Monitoring, Endogenous Comparative Advantage, and Immigration

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Abstract

This paper proposes a theory of free movement of goods and labor between two large economies in the presence of moral hazard. Each country is incompletely specialized in producing two final goods where the productive efforts of workers and firms' output cannot be perfectly observed or verified only in the complex industry. The heart of my analysis lies in the determinants of the distributions of skills in each country. Under free trade, the best institutions and the best early educational system can serve as complementary sources of comparative advantage in the most complex industry. It is shown that individuals' decisions to emigrate are related to the difference of the institutional quality between the two countries. Finally, international trade and emigration affects the income of both countries via an indirect effect on individuals' incentives to invest in their education and a direct effect on prices of goods.

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I. Introduction

In the modern world, a number of recent political developments have intensified the free movement of goods and labor. According to Hatton and Williamson (2005), average industrial tariffs rates around the world have fallen over the last half century from about 40 percent to 3 percent. Over the last 30 years the ratio of exports of goods and services to GDP has doubled. The proportion of the world's population that are immigrants also has increased. The United Nations estimates that international migrants constituted 3 percent of the world population in 2005.[1] The tendency toward the world liberalization of goods and labor can affect the human capital accumulation in each country, which in turn, can cause further effects on international trade, economic development and inequality.

One of the objectives of this paper is to provide a theoretical understanding of the relationship between a country's early educational system and its institutions on the one hand and the human capital accumulation on the other. By focusing on the economic function of early educational systems and institutions, my theory offers an explanation on the distribution of skills in the labor force of a country. Another objective of this paper is to analyze the consequences of the endogenous human capital accumulation in a free trade world, and in a common labor market world. To this end, I develop a story that links the human capital accumulation, as a consequence of the early educational system and institutions with its impact on the organization of production.

This paper is a generalization of Vogel (2007) to allow for immigration and early childhood education. It develops a framework with imperfect labor markets in a world with free movement of goods and labor, which consists of two large economies. In each country there

[1]"In 2005, the number of international migrants in the world reached almost 191 million, up from 155 million in 1990. The number of international migrants has increased by 10 million from 1990 to 1995, going from 155 to 165 million. The estimated increase was close to 12 million from 1995 to 2000 and above 14 million from 200 to 2005." For more details see United National: The International Migration Report (2006, p. 1).

exist a large number of firms grouped into two sectors, an agriculture sector and an industrial sector. In the agriculture sector there exist only firms that consist of one individual each, and in industrial sector, there exist only firms that consist of two individuals each. There are two final goods produced using one factor of production, labor, that is heterogeneous in terms of skills. The heart of my study lies in the determinants of the distribution of skill in the labor force of each country. In a world with imperfect labor contracts, the productive efforts of the workers involved in the production of the industrial good cannot be measured perfectly. Thus, each individual involved in the production process of the industrial good has perfect information about her own level of productive efforts, but imperfect information about the levels of productive efforts of others. Individuals choose their level of skill subject to their early level of education and their country's institutional quality. Individuals with high levels of skill choose high levels of job training in order to maximize their utilities. These types of individuals seek employment in the industrial sector. This is related to the fact that it is easier for high skilled workers to exert high effort levels in the team production process since they have accumulated higher level of human capital. Consequently, is more effective for them to shirk less in the team production process. An efficient matching process takes place, within each country, where the most talented individuals pair up with the most talented managers. The most talented individuals enter in the industrial sector. The least talented individuals enter in the agricultural sector, where they work as self-employed, operating their own individualistic firms.

In the real world, in some sectors it is very difficult for a manager of a firm to observe the productive efforts of her employees that engage in a team project during the production process. Consequently, the manager has perfect information about the skill level of her employers but imperfect information about their productive efforts during the production process. Thus, a manager tends to offer an optimal contract where workers' wages depend on the workers' skill levels and on the quality of national institutions because these are the only things that she can observe perfectly. In other words, in this environment it is difficult to base the contract directly on the workers' effort levels because it is difficult for a court to measure the above. Better national institutions provide higher quality of the performance and verifiability measures. The quality of national institutions can be related to the quality of the national judicial system.[2] The better a country's legal establishments, the more precisely courts can assign credit for each individual contribution to the team production process of a firm operating in this country. As a result, the degree of labor contract perfectibility is proxied by the degree of a country's institutional quality. With imperfect contracts, the higher the quality of institutions, the higher the verifiability of unproductive efforts of a worker and therefore, the higher the productive effort levels exerted by a worker in the team production process.

A country's institutional quality affects the productivity only in those sectors where firms are unable to measure precisely the productive efforts of each individual involved in their production process. Consequently, the quality of institutions in a country will affect an individual's decision about the industry in which she will seek employment, and the early educational system will affect an individual's decision about her skills' level. All things considered, the human capital accumulation will depend on the quality of a country's early educational system and its institutions. Since countries differ in their institutions and early educational system, they will differ in their skills' distribution of their labor force.

[2]According to Vogel (2007) the quality of national institutions can be related not only to the national judicial system but also to the national accounting system. He argues that the more effective national accounting system, the better the reports of data on both the productivity of a firm and the contribution of each individual involved in its production process.

I show that in a world with two open economies under free trade, the country with relatively higher levels of early education or quality of institutions, ceteris paribus, will have relatively more talented individuals, and therefore, will export the industrial good and will import the agricultural good. In a world with free movement of goods and labor, I show that only the most talented individuals have an incentive to emigrate towards the country with the best institutions and early educational systems. This is related to the fact that if they are able to afford the fixed costs of emigration, such as language barriers, they capture higher income to their level of skill in the host country of immigrants, as compared to their income in their country of origin.

I consider certain scenarios, where the government of an origin country of immigrants could reinforce the incentives of its citizens to accumulate skills through its ability to improve the quality of its institutions and early educational system. In particular, I describe a scenario where the government of the origin country can promote the development of more talented individuals in the world and simultaneously increase the income of most of its citizens by simply improving the quality of its early educational system. The latter will increase the intensity of human capital accumulation in the world because of emigration towards the country with the best institutions. This in turn, increases the relative price of the agriculture good, therefore increasing the income of all individuals who work in the agriculture sector. Since the host country is exporting the agriculture good, most of its labor force will enjoy higher income than before as a result of the emigration of its most talented individuals to the host country of immigrants. Therefore, emigration influences the individuals' income via an indirect effect on their incentives to invest in their level of skills and a direct effect on the goods' prices.

This paper is original in four key dimensions. It provides two separate contributions to the burgeoning literature of international trade through the involvement of institutions and endogenously determined human capital accumulation. Also, it makes two equally distinct contributions to the recent literature on immigration and economic development through the involvement of the quality of a country's early educational system and its institutions.

First, this paper contributes to the recent and growing literature on institutions and international trade. It argues that the quality of institutions acts as an independent source of comparative advantage in a country, and therefore, determines the pattern of trade because institutions affect more the productivity in certain sectors of the economy than in others. This result is consistent with Acemoglu, Johnson and Robinson (2001, 2002), Acemoglu, Antras, Helpman (2007), Costinot (2009), Cunat and Melitz (2007), Grossman (2004), Levchenko (2007), Matsuyama (2005), Nunn (2007), and Vogel (2007). In this context, I follow the steps of Vogel (2007) by developing a simple theoretical game in which each individual chooses her skill level, sector of employment, training level, matching co-worker, and level of efforts and distortions. However, my model differs from Vogel (2007) in terms of the endogeneity of individuals' skill level. In my framework an individual chooses her skill level, subject to the quality of institutions and her level of early education.

Second, it contributes to the latest and increasing literature on international trade and allocation of talent. Human capital accumulation and institutions act as complementary sources in the determination of organization of production. Thus, a country with better institutions and a labor force that consists of more talented individuals has a comparative advantage in the production of the more complex goods. This idea is similar to Costinot (2009), Grossman and Maggi (2000), Ohnsorge and Trefler (2007), Lucas (1978), Rosen (1981), and Murphy et al. (1991), Vogel (2007). This paper differs considerably from the above papers, in the definition of talent. In this paper mainly talent is defined as something that an individual develops through the interaction of her early level of education and the quality of her country's institutions. Thus, a distinct contribution that this paper offers to the literature is the ability of my model to make the early educational system of a country the sole determinant of the pattern of trade.

Third, this paper contributes to the literature on economics of immigration. It argues that institutions and early educational systems can determine the pattern of labor migration. It also shows that only the most talented individuals have an incentive to immigrate to the country with the best quality of institutions and early educational system. In other words, only skilled individuals have incentive to emigrate and therefore afford the emigration costs because of the existence of high differences between their earning in their country of origin and their destination country.[3] The latter is consistent with Abowd and Freeman (1991), Blanchard and Katz (1992), Borjas (1987, 1992, and 1993), Freeman (1993), Jensen (1988), and Lucas (1988). This paper differs notably in terms of the mechanism through which the incentives of individuals to emigrate are determined. In particular, this paper sheds light on two separate channels, the institutions and the early educational system, that can determine the pattern of emigration between two otherwise similar countries.

Fourth, it contributes to the recent literature on human capital accumulation, immigration, and economic development. This paper shows that the volume of talented individuals increases when countries that differ in the qualities of their early educational systems and institutions move to a world with free labor mobility. This result is somewhat related to the literature on immigration and beneficial and non-beneficial brain drain as developed in Bhagwati et al. (1974), Beine et al. (2001, 2008), Di Maria et al. (2009), Galor et al. (1997), Miyagiwa (1991),

[3]The model developed in this paper assumes that the wages of unskilled workers are the same in all countries (developed or developing countries). Thus, there are no economic incentives for the unskilled workers of a developing country to immigrate in the developed country.

Mountford (1997), Stark et al. (1997, 1998), and Vidal (1998). The papers that study the theory of brain drain argue that the emigration of skilled workers hurts the origin country of immigrants and promotes the host country of immigrants because immigration increases the volume of skilled workers in the host country and decreases their volume in the origin country of immigrants. On the other hand, the papers that develop the theory of beneficial brain drain argue that the increase in the possibility of emigration increases the volume of skilled workers in the origin country of immigrants because it increases the stock of human capital there. This paper is different from the above papers on the literature of brain drain since it provides another mechanism through which the incentives of individuals on the development of their talent increase with the existence of a common labor market.[4] Moreover, it provides a scenario where the government of the origin country of immigrants can increase the human capital accumulation in its country simply by improving the early educational system or/and its quality of institutions in a common labor market world. This result also is very different with the literature of beneficial brain drain in the sense that the existence of free movement of labor could improve the capital accumulation in the host country of immigrants, not simply the possibility of emigration.

