta I_a}{\Delta w_s}\right)\Big|_{w_u=1\,,n_x,n_y} < L_s \text{ implying } \Delta\left[\frac{(1-\beta)w_u L_u+(\beta-\alpha)I_a}{\beta L_s}\right]/\Delta w_s\,\Big|_{w_u=1\,,n_x,n_y} < 1.$$

Thus there exists a unique equilibrium solution to the model.

Before concluding this subsection, I forward a few comments on the stability of the equilibrium. Consider the relative factor demand equation (equation (2.16)). This equation is a continuous one – to – one function of the factor payments. When the skilled to unskilled relative factor prices approaches zero, the relative demand approaches infinity and vice versa (note that the term in third brackets in the RHS of equation (2.16) is bounded in the interval: $[(1-\beta)/\beta\,,(1-\alpha)/\alpha]$). Hence from the uniqueness of the equilibrium for any given relative supply of the factors, one can surely conclude that the relative demand is a monotonically decreasing function of the relative factor rewards (otherwise one would end up with multiple equilibria) and hence Walras stability of the unique equilibrium characterized above is ensured.

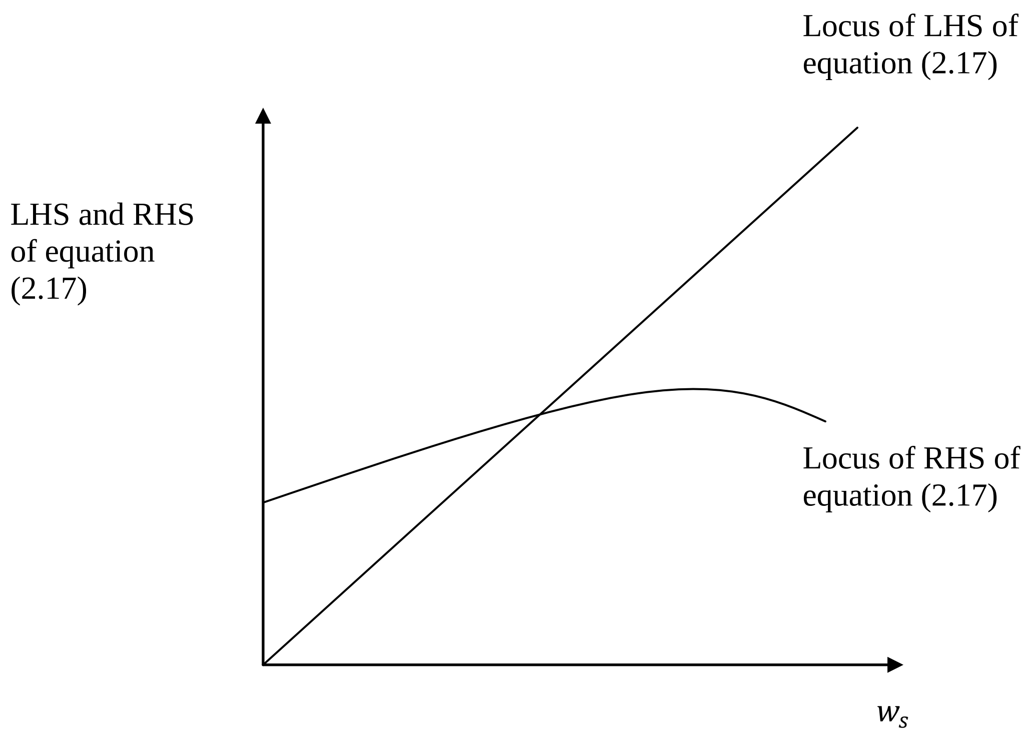


Figure – 1: Uniqueness of the equilibrium

2.3.3 The countries at trade

At trade, free unrestricted movement of goods ensures commodity price equalization across the countries for the goods. Since equations (2.4) and (2.9) remain valid for both the countries at trade, the supply of the variety differentiated goods *X* and *Y* is solely determined by the production technology which is identical across the trading countries and remains fixed across the countries. This together with the demand function for the varieties of the good ensures price equalization for each variety of the goods *X* and *Y*, thus ensuring factor price equalization across the countries. With factor price equalization, the endogenous variables of the trading economies coincide with those of the integrated autarchic economies, and as such, the endogenous variables at trade can be obtained from equations (2.1) through (2.17) by replacing the endowments, with the world (i.e. combined home and foreign) endowments and replacing I_a, by the sum of the home and foreign income surplus. From now on, I append the superscripts '*h*', '*f*', '*a*' and '*t*' to the endogenous variables, to distinguish these variables for home, foreign, autarky and trade respectively. Note that at trade, the home and foreign production of the goods together with the degree of differentiation of the goods *X* and *Y* remains fixed at the respective autarkic levels and the critical income i.e. I_c is equalized across the countries as they face the same factor prices and varieties of goods *X* and *Y*.

2.3.4 The pattern of trade

Since this model deals with non – homotheticity, it is quite reasonable to predict that the pattern of trade implied, differs from standard HOS patterns and this feature is derived exclusively in this section. Before proceeding further, to ease manipulations, I define:

$$\theta_a^{ht} \equiv \frac{I_a^{ht}}{I^{ht}} \text{ and } \theta_a^{ft} \equiv \frac{I_a^{ft}}{I^{ft}}$$

That is, instead of dealing with the absolute values of the surplus income functions of the two countries, I instead use the ratios of the surplus income to the total incomes of the respective countries. The net exports of home country in good *X* denoted by NE_x^h is defined as:

$$NE_x^h \equiv n_x^h x^{hf} - n_x^f x^{fh}$$

where x^{hf} is the amount of each variety of good *X* produced by home and exported to foreign and likewise x^{fh} is the amount of each variety of good *X* produced by foreign to export to home. The inequality $NE_x^h \gtreqless 0$ can be simplified with the above identities to yield:

$$\left(\frac{L_u^h}{L_s^h}\bigg/\frac{L_u^f}{L_s^f}\right) \gtreqless \frac{D^{ht}(1-D^{ft})}{D^{ft}(1-D^{ht})}$$

with $D^{ht} \equiv [\beta(1-\theta_a^{ht})+\alpha\theta_a^{ht}]$ and $D^{ft} \equiv \left[\beta\left(1-\theta_a^{ft}\right)+\alpha\theta_a^{ft}\right]$

Note that D^{ht} denotes the fraction of home's income spent behind good X and D^{ft} denotes the fraction of income of the foreign country spent behind the good at trade. Contrary to standard models incorporating homothetic preferences, the RHS of the above relation is non – unitary which reflects the fact that even when the factor and commodity prices are equalized, the relative demand of the two goods X and Y may differ across the countries because of differences in income distributions. From an inspection of the above inequality, the following proposition is immediate:

Proposition 1: *At trade, if both the countries have identical skilled to unskilled labor endowments* (*resulting in the LHS of the above inequality equating to unity*), *the home country is a net exporter of the unskilled labor intensive good X* (*and consequently a net importer of good Y*) *if and only if it is relatively richer than the foreign country in a sense that the home spends a greater fraction of its income behind the affluent pattern than its trading counterpart.*

In general, thus, the trade balance of a country depends not only on the relative endowments but also on the relative share of incomes spend by the countries following the affluent pattern of consumption. The above model also gives us some indications as to the relation between the trade pattern and income inequality which is summarized below:

Proposition 2: *If the two trading countries have identical absolute values of the factor endowments and the number of individuals in the economies, then at trade, the country having a higher dispersion of income between the individuals whose income lie above and below the critical level of income* (*i.e.* I_c), *is a net exporter of good X and a net importer of good Y.*

To appreciate the above proposition, consider the case where the home and foreign countries have identical factor endowments. So the LHS of the above net export inequality evaluates to unity. Since at trade, the countries have identical incomes (because of identical endowments and factor price equalization) as well as identical number of individuals in the economies, home has a higher value of the income surplus and hence a higher ratio of the surplus income to the total income (i.e. $\theta_a^{ht} > \theta_a^{ft}$) as this country has a higher dispersion of income between the individuals whose income lie above and below the critical level of income (i.e. I_c). Thus the RHS of the above trade balance inequality evaluates to a fraction which proves the above proposition[2]. Also the above chain of arguments leads to:

Corollary: *Given the number of individuals in the trading economies, a rise in the relative dispersion of income between the individuals whose income lie above and below the critical level of income* (*i.e.* I_c) *for any one country, raises the net exports of good X and the net imports of good Y for that country.*

2.4 The widening wage gap

In this section, I show how the above described model can be used to explain the widening of the skilled and unskilled wage gap for both the trading nations.

Proposition 3: *In the case where at autarky both the countries have identical skilled to unskilled wage ratio with at least one country having a strictly positive income surplus* (*i.e. either* $I_a^{ha} > 0$ *or* $I_a^{fa} > 0$ *or both*)*, trade unambiguously leads to an increase in the skilled to unskilled wage ratio for both the trading countries.*

Proof: The proof is best derived with the help of diagrams. If the countries have identical autarkic skilled to unskilled wage ratios, the RHS of equation (2.17) for both the countries must intersect with the LHS (the 45° line) at the same relative wages. This same is depicted in the figure – 2. Given the factor payments, the income surplus function of at least one of the countries experiences an increase following an increase in the number of varieties available to the consumers. This follows from a decrease in the critical income which varies inversely with the number of varieties available in the market. The same can be plotted in a diagram. In figure – 3, this is depicted as an upward shift in the RHS of equation (2.17) for the home and foreign countries (note that, by the assumption at least one country has a strictly positive autarkic income surplus).

[2] For a more detailed evaluation of the role of inequality in trade in the presence of non – homothetic preferences, interested readers may consult Mitra and Trindade (2005).

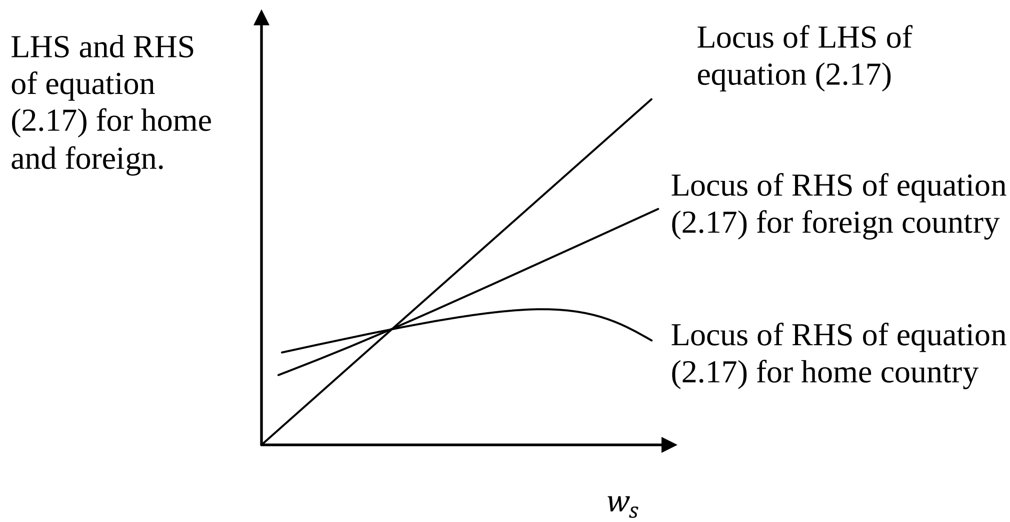


Figure – 2: Identical autarkic wage ratios

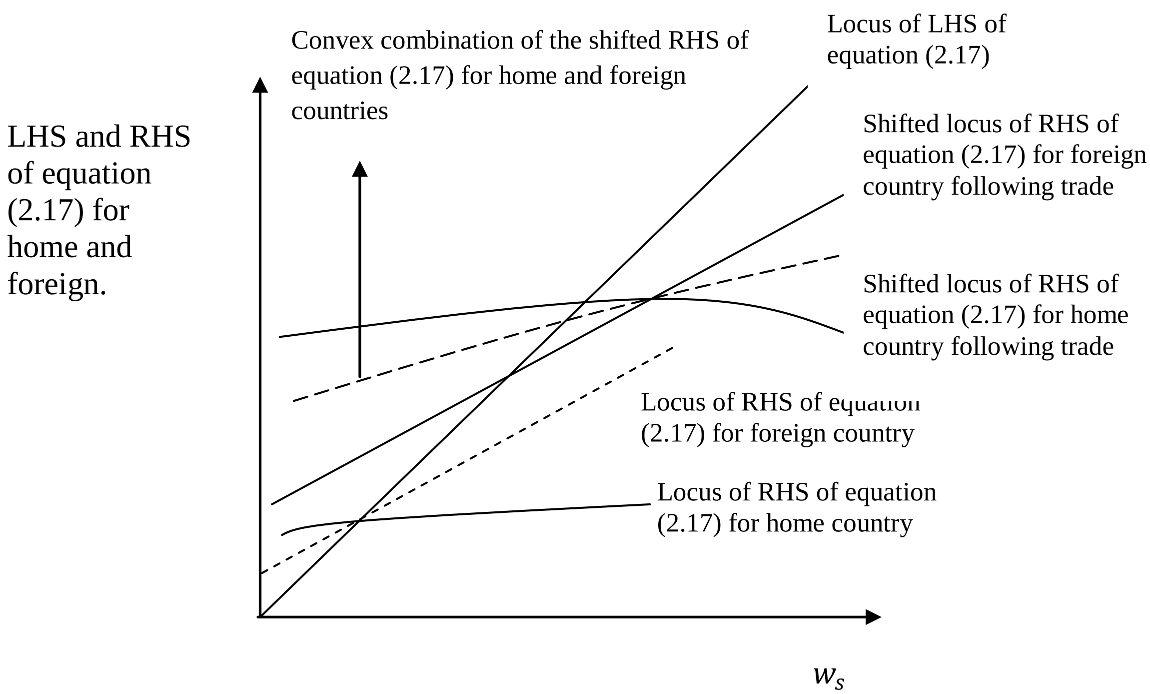


Figure – 3: The rising wage gap

Consequently at trade, the skilled – unskilled wage ratios derived from equation (2.17) must satisfy the following equation:

$$w_s^t = \frac{(1-\beta)\left(L_u^h+L_u^f\right)+(\beta-\alpha)\left(I_a^{ht}+I_a^{ft}\right)}{\beta\left(L_s^h+L_s^f\right)}$$

The above relation can alternatively be rewritten as:

$$w_s^t = \frac{(1-\beta)L_s^h+(\beta-\alpha)I_a^{ht}}{\beta L_s^h}\frac{L_s^h}{L_s^h+L_s^f} + \frac{(1-\beta)L_u^f+(\beta-\alpha)I_a^{ft}}{\beta L_s^f}\frac{L_s^f}{L_s^h+L_s^f}$$

The above relation clearly revels that the skilled to unskilled wage rate prevalent at trade is the one where the convex combination of the shifted RHS of equation (2.17) for home and foreign countries, cuts the 45° line (the LHS of the relation)(See figure – 3). This shows that trade is characterized by a higher skilled to unskilled wage ratio than autarky for both the countries. From continuity of the surplus income function, it can be readily deduced that even if the autarkic skilled unskilled wage ratios of the two countries are not identical, the result can still be guaranteed if the variety gains is large enough. This is summarized as follows:

Corollary: *Given the degree of differentiation of the goods X and Y for the two countries, one can obtain a δ such that, if the autarkic skilled to unskilled wage ratios of the two countries do not differ by more than δ and at least one country has a strictly positive income surplus, then trade unambiguously leads to an increase in the skilled to unskilled wage ratio for the countries.*