The rest of the paper is organized into six sections. I set up the model in Section II, where I describe a five-stage theoretical game in a two sector economy that produces two goods, where labor is considered heterogeneous and is the only input. In Section III, I analyze an individual's decision on her level of skills' accumulation in a world of perfect labor contracts and competitive firms that operate in complete markets. In Section IV, I solve the five-stage theoretical game for a symmetric subgame perfect equilibrium in a closed economy with imperfect labor contracts. Section V investigates the pattern of trade when two large economies enter into a free trade

[4]The term talent' development, introduced in this paper, essentially is the same as the term human capital development, which is used in the literature on the brain drain.

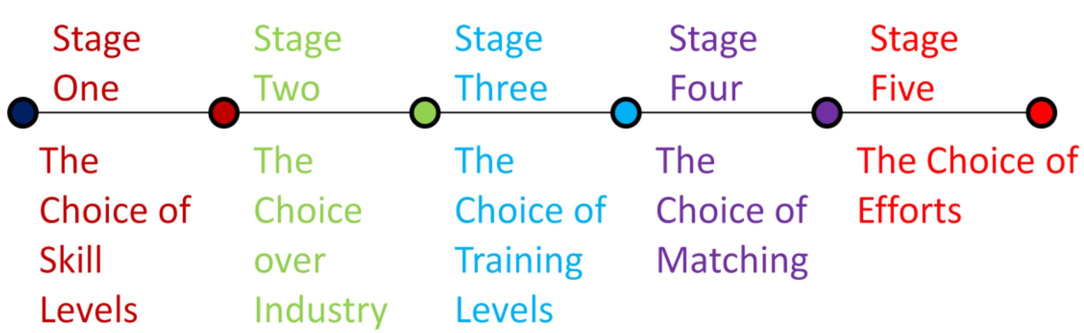
agreement. Section VI explores the pattern of emigration and its effects on individuals' income, when both countries that already enjoy free trade of goods enter into a free common labor market. Section VII presents conclusions.

II. The model

The economy has two sectors (*X* and *Y*). In the *y* sector, individuals work alone. They own their own firm where they produce a final good. Therefore each individual in the y sector provides only productive efforts in order to maximize her profits. For convenience, let me call this sector "the agriculture sector."

In the *x* sector, production of the final good is determined as a result of a team work of a worker and a manager. Managers are matched with workers in order to produce the final good. In this case, managers (or firm owners) only provide productive efforts since their final objective is to maximize the firm's profit. On the other hand, workers might have an incentive to provide unproductive and productive efforts, since they care about their wage and not the firm's profits. Therefore, if a manager is able to measure perfectly a worker's efforts, then the worker will not have any incentive to provide unproductive efforts. However, if the manager is unable to identify perfectly the worker's efforts, then the worker might have an incentive to provide unproductive and productive efforts. The amount of productive and unproductive effort will depend on the wage that the worker receives, but also on the degree of imperfectability of the labor contracts. I assume that the later is related to the country's institutional quality. The better the institutions in a country, the more perfect the labor contract market, the lower the amount of unproductive efforts provided by workers. The amount of unproductive efforts also is related to the level of a worker's ability. Individuals have the same homothetic preferences towards accumulation of human capital. However, individuals possess different levels of early level of education. The higher the early education obtained by an individual, the lower her cost of acquiring skills, and therefore the easier it is for her to obtain higher levels of specific training latter on. The more trained, a worker is, the less the amount of unproductive efforts that she will provide for the firm for a fixed institutional quality level of a country. The latter intuition is related to the relatively easiness of the more talented (skilled) individual to put forth productive efforts. I refer to the *x* sector as the "industry sector". These results are independent of the specific form in which the utility cost of acquiring skills, industry specific training, and productive and unproductive efforts enters in the utility function specified in equation (1) in page 10. Individuals know that it is costly for them, (i) to obtain skills subject to their early educational level, (ii) training, and (iii) efforts, but better trained managers, who are the most skill individuals, under better national institutions are compensated more for their ability to reduce moral hazard in the industry sector.

Figure 1. The five-stage game



I describe an individual's decision on whether to work in the agriculture sector or in the industrial sector with a five-stage game. The timing of such a decision is illustrated in figure 1. After an individual chooses her level of early education, she determines the sector in which she will look for employment. After determining the sector of employment, she decides on how much education (or sector specific training) to achieve. After the implementation of her training, she must select the production team that is matched with her training. At the last stage, after she gets the job, she chooses how much productive and unproductive effort to supply in her work. The above five-stage game is solved for a symmetric, subgame-perfect equilibrium. I first find the equilibrium productive and unproductive effort. Second, I determine the equilibrium level of training. Third, I establish the equilibrium matching of the production teams subject to their skill levels. Fourth, I find the equilibrium level of skill that makes an individual indifferent to the choice of the sector. Finally, I determine the threshold level of early education that would make an individual to seek employment in the x sector.

The utility of an agent, who consumes C_i units of the final good i, with early level of education γ, ability (skill level) q, and observed and verified sector-specific training t, who supplies an amount of productive efforts equal to a and an amount of unproductive efforts equal to d, is given by

$$U = u\left(C_x, C_y\right) - \frac{1}{2t}\left(a^2 + d^2\right) - \frac{1}{2q}t^2 - \frac{1}{3\gamma}q^3 \tag{1}$$

All individuals have identical and homothetic preferences represented by the subutility function u. Let $u\left(C_x, C_y\right) = C_y^{\beta} C_x^{1-\beta}$ and the income of an individual be $I = x + py$, where the price of good x is considered as numeraire and therefore the relative price of y is denoted by p. Each individual maximizes her utility function subject to her income level, giving the following

$$V(a, d) = RI - \frac{1}{2t}\left(a^2 + d^2\right) - \frac{1}{2q}t^2 - \frac{1}{3\gamma}q^3 \tag{2}$$

where $R \equiv \beta^{\beta}(1-\beta)^{1-\beta}p^{-\beta}$. There are many competitive firms in each sector. Each firm in the agriculture sector is characterized by the same individual production process, exerting (a) effort. On the other hand, each firm in the industrial sector is characterized by the same production process, where the manager exerts a_m productive efforts, while the worker exerts a_w productive efforts and d_w unproductive efforts. For an individual, each type of effort is costly, despite the fact that only the productive effort increases firm's output. For example, when institutions are imperfect, a worker has some incentive to put unproductive effort, but that will increase the "non-perfectly measurement" of her productivity as viewed by her manager. The latter can reward only based on a workers performance measure, because she cannot perfectly measure the output. However, this unproductive effort has a cost for a worker. For instance, a researcher of an insurance company has to show up to work, leave his office door open and look busy, in order to give the impression to her manager that she is working hard, but this will not increase the company's output. The more early educational level an individual has, the easier it is for her to acquire more skills, and therefore, much easier it gets for her later on to obtain more industry specific training, which make this individual to put out more productive effort. These results are independent of the utility cost of effort as long as, the latter is an increasing and convex function of productive and productive efforts, and the two type of efforts (a and d) are not written as perfect substitute in the equation (1).

The production functions in both sectors exhibit constant returns to scale. In particular, the production functions in both sectors are

$$y(a) = a \qquad\qquad x(a_w, a_m) = 2\sqrt{a_w a_m} \qquad (3)$$

Thus, in the agriculture sector, an individual who provides one unit of effort (a) gets in return (a) units of final good y. In the industry sector, the final good is produced as a result of matched efforts of a manager and a worker. In this sector, the firm's output depends on the effort levels of both manager and worker matched together in order to produce one unit of final good x. Here, I follow the assumption of complementarities in the production, meaning that it is more efficient for a manager to match with a worker with the same level of training in order to produce the final good x. Therefore a firm, which consists of a manager who exerts one unit of productive effort (a_m) and one unit of unproductive effort (d_m) matched with a worker who exerts one unit of productive effort (a_w) and one unit of unproductive effort (d_w), will produce $2\sqrt{a_w a_m}$ units of x.

In the fifth stage, each individual inelastically provides one unit of labor. In the agriculture sector, each individual is a firm owner. Thus, she provides the amount of effort that maximizes firm's profit. In the industrial sector, the managers exert the amount of effort that maximizes the firm's profit while the workers exert the amount of effort that maximizes their income defined in the contract

$$K(\theta, q_m, a_w, d_w) \equiv a_w + \left(\frac{e^{1-\theta} - 1}{q_m}\right) d_w, \qquad (4)$$

where q_m denotes the skill level obtained by the manager, a_w and d_w respectively denote the amount of unobservable productive and unproductive efforts of the worker paired with the manager of a firm. Therefore, since θ denotes the institutional quality of a country, the higher the institutional quality, the better the manager's monitoring of the worker's distortion levels and therefore, the higher the worker's effort. Hence, $\theta \in [0,1]$. In other words, the ability of the manager to observe the amount of unproductive efforts that the worker exerts in the production function is proxied by the institutional quality of a country. Finally, in this model, when the labor contracts are perfectly observed, the country's institutions also must be perfect, which coincides with $\theta = 1$, which means that $K \equiv a_w$. Therefore, the income of the workers will be translated perfectly from their effort levels in the production process.

In the fourth stage, in the agriculture sector, each individual provides the amount of job training that maximizes the firm's profit. In the industrial sector, a worker decides on her optimal level of job training that she is going to obtain, subject to her wage, which is assumed to be her entire income. The wage is determined in the next stage from the efficient matching system between a worker and a manager. On the other hand, a manager chooses her optimal level of job training that she is going to obtain, in order to maximize the firm's profit, which represents her only income. This is shown to be related to the matching system as described in the next stage.

In the third stage, in the industrial sector, production teams are paired up between a manager and a worker following the assumption of the complementary in production. The managers offer the contract to the workers as defined above. The managers can observe perfectly and verify the worker's skill level but, in the imperfect labor contract case, are unable to perfectly observe the amount of effort that this worker will put into the production process. Also, workers accept the contract after observing the manager's skill level. In the equilibrium with imperfect contracts, workers and managers sort themselves subject to their skill levels. Therefore, in equilibrium contracts also are defined from this type of costless matching between workers and managers conditional on their skill levels. I find the symmetric equilibrium training levels. The more skilled managers will be matched with the more skilled workers. Moreover, the more skilled individuals obtain more training since it is relatively easier for them to do so; therefore, they exert more productive efforts.

In the second stage, I determine the distribution of the labor force in a country subject to individuals' skill level. Put differently, here I construct the labor force of a country, subject to individuals' decisions to join one sector in a two sector economy. The individuals can join the agriculture sector, where they create firms operated by one individual, or they can join the industrial sector by becoming either a manager or a worker. The individuals cannot be employed in both sectors at the same time. Thus, the labor force consists of a continuum of individuals indexed by their skill levels denoted by q. The unskilled individuals will become farmers and obtain less training, while the skilled individuals will create firms, by being a manager or a worker of a firm.