The above discussions highlight the route through which this model succeeds in achieving a symmetric widening of the wage gap. Gains – from – trade manifests itself by increasing the real income of the individuals of the trading economies by raising the available varieties of the goods *X* and *Y*. Thus trade leads to an increase in the income surplus (spent to achieve the 'affluent' pattern of consumption) which gets spent on the good/s, more intensive in skilled labor. When the pre – trade ratio of skilled to unskilled wage amongst the two countries are close enough, trade dictates a symmetric increase in the skilled – unskilled wage differential. In this model, I have taken the supply of skilled and unskilled labor to be fixed and inelastic. In real world situations, the relative supply of skilled to unskilled labor can be an increasing function of the relative skilled to unskilled wage ratio. The model constructed here is such that even in the situation of elastic supplies, the deductions of this model remain valid. To see this, first consider equation (2.17). This equation, now assumes the form:

$$w_s = \frac{(1-\beta)w_u L_u(w_s/w_u)+(\beta-\alpha)I_a}{\beta L_s(w_s/w_u)} \text{ with } \frac{dL_u(w_s/w_u)}{d(w_s/w_u)} \le 0 \text{ and } \frac{dL_s(w_s/w_u)}{d(w_s/w_u)} \ge 0$$

Through the above equation, the supply of unskilled labor is taken to be negatively related to the skilled to unskilled relative wages whereas the skilled labor supply varies positively (as indicated by the signs of the derivatives). Since the slope of the RHS of this function with respect to the skilled to unskilled relative wage rate still remains lesser than unity (because of the signs of the derivatives), the existence and uniqueness of the equilibrium is ensured. Next consider equation (2.16) which depicts the relative skilled to unskilled labor demand. The asymptotic properties of this equation, as a function of the relative factor payments, remain unchanged. Given these facts, the relative demand curve cannot be steeper than the relative supply curve since there exists only one equilibrium. Thus the property of Walras stability of the equilibrium is preserved. The pattern of trade gets evaluated at the equilibrium trading wage rates and thus the deductions of propositions 1, 2 and the corollary remain unaffected by this alteration. Also the arguments put forward in proposition 3 and its corollary make use of fixed relative wages, to deduce the nature of the shifts of the RHS of equation (2.17) and as such, the arguments still continue to hold even if the relative supplies are made elastic. It must be noted however that as one allows for the factor endowments to adjust with the factor rewards, the magnitude of the rise in relative skilled to unskilled wages is dampened.

2.5 Conclusion

The framework set up in this chapter supplements trade, as a cause of the rising wage inequality. It focuses on hierarchical preferences – a behavioral pattern of consumer demand, to justify rising wage inequality amongst nations. With homothetic demands, the relative demand of a good with respect to some other good remains insensitive to the income levels of the economy. The notion of hierarchical preferences which introduces non – homotheticity in the demand makes this relative demand responsive to the individuals' income levels. Thus trade, which brings about a rise in the real income, alters the relative demands of the goods in favor of a more skill intensive 'luxurious' good. This raises the relative demand of the skilled labor for all the trading countries. In this way, trade brings about a symmetric rise in the wage inequality.

Chapter 3

Trade and market congestion:

an explanation for widening skilled – unskilled wage differential*

3.1 Introduction

This chapter sets up a two factor – two country model of trade incorporating the features of increasing returns and monopolistic competition, to give a theoretical premise for a case where trade induces a rise in wage inequality in both the trading countries through interactions in the supply side of the economies. The specific modeling strategy that is used is as follows. Trade opens up the market of a country, leading to an increase in the number of firms catering the market. This creates market congestion which is captured in the model by an increase in the fixed costs of the firms operating in the market. For example, when new firms enter a market, the incumbent firms increase their fixed expenditures on R&D projects and/or advertisement expenditures as they try to retain their command over the market. The rise in the fixed cost translates to a rise in the relative demand of skilled labor which in turn raises the relative skilled – unskilled wage ratio. Since the firms of all the trading countries are affected by market congestion, the rise in the skilled – unskilled wage ratio is experienced by all the trading

* This Chapter is based on Santra(2011).

economies. The results are also robust in the sense that they do not depend upon the factor endowments of the trading nations.

Section 3.2 of this chapter builds up the basic model which is solved for the endogenous variables in section 3.3. Section 3.4 introduces trade in the framework and shows how the result is generated in the model. Conclusion is drawn next in section 3.5, highlighting some key features of this model.

3.2 The Model

In the following sections, I set up the structure of a representative economy. I assume that there are two countries: 'home' and 'foreign', having identical preference and production structure as that of the representative economy but possibly differing in factor endowments.

3.2.1 Preferences

The preference structure of the individuals of the representative economy is given by the standard CES utility function defined over a differentiated good *x*. The utility function of individual 'i', assumes the form:

$$U^i = \left(\int_0^n x^i(j)^\rho \, dj\right)^{1/\rho}$$

Here, $x^i(j)$ is the consumption of the j th differentiated good *x* by the individual and *n* is the number of varieties available in the market.

3.2.2 Production

The production of the differentiated good is organized by a number of monopolistically competitive firms with the help of two factors: skilled labor (l_s) and unskilled labor (l_u). The representative firm *i*'s production function takes the form:

$$x(i) = T l_{ui}^{\theta} l_{si}^{1-\theta} \text{ where } \theta \in (0,1).$$

In addition to this, production requires an overhead expenditure in the form of two additional goods: *f* and *z* (i.e. these goods are not marketed). Good *f* can be thought of as an infrastructure good that needs to be produced by a fixed amount: *F*. The production technology of good *f* is of the form:

$$A l_{ui}^{\alpha} l_{si}^{1-\alpha} \text{ where } \alpha \in (0,1).$$

Good *z* can be interpreted as an R&D and/or advertisement good, required to be produced by the firms to survive in the market. It is assumed that the overhead expenditure in the form of good *z* varies positively with the number of market participants. If there are *n* firms in the market, then $Z(n)$ amount of the *z* good needs to be produced by a firm where $Z(\cdot) \geq 0$ and $Z'(\cdot) > 0$. A close analogue to this specification can be found in Collie & Su (1998). In their paper, an entrant incurs an entry cost which is a positive function of the number of incumbents. Thus the entry costs for each successive entrant increases. But here, I assume that the fixed costs of all firms are affected symmetrically.

This assumption suits the modern production technology which is characterized by a large number of production processes having considerable amount of fixed costs. Market congestion affects these processes asymmetrically with a bias towards skill intensive processes especially towards R&D and promotional activities such as advertisements. A nice example would be the adoption of green technology (low fuel consumption) adopted by the automobile industries of the European countries or the miniaturization of the electronic equipments as done by Japanese firms to capture a share of the world market in the respective fields.

The production function of good *z* for the representative firm 'i', assumes the form:

$$B l_{ui}^{\beta} l_{si}^{1-\beta} \quad \text{where } \beta \in (0, 1).$$

I assume that the skill intensity of the *z* good is greater than that of good *f*. This assumption is incorporated by taking $\alpha > \beta$.

3.3 The Solution

In this section, I derive the equilibrium of the representative economy and from it, deduce the autarkic equilibrium of the two countries.

3.3.1 Commodity market

The demand function generated by the utility structure is of the form (Helpman and Krugman (1987)):

$$x(i) = \frac{p(i)^{-\sigma} M}{\int_0^n p(j)^{1-\sigma} dj} \qquad \dots (3.1)$$

Here $M(\equiv w_u L_u + w_s L_s)$ is the total income of the economy, $p(i)$ is the price of the i^{th} differentiated good and $\sigma \equiv 1/(1-\rho)$ is the elasticity of substitution between any two varieties. The endowments of skilled and unskilled labor are taken to be L_s and L_u respectively with w_s and w_u as the respective factor payments.

Since the firms are monopolistically competitive, each firm which acts as a monopolist in its differentiated goods market and equates its marginal revenue to its marginal cost. For any firm 'i', this yields the relation:

$$p(i)\left(1-\frac{1}{\sigma}\right)=\frac{w_u^{\theta}w_s^{1-\theta}}{T\theta^{\theta}(1-\theta)^{1-\theta}}$$

where the LHS of the above equation is the marginal revenue and the RHS is the marginal cost of the firm. Noting $\sigma \equiv 1/(1-\rho)$, the above equation implies:

$$\rho p(i)=\frac{w_u^{\theta}w_s^{1-\theta}}{T\theta^{\theta}(1-\theta)^{1-\theta}}$$

Since labor (of both types skilled and unskilled) is perfectly mobile between the firms, the prices of *x* good is equalized across firms i.e.:

$$p(i)=p=\frac{w_u^{\theta}w_s^{1-\theta}}{\rho T\theta^{\theta}(1-\theta)^{1-\theta}} \quad \dots (3.2)$$

From the demand (equation (3.1)), thus, equal prices imply equal demand for all the varieties. Since the industry is characterized by free entry and exit, the profits over and above the variable cost of the firms (the LHS of the following equation), gets equated to the fixed costs (the RHS of the following equation), ensuring the relation:

$$(1-\rho)px=\frac{Fw_u^{\alpha}w_s^{1-\alpha}}{A\alpha^{\alpha}(1-\alpha)^{1-\alpha}}+\frac{Z(n)w_u^{\beta}w_s^{1-\beta}}{B\beta^{\beta}(1-\beta)^{1-\beta}}$$

This relation due to the firms' profit maximization condition (equation (3.2)), can be rewritten as:

$$\frac{1-\rho}{\rho}\frac{xw_u^{\theta}w_s^{1-\theta}}{T\theta^{\theta}(1-\theta)^{1-\theta}}=\frac{Fw_u^{\alpha}w_s^{1-\alpha}}{A\alpha^{\alpha}(1-\alpha)^{1-\alpha}}+\frac{Z(n)w_u^{\beta}w_s^{1-\beta}}{B\beta^{\beta}(1-\beta)^{1-\beta}} \quad \dots (3.3)$$

3.3.2 Factor market

I assume that factor markets are perfectly competitive. The factors of production are supplied inelastically and there is full employment of the factors. The overall factor demands are equated to the factor supplies. The unskilled labor market clearing condition yields:

$$\frac{\theta}{w_u}\frac{nxw_u^{\theta}w_s^{1-\theta}}{T\theta^{\theta}(1-\theta)^{1-\theta}}+\frac{\alpha}{w_u}\frac{nFw_u^{\alpha}w_s^{1-\alpha}}{A\alpha^{\alpha}(1-\alpha)^{1-\alpha}}+\frac{\beta}{w_u}\frac{nZ(n)w_u^{\beta}w_s^{1-\beta}}{B\beta^{\beta}(1-\beta)^{1-\beta}}= L_u \quad \dots (3.4)$$

The skilled labor market clearing condition can be written as:

$$\frac{1-\theta}{w_s}\frac{nx\, w_u^{\theta} w_s^{1-\theta}}{T\theta^{\theta}(1-\theta)^{1-\theta}} + \frac{1-\alpha}{w_s}\frac{nF\, w_u^{\alpha} w_s^{1-\alpha}}{A\alpha^{\alpha}(1-\alpha)^{1-\alpha}} + \frac{1-\beta}{w_s}\frac{nZ(n) w_u^{\beta} w_s^{1-\beta}}{B\beta^{\beta}(1-\beta)^{1-\beta}} = L_s \quad \ldots (3.5)$$

Equation (3.3) can be substituted in equations (3.4) and (3.5) to eliminate *x*, resulting in:

$$\left(\frac{\rho\theta}{1-\rho} + \alpha\right)\frac{nF\, w_u^{\alpha} w_s^{1-\alpha}}{A\alpha^{\alpha}(1-\alpha)^{1-\alpha}} + \left(\frac{\rho\theta}{1-\rho} + \beta\right)\frac{nZ(n) w_u^{\beta} w_s^{1-\beta}}{B\beta^{\beta}(1-\beta)^{1-\beta}} = w_u L_u \quad \ldots (3.6)$$

$$\left(\frac{\rho(1-\theta)}{1-\rho} + 1 - \alpha\right)\frac{nF\, w_u^{\alpha} w_s^{1-\alpha}}{A\alpha^{\alpha}(1-\alpha)^{1-\alpha}} + \left(\frac{\rho(1-\theta)}{1-\rho} + 1 - \beta\right)\frac{nZ(n) w_u^{\beta} w_s^{1-\beta}}{B\beta^{\beta}(1-\beta)^{1-\beta}} = w_s L_s \quad \ldots (3.7)$$

3.3.3 The general equilibrium

To facilitate manipulations, I define some constants:

$$K_1 \equiv \left(\frac{\rho\theta}{1-\rho} + \alpha\right)\frac{F}{A\alpha^{\alpha}(1-\alpha)^{1-\alpha}}, \; K_2 \equiv \left(\frac{\rho\theta}{1-\rho} + \beta\right)\frac{1}{B\beta^{\beta}(1-\beta)^{1-\beta}}$$

$$K_3 \equiv \left(\frac{\rho(1-\theta)}{1-\rho} + 1 - \alpha\right)\frac{F}{A\alpha^{\alpha}(1-\alpha)^{1-\alpha}}, \; K_4 \equiv \left(\frac{\rho(1-\theta)}{1-\rho} + 1 - \beta\right)\frac{1}{B\beta^{\beta}(1-\beta)^{1-\beta}}$$

Note the earlier assumption that $\alpha > \beta$ ensures $K_1 K_4 > K_2 K_3$.

The above definitions together with ω ($\equiv w_s/w_u$) the skilled to unskilled relative wage can be used to restructure equations (3.6) and (3.7) as:

$$nK_1\omega^{1-\alpha} + nK_2 Z(n)\omega^{1-\beta} = L_u \quad \ldots (3.6`)$$

$$nK_3\omega^{-\alpha} + nK_4 Z(n)\omega^{-\beta} = L_s \quad \ldots (3.7`)$$

The LHS of equation (3.6`) is increasing in *n* and *ω*. As *n* tends to zero, the value of *ω* that satisfies the equation, tends to infinity. Likewise as *n* tends to infinity, the value of *ω* that satisfies the equation, tends to zero. Thus, given the unskilled labor endowment, the locus of *n* and *ω* that satisfies equation (3.6`) can be plotted in the *n* – *ω* plane as a strictly negatively sloped line asymptotic to both the *n* – *ω* axes. In the case of equation (3.7`), the LHS is increasing in *n* but decreasing in *ω* and as *n* tends to zero, the value of *ω* that satisfies this equation, tends to zero. Given the skilled labor endowment, thus, the locus of *n* and *ω* that satisfies equation (3.7`) is a strictly positively sloped line emanating from the origin (though it is not defined at the origin itself) in the *n* – *ω* plane.

The results depicted above are illustrated in figure – 1. The above argument implies that there exists a unique strictly positive value of the number of varieties (n) and the skilled to unskilled relative wage (ω) that satisfies the above two equations. These values can be substituted in equations (3.2) and (3.3) (along with a numéraire) to obtain the commodity price (in terms of the numéraire) and the per – firm output of the economy. Thus the representative economy is characterized by a unique equilibrium.

3.3.4 The countries at autarky

Since the representative economy has a unique equilibrium, by the same reasoning, the countries at autarky have unique equilibrium values of the skill – unskilled relative wage and the variety of good *x*. These values can be obtained for the two countries by substituting the respective endowments in equations (3.6`) and (3.7`).

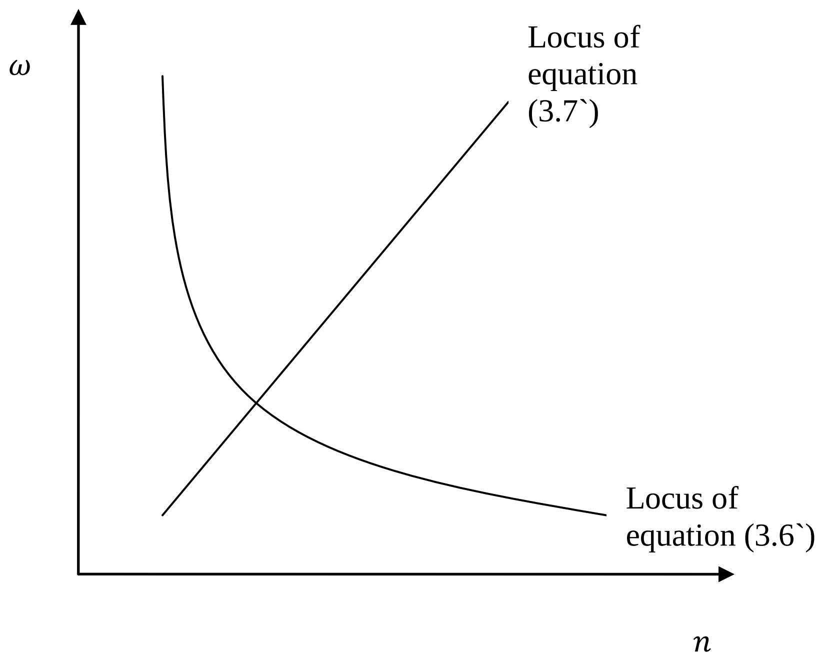


Figure – 1: Existence and uniqueness of Equilibrium

3.4 Trade and its impact

In this section the countries are opened to trade in the variety differentiated good *x*. I assume that both the factors of production are immobile across the countries. Trade, on one hand, increases the number of varieties available to the consumers of any country, on the other hand, it increases the per – firm requirement of good *z* (which by assumption depends on the total number of firms operating in the market). The effect of trade on the endogenous variables of the countries is discussed in the following sections. For the sake of clarity, I denote the country specific variables with '*h*' and '*f*' superscript for home and foreign respectively.

<u>3.4.1 General equilibrium at trade</u>

When the two countries are opened to trade, the relations depicted through equations (3.1) to (3.7) for the respective countries remain unchanged. Now the utility function of an individual '*i*' (of any country) assumes the form:

$$U^i = \left(\int_0^{n^h} x^i(j)^\rho\, dj + \int_0^{n^f} x^i(j)^\rho\, dj\right)^{1/\rho}$$

implying the demand for the output of any firm '*i*' (of the superscripted country) to be:

$$x(i)^{h/f} = \frac{p(i)^{h/f^{-\sigma}}(M^h + M^f)}{\int_0^{n^h} p(j)^{h^{1-\sigma}} dj + \int_0^{n^h} p(j)^{h^{1-\sigma}} dj}$$

An additional trade balance condition closes the model. This condition is given by:

$$\frac{n^h p^{h^{1-\sigma}}\left(w_u^f L_u^f + w_s^f L_s^f\right)}{n^h p^{h^{1-\sigma}} + n^f p^{f^{1-\sigma}}} = \frac{n^f p^{f^{1-\sigma}}\left(w_u^h L_u^h + w_s^h L_s^h\right)}{n^h p^{h^{1-\sigma}} + n^f p^{f^{1-\sigma}}}$$

The RHS of the above relation is the value of home imports while the LHS is the value of home exports. From the relation between price and average costs (equation (3.2) for the respective countries), the above equation rewritten in terms of the unskilled wages and the relative skilled – unskilled wage ratios turns out to be:

$$\frac{n^h}{n^f}\left(\frac{\omega^h}{\omega^f}\right)^{(1-\theta)(1-\sigma)} = \left(\frac{w_u^h}{w_u^f}\right)^{\sigma} \frac{L_u^h + \omega^h L_s^h}{L_u^f + \omega^f L_s^f} \quad \dots (3.8)$$

At trade, the home and foreign factor market clearing conditions are given by:

$$n^h K_1 \omega^{h^{1-\alpha}} + n^h K_2 Z(n^h + n^f)\omega^{h^{1-\beta}} = L_u^h \quad \dots (3.9)$$

$$n^h K_3 \omega^{h^{-\alpha}} + n^h K_4 Z(n^h + n^f)\omega^{h^{-\beta}} = L_s^h \quad \dots (3.10)$$

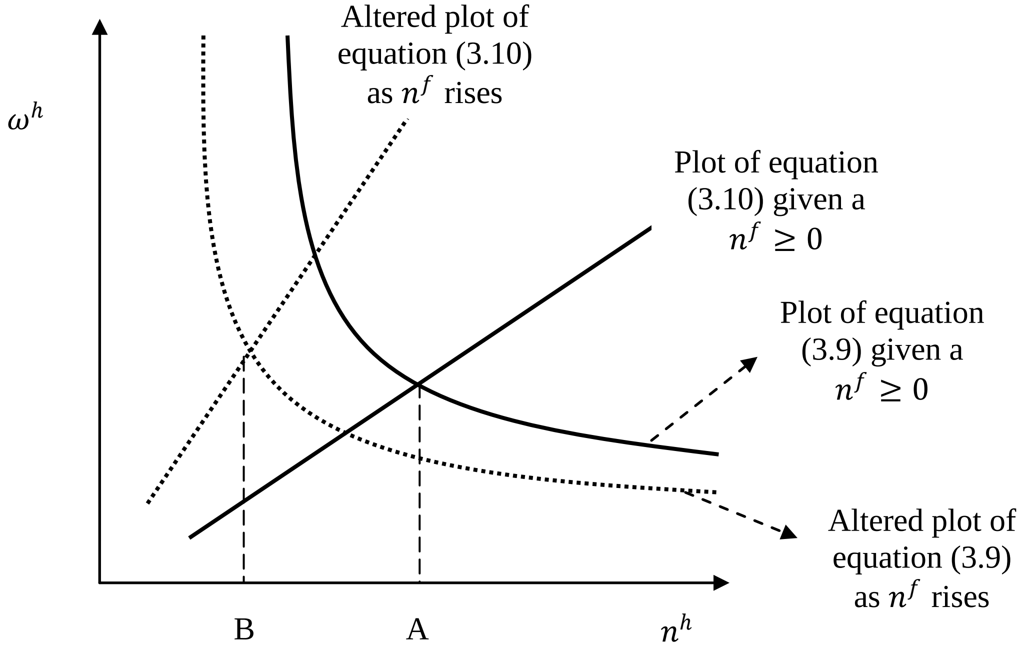
$$n^f K_1 \omega^{f^{1-\alpha}} + n^f K_2 Z(n^h + n^f)\omega^{f^{1-\beta}} = L_u^f \quad \dots (3.11)$$

$$n^f K_3 \omega^{f^{-\alpha}} + n^f K_4 Z(n^h + n^f)\omega^{f^{-\beta}} = L_s^f \qquad \dots (3.12)$$

Take note of the coupled equations (3.9) and (3.10) and compare it with equations (3.6`) and (3.7`) respectively. They are similar, but with n^f now entering as a shift parameter in the Z(.) function of equations (3.9) and (3.10). Thus for any given non negative n^f, equation (3.9) can be plotted as a negatively sloped curve in the $n^h - \omega^h$ plane. The properties of this curve are same as that of the curve of equation (3.6`) (in the $n$ – $\omega$ plane). Similarly for any given non negative $n^f$, equation (3.10) can be plotted as a positively sloped curve in the $n^h - \omega^h$ plane with same properties as of the curve of equation (3.7`) in the respective plane. For any fixed ω^h, with a rise in n^f, n^h must fall to maintain the equality of equation (3.9) and similarly, for any fixed ω^h, a rise in n^f dictates a fall in n^h to maintain the equality of equation (3.10). Thus with an exogenous increase in n^f, the loci of equations (3.9) and (3.10) shift to the left as depicted in figure – 2, implying that the n^h (corresponding to the intersection point of the curves) required to clear the skilled and unskilled labor markets in home falls as n^f increases. From equations (3.9) and (3.10), thus, n^h can be obtained as a strictly positive, continuous (due to continuity of the Z(.) function in its argument) and strictly decreasing function of n^f whose upper bound is its autarchic value (when $n^f = 0$).

Similarly from equations (3.11) and (3.12), n^f can be obtained as a strictly positive, continuous, and strictly decreasing function of n^h whose upper bound is its autarchic value (when $n^h = 0$). These two negatively sloped functions in the n^h– n^f plane, must have at least one intersection point (figure – 3). This shows that equations (3.9) through (3.12) can be solved for strictly positive values of n^h, ω^h, n^f and ω^f though the values need not be unique. These values can be incorporated in equation (3.8) to get the inter country relative unskilled wage rate: w_u^h / w_u^f. Thus from equations (3.8) to (3.12), the endogenous variables of the trading countries can be obtained. The reader is asked to note that the locus of equations (3.9) and (3.10) and that of equations (3.11) and (3.12) in the n^h– n^f plane as inscribed in figure – 3, are strictly negatively sloped with the autarkic values as their upper bounds. Thus the following proposition is immediate:

Proposition 1: *Under trade, the number of varieties produced by a country is less than that of its autarkic value.*



n^h falls from A to B with a rise in n^f

Figure – 2: Effect of n^f on n^h

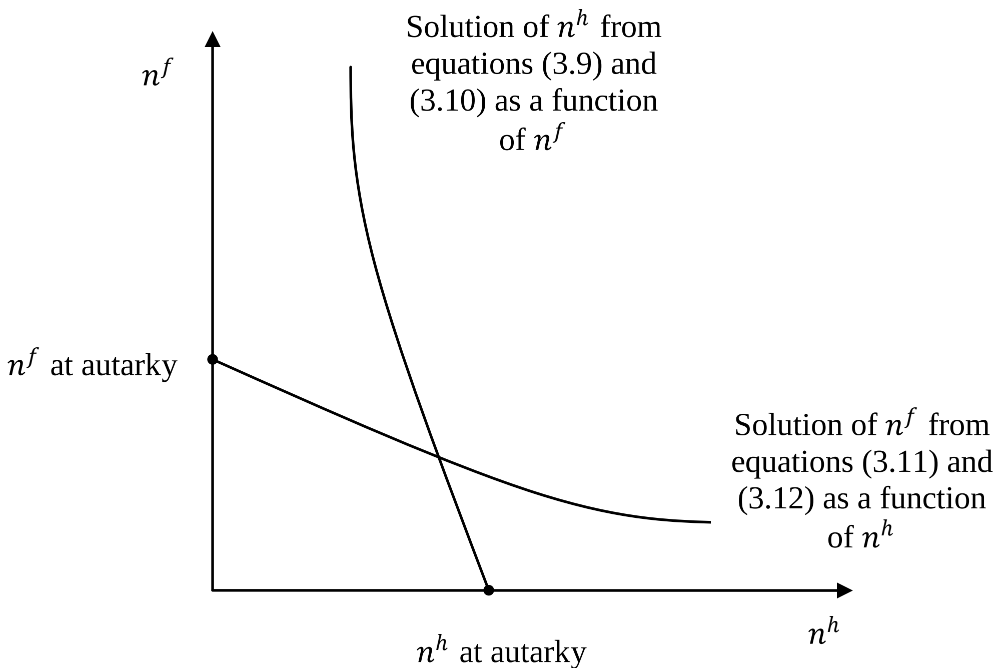


Figure – 3: Equilibrium at trade

3.4.2 The widening wage gap

The previous sections reveal that trade can possibly affect an economy through a change in the fixed costs requirements. In the proposition that follows, this effect of trade on the countries' relative wages is discussed.

Proposition 2: *Trade unambiguously raises the relative skilled to unskilled wage ratio for both countries irrespective of their endowments.*

Proof: I prove the above statement through contradiction. For the sake of exposition, I now add two additional superscripts 'a' and 't' to the endogenous variables, to distinguish between the equilibrium values of these variables assumed at autarky and trade respectively.

If the above statement is false, then there exists (at least) one country whose skilled to unskilled wage ratio does not rise following trade. Without loss of generality, let the home country does not experience any raise in the skilled to unskilled wage ratio. This implies that $\omega^{ht} \leq \omega^{ha}$. Dividing equation (3.6`) by equation (3.7`) and substituting the home endowments and the autarkic equilibrium values of the endogenous variables for the home country, we obtain:

$$\frac{K_1 {\omega^{ha}}^{1-\alpha} + K_2 Z(n^{ha}) {\omega^{ha}}^{1-\beta}}{K_3 {\omega^{ha}}^{-\alpha} + K_4 Z(n^{ha}) {\omega^{ha}}^{-\beta}} = \frac{L_u^h}{L_s^h} \qquad \ldots (3.13)$$

At trade, this equality gets altered to:

$$\frac{K_1 {\omega^{ht}}^{1-\alpha} + K_2 Z(n^{ht}+n^{ft}) {\omega^{ht}}^{1-\beta}}{K_3 {\omega^{ht}}^{-\alpha} + K_4 Z(n^{ht}+n^{ft}) {\omega^{ht}}^{-\beta}} = \frac{L_u^h}{L_s^h} \qquad \ldots (3.14)$$

This equality is obtained by dividing equation (3.9) with equation (3.10) and substituting the equilibrium values of the endogenous variables of the countries, prevailing at trade.

Now consider the functional form given by:

$$\frac{K_1 \omega^{1-\alpha} + K_2 Z(.) \omega^{1-\beta}}{K_3 \omega^{-\alpha} + K_4 Z(.) \omega^{-\beta}}$$

This function is evidently increasing in ω. That it is decreasing in $Z(.)$ by the virtue of $K_1 K_4 > K_2 K_3$ (which follows from the intensity assumption $\alpha > \beta$) can be seen from the fact that:

$$\frac{\partial \left(\frac{K_1 \omega^{1-\alpha} + K_2 Z(.) \omega^{1-\beta}}{K_3 \omega^{-\alpha} + K_4 Z(.) \omega^{-\beta}} \right)}{\partial Z(.)} = \frac{(K_2 K_3 - K_1 K_4) \omega^{1-\alpha-\beta}}{\left(K_3 \omega^{-\alpha} + K_4 Z(.) \omega^{-\beta}\right)^2}$$

Thus for equations (3.13) and (3.14) to hold simultaneously, $\omega^{ht} < \omega^{ha}$ implies $Z(n^{ht} + n^{ft}) < Z(n^{ha})$ and $\omega^{ht} = \omega^{ha}$ implies $Z(n^{ht} + n^{ft}) = Z(n^{ha})$. Now, from the previous section we know that n^{ha}, n^{ht} and n^{ft} are all strictly positive and $n^{ha} > n^{ht}$(see proposition 1). This leads to the inequality:

$$n^{ha}K_1{\omega^{ha}}^{1-\alpha} + n^{ha}K_2Z(n^{ha}){\omega^{ha}}^{1-\beta} > n^{ht}K_1{\omega^{ht}}^{1-\alpha} + n^{ht}K_2Z(n^{ht} + n^{ft}){\omega^{ht}}^{1-\beta}$$

The above strict inequality implies that the following equalities, representing the unskilled labor market clearing conditions for the home country at autarky and at trade, cannot be satisfied together:

$$n^{ha}K_1{\omega^{ha}}^{1-\alpha} + n^{ha}K_2Z(n^{ha}){\omega^{ha}}^{1-\beta} = L_u^h$$

$$n^{ht}K_1{\omega^{ht}}^{1-\alpha} + n^{ht}K_2Z(n^{ht} + n^{ft}){\omega^{ht}}^{1-\beta} = L_u^h$$

The first equality is obtained from equation (3.6`) by substituting the home endowments and the autarkic equilibrium values of the endogenous variables for the home country. The later equality is equation (3.10) substituted with the equilibrium values of the endogenous variables of the countries at trade. The above argument yields a contradiction which shows that, with trade, a stationary or falling skilled to unskilled wage ratio is unviable for any country thus proving the proposition[3].