Finally, in the first stage, I endogenize the skill level of individuals (q). I assume that the latter depends on the early education level, or the early childhood, or the economic environment, or the general culture in a country, or on all of the above denoted by γ. The level of early childhood education is exogenous in my model. Also, the skill level of individuals depends on the institutional quality of their country (also exogenous) even before an individual determines the industry, where she will seek employment. In this stage, I find the threshold level of γ, where γ is defined as $\gamma \in [\gamma_{min}, \gamma_{max}]$. The higher the early education obtained by an individual, the greater her skill level and therefore the easier it is for her to obtain higher levels of training. Thus, a country that has a better system of early education, ceteris paribus, will have a labor force that consists of more skilled individuals. They might work in the industry sector, but this depends on the imperfectability of the labor contract market. Therefore, this country has a comparative advantage in the industry sector. In the same way, the country with better institutions, ceteris paribus, will consist of more individuals who will choose to obtain more training and self-select in the matching process of production in the industry sector. Hence, the country with better institutions has the comparative advantage in the industry sector.

III. Perfect labor contracts

In this section, I describe a typical Walrasian equilibrium in a perfect information world that consists of one country with two sectors. The productive and unproductive efforts of workers and managers are perfectly observable and verifiable in each industry. This corresponds to the case where $\theta = 1$, which implies perfect quality of institutions.

Let's first look at the *y* sector, where by using backward induction, I determine the cutoff level of γ that an individual must possess in order to work in the *x* industry. The level of γ is exogenous in my model. However, I can determine that if the early level of education of an individual is lower that the cutoff level, then she will seek employment in the *y* sector. Otherwise, she will seek employment in the *x* sector. An individual operating in the *y* sector with skill level q, endowed with *t* units of training and who provides *a* productive and *d* unproductive efforts has homothetic preferences generated by the indirect utility $V_y = Rpa - \frac{1}{2t}(a^2 + d^2) - \frac{1}{2q}t^2 - \frac{1}{3\gamma}q^3$. Her optimal effort levels are $a = Rpt$. This indicates that the optimal levels of effort in this sector are a monotonically increasing function of the levels of training. Thus, the indirect utility function with optimal efforts in the agriculture sector is given by

$$V_y = \frac{1}{2}(Rp)^2 t - \frac{1}{2q}t^2 - \frac{1}{3\gamma}q^3 \tag{5}$$

In the fourth stage, I determine the optimal level of efforts exerted form individuals working in the agriculture sector subject to their skill levels, which are $t = \frac{1}{2}(Rp)^2 q$. The optimal levels of training of an individual working in the *y* sector are a linearly increasing function of her skill levels. Hence, the indirect utility function with optimal training of an individual working in the agriculture sector is

$$V_y = \frac{1}{8}(Rp)^4 q - \frac{1}{3\gamma}q^3 \tag{6}$$

I skip the third stage in the agriculture sector since there is no team production in this sector. In order to analyze the second and the first stage, I first should find the optimal skill levels in the industrial sector.

Let's assume that a manager endowed with t_m units of training, who provides a_m productive and d_m unproductive efforts, pairs up with a worker endowed with t_w units of training, who provides a_w productive and d_w unproductive efforts. They produce an efficient outcome by choosing their productive and unproductive effort to maximize the sum of their indirect utilities

$V_x = RI_x - \frac{1}{2t_m}(a_m^2 + d_m^2) - \frac{1}{2t_w}(a_w^2 + d_w^2) - \frac{1}{2q_m}t_m^2 - \frac{1}{2q_w}t_w^2.$

In the fifth stage, I find the optimal level of efforts exerted by individuals working in the industrial sector subject to their training and skill levels.[5] The indirect utility of a worker is

$V_w = RI_w - \frac{1}{2t_w}(a_w^2 + d_w^2) - \frac{1}{2q_w}t_w^2$. The indirect utility of a manager is

$V_m = RI_m - \frac{1}{2t_m}(a_m^2 + d_m^2) - \frac{1}{2q_m}t_m^2.$

The income of a worker is $I_w = wK$, where w represents the wage of a worker, which is derived from the matching process, and K represents the contract. Equation (4) now can be equal to a simpler contract design $K = a_w$ since $\theta = 1$. Hence, the income of a worker is $I_w = wa_w$. Substituting this in the indirect utility of a worker, I find her optimal productive and unproductive effort levels, which are $a_w = Rwt_w$ and $d_w = 0$. The optimal unproductive effort levels for the worker are equal to zero since her efforts are perfectly observed and verified from the manager. The optimal effort levels of a worker are strictly increasing in her wage and in her training levels. Consequently, the indirect utility of a worker with optimal effort levels is

$V_w = \frac{1}{2}(Rw)^2 t_w - \frac{t_w^2}{2q_w}.$

The income of a manager is equal to the profits (π) of the firm that she is operating. The profit function is represented by $\pi = x - wa_w = 2\sqrt{a_w a_m} - wa_w$. Substituting this in the indirect utility of a manager, I find her optimal productive and unproductive effort levels, which are $a_m = Rw^{\frac{1}{3}} t_m^{\frac{2}{3}} t_w^{\frac{1}{3}}$ and $d_m = 0$. It should be obvious that the manager will exert zero

[5] Here, I do not include individual's utility cost of acquiring skill which is related to her early education level, for presentation convenience only $\left(-\frac{1}{3\gamma}q^3\right)$. I do include this portion, however, in equation 9, where I solve for the equilibrium level of skills.

unproductive effort levels since she maximizes her profits. The manager's optimal efforts levels are strictly increasing in her training levels, worker's training levels and wage. Consequently, the indirect utility of a manager with optimal effort levels is $V_m = R^2 w^{\frac{2}{3}} t_m^{\frac{1}{3}} t_w^{\frac{2}{3}} - R^2 w^2 t_w - \frac{t_m^2}{2q_m}$.

In the fourth stage, I find the optimal level of training obtained from individuals working in the industrial sector subject to their skill levels. Using the indirect utility of a worker with optimal training, I establish the optimal training level of a worker that is $t_w = \frac{1}{2}(Rw)^2 q_w$. The optimal level of training for a worker is strictly increasing in her wage and her skill level. In a similar way, using the indirect utility of a manager with optimal training, I find that the optimal training level of a manager is $t_m = \frac{1}{2} R^2 w^{\frac{6}{5}} q_m^{\frac{2}{5}} q_w^{\frac{3}{5}}$. The optimal level of training for a manager is increasing in the wage, her skill level and workers skill level.

In the third stage, the optimal production team is chosen by the managers and the workers. The manager supplies the optimal efficient wage to the worker and then the worker decides on accepting the efficient wage subject to her and her manager's skill level. A manager maximizes her profits subject to her optimal levels of effort and training, worker's efficient wage and optimal levels of effort and training. Thus, the manager is maximizing her profits on her post skill indirect utility $\Lambda_m = R\pi - \frac{a_m^2}{2t_m} - \frac{t_m^2}{2q_m}$ by designing an efficient wage that corresponds to her optimal levels of skills. A worker maximizes her income levels by accepting an efficient wage that corresponds to her optimal level of skill. Thus, the worker is optimizing her income on her optimal post skill indirect utility $\Lambda_w = Ra_w w - \frac{a_w^2}{2t_w} - \frac{t_w^2}{2q_w}$. Let's denote with Λ the total post skilled level utility derived from matching a manager with skill level q_m with a worker with skill level q_w. This is described by $\Lambda = \frac{7}{6} R\sqrt{a_w a_m} - \frac{1}{2t_m}(a_m^2 + d_m^2) - \frac{1}{2t_w}(a_w^2 + d_w^2)$.

After I substitute the optimal efforts, and training levels in the above equation, I determine the equilibrium, efficient wage, which is $w = \left(\frac{q_m}{q_w}\right)^{\frac{1}{8}}$ for each unit of effort exerted from the manager and the worker. Therefore, the aggregate post utility level with efficient wage is

$$\Lambda = \frac{1}{12} R^4 \sqrt{q_m q_w} \tag{7}$$

Therefore, each member of the team is maximizing (7) by choosing the right partner, where the worker's and manager's levels of effort and training are known perfectly and verified in this labor market. Hence, it is optimal for each manager to match with a worker who obtains the same skill level $q_m = q_w$.[6]

In the third stage, individuals choose the optimal amount of training. Thus, the indirect utility of an individual with optimal levels of effort and training and efficient wage is given by

$$V_x = \frac{1}{8} R^4 q \tag{8}$$

Now, I am ready to proceed with the second stage, where I find the optimal choice of individuals' decisions on the selection of the industry where they will seek employment. I assumed that in a country there are only two sectors. The indirect utility of an individual working in the agriculture sector must be equal to the indirect utility of an individual working in the industrial sector in a closed economy. Therefore, $V_y = V_x = V = \frac{1}{8}(Rp)^4 q = \frac{1}{8} R^4 q \Rightarrow p = 1$. Consequently, in autarky, the relative price of the agriculture good is equal to its return on technology, which is equal to unity by the design of the agriculture production function. So, each individual is indifferent as to what sector in which she will seek employment.

[6] This result is efficient because it satisfies the assumption of complementary in the production process. This assumption is related to the property of the supermodularity of the post training indirect utility described in (7). Mathematically, this property is satisfied because $\frac{\partial^2 \Lambda}{\partial q_m \partial q_w} > 0 \; \forall \; q_m, q_w > 0$.

In stage 1, I assume that the skill level depends on the early education levels (γ) and on the degree of perfectibility of institutions (θ) of a country. Here, I find the threshold level of γ, which is defined as $\gamma \in [\gamma_{min}, \gamma_{max}]\ \forall\, \gamma > 0$. When $p = 1$, the indirect utility of an individual working in the industrial sector with optimal levels of training is $V_x = \frac{1}{8} R^4 q_x$. After endogenizing the skill levels as described above, the indirect utility of an individual working in the industrial sector, with optimal training levels, can now be written as

$$V_x = \frac{1}{8} R^4 q_x - \frac{1}{3\gamma} q_x^3 \tag{9}$$

Individuals before making the decision on the selection of the sector in which they will seek employment, choose the amount of skill level they want to achieve, subject to their early education levels. Hence, all individuals working in the industrial sector maximize $V_x(q, \gamma)$ over their choice of q_x. The optimal level of skill as a function of early education is $q_x = \frac{1}{2\sqrt{2}} R^2 \sqrt{\gamma}$, which shows that the optimal skill level of each individual is a concave function of her early education level. Substituting the optimal skills in the indirect utility of equation (9), I obtain the following indirect utility of an individual, working in the industrial level, with optimal skills

$$V_x = \frac{1}{3 \cdot 2^{7/2}} R^6 \sqrt{\gamma} \tag{10}$$

The indirect utility of an individual working in the agriculture sector, with optimal training levels, now can be written as

$$V_y = \frac{1}{8} (Rp)^4 q_y - \frac{1}{3\gamma} q_y^3 \tag{11}$$

In a similar way to the industrial sector, individuals in the agriculture sector maximize equation (10) over their choice of skill level. Thus, the optimal level of skills as a function of early education is $q_y = \frac{1}{2\sqrt{2}} (Rp)^2 \sqrt{\gamma}$. Substituting the optimal skills of an individual working in the x sector into the $V_y(q,\gamma)$ of equation (11), I can write the indirect utility of an individual, working in the agriculture sector, with optimal skills as

$$V_y = \frac{1}{3 \cdot 2^{7/2}}(Rp)^6\sqrt{\gamma} \tag{12}$$

Thus, the indirect utility with optimal skill levels of an individual working in the agriculture sector is concave in her skill levels. Equalizing the indirect utility of (10) with the indirect utility of (12) I can establish that $p = 1$. Therefore, in autarky, the relative price of the agriculture sector is equal to unity. Hence, the indirect utility of every individual in a country, with optimal skill levels, is: $V = \frac{1}{3 \cdot 2^{7/2}} R^6 \gamma \quad \forall \gamma > 0$. The indirect utility of an individual with optimal skill levels is a continuous and linear increasing function of early education levels.

In conclusion, in a two country model with perfect information, if a country has a relatively better early education system, ceteris paribus, it will not engage in international trade, even though it has a relatively more skilled labor force. This is related to the fact that the pattern of trade between these two countries is independent of the allocation of skills within each country. The engagement of a country to international trade follows the comparative advantage theory according to a simple Ricardian model for two countries that exhibit the same technologies. Therefore, the autarky relative price of both countries that share the same production technologies in the agriculture sector is identical and is not determined by the allocation of the skill levels within each country. As a result, these countries will produce the same amount of output in each sector as they did in autarky. The perfect labor contract model gives the same results as the Grossman's (2004) and Vogel's (2007) perfect institution models.

IV. Imperfect labor contracts

In this section, in the industrial sector, worker effort levels are not observable and verifiable. The same stands for the output of the firms in the industrial sector. Therefore, it is difficult to base the contract directly on the firm's output and workers' effort and distortion levels because it is difficult for a court to measure the above due to the assumption of imperfect information. However, the firm's manager is able to measure the level of a worker's performance that is partially related to her efforts. As a result, because of the imperfect monitoring, the managers offer contracts as described by the equations (4). Thus, the degree of labor contract perfectibility is proxied by the degree of the quality of the institutions. With imperfect contracts, the higher the quality of institutions (θ), the higher the effort levels (a_w) put by a worker in the team production process because the higher the verifiability of unproductive effort levels of the same worker in the industrial sector. On the other hand, every individual working in the agriculture sector is a capital owner and has no incentives whatsoever to exert any positive level of unproductive efforts in her production process. Consequently, with imperfect labor contracts, the analysis of the last four stages is exactly the same as the analysis with perfect labor markets in the agriculture sector. This is not the case for the industrial sector. Below I examine the five stages of the industrial sector with imperfect information.

Stage 5. The decisions on productive and unproductive effort levels

An individual working in *x* sector, who is endowed with t_i units of training and who obtains q_i level of skills has homothetic preferences that are generated by the indirect utility[7]

$$V_x = RI_x^i - \frac{1}{2t_m}(a_m^2 + d_m^2) - \frac{1}{2t_w}(a_w^2 + d_w^2) - \frac{1}{2q_m}t_m^2 - \frac{1}{2q_w}t_w^2.$$

[7] To keep the model as simple and as presentable as possible I do not include agent's utility cost of acquiring skill. However, it can be shown that the results remain unchanged if I write the indirect utility as:

$$V_x = RI_x^i - \frac{1}{2t_m}(a_m^2 + d_m^2) - \frac{1}{2t_w}(a_w^2 + d_w^2) - \frac{1}{2q_m}t_m^2 - \frac{1}{2q_w}t_w^2 - \frac{1}{3\gamma_m}q_m^3 - \frac{1}{3\gamma_w}q_w^3$$

However, in equation *23*, I include individual's utility cost of acquiring skill, in order to find the equilibrium level of skills for individuals that seek employment in the *x* sector.

With imperfect information the manager's profits are described by the following profit function $\Pi = x - w\left[a_w + \left(\frac{e^{1-\theta}-1}{q_m}\right)d_w\right]$. Hence, a manager matched with a worker has homothetic preferences described by the following indirect utility

$$V_m = R\left\{x - w\left[a_w + \left(\frac{e^{1-\theta}-1}{q_m}\right)d_w\right]\right\} - \frac{1}{2t_m}(a_m^2 + d_m^2) - \frac{1}{2q_m}t_m^2.$$

On the other hand, a worker matched with a manager has homothetic preferences described by the following indirect utility

$$V_w = Rw\left[a_w + \left(\frac{e^{1-\theta}-1}{q_m}\right)d_w\right] - \frac{1}{2t_w}(a_w^2 + d_w^2) - \frac{1}{2q_w}t_w^2.$$

The manager and the worker choose the optimal levels of productive and unproductive effort by maximizing the above indirect utilities. The optimal unproductive effort levels for the manager are equal to zero $d_m = 0$ because she maximizes firm's profits. The optimal unproductive effort levels for the worker are $d_w = Rwt_w\frac{e^{1-\theta}-1}{q_m}$, which shows that higher levels of institutional quality and more skilled managers increases the verifiability of workers' performance giving them an incentive to reduce their unproductive effort levels.

The optimal productive effort levels for a worker are $a_w = Rwt_w$ which indicates that they are a monotonically increasing function of the levels of her training and her efficient wage. It makes sense for a worker to exert higher productive effort levels when her income is higher because she might be afraid of losing her job. Moreover, when a worker is better trained it is easier for her to provide higher levels of productive effort.

The optimal effort levels for a manager are $a_m = R(wt_w)^{\frac{1}{3}}t_m^{\frac{2}{3}}$. Thus, the higher the wage and training levels of the worker, or/and the manager, the higher the effort levels exerted by the manager of the firm. Substituting, the optimal distortion and effort levels of a worker into her indirect utility function, I obtain the indirect utility with optimal distortion and effort levels, for a worker who is employed in the industrial sector. This is represented by the following equation

$$V_w = \frac{1}{2}(Rw)^2 t_w \left[1 + \left(\frac{e^{1-\theta} - 1}{q_m}\right)^2\right] - \frac{t_w^2}{q_w} \tag{13}$$

In an analogous way, the indirect utility with optimal distortion and effort levels for a manager who is employed in the industrial sector can be described by

$$V_m = \frac{3}{2}R^2 t_m^{\frac{1}{3}}(wt_w)^{\frac{2}{3}} - (Rw)^2 t_w \left[1 + \left(\frac{e^{1-\theta} - 1}{q_m}\right)^2\right] - \frac{t_m^2}{q_m} \tag{14}$$

Stage 4. The decisions on training levels

Workers maximize (13) over the choice of their training. Thus, the optimal level of training for a worker is $t_w = \frac{1}{2}(Rw)^2 q_w \left[1 + \left(\frac{e^{1-\theta}-1}{q_m}\right)^2\right]$. Therefore, the most skilled workers obtain the highest levels of optimal job training. This is related to the fact that it is easier for the more skilled workers to invest more in their job training choices. Managers maximize equation (14) over the choice of their training. Hence, the optimal level of training for a manager is $t_m = \frac{1}{2}R^2 w^{\frac{6}{5}}(q_m^3 q_w^2)^{\frac{1}{5}}\left[1 + \left(\frac{e^{1-\theta}-1}{q_m}\right)^2\right]^{\frac{2}{5}}$. Substituting worker's optimal training level into (13) I obtain the indirect utility of a worker

$$V_w = \frac{1}{8}(Rw)^4 q_w \left[1 + \left(\frac{e^{1-\theta} - 1}{q_m}\right)^2\right]^2 \tag{15}$$

In an analogous way, the indirect utility of a manager, with optimal training levels is

$$V_m = \frac{5}{8}R^4 w^{\frac{12}{5}} q_m^{\frac{1}{5}} q_w^{\frac{4}{5}} \left[1 + \left(\frac{e^{1-\theta} - 1}{q_m}\right)^2\right]^{\frac{4}{5}} - \frac{1}{2}(Rw)^4 q_w \left[1 + \left(\frac{e^{1-\theta} - 1}{q_m}\right)^2\right]^2 \tag{16}$$

Stage 3. The choice of matching

The manager presents the wage to the worker after observing the worker's levels of training and the worker decides on whether to accept it by focusing on the manager's training levels. Since, there is imperfect information on the labor contract market, the optimal contract that a manager offers to a worker is related to a country's institutional quality and her training levels. A manager (worker) maximizes her profits (income) by designing (accepting) such a contract that corresponds to her levels of training, subject to the quality of institutions that exist in a country. Qualitatively, I maximize the aggregate post training utilities of a worker and a manager who work together in a team. Therefore, the indirect utility is given by

$$\Lambda = \frac{5}{24} R^4 w^{\frac{12}{5}} q_m^{\frac{1}{5}} q_w^{\frac{4}{5}} \Psi^{-\frac{4}{5}} - \frac{1}{8}(Rw)^4 q_w \, \Psi^{-2} \tag{17}$$

I follow the work of Vogel (2007) and define $\Psi \equiv \left[\frac{q_m^2}{q_m^2 + \left(e^{1-\theta} - 1\right)^2}\right]$, where Ψ shows the quality of the monitoring ability of a manager with skills q_m in a country with institutional quality level θ. Therefore, the higher the quality of institutions in a country, the higher the quality of the monitoring ability of a manager. Maximizing equation (17) over the wage, I find

$$w = \left(\frac{q_m}{q_w}\right)^{\frac{1}{8}} \Psi^{\frac{3}{4}} \tag{18}$$

The wage in a country with imperfect labor contracts is related positively to the manager's quality performance measure and to her skill level, but is negatively related to the skill level of the worker who works with a manager in the same firm. Substituting the wage of equation (18) into equation (17) I get the aggregate post training utilities of a worker matched with a manager under the optimal wage, which is given by

$$\Lambda(t_i) = \frac{1}{12} R^4 \Psi \sqrt{q_m \, q_w} \tag{19}$$

Each member of a production team is maximizing equation (19) by choosing the right partner, where the worker's and manager's levels of effort cannot be perfectly verified. However, both members of the team have perfect information on their skill levels, on the quality of the measure performance of the manager, and on a country's institutional quality. Using equation (19), I find that it is optimal for each manager to match with a worker who obtains the same level of skills $q_m = q_w = q$.[8] Consequently, the wage after the efficient matching process is $w = \Psi^{\frac{3}{4}}$. Equalizing the indirect utility of a worker with that of a manager implies that their skill levels also must be identical after the efficient matching process. Substituting the manager's and worker's levels of training and skill, after the choice of the efficient matching, into equations (15) and (16), I obtain the indirect utility function of an individual, with optimal productive and unproductive effort, and training levels after the establishment of the efficient wage

$$V_x = V_m = V_w = \frac{1}{8} R^2 \Psi q \qquad (20)$$

From the above indirect utility one can observe that each individual gets a higher level of satisfaction for higher quality levels of the measure of manager's performance, which in turn depends on the quality levels of the country's institutions. In particular, the better institutions a country has, the higher the level of satisfaction of the individuals working in the *x* sector.