The above argument also yields the fact that compared to autarky, the per firm requirement of the *z* good (i.e. *Z*(.)) rises post trade. This is evident from noting that the functional form of the LHS of equations (3.13) and (3.14) is increasing in ω and decreasing in *Z*(.) and then observing that $\omega^{ht} > \omega^{ha}$. This leads naturally to the following:

Corollary to proposition 2: *At trade, the number of varieties produced globally is greater than that produced by either country at autarky* (*i.e.*$(n^{ht} + n^{ft}) > n^{ha}, n^{fa}$). *Consequently, trade leads to a rise in market congestion by increasing the per – firm requirement of good z.*

Summing up the implicit mechanisms of the model, we observe that, consequent to trade, the number of varieties of each country falls. This is clearly revealed form figure – 3 and from the discussion in section 3.4.1. But even if the number of varieties produced in the respective countries falls relative to their autarkic levels, the global number of varieties still exceeds each country's individual autarkic variety. This leads to a rise in the demand for good *z* which being skill intensive compared to good *f* raises the relative skill demand in both the countries and thus unambiguously raises the equilibrium relative skill rewards.

In this model congestion effect is incorporated only in the fixed costs of production of the final good. One may be interested in knowing the impact of trade on wage inequality when market

[3] In case of multiple equilibria, all the solutions are characterized by higher skilled to unskilled wage ratios compared to autarky.

congestion affects the variable cost component of manufacturing of the final consumable. This can be deduced from this model by assuming θ (which determines the relative skilled to unskilled labor demand for the manufacture of good x) to be negatively related to the number of firms operating in the market. Even in such circumstances all of the analyses done so far will continue to hold and especially proposition 2. This follows from the fact that, the LHS of equation (3.13) will continue to be negatively related to the number of firms operating in the market and the logical implications used in the proof of proposition 2 will remain unaltered. This exposition suggests that market congestion, whether it affects the fixed or variable component of the cost of manufacture of the final good, affects the factor prices towards an increase in the skilled to unskilled wage inequality.

3.5 Conclusion

To justify rising wage inequality amongst nations, this chapter tries to focus on the changes in the skill intensity of production brought about by trade. This model is novel in the sense that the result of this model is immune to specifications made regarding the factor endowments of the trading countries. The reasoning of the model is not limited to the sphere of product differentiation. The CES utility function used in this model merely ensures positive demands for each firm operating in the market and as such the argument, along with suitable modifications, can also be extended to other models of trade. It is true that the issue of growing income inequality has to be more complex that this model might suggest and surely involves more factors than one, yet then this analysis proposes a pretty reasonable channel through which trade can cause wage inequality to rise in both the trading countries.

Chapter 4

Globalization and factor market integration:

an explanation for widening skilled – unskilled wage differential

4.1 Introduction

This chapter explores the avenue of factor market integration to explain the rise in wage inequality. Here, I specifically assume that at trade, in addition to free exchange of produced commodities, the firms utilizing the skilled laborers are free to move across the trading countries. With these assumptions, I show that with heterogeneous skilled laborers (with heterogeneity captured by a quality attribute), and with the production technology employing these skilled laborers exhibiting super modularity or O – ring type of production complementarities (Kremer (1993)), a factor market integration raises the productivity of the skilled workforce. This in a two commodity setup, lowers the relative price of the relatively skill intensive commodity. In the presence of an elasticity of substitution of preferences greater than unity, the fall in relative price of the relatively skill intensive commodity translates to a rise in the relative demand of the skilled labor thus leading to a rise in the relative skilled – unskilled wage ratio. I have also shown that this result is robust to the extent that it remains unaltered in both the cases of perfect and imperfect matching of the skilled laborers (with respect to their quality attribute). The type of production technology resorted to here, is suited for most type of modern day production processes such as R&D activities, assembly lines etc, where the production chain consists of a vertically integrated multitude of tasks where the 'inefficiency' of any one particular step bottlenecks the whole production process. Kremer and Maskin (1996) have shown that when the production technology exhibits imperfect substitution in skill levels, in a production process involving a series of complementary tasks which are differentially sensitive to the skill levels, a change in the distribution of skill leads to a systematic widening of the skilled to unskilled wage premiums as well as an increase in segregation of the workers based on their skill levels. Similar contributions were made by Antràs, Garicano, and Rossi-Hansberg (2006). This work adds on to these contributions by relating factor market integration to the widening of the skilled to unskilled wage premiums neither resorting to any differences in the distribution pattern of skill nor the type of skill matching (the above papers assumed perfect matching of skill i.e. where skill types are common knowledge). Thus this chapter provides an explanation for rising wage inequality for amongst the OECD countries which extensively trade amongst themselves and whose endowments and distributions of skills are not significantly different[4]. In fact this work throws up a plausible cause of intra industry trade in intermediates among 'similar' countries having non – significant differences in factor endowments. Also by introducing two commodities, this chapter focuses how complementarities in production in one sector widens the inter – sectoral wage gap even when the other sector does not exhibit production complementarities. It is also shown how the increasing segregation of the workers based on their skill levels may be explained by this model under such circumstances.

In sections 4.2 and 4.3, I respectively set up and solve for the endogenous variables of a two good two factor model which incorporates production complementarities in one of its industry along with a heterogeneous skilled labor force. These sections deals with imperfect matching of the skilled labor force and shows how the industry (which is subject to the technological complementarity) as well as the whole economy, responds to changes in factor endowments. Section 4.4 establishes a link between trade liberalization and factor market integration with factor efficiency and explores the effect on wage inequality. Section 4.5 extends the model to the realm of perfect matching and reasserts the validity of the conclusions drawn in the previous sections. Section 4.6 concludes.

[4] In fact this has been a major critique of trade induced wage inequality thus heralding technological progress as the chief contributor of a rising wage inequality.

4.2 The Model

I assume that there are two economies – Home and Foreign which are completely symmetric structurally. I present the equations defining a representative economy's tastes and technology, simply noting that the same equations apply to both Home and Foreign.

4.2.1 Preferences

The representative consumer in the economy is assumed to consume two goods – X and Y. The preference structures of the individuals are identical and the utility function representing the same is given by:

$$U = X^{\frac{\sigma-1}{\sigma}} + Y^{\frac{\sigma-1}{\sigma}}, \sigma \in (1, \infty)$$

4.2.2 Production

There are two factors of production in the economy – skilled and unskilled labor. Unskilled labor is used in the production of good X where one unit of the good is produced by one unit of unskilled labor. The total unskilled labor endowment of the economy is $\bar{L}_u$. The production of good Y involves the completion of 'n' jobs or tasks which have to be conducted simultaneously. Each of the jobs requires exactly one skilled laborer. Skilled laborers have different quality types and it is assumed that they come in two qualities – a good type: θ^g and a bad type: θ^b with $\theta^g > \theta^b$. An assignment of 'n' skilled workers to the 'n' jobs is defined as a production lineup and the output of good Y from such a lineup is given by:

$$y = \text{Minimum}\{l_i\}\ \text{Minimum}\{q_i\}, i = 1\ to\ n$$

Here 'i' indexes the task and hence, l_i is the amount of labor hours devoted to the 'i'th task by the laborer assigned to that task and q_i is her quality. The above production function can be interpreted in a way such that the output produced by a lineup depends on the minimum amount of labor hours devoted to the 'n' jobs (since they have to be conducted simultaneously) as well as the productivity of the workers (here captured by q_i) which can be interpreted as the per – hour processing speed of the workers. Since the overall output is constrained by the worker having the lowest processing speed the production function assumes the above mentioned functional form. Firms can employ multiples of such above mentioned production lineup as well as adjust the amounts of skilled labor hours devoted to each lineup. For example, if there are three skilled laborers in the economy numbered – 1, 2 and 3, and if n = 2 and each laborer is endowed with 2 hours of labor, then a firm can employ person 1 and 2 for 1 hour and person 1 and 3 for another one hour. In this case the firm is using two production lineups as there are two assignments of skilled workers to the two jobs.

I assume that each skilled laborer has identical amounts of labor hours that they inelastically supply to the firms. Without loss of generality, each individual's labor endowment has been normalized to unity. The laborers only differ with respect to the quality of labor. Furthermore there are 'p' numbers of high quality skilled workers and 'q' numbers of low quality skilled workers implying that the total skilled labor endowment of the economy: $\bar{L}_s$ is p+q labor hours. I also assume that $n < p, q$.

The firms cannot distinguish between the skilled worker types and takes the laborers as homogenous entities and pays a homogenous wage rate accordingly. The skilled laborers that a firm obtains for its production are randomly selected from the skilled labor pool such that each laborer has equal probability of being selected in any particular job. Hence the quality of workers obtained by the firms is random. The firms form rational expectations about the workers' quality ex – ante and are assumed to be risk neutral. The firms in both the industries are assumed to be perfectly competitive and so are the factor markets.

4.3 The solution

Having described the representative economy, I now move on to find the analytical values of the endogenous variables in terms of the exogenous parameters.

4.3.1 Commodity and factor markets

Since perfect competition prevails in the market of good X and Y, the firms producing these goods reap zero profits. Thus the following relation can be deduced:

$$p_X x = p_X l_u = w_u l_u$$

or,

$$w_u = p_X \qquad \dots (4.1)$$

Here w_u is the wages paid to the unskilled laborers and p_X is the market price of good X.

The unskilled labor market clearing condition yields the total output of good X to be:

$$X = \bar{L}_u \qquad \dots (4.2)$$

Similarly for good Y, the total revenue obtained by the firms when equated to the total costs (to ensure zero profits of the firms) yields:

$$p_Y y = p_Y \frac{E(\theta)}{n} l_s = w_s l_s$$

or,

$$w_s = p_Y \frac{E(\theta)}{n} \qquad \ldots (4.3)$$

Here w_s is the skilled wage rate, p_Y is the market price of good Y and, $E(\theta)$ is the firms' expectation (which is rational) about the average quality of the skilled laborers. The particular form of $E(\theta)$ is detailed later in the following subsection. The skilled labor market clearing condition gives the total production of good Y as:

$$Y = \frac{\bar{L}_s E(\theta)}{n} \qquad \ldots (4.4)$$

4.3.2 The general equilibrium

The relative demand of the goods (as a function of the prices) when equated to the relative supplies yields:

$$\frac{Y}{X} = \left(\frac{p_Y}{p_X}\right)^{-\sigma} \qquad \ldots (4.5)$$

Substituting the values of p_x and p_Y from equations (4.1) and (4.3) in the above equation and rearranging terms yields:

$$\frac{w_s}{w_u} = \left(\frac{\bar{L}_u}{\bar{L}_s}\right)^{\frac{1}{\sigma}} \left(\frac{E(\theta)}{n}\right)^{1-\frac{1}{\sigma}} \qquad \ldots (4.6)$$

For the firms producing good Y, the expectation about the average quality of the skilled laborers (i.e. $E(\theta)$) has the form:

$$E(\theta) = \theta^g \lambda + \theta^b (1 - \lambda)$$

with $\lambda = \frac{{}^{p}C_n}{{}^{p+q}C_n}$ where 'C' is the combination operator defined as: ${}^{x}C_y \equiv \frac{x!}{(x-y)!y!}$

Thus λ gives the probability of obtaining 'all high quality' skilled workers whereas $(1 - \lambda)$ gives the probability of 'at least one low quality' skilled worker (in which case the productivity is determined by the low quality type/s who bottlenecks the process). Note that the value of 'λ' increases as the skilled labor population is replicated. Since

$$\lambda = \frac{p(p-1)(p-2)\ldots(p-n+1)}{(p+q)(p+q-1)(p+q-2)\ldots(p+q-n+1)}$$

a replication of the population where p and q are replaced by *tp* and *tq* respectively (with 't' being a positive number greater than one such that *tp* and *tq* remain integers), changes 'λ' to:

$$\frac{tp\,(tp-1)(tp-2)\ldots(tp-n+1)}{t(p+q)(tp+tq-1)(tp+tq-2)\ldots(tp+tq-n+1)}$$

Now

$$\frac{tp-i}{(tp+tq-i)} > \frac{p-i}{(p+q-i)}\, \forall i \in 1 \text{ to } n-1$$

holds (which can be readily found by cross multiplication of the terms) showing the fact that with a replication of the population of the skilled workers, the value of 'λ' and hence $E(\theta)$ rises. This yields the result:

Proposition 1: *If the skilled labor population is replicated, the average productivity of the skilled laborers increases. This also reflects the fact of a growing segregation of the skilled laborers based on their quality.*

And thus from equation (4.6) we may conclude that:

Proposition 2: *If both the skilled and unskilled population is replicated, the skilled to unskilled wage ratio increases.*

When the skilled workers are randomly selected, a replication of the population raises the homogeneity of the workforce for any particular production lineup. This result stems from the fact that as the population is replicated, the value of obtaining 'all high type' skilled workers (i.e. λ) increases to the asymptotic value of: $(p/p+q)^n$ as $(p-i)\sim p$ and $(p+q-i)\sim(p+q)$ $\forall i \in$ 1 to $n-1$ as $\{p,q\} \to \infty$.