Stage 2. The choice over industry

In this stage I equate the indirect utility of an individual working in *y* sector with that of an individual working in *x* sector. Combining equation (6) with equation (20) implies that an individual is indifferent when choosing the sector only if the following is satisfied

[8] This result is efficient because it satisfies the assumption of complementary in the production process. This assumption is related to the property of the supermodularity of the post training indirect utility described in equation (19). Mathematically, the property of supermodularity is satisfied in the post training indirect utility because $\frac{\partial^2 \Lambda(q_i)}{\partial q_m \partial q_w} > 0 \; \forall \; q_m, q_w > 0$. It shows that in a firm a manager and a worker have identical skill levels.

$$V_y = V_x = V = \frac{1}{8}(Rp)^4 q = V_x(q) = \frac{1}{8}R^4\Psi \mathrm{q} \quad (21)$$

This implies that $p = \Psi^{\frac{1}{4}} \neq 1$. Thus, with imperfect information, in autarky, the relative price of y is related positively to the manager's quality performance level, which in turn is positively related to the quality levels of the country's institutions. Equations (6) and (20) also reveal that the indirect utility with optimal training for an individual working in the agriculture sector is linearly increasing with her skill levels, while the indirect utility with optimal training for an individual working in the industrial sector is increasing in her skill level. Moreover, (6) and (16) show that the indirect utility of an individual working in the agriculture sector is independent of a country's institutional quality. On the other hand, the indirect utility for an individual working in the industrial sector is increasing in the quality of the performance measure of a manager and in a country's institutional quality.

Stage 1. The choice over skill level

In the previous section, I showed that the indirect utility with optimal skill levels of an individual working in the agriculture sector is concave in her skill levels. In this stage, I find the cutoff level of γ. In order to do so, I first must find the optimal level of early education for individuals working in the industrial sector.

The choice over skill level in the industrial sector

In the industrial sector, an individual who obtains γ early level of education before deciding on working on the industrial sector, optimizes her levels of skill subject to her levels of early education represented by the following indirect utility

$$V_x = \frac{1}{8}R^4\Psi q_x - \frac{q_x^3}{3\gamma} \quad (22)$$

The above indirect utility is constructed by the use of equation (20) and by endogenizing the levels of skill. Individuals in x maximize (22) over their choice of q. The optimal skill level of individuals that will choose the industrial sector is determined implicitly by the following

$$1 = \frac{1}{8} R^4 \frac{q_x^2 + 3\left(e^{1-\theta} - 1\right)^2}{[q_x^2 + (e^{1-\theta} - 1)^2]^2} \gamma \tag{23}$$

As in the case of the agriculture sector, the higher the level of early education in a country, the higher the optimal skill levels of individuals who will work in the industrial sector. However, there exists a positive relationship between the skill levels and country's institutional quality or/and its early educational levels.[9]

Substituting the optimal levels of skill of equation (23) into equation (22) I obtain the indirect utility of an individual in the industrial sector with optimal skill levels. This is given by

$$V_x = \frac{1}{12} R^4 \Psi^2 q_x \tag{24}$$

Hence, the higher the levels of skill an individual working in the industrial sector possesses, or the better institutions a country has, or the higher the ability of the performance measure of a manager, the higher the individual's level of satisfaction.

The determination of the threshold level of early education

Combining equation (12) with equation (24) implies that the cutoff level of early education is achieved only when $V_y = V_x = \frac{1}{2^{11/2}} (pR)^6 \sqrt{\gamma} = \frac{1}{12} R^4 \Psi^2 q_x$, which in turn, implies that $p = \left\{ \frac{\Psi^3 \left[q_x^2 + 3\left(e^{1-\theta} - 1\right)^2 \right]}{\left[q_x^2 + \left(e^{1-\theta} - 1\right)^2 \right]^2} \right\}^{\frac{1}{12}}$. Thus, with imperfect information, in autarky, the relative price of

[9] It can be shown that $\frac{\partial q_x}{\partial \gamma} > 0$, which implies that in the industrial sector, individuals who obtain high levels of early education will obtain high levels of skills or more able individuals are those who obtained high levels of early education.

y is related positively to the manager's quality performance level, and to a country's institutional quality. I summarize the above results with the use of the following three propositions.

Proposition 1. *In a closed economy with* $\theta \in [0,1)$ *there exists a* $\gamma^* \in [\gamma_{min}, \gamma_{max}]$*, such that individuals join the industrial sector, if and only if* $\gamma > \gamma^*$.

The intuition behind proposition 1 is related to the fact that under imperfect information all individuals have to make a choice on how much skill they will obtain, even before making the choice of the industry in which they will seek employment. As indicated in equations (23) and (20), the higher the individuals' early education levels, the higher their optimal skill levels for each industry. The reason behind such a positive relationship has to do with the existence of different incentives of individuals for skill accumulation. Thus, individuals who have higher levels of early education have higher incentives for skill accumulation because it is relatively easier for them to obtain more skills than individuals who possess lower early levels of education. In few words, a country with a better early education system also will have a more skilled labor force. Consequently, individuals who possess relatively high levels of early education will join the industrial sector. This is because it is more effective for high skilled workers to put high effort levels in the production function and consequently low distortion levels. Therefore, they optimize by working in the industrial sector. Thus, with an imperfect labor contract market, in a closed economy that obtains a labor force with more skilled workers, there are more individuals working in the industrial sector than in the agriculture sector.

Since there is a positive relationship between individuals' skill levels and their early education levels independent of their choice over industry, there must exist a unique early level of education threshold. Individuals who possess higher levels of early education than the threshold level will enter into the industrial sector. The uniqueness of γ^* is determined by the relationships of optimal skill levels and early education level as represented in equations (23) and (20). Then, corollary 1 follows.

Corollary 1: *The following inequalities hold: i)* $\frac{\partial \gamma^*}{\partial \theta} < 0$; *and ii)* $\frac{\partial \gamma^*}{\partial \Psi} < 0$.

The intuition behind the first part of corollary 1 is related to the fact that better institutions will increase the incentives of individuals to join the industrial sector since V_x is increasing in the quality of institutions, but V_y is independent of the institutional quality [see equations (12), (23) and (24)]. Following the same logic, the second part of the above corollary shows that better institutions also will increase the quality of performance measure of a manager in the industrial sector. Therefore more individuals will enter into the industrial sector.

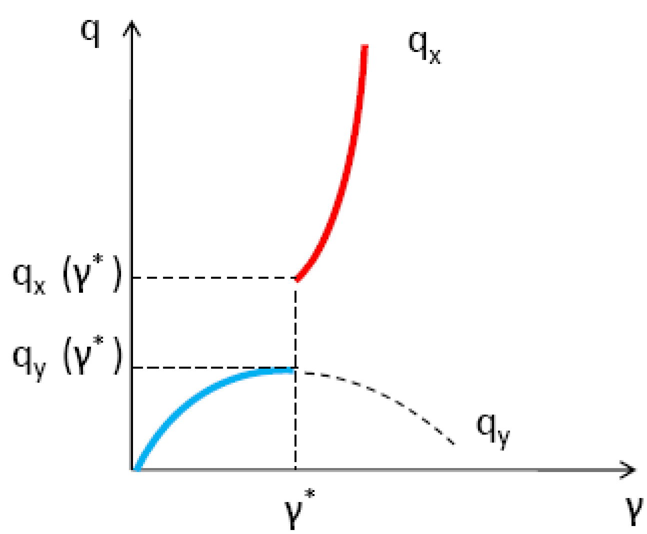
From proposition 1, we know that individuals who obtain relatively high level of skills optimize their efforts by working in the industrial sectors, while less skilled individuals optimize their effort by working in the agriculture sector. However, the more skilled individuals are those with relatively high early educational levels. Therefore, all individuals with higher levels of early education than the threshold level of early education will accumulate relatively high levels of skills and they will work in the industrial sector. To clarify this result and to give the intuition on the incentives of individuals who enter in the industrial sector, I proceed with proposition 2.

Proposition 2. *In a closed economy with imperfect labor contracts' market*:

1) $\forall \gamma \geq \gamma^*,\ q_x(\gamma)$ *is convex in* γ;
2) $\forall \gamma \geq \gamma^*,\ q_x(\gamma) > q_y(\gamma)$;
3) $\forall \gamma \geq \gamma^*,\ t_i(\gamma) > t_y(\gamma), where\ i \equiv [w, m]$.

Part 1 and 2 of proposition 2 show that in a closed economy with imperfect institutions, any individual with an initial level of education greater than the threshold level of utility (γ^*) accumulates a higher level of skills if she enters into the industrial sector as compared with her level of skills if she were to enter into the agriculture sector. In my model, this statement is obvious because an individual's level of skills is a strictly convex function of her early educational levels for all individuals who enter into the industrial sector, X, while it is a concave function of her early educational level for all individuals who enter into the agriculture sector, Y. I illustrate the statements of part 1) and 2) of proposition 2 with the help of figure 2, where in the vertical axes I plot the values of all individuals' levels of skills [$q_i(\gamma^*)$] as a function of their initial educational level (γ). An individual optimizes her utility, and therefore enters into the agriculture sector only if her initial educational level is strictly smaller than the threshold level, and enters into the industrial sector if her initial educational level is equal or greater than the threshold level. As one can observe from figure 2, there is a jump point in levels of skills right at the threshold level of utility. The red curve represents the q_x function for all $\gamma \geq \gamma^*$ and the blue curve illustrates q_y function for all $\gamma \geq \gamma^*$, where $\theta \in [0,1)$ and $\gamma^* \in [\gamma_{min}, \gamma_{max}]$.

Figure 2. Skill level as a function of early educational level



Part 3) of proposition 2 states that each individual with more or equal early educational levels than the threshold level (γ^*) is more talented if she entered into the industrial sector than

she would have been had she entered the agriculture sector. For all individuals training is a linear function of their skill level. However, as stated in part 1) and 2) of proposition 2, an individual's level of skill is a strictly convex function in her early educational level for all individuals (with $\gamma \geq \gamma^*$) who join the industrial sector, while it is a strictly concave function in her early educational level for all individuals (with $\gamma < \gamma^*$) who join the agriculture sector.

Proposition 3. *In a closed economy with $\theta \in [0,1)$, the income of an individual who works in the industrial sector always is strictly higher than the income of an individual who works in the agriculture sector for all $\gamma > \gamma^*$.*

Proposition 3 states that individuals who obtain an equal or greater early educational level than the threshold level are strictly richer at any point in their life if they enter into the industrial sector than they would have been had they entered the agriculture sector.[10] Individuals in the industrial sector are more talented because they receive more job training. Thus, their utility is equal or higher in the industrial sector as compared to that of the agriculture sector, while their utility cost of obtaining skills, and therefore, of training is strictly higher in the industrial sector. Thus, their income also must be strictly greater in the industrial sector.

V. The effects of international trade in two large economies

In this section, I associate the existence of a trade pattern with the differences on the distribution of skills in the labor force of each country. The allocation of skills in the labor force of a country is determined by the distribution of the early education levels that individuals possess, and by its institutional quality. Focusing on these two exogenous variables, I am able to determine which country exports what, in a world that consists of two large countries.

[10] This is valid under the assumption that, in a closed economy, every individual's wealth consists of her current income all of which is spent on the consumption of industrial and agriculture goods, *x* and *y*. Also assume that there is no borrowing and no unemployment and an individual's source of income comes only from her firm's profits if she runs a firm or from her wage if she works in the industrial sector.

I assume that there are two countries, a developed Country (*H*), and a developing country (*O*), that have two sectors each, an agriculture sector and an industrial sector.[11] Also, suppose that these two countries are exactly the same in all aspects except the quality of their institutions and the distribution of their citizens' early education levels. Consequently, there exists a difference in the distribution of skill levels between the two countries.

Let's first assume that country *H* has institutions of identical quality, but more individuals with higher levels of early education as compared to country *O*. The latter is related to the fact that *H* offers a better early educational system than *O*. If the two countries decide to engage in free trade, I shall be able to determine the distribution of skills of their labor force within each sector, and therefore, predict the pattern of trade. For convenience, suppose that after trade each country is incompletely specialized in the production of both goods. Then, proposition 4 follows.

Proposition 4. *In a developed country [developing country] with imperfect information* $\theta < 1$, *where* $\theta^j = \theta$ *and* $j \equiv (O, H)$, *there exists a unique* $(\gamma^*)^H$, $[(\gamma^*)^O]$, *such that individuals enter into the industrial sector if and only if*

1) $\gamma^H > (\gamma^*)^H$, $[\gamma^O > (\gamma^*)^O]$. *Consequently, the assumption that* $\gamma^H > \gamma^O$ *implies that the following inequalities are always true:*

2) $(\gamma^*)^H < (\gamma^*)^O \; \forall \, \gamma^j > 0$

3) $(\gamma^*)^O \geq \gamma_{min} and \; (\gamma^*)^H \leq \gamma_{max}$.

Proposition 4 concludes that country *H* will export the industrial good to country *O* in exchange for imports of the agriculture good from country *O*. The main implication of proposition 4 is that it considers the early education system of a country as a unique, independent source of comparative advantage.

[11]The reason for denoting *O* as the developing country and *H* as the developed country is related to the intuition of the next section, where "*O*" stands for the origin country of immigrants and "*H*" stands for the host country of immigrants.

Let us now assume that H and O differ only on the quality level of their institutions. In the remainder of this section I examine the effects of institutional differences on international trade that takes place between two large economies. Thus, proposition 5 follows.

Proposition 5. *In a developed country [developing country] with imperfect information $\theta < 1$, where $\gamma^j = \gamma$, there exists a unique $(\gamma^*)^H$, $[(\gamma^*)^O]$, such that individuals enter into the industrial sector if and only if*

1) $\gamma^H > (\gamma^*)^H$, $[\gamma^O > (\gamma^*)^O]$. *Thus, the assumption that $\theta^H > \theta^O$ implies that the following inequalities are always true:*

2) $(\gamma^*)^H < (\gamma^*)^O \; \forall \, \gamma^j > 0$

3) $(\gamma^*)^O \geq \gamma_{min} and \; (\gamma^*)^H \leq \gamma_{max}$.

The intuition behind proposition 5 is analogous to that of proposition 4. The only difference between these propositions lies in the source of a country's comparative advantage. The determination of such a comparative advantage for each country is accompanied with the following corollary.

Corollary 2. *In a free trade world that consists of two large economies, with $\theta < 1$, where $\gamma^j = \gamma$ and $\theta^H > \theta^O$, the following inequalities always are true:*

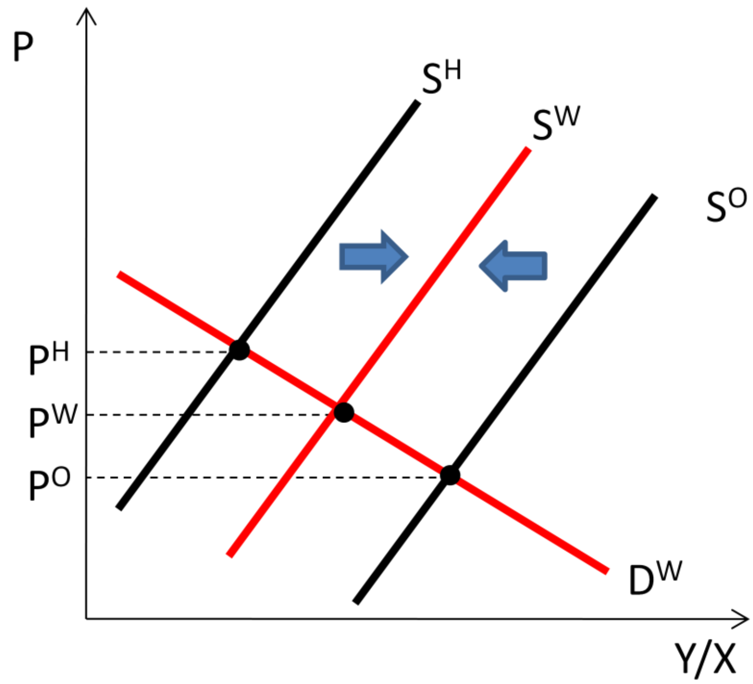
1) $q_x(\gamma)^H > q_x(\gamma)^O \;\; \forall \gamma > (\gamma^*)^H$

2) $t_x(\gamma)^H > t_x(\gamma)^O \;\; \forall \gamma > (\gamma^*)^H$

3) $I_x(\gamma)^H > I_x(\gamma)^O \;\; \forall \gamma > (\gamma^*)^H$

The main implication of proposition 5 is that it considers the quality of a country's institutions as an independent source of comparative advantage. Country H will export the industrial good as a result of having a labor force that consists of more talented individuals (as compared to country O). This is related to the fact that country H has better institutions as compared with country O. This fact gives more incentives to individuals of country *H* to accumulate more skills, and seek employment into the industrial sector. Thus, they obtain higher levels of job training and therefore become more talented in order to gain higher income levels.

Figure 3. World equilibrium under free trade



I illustrate this situation in figure 3. In the vertical axes, I plot the values of the relative price of the agriculture good, and in the horizontal axes I plot the values of the production of the agriculture good in terms of the industrial good. Since I assumed that each individual in each country has identical and homothetic preferences, then the relative demand line must be the same for both countries. But, if I consider both countries as closed economies, then there exists two different relative supply curves. The relative supply curve of the *O* country is higher than that of the *H* country because the labor force of *O* consists of less talented workers than *H*. Therefore, RS^O lies in the right of RS^H. Consequently, the relative autarky price of the agriculture good in *O* is lower than that of the agriculture good in H. According to proposition 4 and 5, *O* is exporting the agriculture good to *H* and importing the industrial good from H. Hence, the world relative supply curve is to the right of RS^H and to the left of RS^O. Thus, the world relative price of the agriculture good should be higher than the relative autarky price of the agriculture good in *O* and lower than the relative autarky price of the agriculture good in *H*.

In summary, both propositions described in this section indicate that in a free trade world, a country that has a better early educational system and better institutions exports the industrial good and imports the agriculture good.

VI. The effects of emigration in two large economies

In this section, I investigate the pattern of labor movements in a free trade world that consists of two large economies with imperfect labor contracts. I associate the individual's decision to emigrate with her income difference, subject to her skill level, which exists between her country of origin and the host country of immigrants. I assume that there exist certain fixed costs of migration, such as language and culture barriers. The fixed costs are the same for each individual who decides to move permanently from one country to the other. Let us assume that there are no illegal immigrants in any country. Skills are considered perfectly substitutable among individuals who obtain the exact same level of skills, but are citizens of different countries. Suppose that these two countries are the same in all aspects except the quality of their institutions and the distribution of their citizens' early education levels.

Let's first assume that country *H* has better institutions than country *O*, but has identical system of early education. Consequently, in a free trade world according to proposition 5, *H* will export the industrial good to *O* and *O* will export the agriculture good to *H*. If the two countries decide to engage in a free movement of their respective labor force, I am able to predict the pattern of immigration. Then, proposition 6 can be established as follows

Proposition 6. *Under international free movements of labor:*

1) In country $j \equiv (O, H)$ *with* $\theta < 1$*, where* $\gamma^j = \gamma$ *and* $\theta^H > \theta^O$*, there exists a unique* $(\gamma^*)^j$*, such that individuals enter into the x sector if and only if* $\gamma^j > (\gamma^*)^j$*.*

2) $(\gamma^*)^O \geq \gamma_{min}$ *and* $(\gamma^*)^H \leq \gamma_{max}$*.*

3) $(\gamma^*)^H < (\gamma^*)^O \;\; \forall \gamma^j > 0$ *and* $I_x(\gamma)^H > I_x(\gamma)^O \;\; \forall \gamma > \gamma^*$*.*

4) H will be the host country of immigrants and O will be the origin country of immigrants only if there exists a $\tilde{\gamma} > \gamma^*$ *such that* $I_x(\gamma)^H > [I_x(\gamma)^O - c] \; \forall \gamma > \tilde{\gamma}$ *, where* $c \equiv$ *costs of immigration.*

Part 1), 2) and 3) of proposition 6 replicate proposition 5 and corollary 2 but for open labor markets. Proposition 6 reinforces the fact that considers institutions of a country as an independent source of comparative advantage. Label $\tilde{\gamma}$ as the migration threshold level. The main implication of proposition 6 is related to part 4) that states that early educational system acts as an independent source of the establishment of the direction of the labor movement. The intuition is that Country *H* will continue to export the industrial good as a result of having an even larger labor force that consists of more talented individuals than country *O*, which means that country *H* has better institutions than country *O*. Thus, individuals of country *H* have more incentive for skill accumulation, and therefore, they seek employment into the industrial sector; as a result they become more talented in order to gain higher income levels. Hence, individuals who have the exact same level of skills but work in different countries obtain different levels of income. Since the quality of institutions in a closed economy is not related to the income of individuals who work in the agriculture sector, their income will be the same independent of their firm's location. Consequently, there will be no migration of any individual who works in the agriculture sector. On the other hand, an individual who works in the industrial sector in country *H* obtains a higher income than an individual who works in the same sector in country *O* despite the fact that they have the same level of skills. Therefore, all individuals of *O* with early educational levels (γ) greater than the migration threshold level $(\tilde{\gamma})$ have an incentive to move to *H* because of the difference in income. This is described by proposition 7.