4.4 Effects of globalization on wage inequality

In this section I examine the effects of globalization on the endogenous variables of two countries – Home and Foreign. The countries differ only with respect to the amounts of skilled and unskilled labor endowments. Even the distribution of skilled laborers amongst the two quality types, is identical across the countries i.e. the ratio: *p/q* is same for both the countries. To capture the spirit of globalization, I define trade between the countries as unrestricted movement of the two goods – X and Y as well as the ability of the firms producing good Y to locate their plants (i.e. any part of the required amount of tasks) anywhere in the two countries. With these assumptions we can see readily that at trade, the prices of the goods as well as the wages to unskilled labor will be equalized across the nations. Along with these, the expectations about the skilled workers' ability and the skilled wage rate will also get equalized across the firms' of the two countries. Equalization of skilled wage rates follows from the ability of the firms producing good Y to locate their plants anywhere in the two countries. That the expectations about the skilled workers' ability will become equal for the firms (producing good Y) of the countries follows from proposition 1. This proposition establishes the fact that the expected skilled labor quality increases with the size of the skilled labor pool implying that the firms belonging to the Y industry of either country will always find it profitable (by a raise in $E(\theta)$) to locate their plants in the both the countries. Since the Y industry firms of both the trading nations find it necessary to draw from the skilled labor force of both the countries, an important conclusion that can be drawn here is that, trade between the countries will always persist irrespective of the autarkic price levels of the two goods (c.f. a HOS model of trade where the relative factor endowments and hence the autarkic relative prices of two countries are the same). Since at trade, the firms fill up their production processes with laborers from both the trading economies, immobility of skilled labor implies movement of partially produced intermediates across the manufacturing plants of a firm located in the two countries. Thus this work provides us a cause of intra industry trade in vertically differentiated intermediates amongst countries which are identical with respect to their factor endowments. From the above argument it follows that at trade, the countries behave as an integrated economy having skilled and unskilled labor endowments equal to the sum of the respective endowments of the home and foreign countries. The endogenous variables of the trading economies can be obtained from equations (4.1) to (4.6) by simply substituting the conjoined unskilled and skilled labor endowments of the two countries and accordingly revising the values of the number of good and bad quality skilled workers. Keeping the above facts in mind, I now put forward a proposition that relates trade and wage inequality. This goes as follows:

Proposition 3: *In the case where at autarky both the countries have identical skilled to unskilled relative endowments, trade unambiguously leads to a bilateral increase in the skilled to unskilled wage ratio.*

Proof: To facilitate manipulation, I affix the superscripts 'h', 'f', 'a' and 't' to the endogenous variables, to distinguish these variables for home, foreign, autarky and trade respectively. At autarky the skilled to unskilled wage ratios for the home and foreign countries are respectively given by:

$$\frac{w_s^{ha}}{w_u^{ha}} = \left(\frac{\bar{L}_u^h}{\bar{L}_s^h}\right)^{\frac{1}{\sigma}} \left(\frac{E^{ha}(\theta)}{n}\right)^{1-\frac{1}{\sigma}} \qquad \dots (4.7)$$

$$E^{ha}(\theta) = \theta^g \frac{{}^{p^h}C_n}{{}^{p^h+q^h}C_n} + \theta^b \left(1 - \frac{{}^{p^h}C_n}{{}^{p^h+q^h}C_n}\right) \qquad \dots (4.8)$$

$$\frac{w_s^{fa}}{w_u^{fa}} = \left(\frac{\bar{L}_u^f}{\bar{L}_s^f}\right)^{\frac{1}{\sigma}} \left(\frac{E^{fa}(\theta)}{n}\right)^{1-\frac{1}{\sigma}} \qquad \dots (4.9)$$

$$E^{fa}(\theta) = \theta^g \frac{{}^{p^f}C_n}{{}^{p^f+q^f}C_n} + \theta^b \left(1 - \frac{{}^{p^f}C_n}{{}^{p^f+q^f}C_n}\right) \qquad \dots (4.10)$$

At trade, the same relations get altered to:

$$\frac{w_s^t}{w_u^t} = \left[\frac{\left(\bar{L}_u^h + \bar{L}_u^f\right)}{\left(\bar{L}_u^h + \bar{L}_u^f\right)}\right]^{\frac{1}{\sigma}} \left(\frac{E^t(\theta)}{n}\right)^{1-\frac{1}{\sigma}} \qquad \dots (4.11)$$

$$E^t(\theta) = \theta^g \frac{{}^{p^h+p^f}C_n}{{}^{p^h+q^h+p^f+q^f}C_n} + \theta^b \left(1 - \frac{{}^{p^h+p^f}C_n}{{}^{p^h+q^h+p^f+q^f}C_n}\right) \qquad \dots (4.12)$$

Since $\frac{\bar{L}_u^h}{\bar{L}_s^h} = \frac{\bar{L}_u^f}{\bar{L}_s^f} = \frac{\left(\bar{L}_u^h + \bar{L}_u^f\right)}{\left(\bar{L}_u^h + \bar{L}_u^f\right)}$ by assumption and $E^t(\theta) > E^{ha}(\theta), E^{fa}(\theta)$ (since $\frac{p^h}{q^h} = \frac{p^f}{q^f}$ proposition 1 implies that $E(\theta)$ rises) it follows readily that $\frac{w_s^t}{w_u^t} > \frac{w_s^{ha}}{w_u^{ha}}, \frac{w_s^{fa}}{w_u^{fa}}$.

From continuity of equation (4.11) in its arguments, it can also be inferred that even if the autarkic skilled to unskilled relative endowments of the two countries are not identical, the result can still be guaranteed if the increase in the productivity of the skilled laborers brought about by trade and consequent market integration, is high enough. Similar deductions can be made regarding the distribution of skilled labor quality. Thus:

Corollary: *Given the economic structure of the two countries, one can obtain a δ and an ε such that, if the autarkic skilled to unskilled relative endowments of the two countries do not differ by more than δ and the ratio of the good and bad quality types of the skilled workforce of the two countries do not differ by more than ε then trade unambiguously leads to an increase in the skilled to unskilled wage ratio.*

4.5 An extension to the model

In this section I alter two assumptions of the model set up earlier, to illustrate the applicability of this model under fairly general circumstances. These assumptions relate only to the factor market of the industry manufacturing good *Y*. The structures of all the other markets are kept the same as before. I now assume that there is a continuum of skilled laborers distributed over an interval: $[0, \bar{L}_s)$ with the quality of their labor distributed over a positive region: $[\underline{\theta}, \overline{\theta}]$, following the continuously increasing distribution function – $F\ (\cdot)$[5]. The laborers are so indexed, that they are arranged in increasing quality of labor. Next, adjustments are made to the production technology to comply with the fact that skilled laborers are now defined over a continuum. So I assume that the production lineup is such that there is a continuum of tasks which requires a continuum of skilled laborers. This continuum of tasks has a length which, without loss of generality, is taken to be unity. Thus the production lineup assumes the form:

$$y = \text{Infimum}\{l(i)\}\ \text{Infimum}\{q(i)\}\ , \forall\ i \in I \text{ such that } I \subset [0, \bar{L}_s) \text{ and } \int_I dx = 1$$

Here '*I*' is the set of the index of the skilled laborers employed in the lineup, with $q(i)$ and $l(i)$ representing the quality and labor hours employed respectively of the 'i'[th] indexed skilled laborer.

As before, firms can employ multiple of such above mentioned production lineups as well as adjust the amounts of skilled labor hours devoted to each lineup. For any production lineup, it is assumed that the firms select countable number/s of left – closed interval/s[6] of skilled laborers from the interval: $[0, \bar{L}_s)$. If a single interval is selected, it must be of unit length and in the case of multiple selected intervals (that are disjoint), the sum of the lengths of the intervals must add up to unity. To keep matters simple, I assume that $\bar{L}_s$ is a positive integer greater than unity.

The second assumption that I change concerns the information set of the firms of industry *Y* regarding the skilled labor market. The firms of the industry are now assumed to possess perfect information about the quality of the skilled laborers. All other assumptions regarding the market structure are kept same as before. With these assumptions, it can readily be inferred that instead of a single skilled wage rate, the factor market of good *Y* is now characterized by a continuum of

[5] This function maps quality to proportion i.e. $F(x)$ gives the proportion of laborers whose quality is less than or equal to '*x*'. Also since $F(x)$ is continuously increasing, $F'(x) > 0$.

[6] Since we are using left closed intervals, from now onwards, we use 'minimum' instead of 'infimum' in the production technology.

skilled wage rate that depends on the labor quality. So to address the issue of wage inequality, I now define an average skilled wage index: ω_s that satisfies:

$$\omega_s \equiv \frac{1}{\bar{L}_s}\int_0^{\bar{L}_s} w_s(i)di$$

Also note that because of perfect competition prevailing in the market of good Y, ω_s satisfies:

$$\omega_s \bar{L}_s = p_Y Y \quad \ldots (4.3')$$

I now redefine $E(\theta)$ as the average (rather than expected) productivity of the skilled labor force i.e. $E(\theta) \equiv Y/\bar{L}_s$. Thus for this extension, equations (4.1) and (4.2) continue to hold and these together with equations (4.3′) and (4.5) (the relative demand equation) and the fact that $\bar{L}_s E(\theta) = Y$ yields the relative average skilled wage ratio as:

$$\frac{\omega_s}{w_u} = \left(\frac{\bar{L}_u}{\bar{L}_s}\right)^{\frac{1}{\sigma}} E(\theta)^{1-\frac{1}{\sigma}} \quad \ldots (4.6')$$

This equation is the analogue of equation (4.6) with w_s in equation (4.6) replaced by ω_s and 'n' replaced by 1.

Since entry and exit in the industry for good Y is assumed to be free (because of perfect competition prevailing in the market), the market equilibrium is characterized by a wage schedule such that the firms earn zero profits and do not gain by redistributing skilled labor from the skilled labor population for their production lineups. For this extension I do not specifically derive the skilled wage schedule: $w_s(i)$ but rather characterize an important aspect of the market equilibrium of the industry producing good Y[7].

Proposition 4: *If I(j) represents the collection of left – closed intervals selected by firm 'j' to fill up one of its production lineup such that $\int_{I(j)} dx = 1$, then I(j) must consist of a single interval.*

Proof: Define $I_1(j)$ such that $I_1(j)$ is a left – closed interval belonging to $I(j)$ and Minimum$\{I_1(j)\}$ = Minimum$\{I(j)\}$. Thus $I_1(j)$ is the interval belonging to $I(j)$ consisting of the lowest indexed (and thus the lowest skilled) skilled worker. Similarly for all integer $m \geq 2$, recursively define $I_m(j)$ such that $I_m(j) \in I(j)$ and Minimum$\{I_m(j)\}$ = Minimum$\{I(j) - \bigcup_{t=1}^{m-1} I_t(j)\}$ where the '–' sign signifies deletion and not subtraction. The proposition implies that $I_m(j) = \phi$ for all $m \geq 2$.

[7] It might interest the readers that if $F^{-1}(\cdot)$ where $F^{-1}(y) \equiv \{x \in [\underline{\theta}, \overline{\theta}] \mid F(x) = y\}$ is concave, then the wage schedule given by:
$w_s(i) = p_Y F^{-1}\left(\frac{\text{int}(i)}{\bar{L}_s}\right) \forall\, i \in [0, \bar{L}_s)$ with int(i) as the maximum integer lesser than 'i' is 'an' equilibrium wage schedule. Though such trivial wage schedule cannot be derived for non – concave $F^{-1}(\cdot)$.

Suppose the above proposition is not true. Then it must be that $I_2(j) \neq \phi$. Lets consider the (left closed) interval belonging to $[0, \bar{L}_s)$ lying between $I_1(j)$ and $I_2(j)$ and call it I_0. It must be that for all left closed subintervals $I_1^{'}(j) \subseteq I_1(j)$ and $I_0^{'} \subseteq I_0$ such that Minimum$\{I_1^{'}(j)\} =$ Minimum$\{I_1(j)\}$ and $\int_{I_1^{'}(j)} dx = \int_{I_0^{'}} dx$ it must be that $\int_{I_1^{'}(j)} w_s(x)dx < \int_{I_0^{'}} w_s(x)dx$ otherwise the firm 'j' profits by replacing skilled laborers of $I_1^{'}(j)$ with those of $I_0^{'}$ since then the productivity rises whereas the wage bill either falls or remains unchanged. This also implies that all skilled laborers belonging to I_0 has strictly greater wages than those belonging to $I_1^{'}(j)$ and are employed with some other firms (otherwise their wages would be zero). Next consider any firm 'k' that employs skilled labor from I_0 and $I(j) \cap I(k) = \phi$. The existence of this firm is guaranteed because if firm 'j' operates it production lineup by employing skilled workers from $I(j)$ for 'h' amount of time, then skilled workers from I_0 cannot be employed with those belonging to $I(j)$ for at least 'h' amount of time. But since each skilled laborer is endowed with identical amounts of labor hours and equilibrium equates demand (for labor hours) to supply, the existence of firm 'k' is ascertained. For this firm 'k', two cases can arise: Minimum$\{I_1(k)\} <$ Minimum$\{I_0\}$ and Minimum$\{I_1(k)\} \geq$ Minimum$\{I_0\}$. If Minimum$\{I_1(k)\} <$ Minimum$\{I_0\}$ then the firm 'k' can gain by replacing skilled labor from $I(k) \cap I_0$ with those of $I_1^{'}(j)$ as that replacement lowers the wage bill without affecting the productivity. If Minimum$\{I_1(k)\} \geq$ Minimum$\{I_0\}$ then for all left closed subintervals $I_1^{'}(k) \subseteq I_1(k) \cap I_0$ and $I_2^{'}(j) \subseteq I_2(j)$ such that Minimum$\{I_1^{'}(k)\} =$ Minimum$\{I_1(k)\}$ and $\int_{I_1^{'}(k)} dx = \int_{I_2^{'}(j)} dx$, it must be that $\int_{I_1^{'}(k)} w_s(x)dx < \int_{I_2^{'}(j)} w_s(x)dx$, otherwise firm '$k$' profits by replacing skilled laborers of $I_1^{'}(k)$ with those of $I_2^{'}(j)$ as such a move raises the productivity of the firm while either lowering or keeping its wage bill unchanged. But this in turn shows that firm 'j' can profit by replacing skilled laborers from $I_2^{'}(j)$ with those of $I_1^{'}(k)$ as, in doing so, the firm decreases its wage bill keeping its productivity untouched. Since a competitive market equilibrium is characterized by a wage schedule and an allocation of skilled laborers such that firms don't find it profitable to reallocate skilled labors to their production lineup/s (which raises or lowers the skilled labor demand in turn raising or lowering the skilled wages) the above argument shows that $I_2(j) = \phi$ which in turn implies that $I_m(j) = \phi$ for all $m \geq 2$.

With the above characterization of the market equilibrium, it is clearly evident that any firm fills up any of its production lineup by selecting intervals from: $[0, 1)$, $[1, 2) \ldots [\bar{L}_s - 2, \bar{L}_s - 1)$, $[\bar{L}_s - 1, \bar{L}_s)$. Thus the average productivity of the skilled labor force: $E(\theta)$ is given by:

$$E(\theta) = \frac{1}{\bar{L}_s} \sum_{i=0}^{\bar{L}_s - 1} F^{-1}\left(\frac{i}{\bar{L}_s}\right) \qquad \ldots (4.13)$$

Where $F^{-1}(\cdot)$ is defined as: $F^{-1}(y) \equiv \{x \in [\underline{\theta}, \overline{\theta}] \mid F(x) = y\}$

If it can be shown that $E(\theta)$ rises with $\bar{L}_s$, then propositions 1 through 3 can be guaranteed for this altered model[8]. To show this, consider a positive continuous increasing function G (·) defined over the interval: $[0, 1)$. Let the area formed by the curve with the x – axis (in the interval) be coined as Δ. Let this interval be now divided into 'm' equal parts. Since G (·) is an increasing function, $(1/m) \sum_{i=0}^{m-1} G(i/m)$ represents the area of the equally spaced stepped curve whose upper envelope is the above mentioned function. Let the area formed by the stepped curve with the x – axis (in the interval) be coined as $\underline{\Delta}$. It is evident that $\underline{\Delta}$ is strictly lesser than Δ and approaches Δ as 'm' is increased. By identical reasoning, thus, $E(\theta)$ rises with $\bar{L}_s$. Also since the distribution of skill remains unchanged, the dispersion of skill for any firm (which selects individuals form left – closed intervals of unit length from the continuum of skilled laborers), falls with an increase in the amount of skilled labor i.e.: $\bar{L}_s$. Thus it can be concluded that proposition – 1 holds even for this extension of the model ensuring the validity of all the ensuing propositions. A little reflection, yields the fact that though the corollary does not hold for this extension, it may be alternatively claimed that if the skill distribution and/or the relative endowments of the countries do not differ too much, the rise in skilled labor productivity and the associated rise in relative wages can still be guaranteed for this extended model. The natural question that arises next is whether the dispersion of skilled wages within the *Y* sector rises or falls. If the dispersion measured as the ratio of wages paid to a skilled worker to the lowest paid skilled worker is calculated, it can be shown to be non – decreasing. This follows from two facts namely (i) given the price of good Y, the wages received by the lowest paid skilled worker does not change following an increase in $\bar{L}_s$ (since it is the skill level of the lowest skilled worker that determines the lowest wage payment) whereas (ii) the overall productivity of the sector rises (which in turn raises the wage of some workers because of zero profits). This brings us to:

[8] Note that if two populations following same quality distributions are mixed together, the quality distribution of the mixed population remains unchanged. Also note that at trade, the firms producing good *Y* can freely choose from the skill labor markets of both the countries thus ensuring an integrated equilibrium.