Proposition 7. *In a world that consists of two large economies with free movement of goods and labor, and with* $\theta < 1$, *where* $\gamma^j = \gamma$ *and* $\theta^H > \theta^O$.

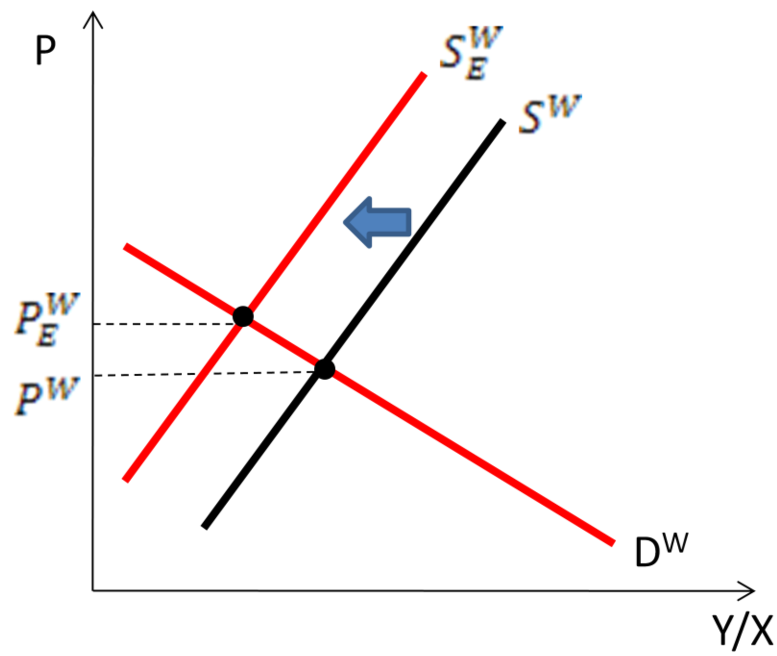
1) *Only the most talented individuals of country O will immigrate in country H.*

2) *There exists a* $\bar{\gamma}$ *that corresponds to a* $\bar{c}$ *such that it provides incentive to some individuals, with* $\tilde{\gamma} < \gamma^O < (\gamma^*)^O$, *from O to immigrate in H in order to enter into the industrial sector. These individuals would never have entered into the industrial sector if immigration was prohibited in H.*

Part 2) of proposition 7 states that because country *H* has better institutions, the income of an individual who works in the industrial sector in *H* is strictly higher than the income of an individual who possesses an identical skill level to the former and who works in the industrial sector in *O*. Thus, such an individual of country *O* has an incentive to immigrate in *H* only if her difference of income because of immigration exceeds the cost of immigration. This is the same intuition as in proposition 6, but with a new ingredient in the mix, the human capital accumulation. With the opening of the labor markets, there will be an increase in production of the industrial good because some individuals from *O* [those with $\tilde{\gamma} < \gamma^O < (\gamma^*)^O$] will immigrate in *H* and enter into the industrial sector.

Since, there is an increase in the production of the industrial good in the world, then the world relative price of the agriculture good will increase, which in turn will increase the income of the individuals who enter into the agriculture sector independent of their job location. I illustrate the part 2) of proposition 7 in figure 4, where I borrow the world relative demand and supply from figure 3. Thus, the world relative price of the agriculture good in a world with free movement of goods is represented by p^W. According to proposition 7, in a world with free movements of goods and labor, the number of talented individuals will increase, implying a boost in the production of the industrial good. Hence, the world relative supply curve should shift to the left of RS^W, in $(p,\ Y/X)$ space, when I move in a free international labor market. Consequently, since the world relative demand does not change, the world relative price of the agriculture good should be higher than before. This is indicated by $(p_E^W > p^W)$ in my graph. Thus, another important implication of proposition 7 is the fact that, through the price effect, immigration increases the income of individuals who work in the agriculture sector.

Figure 4. World equilibrium under free movement of goods and labor



Let us consider the case where country *H* has identical quality level of institutions, but obtains more individuals with higher levels of early education as compared to country *O* because *H* offers a better early educational system than *O*. Therefore, in a free trade world according to proposition 4, *H* exports the industrial good to *O* and imports the agriculture good from *O*. If both countries decide to engage in a free movement of their respective labor force, I am able to predict the pattern of immigration. In this case, there will be no individual who will have an incentive to immigrate. The intuition is related to the fact that there are no differences in income among individuals with identical skill levels who work in different locations of the industrial sector because institutional qualities are the same in both countries. Thus, there will be no movement of labor between both countries when they operate in a free movement of labor world despite the fact that *H* has a better system of early education than *O*.

Let us consider a third scenario where *H* has better institutions and a better early educational system than O. In such a case, the quality of early educational system in O, the quality of institutions in H, and the costs of immigration play crucial roles on the volume of immigrants, on the human capital accumulation, and on the income of individuals who work in the agriculture sector. Let us assume that the government of the developing country is concerned only about the income of the majority of its citizens. Also assume that the cost of improving the quality of its institutions is strictly higher than the cost of improving its early educational system. According to this scenario, the government of *O* can use the improvement of her early educational system as a mechanism in order to promote the human capital accumulation through emigration in a world of free movement of goods and labor, where immigration costs are low enough. Thus, corollary 3 follows.

Corollary 3. *In a world that consists of two large economies with free movement of goods and labor, and $\theta < 1$, where $\gamma^H > \gamma^O$ and $\theta^H > \theta^O$, the government of O ameliorates the income of* *most of its labor force by improving its system of early education since the latter will encourage more emigration of its citizens towards H.*

Corollary 3 states that a government of a developing country can promote the development of more talented individuals in the world simply by improving the quality of its early educational system. The lower the costs of immigration (c), or/and the higher the difference of the quality of institutions between the two countries $(\theta^H - \theta^O)$, the more talented individuals will emigrate from *O* towards *H*. This will increase the intensity of human capital accumulation in the world, and also increase the efficiency of the government of *O* in achieving its goal. In other words, the improvement of the early educational system will increase the relative price of the agriculture good, increasing the income of all individuals that work in the agriculture sector. Since *O* is exporting the agriculture good, most of its labor force will enjoy higher income as a result of the emigration of its most talented individuals towards *H*.

It should be obvious to the reader that corollary 3 fails to hold in the case of small open economies, since the price of each good will not be affected by trade or immigration. Thus, in such a case the improvement of the early educational system in the origin country of immigrants only will increase the volume of its emigrants for sufficient low immigration costs and will not affect the income of the individuals who work in the agriculture sector. Consequently, in this scenario, the only way for the government of the origin country to ameliorate the income of its citizens is to encourage the development of its institutions.

VII. Conclusions

In this paper, I have analyzed a simple general equilibrium model with imperfect labor contracts, between two large economies that have two sectors. In the industrial sector, there exist only firms that produce an industrial good through a team production process. In the agriculture sector, there exist only firms that consist of one employer, the owner, and that produce an agriculture good. The heart of my study lies in the determinants of skill distribution in the labor force of each country. In my model the distribution of skills is endogenously determined by each individual subject to her early educational level and a country's institutional quality.

I have described individuals' decisions on their level of skills, and therefore, on their choice of the sector where they will seek employment, by developing a five-stage game similar to the four-stage game developed in Vogel (2007). I have shown that the most talented individuals prefer to work in the industrial sector, where the most talented workers match with the most talented managers in the team production process. The most talented individuals have higher incentives to seek employment in the industrial sector because there they gain a higher level of income subject to their skill level. The remaining individuals with less talent join the agriculture sector.

Countries differ in their distribution of their labor force since their early educational system and institutions have different quality levels. It is shown that in a free trade world, the country with the best system of early education, or/and quality of institutions, obtains a labor force that consists mainly of talented individuals. Consequently, it exports the industrial good and imports the agriculture good.

In a two large economies world with free movements of goods and labor, it is shown that the country which exports the industrial good is the host country, while the country that exports the agriculture good is the origin country of immigrants. Also I have demonstrated that only the most talented individuals prefer to emigrate towards the host country because there they capture higher incomes to their level of skill, if they can afford the fixed costs of immigration.

Finally, I have shown that the economic progress of the origin country of immigrants is related to its ability to improve its quality of institutions in order to prevent its most talented individuals from emigrating. I have also described a scenario where the government of the origin country can promote the development of more talented individuals in the world simply by improving the quality of its early educational system. The latter is shown to increase the intensity of human capital accumulation in the world because of immigration. This in turn, causes a raise in the relative price of the agriculture good, therefore increasing the income of all individuals who work in the agriculture sector. Thus, since the host country is exporting the agriculture good, most of its labor force will enjoy higher income as a result of the emigration of its most talented individuals towards the host country of immigrants. Consequently, it is argued that immigration influences the individuals' income via an indirect effect on their incentive to invest in their skill level and a direct effect on the goods' prices.

It is fair to admit that my model has certain limitations that are related with some of my assumptions. For instance, in my model the efficient matching process that concludes that the most talented worker pairs up with the most talented individual relies on the assumption of complementarities in the production of the industrial good consistent with Kremer's O-Ring theory of production (Kremer, 1993). Thus, a possible extension of the model is to solve the five stage game developed here under the assumption of substitutabilities in the production of the industrial good. Under this assumption it might be optimal for the most talented managers to pair up with the least talented workers in the efficient matching process. Another possible interesting extension of the model is to include certain spillover effects associated with the availability of the most talented individuals in a country.

Appendix A

In this appendix we provide the proof of Proposition 1 and Corollary 1.