Proposition 5: *If the skilled labor population is replicated, the dispersion in wages amongst the skilled laborers as measured by the ratio of wages paid to a skilled worker to the lowest skilled worker increases is non – decreasing. Also there exists a class of skilled laborers whose wages relative to that of the lowest skilled laborer increases unambiguously. These results remain valid even when instead of a population replication* (*where the skill distribution remains unaltered*)*, two skilled labor populations having a 'not too different' distribution of skill are integrated through trade.*

All the above results deduced so far, save proposition 5, hinges on one crucial assumption of the demand structure exhibiting an elasticity of substitution greater than unity (e.g. it rules out a Cobb – Douglas utility function). Through this substitution effect in demand, it explains a rising wage inequality across sectors that are not linked by production complementarities and links globalization to technological progress in a sense that it uses the rise in skilled labor efficiency brought about by an integrated skilled labor market.

4.6 Conclusion

This discussion proposes a super modular production technology which borrows the spirit of non – substitutability of quantity over quality as in Kremer (1993), Kremer and Maskin (1996). It has been shown that under this production function irrespective of the type of skill matching – random or perfect (in the sense of overall efficiency), a factor market integration brought about by globalization, raises the productivity of the skilled workers. This occurs as such market integration brings about homogenization of the factor market. The prediction of the model regarding wage inequality and rising segregation of workers based on skill levels match stylized facts about the world economy which have empirically been verified and is suited to explain the phenomena of trade induced wage inequality for developed countries that are similar with respect to their factor endowments. The rise in productivity in turn lowers the price of the skill intensive good which coupled with non unitary elasticity of demand translates to a rise in the overall relative demand of skilled labor and hence the relative skilled to unskilled wage ratio rises symmetrically for all the trading countries.

Chapter 5

Skilled – unskilled labor endowments and relative wages: the inverted U relationship and trade induced wage inequality

5.1 Introduction

In economic theory one of the basic tenets is the law of supply and demand: that a lower/higher price of a good relative to some other, reflects its relative abundance/scarcity. Thus resources and commodities that are in short supply relative to their demands are priced higher than those, whose relative supplies are ample. This principle if applied to the countries of the world, tells us that in the absence of trade, countries having a higher endowment of a factor should have a lower factor price in contrast to those having a lower endowment. An empirical analysis of the skilled to unskilled wage ratios of a number of developed, developing and under – developed countries during 1983 to 86 reveals a quite different picture altogether. The analysis is undertaken from this particular period as this time span marks an era of increasing market openness and trade deregulations[9] and also because a few cross country data on wages are available before this date. This analysis reveals that while the skilled to unskilled wage ratio is found to rise with the relative abundance of unskilled labor for the developed countries, the trend seems to get reversed for the developing and the underdeveloped nations. That is, for the developing and especially for

[9] Chiefly due to the policies adopted by Ronald Reagan and Margaret Thatcher coined as the "Reagan-Thatcher Revolution".

the underdeveloped ones, the relative skilled to unskilled wage ratio is found to decline with an increasing unskilled to skilled labor endowment.

Wage data for 162 occupations was collected for 57 countries averaged over four consecutive years starting from the period of 1983[10]. The occupations were divided into four categories according to the skill required for the occupations based on the classification by the International Labour Organization[11] and the average wage of these groups were then evaluated. Next the occupation group requiring lowest level of skill (termed as "elementary occupations" in ISCO-88) was dropped. This was done to ensure uniformity of skill required for the occupations across the developed, developing and under – developed nations. For the remaining three groups, the ratio of the average wages between a relatively high skilled occupation group to a relatively low skilled occupation group was next evaluated (i.e. if there are three occupation groups 1, 2 and 3 with group 3 requiring the most skill and group 1 requiring the least skill, the ratio of the average wages of groups 3 to 2, 3 to 1 and 2 to 1 were evaluated). Finally the average skilled to unskilled wage ratios were obtained by averaging the three relative wages obtained thus, for the countries. To get an idea of the average unskilled to skilled labor endowment of the countries, the reciprocal of the average years of schooling was tabulated[12]. The relationship between the skilled to unskilled wage ratio and the reciprocal of the average years of schooling (which serves as a proxy for unskilled to skilled labor endowment) is shown as a scatter plot in Figure 1a. While consulting the figure please note that both the axes are taken to be of logarithmic scales of base 2. This has been done to fit the scatter plot in a single page while keeping all the points as distinct as possible.

From the scatter plot one cannot unambiguously derive a positive relationship between the skilled to unskilled average wage (the Y axis) and the reciprocal of the average years of schooling – a proxy for the unskilled to skilled relative endowments. Statistically, several linear and non – linear models (exponential, logarithmic and polynomial of various degrees) were fitted to the data and the best fit as suggested by the lowest value of 'Akaike information criterion' and 'Schwarz information criteria' was obtained as: $Y = 16.83X - 44.33X^2 + 36.07X^3$. Table 1 reports the standard errors as well as the p – values of the coefficients as well as some other

[10] Source: International Labour Organization (LABORSTA: http://laborsta.ilo.org/)

[11] The Revised International Standard Classification Of Occupation (ISCO-88)

[12] Source: World Bank Education Statistics (http://data.worldbank.org)

statistical outputs from the model. The fitted polynomial curve in the scatter plot is depicted in Figure 1b. Note that three countries were omitted from the analysis as they failed to clear the tests for outliers. Thus one can conclude that the observed data presents us an inverted – U relationship between skilled to unskilled wage differential and the relative skilled to unskilled labor endowment.

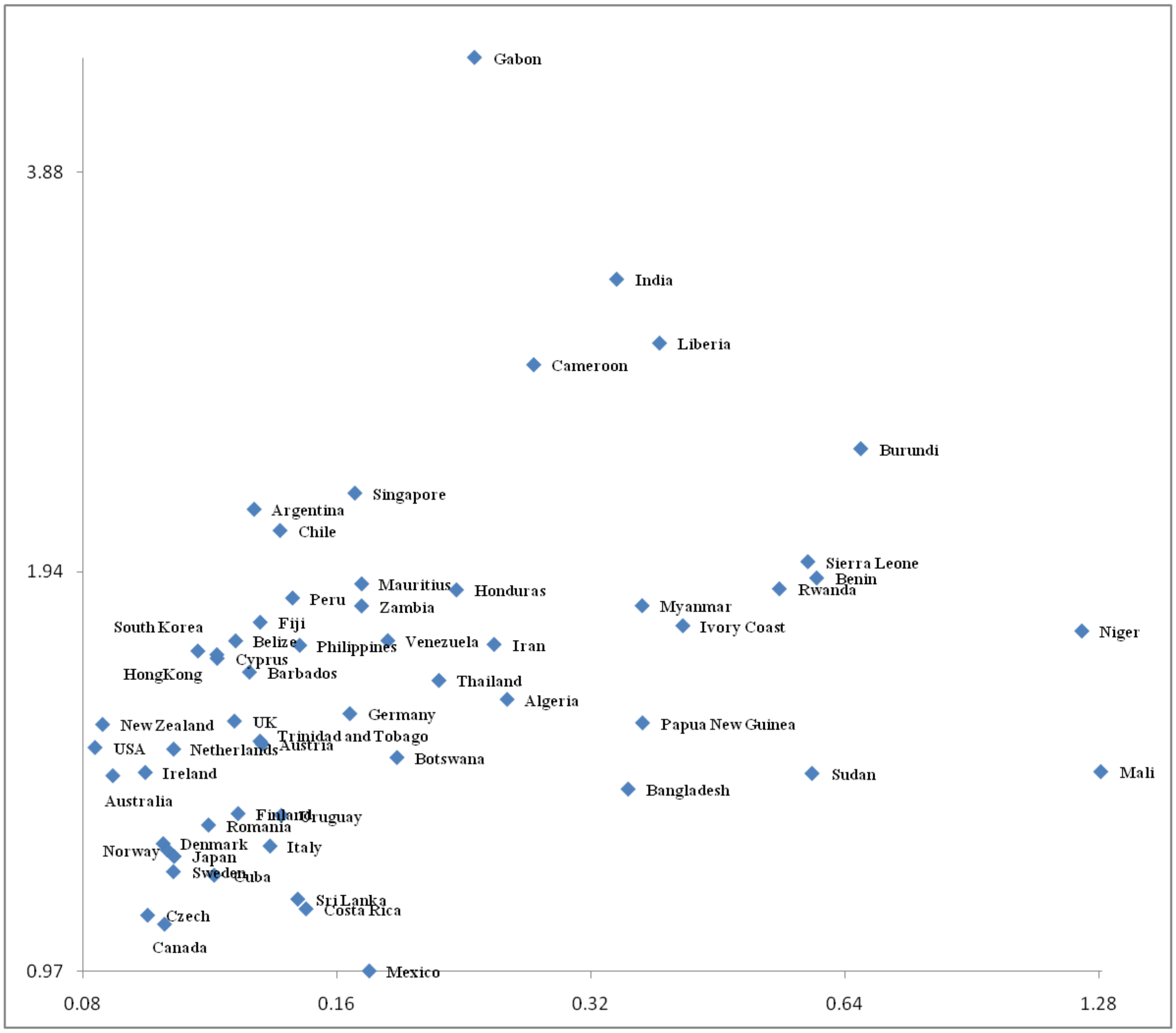


Figure 1a: Scatter plot of skilled to unskilled wage ratio (Y axis) and the reciprocal of the average years of schooling (X axis) (note both the axes are logarithmic scales of base 2)

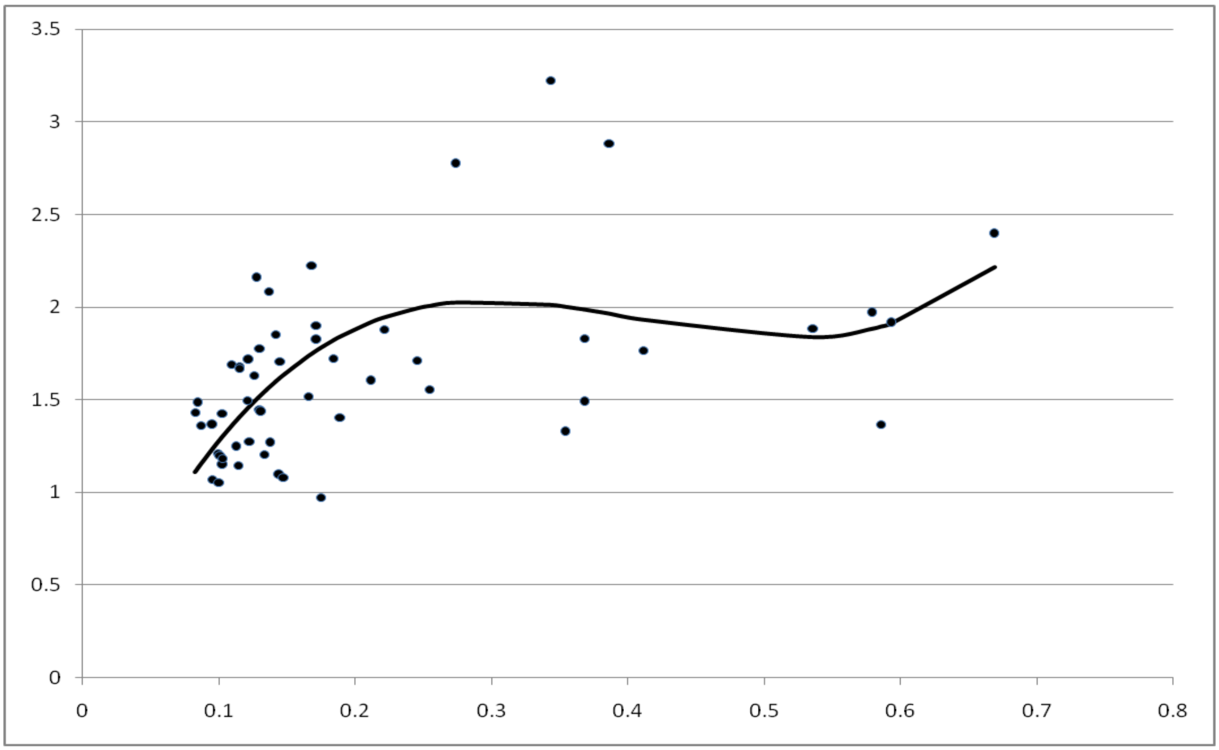


Figure 1b: Scatter plot of skilled to unskilled wage ratio (Y axis) and the reciprocal of the average years of schooling (X axis) together with the polynomial fit: $Y = 16.83X - 44.33X^2 + 36.07X^3$

Dependent Variable: Y
Method: Least Squares
Included observations: 54
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
X	16.82533	1.018946	16.51248	0.0000
X^2	-44.33201	7.347539	-6.033587	0.0000
X^3	36.07293	9.547450	3.778279	0.0004

Mean dependent var	1.625605
S.D. dependent var	0.461889
Akaike info criterion	1.039903
Schwarz criterion	1.150402

Table 1: Results of OLS regression between the skilled to unskilled average wages (Y) and unskilled to skilled relative endowments (X)

This chapter provides a theoretical justification to the observed inverted – U relationship between skilled to unskilled wage differential and the relative skilled to unskilled labor endowment. Furthermore, this work goes on to show that in the presence of factor price equalization, the same explanation may be extended to justify a rise in skilled to unskilled wage ratios as experienced by many countries in this era of globalization and free trade. This chapter sets up an economic structure that exhibits a non – monotonic association between skilled to unskilled relative wages and their relative endowments and explores the possibility of a symmetric rise in the wage inequality when two economies having economic structures as above, are subjected to free trade. The main results that this work bears are: (i) in the presence of an externality captured in this construction through an increasing cost associated with a lower relative endowment of skilled labor, the relative skilled to unskilled wage ratio may diminish with a decline in the relative endowment of skilled labor and (ii) if two countries have the same type of externalities as prescribed above, both the countries may experience a simultaneous increase in their skilled to unskilled relative wages at trade compared to autarky, if the autarkic relative wage rates of the two countries are "close enough". In the process, the discussion also highlights how outsourcing of skill intensive manufactured commodities and services plays a key role in widening the wage gap of the trading partners. Outsourcing is shown to mimic technological progress in a sense that it raises the relative productivity of skilled labor (by reducing their costs associated with the externality) and raises the relative skilled wage rate. The model set up here resembles the structure of a Heckscher – Ohlin – Samuelson framework involving comparative advantage, while retaining a Ricardian flavor of complete specialization that makes outsourcing a key ingredient in driving wage inequality.

In the following section the mathematical structure of the basic economy is set up, the solution of whose equilibrium and its nature is derived in section 5.3. The next section explains when an inverted – U relationship between the skilled to unskilled wage differential and the relative skilled to unskilled labor endowment can be generated. Section 5.5 extends the model to the realm of free trade and shows how a symmetric rise in wage inequality for two trading economies may be explained through the setup. The following section concludes.

5.2 The Model

Consider an economy whose individuals consume two manufactured goods: a relatively unskilled labor intensive good: *X* and a relatively skilled labor intensive good: *Y* (since the goods use different inputs for production, the notion of skill intensity will be discussed at the end of section 5.2.2).

5.2.1 Preferences

The preference structure of the individuals is identical and is summarized by the Cobb Douglas utility function:

$$U = X^{\alpha} Y^{1-\alpha}\ , \alpha \in (0,1)$$

5.2.2 Production

The production of good *X* is organized with the help of unskilled labor (L_u) and skilled labor (L_s) with the production technology:

$$x = \left[l_u^{\frac{\sigma-1}{\sigma}} + A l_s^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}\ , \sigma \in (1, \infty), A > 0$$

Note that capital letters are used to indicate a particular good or factor whereas small letters are used to quantify the amounts of the corresponding good or factor used.

The inputs of good *Y* comprise of unskilled labor (L_u) and an intermediate input: *Z* and for simplicity is assumed to possess the same technology as that of good *X* save for the coefficients of the input factors:

$$y = \left[l_u^{\frac{\sigma-1}{\sigma}} + B z^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}\ , \sigma \in (1, \infty), B > A$$

The intermediate input *Z* is in turn produced by skilled laborers and the final produced good *X* and the production function representing the production technology of the intermediate input *Z* can thus be put down as:

$$z = \text{Min}\left\{ l_s, \frac{x}{T} \right\}$$

This requirement of good *X* in the production of the intermediate *Z* can be thought of as a training cost associated with the use of skilled laborers. Thus the production of good *Y* involves an ingrained (through the intermediate good *Z*) use of skilled labor as well as an amount of good

X required to train the skilled labor. Given the above Leontief structure of the production function, one can see that at equilibrium, $l_s = x/T$ must be satisfied. This can be rearranged to $T = x/l_s$ indicating 'T' to be the amount of the final good *X* required to train a unit of skilled labor. This model, thus, incorporates a kind of externality in production. Presence of such production externalities is not uncommon in the economic literature. A number of growth and trade models that deals with international labor migration with similar external effects built into their production structures. For example in Lucas (1988), the average level of skill or human capital is assumed to affect the productivity of the overall production process. Also one can consult Wong (1997) chapter 14 or Romer (1986) as an example. In this model, the aforesaid externality is incorporated by assuming that the amount of good *X* required to train a unit of skilled labor for the production of good *Z*, (i.e. '*T*') is a function of the unskilled to skilled labor endowment. The justification of the above assumption is that, in reality, if one considers the distribution of skill in a labor market, one cannot obtain two distinct groups of labor based on their skill levels and term them as skilled and unskilled labor. Instead one obtains different 'classes' of skill levels as is the case for the empirical work undertaken at the beginning of this paper. Of these 'classes', laborers only above a certain 'threshold' can be utilized in the production of goods that require a high level of skill. Generally, the more skill deficit a country is (i.e. the greater is the proportion of people having skills below the 'threshold' than those above it), the lesser is the average skill levels of the individuals above this 'threshold' and the more are the costs associated in training the individuals above this 'threshold'. This very idea is captured in this model through the externality, where the total skilled to unskilled labor endowment is assumed to be a proxy for the training costs of production of the highly skilled intensive intermediate good *Z*. To simplify matters, '*T*' is taken to be a strictly increasing function of the unskilled to skilled labor endowment.

Two comments about the skill intensity of production of the final consumables *X* and *Y* are in order. Firstly, had the cost of training the skilled laborers been zero (i.e. 'T=0' and $z = l_s$) the parametric restriction: $B > A$ would imply a greater employment of skilled laborers in industry *Y* (embodied in the intermediate input *Z*) than industry *X* (given the wages). Also the intermediate input *Z* can be thought of as skilled laborers who have received training (using good *X*) and are thus more skilled than those employed in the production of good *X*. In a sense thus, good *Y* is more skill intensive than good *X* as commented in at the beginning of this section.

As for the structure of the markets, I assume that all the markets are perfectly competitive. The endowments of skilled and unskilled laborers are respectively taken to be $\bar{L}_u$ and $\bar{L}_s$. With the structure set thus, we proceed to the next section to obtain the solution to the endogenous variables of the market equilibrium.

5.3 The Solution

In this section, I solve for the endogenous variables of the economy at equilibrium and check the properties of the equilibrium.

5.3.1 Commodity market

First of all, let us focus our attention on the profit maximization condition for the firms in the industry producing good *X*. Since the price of the good gets equated to the marginal cost, the same is given by:

$$p_x = [w_u^{1-\sigma} + A^\sigma w_s^{1-\sigma}]^{\frac{1}{1-\sigma}} \qquad \ldots (5.1)$$

In the above relation, p_x denotes the price of good *X*, w_u is the unskilled wage rate and w_s is the skilled wage rate. Identical reasoning for the firms producing good *Y* yields the relation:

$$p_y = [w_u^{1-\sigma} + B^\sigma p_z^{1-\sigma}]^{\frac{1}{1-\sigma}} \qquad \ldots (5.2)$$

where, p_y denotes the price of good *Y* and p_z is the price of the intermediate input *Z*. Turning our focus, now, towards the industry producing the intermediate input *Z*, again, identical reasoning yields the relation:

$$p_z = w_s + Tp_x \qquad \ldots (5.3)$$

5.3.2 Factor Market

If at equilibrium, the economy produces 'x' amount of good *X* and 'y' amount of good *Y*, then the demands for unskilled and skilled labor are respectively given by the relations:

$$xp_x^\sigma w_u^{-\sigma} + yp_y^\sigma w_u^{-\sigma}$$

$$xp_x^\sigma A^\sigma w_s^{-\sigma} + yp_y^\sigma B^\sigma p_z^{-\sigma}$$

These two relations are obtained by differentiating the cost functions associated with the production of goods *X* and *Y* given respectively by:

$$x[w_u^{1-\sigma} + A^\sigma w_s^{1-\sigma}]^{\frac{1}{1-\sigma}}$$

$$y[w_u^{1-\sigma} + B^\sigma p_z^{1-\sigma}]^{\frac{1}{1-\sigma}}$$

with respect to unskilled and skilled wages. Hence the relative demand of unskilled to skilled labor when equated to the relative supplies, gives us the equation:

$$\frac{\bar{L}_u}{\bar{L}_s} = \frac{x p_x^\sigma w_u^{-\sigma} + y p_y^\sigma w_u^{-\sigma}}{x p_x^\sigma A^\sigma w_s^{-\sigma} + y p_y^\sigma B^\sigma p_z^{-\sigma}} \qquad \ldots (5.4)$$

From the utility function one can arrive at the relative demands of goods *X* and *Y* as a function of their prices. This is given by:

$$\frac{x}{y} = \frac{\alpha p_y}{(1-\alpha) p_x} \qquad \ldots (5.5)$$

The above two equations can be combined together to yield:

$$\frac{\bar{L}_u}{\bar{L}_s} = \frac{\alpha p_x^{\sigma-1} w_u^{-\sigma} + (1-\alpha) p_y^{\sigma-1} w_u^{-\sigma}}{\alpha p_x^{\sigma-1} A^\sigma w_s^{-\sigma} + (1-\alpha) p_y^{\sigma-1} B^\sigma p_z^{-\sigma}} \qquad \ldots (5.6)$$

5.3.3 The general equilibrium

I set the consumable good *X* as the numéraire and thus set $p_x = 1$ to obtain a solution to the endogenous variables of the model. This results in the following relationship obtained by equating p_x in equation (5.1) to unity:

$$1 = w_u^{1-\sigma} + A^\sigma w_s^{1-\sigma} \qquad \ldots (5.7)$$

Since $\sigma > 1$, from this equation, given non – negative wages, it can be concluded that $w_s \geq A^{\frac{\sigma}{\sigma-1}}$ and that, w_u can be obtained as a strictly decreasing function of w_s[13]. Similarly multiplying the numerator and the denominator of equation (5.6) with $p_y^{1-\sigma}$ and substituting p_x with unity, the form of p_y from equation (5.2) and that of p_z from equation (5.3) results in:

$$\frac{\bar{L}_u}{\bar{L}_s} = \frac{\alpha\left[w_u^{1-\sigma} + B^\sigma (w_s+T)^{1-\sigma}\right] w_u^{-\sigma} + (1-\alpha) w_u^{-\sigma}}{\alpha A^\sigma \left[w_u^{1-\sigma} + B^\sigma (w_s+T)^{1-\sigma}\right] w_s^{-\sigma} + (1-\alpha) B^\sigma (w_s+T)^{-\sigma}} \qquad \ldots (5.8)$$

The LHS of the above equation is the unskilled to skilled relative labor endowment while the RHS is the unskilled to skilled relative labor demand. The unskilled to skilled relative labor demand is strictly increasing in w_s and strictly decreasing in w_u (see the appendix for the explicit form) and equates to zero when evaluated at $w_s = A^{\sigma/(\sigma-1)}$. Thus the RHS of the following

[13] Another straightforward assumption would be to restrict w_s above w_u. This imposes the restriction of $w_s > (1 + A^\sigma)^{\frac{1}{\sigma-1}}$.

equation obtained by substituting for w_u from equation (5.7) to equation (5.8), is strictly increasing in w_s and equates to zero when evaluated at $w_s = A^{\sigma/(\sigma-1)}$:

$$\frac{\bar{L}_u}{\bar{L}_s} = \frac{\left[\alpha\left\{1-A^{\sigma}w_s^{1-\sigma}+B^{\sigma}(w_s+T)^{1-\sigma}\right\}+(1-\alpha)\right]\left(1-A^{\sigma}w_s^{1-\sigma}\right)^{\frac{\sigma}{\sigma-1}}}{\alpha A^{\sigma}\left[1-A^{\sigma}w_s^{1-\sigma}+B^{\sigma}(w_s+T)^{1-\sigma}\right]w_s^{-\sigma}+(1-\alpha)B^{\sigma}(w_s+T)^{-\sigma}} \quad \ldots (5.9)$$

This equation thus, indicates that for any given level of labor endowments, there exists a unique equilibrium that characterizes the basic economy. The same is illustrated in figure 2.

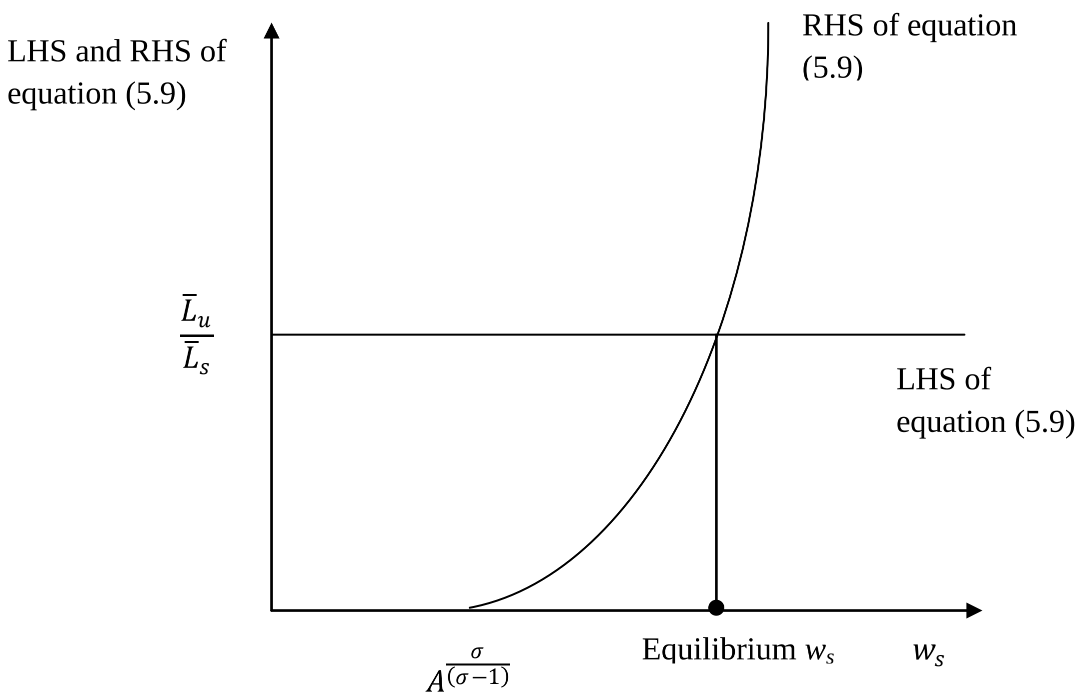


Figure 2: Existence and uniqueness of equilibrium

5.4 The inverted – *U*

In this section, it is shown how this model can produce a decreasing relation between the skilled to unskilled relative wages and the unskilled to skilled relative endowments. One important consequence of the choice of the numéraire (readers are requested to note equation (5.7)) is that there exists a one to one monotone increasing relationship between the skilled wage rate and the skilled to unskilled relative wage rate. For the needed decreasing relationship between the skilled to unskilled relative wages and the unskilled to skilled relative endowments it is sufficient thus to show a negative relationship between the relative unskilled to skilled labor endowments and the skilled wage rate. For the purpose, equation (5.9) is differentiated with respect to the relative unskilled to skilled labor endowments (denoted by *RE*) and the skilled wage rate w_s to yield:

$$\frac{dw_s}{dRE} = \frac{1 - \frac{\partial RD}{\partial T}\frac{\partial T}{\partial RE}}{\frac{\partial RD}{\partial w_s}}$$

In the above expression *RD* is the relative unskilled to skilled labor demand (i.e. the RHS of equation (5.9)) as a function of skilled wage rate and '*T*'. From the argument presented to prove the existence and uniqueness of the equilibrium of the model it is straightforward to see that the denominator of the above equality is strictly positive. Thus a necessary and sufficient condition for a negative relation between the relative unskilled to skilled labor endowments and the skilled wage is given by:

$$1 < \frac{\partial RD}{\partial T}\frac{\partial T}{\partial RE}$$

Again, it can be verified that *RD* is strictly increasing in '*T*' (readers are again referred to the appendix for an explicit form). Thus from the above relation it can be stated that:

Proposition 1: *For any given value of the unskilled to skilled labor endowment, if the responsiveness of the amount of good X required to train a unit of skilled labor* (*i.e.* $\partial T/\partial RE$) *is high enough, a negative relation between the skilled to unskilled relative wages and the unskilled to skilled relative endowments can be ensured.*

As an illustration, the skilled wage rate is solved for and plotted against the relative unskilled to skilled labor endowment[14] in figure 3. The parameters taken are:

$$\alpha = 0.5, A = 5, B = 25, \sigma = 5 \text{ and } T = 1 + 2RE$$

[14] Note the similarity between the graph generated by the simulation to the one empirically determined.

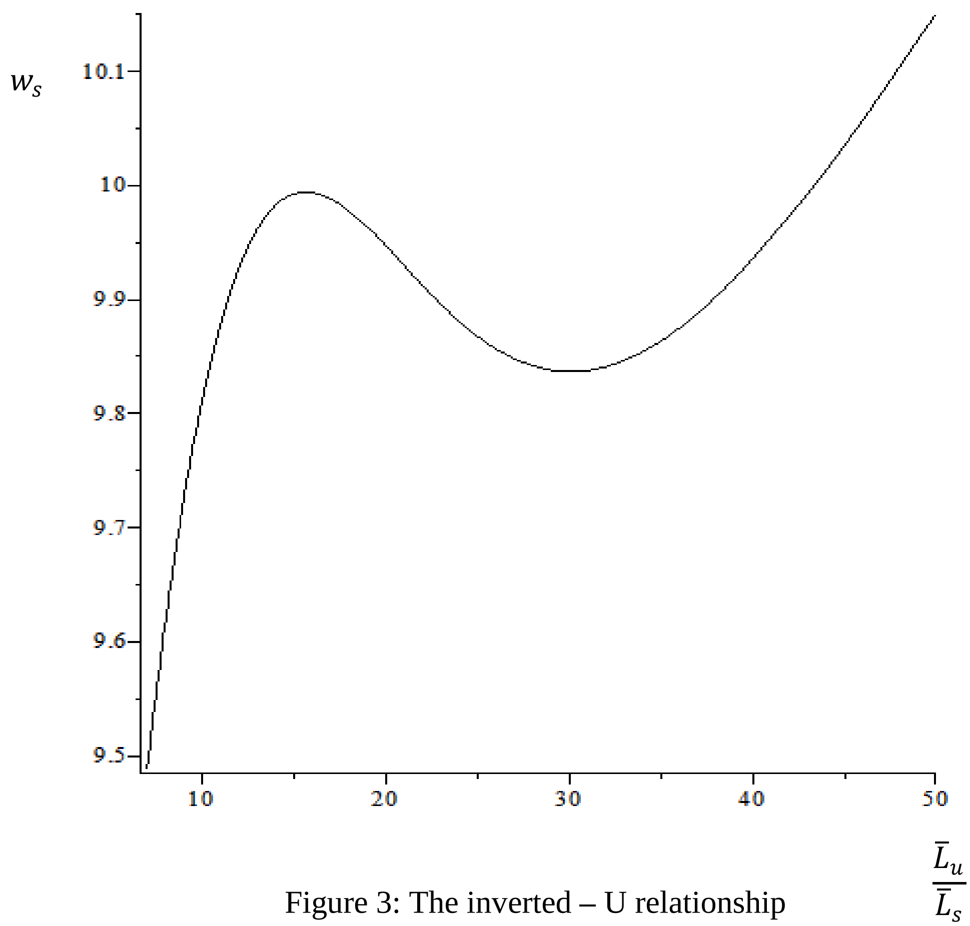


Figure 3: The inverted – U relationship

5.5 Effects of trade

In this section I examine the effects of bilateral trade on the endogenous variables of two countries – Home and Foreign having the economic structure set up earlier with special attention to wage inequality. The countries differ only with respect to the amounts of skilled and unskilled labor endowments. I define trade between the countries as unrestricted movement of the two final consumable goods – X and Y as well as the intermediate – Z. I also assume that the endowments of the two countries are such that at trade, both the countries produce goods – X and Y. With these assumptions we can see readily that the prices of the goods as well as the wages to skilled and unskilled labor will be equalized across the nations (this follows from equations 1 and 2 and equal prices of the three manufactured goods). With factor price equalization, the endogenous variables of the trading economies coincide with those of the integrated autarchic economies, and as such, the endogenous variables at trade can be obtained from equations (5.1) through (5.8) by replacing the endowments, with the world (i.e. combined home and foreign) endowments. From now on, I append the superscripts '*h*', '*f*', '*a*' and '*t*' to the endogenous variables, to distinguish these variables for home, foreign, autarky and trade respectively. Note that at trade, parameter '*T*' (being a function of the respective unskilled to skilled labor endowment) of the countries remains fixed at their respective autarkic levels. But since commodity and factor price is equalized across the countries, equation (5.3) (obtained from the profit maximization and zero profit conditions of the firms in industry Z) dictates that the country having a lower value of '*T*' will be the sole producer of the intermediate good Z (otherwise firms producing good Z in the country having a higher '*T*', will incur losses). Thus the following proposition is immediate:

Proposition 2: *At trade, the country having a higher relative endowment of skilled labor will be the sole producer and exporter of the skill intensive intermediate good Z.*

5.5.1 The rising wage inequality

This subsection explores the topic of rising wage inequality that may be simultaneously experienced by both the trading economies compared to autarky. It is here that the Ricardian structure of complete specialization ingrained in this model comes into play. For the rest of this section, it is assumed that home is relatively skilled labor abundant compared to foreign. The counterpart of equation (5.9) for the integrated world economy is given by:

$$\frac{\bar{L}_u^h+\bar{L}_u^f}{\bar{L}_s^h+\bar{L}_s^f}=\frac{\left[\alpha\left\{1-A^\sigma w_s^{1-\sigma}+B^\sigma\left(w_s+T^t\right)^{1-\sigma}\right\}+(1-\alpha)\right]\left(1-A^\sigma w_s^{1-\sigma}\right)^{\frac{\sigma}{\sigma-1}}}{\alpha A^\sigma\left[1-A^\sigma w_s^{1-\sigma}+B^\sigma(w_s+T^t)^{1-\sigma}\right]w_s^{-\sigma}+(1-\alpha)B^\sigma(w_s+T^t)^{-\sigma}} \text{ with } T^t=\mathrm{Min}\{T^h,T^f\} \ldots(5.10)$$

For the purpose of comparison, figure – 4 depicts the relative labor demand and supplies of the two countries at autarky and at trade given by equations (5.9) and (5.10) respectively. In the figure, the relative demands for home and foreign respectively marked by RD^h and RD^f are positively sloped curves that start from $w_s = A^{\sigma/(\sigma-1)}$ (because of the properties of equation (5.9) discussed previously). Owing to the fact that $\partial RD/\partial T > 0$ (as derived in the appendix) and '*T*' (the amount of good *X* required to train a unit of skilled labor for the production of good *Z*) is increasing in the relative unskilled to labor endowment, given any value of $w_s > A^{\sigma/(\sigma-1)}$ thus, RD^f lies above RD^h. Thus points *H* and *F* represent the home and foreign autarkic equilibrium. Since home is relatively richer in skilled labor, the RHS of equation (5.10) coincides with that of equation (5.9) for this country (by proposition 2). Thus *W* marks the equilibrium of the countries at trade. This figure depicts a case where trade may lead to a rise in skilled to unskilled relative wages (note the one to one increasing relation between skilled wages and the skilled to unskilled relative wages (equation (5.7)). Thus inspection of equations (5.9), (5.10) and the figure yields:

Proposition 3: *If at autarky the countries have identical skilled to unskilled wage ratios* (*note they must differ in their relative endowments otherwise trade in commodities will not persist*) *then at trade* (*assuming incomplete specialization in goods X and Y*)*, both the countries experience an increase in skilled to unskilled relative wage increase.*

Corollary: *There exists a* $\delta > 0$ *such that at trade* (*assuming incomplete specialization in goods X and Y*)*, both the countries experience an increase in skilled to unskilled relative wages , if the autarkic skilled to unskilled wage ratios of the countries do not differ by more than* δ.

Proposition 4: *Given the relative unskilled to skilled labor endowments of the countries, there exists a* $\delta > 0$ *such that, as long as difference between the relative unskilled to skilled labor endowment of the relatively skill scarce country and that of the integrated world economy do not exceed* δ, *trade* (*assuming incomplete specialization in goods X and Y*) *dictates an increase in skilled to unskilled relative wages of both the countries compared to autarky.*

Proposition 5: *If at autarky the country that is relatively highly skill endowed has a higher value of skilled to unskilled wage ratio, then trade* (*assuming incomplete specialization in goods X and Y*) *unambiguously leads to an increase in skilled to unskilled relative wages of both the countries.*

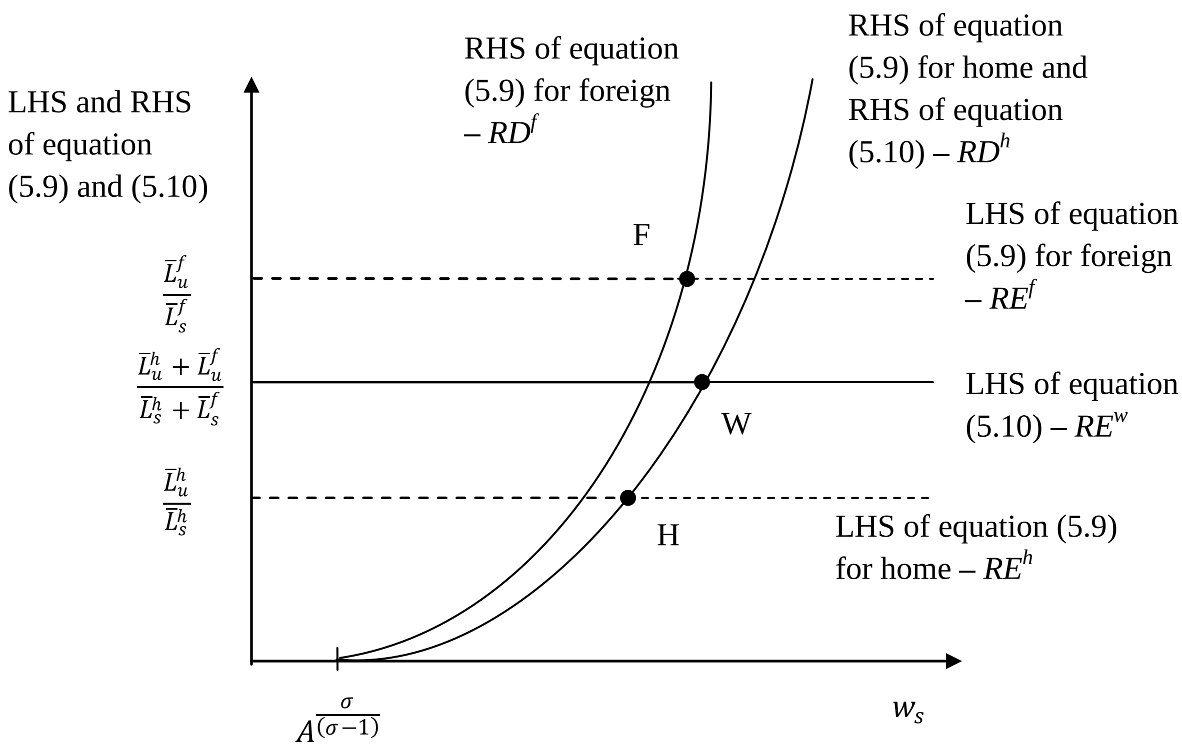


Figure 4: The rising wage inequality

The basic intuition behind the results is as follows. With trade and factor price equalization, the result of a rise in the relative skilled to unskilled wage ratio of the relatively skill abundant country follows from factor abundance. Had the relatively unskilled abundant country faced the same value of unit requirement of good *X* required to produce the intermediate good *Z* (i.e. '*T*'), we would have landed with the classical HOS result of a decreasing skilled to unskilled relative wage for this country (note figure – 4). Since this country is faced with a greater value of '*T*' it is profitable for this country to outsource its production of the intermediate good. This in turn lowers the global requirement of labor embodied in good *X* required to produce the intermediate compared to autarky. This rise in efficiency mimics a technological progress which raises the productivity of the skilled labor in the *Y* sector and raises the relative demand of the skilled labor vis – a – vis unskilled labor for this country. If this induced technological change brought about by trade is strong enough, it leads to a rising wage gap for the relatively unskilled labor abundant country.

Before concluding this section a few comments about the above discussions on trade induced wage inequality are in order. First it must be mentioned that the above results are independent of the inverted – *U* relationship between the relative factor supplies and the relative wages. The second comment concerning the wage inequality is that the results put forward in the above propositions continue to hold even if the relative labor supplies are made responsive to the labor payments i.e. the factor supplies are made elastic in the factor rewards.

5.6 Conclusion

This work puts forward a model that simultaneously explains two empirically observed issues one regarding the inverted – *U* relationship between relative factor endowments and relative factor payments observed across a cross section of countries and another concerning a much debated issue of trade induced wage inequality. The analysis done in this chapter explores the role of externalities in production that can address the two issues simultaneously.

Appendix

The RHS of equation (5.8) is given by:

$$\frac{\alpha[w_u^{1-\sigma} + B^\sigma(w_s+T)^{1-\sigma}]w_u^{-\sigma} + (1-\alpha)w_u^{-\sigma}}{\alpha A^\sigma[w_u^{1-\sigma} + B^\sigma(w_s+T)^{1-\sigma}]w_s^{-\sigma} + (1-\alpha)B^\sigma(w_s+T)^{-\sigma}}$$

Differentiating the above with respect to w_s yields an expression whose numerator is given by:

$$w_u^{-\sigma}\left[\left(\frac{\alpha}{1-\alpha}\right)^2 \sigma A^\sigma w_s^{-\sigma-1}\{w_u^{1-\sigma} + B^\sigma(w_s+T)^{1-\sigma}\}^2 + \left(\frac{\alpha}{1-\alpha}\right)\left[[B^\sigma(w_s+T)^{-\sigma} + \{(2w_s+T)^\sigma - w_s\}w_s^{-\sigma-1}A^\sigma]B^\sigma(w_s+T)^{-\sigma} + \{(w_s+T)^{-\sigma-1}B^\sigma + w_s^{-\sigma-1}A^\sigma\}\sigma w_u^{1-\sigma}\right] + \sigma B^\sigma(w_s+T)^{-\sigma-1}\right]$$

And the denominator is:

$$[\alpha A^\sigma\{w_u^{1-\sigma} + B^\sigma(w_s+T)^{1-\sigma}\}w_s^{-\sigma} + (1-\alpha)B^\sigma(w_s+T)^{-\sigma}]^2$$

Clearly the numerator and the denominator is strictly positive (note $\sigma > 1$).

Similarly differentiating equation (5.8) with respect to w_u yields an expression whose numerator is given by:

$$-w_u^{-\sigma-1}\left[\left(\frac{\alpha}{1-\alpha}\right)^2 \sigma A^\sigma w_s^{-\sigma}\{w_u^{1-\sigma} + B^\sigma(w_s+T)^{1-\sigma}\}^2 + \left(\frac{\alpha}{1-\alpha}\right)[\sigma B^\sigma\{B^\sigma(w_s+T)^{-\sigma} + w_s^{-\sigma}A^\sigma\}(w_s+T)^{1-\sigma} + \{(2\sigma-1)(w_s+T)^{-\sigma}B^\sigma + w_s^{-\sigma}A^\sigma\}w_u^{1-\sigma}] + \sigma B^\sigma(w_s+T)^{-\sigma}\right]$$

while the denominator remains same as before. Thus the RHS of equation (5.8) is strictly rising in w_s and strictly decreasing in w_u.

The value of $\frac{\partial RD}{\partial T}$ may be evaluated to:

$$\frac{\left(\frac{\alpha}{1-\alpha}\right)[\sigma(w_s+T)^{-\sigma-1}(1-A^\sigma w_s^{1-\sigma})+(w_s+T)^{-\sigma}\{B^\sigma(w_s+T)^{-\sigma}+A^\sigma w_s^{-\sigma}(\sigma-1)\}]+\sigma(w_s+T)^{-\sigma-1}B^\sigma(1-A^\sigma w_s^{1-\sigma})^{\frac{\sigma}{\sigma-1}}}{\left[\left(\frac{\alpha}{1-\alpha}\right)(1-A^\sigma w_s^{1-\sigma}+B^\sigma(w_s+T)^{1-\sigma})A^\sigma w_s^{-\sigma}+B^\sigma(w_s+T)^{-\sigma}\right]^2}$$

The above expression is clearly positive (note $\sigma > 1$).

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