Proof of Proposition 1:

Proposition one is proven in two steps. In the first step, I show that if there exists a $\gamma^* \in [\gamma_{min}, \gamma_{max}]$, where $V_x(\gamma^*) = V_y(\gamma^*)$, then this γ^* is unique. In the second step, I prove the existence of γ^*.

Step 1.

Let's assume that γ^* exists. From equation 24 we know that $V_x(\gamma) = \frac{1}{12} R^4 \Psi^2 q_x$ and from equation 12 we know that $V_y(\gamma) = \frac{1}{3 \cdot 2^{7/2}} (Rp)^6 \sqrt{\gamma}$. When $V_x(\gamma^*) = V_y(\gamma^*)$, there exists a γ^*, such that for any $\gamma > \gamma^*$, $V_x(\gamma^*) \geq V_y(\gamma^*)$, this γ^* is unique.

With the help of equations 12 and 24, $V_x(\gamma^*) \geq V_y(\gamma^*)$ can be written as $2^{3/2}\Psi^2 q_x \geq R^2 p^6 \sqrt{\gamma}$

We can write the optimal skill level of an individual working in the industrial sector as

$q_x = \frac{1}{2^{3/2}} R^2 \sqrt{\Psi\gamma \frac{q_x^2 + 3\left(e^{1-\theta} - 1\right)^2}{\left[q_x^2 + \left(e^{1-\theta} - 1\right)^2\right]^2}}$. This expression is determined from the skill level first-order condition for utility maximization in the case of an individual who works in the industrial sector. Substituting this into the above inequality we obtain

$$\Psi^{\frac{5}{2}} \sqrt{\frac{q_x^2 + (e^{1-\theta} - 1)^2}{[q_x^2 + (e^{1-\theta} - 1)^2]^2}} \geq p^6 \qquad (A-1)$$

Let $L \equiv \Psi^{\frac{5}{2}} \sqrt{\frac{q_x^2 + 3\left(e^{1-\theta} - 1\right)^2}{\left[q_x^2 + \left(e^{1-\theta} - 1\right)^2\right]^2}}$ $, and\ D \equiv p^6$. Then, $\frac{\partial L}{\partial \gamma} > 0\ and\ \frac{\partial D}{\partial \gamma} = 0$. This implies that the left hand side of A-1 is increasing in the early educational levels, while the right hand side of A-1 is constant in the early educational levels. Thus, γ^* is unique.

Step 2.

Here I start with the proof of $\gamma^* \leq \gamma_{max}$Let's assume that $\gamma^* > \gamma_{max}$. In terms of A-1, this implies that $V_x(\gamma_{max}) > V_y(\gamma_{max})\ \forall\ \gamma^* \in [\gamma_{min},\ \gamma_{max}]$. This indicates that no individual will be employed in the industrial sector, which implies that the relative price of the agriculture good approaches zero ($p \to 0$). This implies that $\gamma^* < \gamma_{max}$. But, this contradicts our assumption that $\gamma^* > \gamma_{max}$. Hence, $\gamma^* \leq \gamma_{max}$. In an analogous way, one can show that $\gamma^* > \gamma_{min}$.

Proof of Corollary 1.

In order to prove both parts of corollary one we must find an expression for γ^*. From the proof of proposition one, we know that $V_x(\gamma^*) = V_y(\gamma^*)$ can be written as: $2^{3/2}\Psi^2 q_x = R^2 p^6 \sqrt{\gamma}$. We also know that $q_x = \frac{1}{8} R^4 q_x \frac{q_x^2 + 3\left(e^{1-\theta} - 1\right)^2}{\left[q_x^2 + \left(e^{1-\theta} - 1\right)^2\right]^2} \gamma$ from 23. Substituting this into $V_x(\gamma^*) = V_y(\gamma^*)$ and rearranging it, we obtain:

$$\gamma^* = 8\left(\frac{p^3}{R\Psi}\right)^4 \frac{1}{q_x^2} \frac{\left[q_x^2 + \left(e^{1-\theta} - 1\right)^2\right]^4}{[q_x^2 + (e^{1-\theta} - 1)^2]^2} \qquad (A-2)$$

i) $\frac{\partial \gamma^*}{\partial \theta} = -\left\{\left(\frac{2p^3}{R\Psi}\right)^4 \frac{e^{1-\theta}\left(e^{1-\theta} - 1\right)}{q_x^{10}} \frac{\left[q_x^2 + 9\left(e^{1-\theta} - 1\right)^2\right]\left[q_x^2 + \left(e^{1-\theta} - 1\right)^2\right]^7}{\left[q_x^2 + 3\left(e^{1-\theta} - 1\right)^2\right]^2}\right\} < 0 \ \ \forall \theta \in [0,1)$

ii) $\frac{\partial \gamma^*}{\partial \Psi} = -\left\{32\left(\frac{p^3}{R\Psi}\right)^4 \frac{1}{\Psi} \frac{1}{q_x^2}\right\} < 0 \ \ \forall \theta \in [0,1)$.

Appendix B

Proof of Proposition 2.

I prove part one and part two of proposition two with the help of two lemmas. Then part three of proposition two follows.

Lemma 1. $\forall \theta \in [0,1) \exists\ \gamma(\theta)$ *where* q_x *is convex in* γ *if and only if* $\gamma > \gamma(\theta)$.

Lemma 2.

1) $\exists\, \gamma_0 \in [\gamma_{min},\ \gamma_{max}]$*, such that* $q_x(\gamma_0) = q_y(\gamma_0)$

2) $\forall \theta \in [0,1)$ *the following inequality is always valid:* $\gamma_0 < \gamma^*$

Proof of Lemma 1.

We know from 23 that $q_x = \frac{1}{8} R^4 q_x \frac{q_x^2 + 3\left(e^{1-\theta} - 1\right)^2}{\left[q_x^2 + \left(e^{1-\theta} - 1\right)^2\right]^2} \gamma$. Dividing both sides with q_x we get

$f(q_x, \gamma) \equiv 1 = \frac{1}{8} R^4 \frac{q_x^2 + 3\left(e^{1-\theta} - 1\right)^2}{\left[q_x^2 + \left(e^{1-\theta} - 1\right)^2\right]^2} \gamma$. From the implicit theorem, we know that $\frac{\partial q_x}{\partial \gamma} = -\frac{\partial f / \partial \gamma}{\partial f / \partial q_x}$.

$\frac{\partial f}{\partial \gamma} = \frac{1}{8} R^4 \frac{q_x^2 + 3\left(e^{1-\theta} - 1\right)^2}{\left[q_x^2 + \left(e^{1-\theta} - 1\right)^2\right]^2}$ *and* $\frac{\partial f}{\partial q_x} = -\frac{1}{4} R^4 q_x \frac{q_x^2 + 5\left(e^{1-\theta} - 1\right)^2}{\left[q_x^2 + \left(e^{1-\theta} - 1\right)^2\right]^3} \gamma$. This implies that

$$\frac{\partial q_x}{\partial \gamma} = \frac{q_x^4 + 4 q_x^2 \left(e^{1-\theta} - 1\right)^2 + 3\left(e^{1-\theta} - 1\right)^4}{q_x \left(q_x^2 + 5(e^{1-\theta} - 1)^2\right)} \frac{1}{2\gamma} > 0$$

This shows that the optimal skill level of an individual working in the industrial sector is increasing in her early educational level $\forall \theta \in [0,1)$.

Let $g(q_x, \gamma) \equiv 0 = \frac{q_x^4 + 4 q_x^2 \left(e^{1-\theta} - 1\right)^2 + 3\left(e^{1-\theta} - 1\right)^4}{q_x \left(q_x^2 + 5\left(e^{1-\theta} - 1\right)^2\right)} \frac{1}{2\gamma} - A$ where A is a constant.

Then using the help of the implicit theorem, I can obtain the following $\frac{\partial^2 q_x}{\partial \gamma^2} = -\frac{\partial g / \partial \gamma}{\partial g / \partial q_x}$. So,

$\frac{\partial g}{\partial \gamma} = -\left\{\frac{q_x^4 + 4 q_x^2 \left(e^{1-\theta} - 1\right)^2 + 3\left(e^{1-\theta} - 1\right)^4}{q_x \left(q_x^2 + 5\left(e^{1-\theta} - 1\right)^2\right)} \frac{1}{2\gamma^2}\right\}$; $\frac{\partial g}{\partial q_x} = \frac{q_x^6 + 11 q_x^4 - 9 q_x^2 \left(e^{1-\theta} - 1\right)^2 - 15\left(e^{1-\theta} - 1\right)^4}{q_x^2 \left(q_x^2 + 5\left(e^{1-\theta} - 1\right)^2\right)^2} \frac{1}{2\gamma}$. Hence,

$$\frac{\partial^2 q_x}{\partial \gamma^2} = \frac{1}{2\gamma} \frac{q_x \left[q_x^4 + 4 q_x^2 \left(e^{1-\theta} - 1\right)^2 + 3\left(e^{1-\theta} - 1\right)^4\right] \left(q_x^2 + 5\left(e^{1-\theta} - 1\right)^2\right)}{q_x^6 + 11 q_x^4 - 9 q_x^2 (e^{1-\theta} - 1)^2 - 15 (e^{1-\theta} - 1)^4}$$

Hence, $\frac{\partial^2 q_x}{\partial \gamma^2} > 0$ only if $q_x > \gamma(\theta)$, and $\frac{\partial^2 q_x}{\partial \gamma^2} < 0$ only if $q_x < \gamma(\theta)$, where

$\gamma(\theta) \equiv \frac{(e^{1-\theta}-1)}{q_x}\sqrt{3\frac{3q_x^2+5(e^{1-\theta}-1)^2}{q_x^2+11(e^{1-\theta}-1)^2}}$; $\lim_{\theta\to 0}\frac{(e^{1-\theta}-1)}{q_x}\sqrt{3\frac{3q_x^2+5(e^{1-\theta}-1)^2}{q_x^2+11(e^{1-\theta}-1)^2}} = 0$; $\frac{\partial\gamma(\theta)}{\partial\theta} < 0$. In order to complete the proof of lemma 1, we have to show the existence of $\gamma(\theta)$. This is done by substituting $\gamma(\theta)$ into 23 and then putting it into 24. Therefore, $V_x[\gamma(\theta)]$ exists and is strictly higher than zero. Since, we know that the indirect utility with optimal skill levels is strictly convex in individual skill level, and since $\lim_{\theta\to 0}\gamma(\theta) = 0$; $\frac{\partial\gamma(\theta)}{\partial\theta} < 0$; $\frac{\partial q_x}{\partial\gamma} > 0$; $\frac{\partial^2 q_x}{\partial\gamma^2} > 0$ only if $\gamma > \gamma(\theta)$, while $\frac{\partial^2 q_x}{\partial\gamma^2} < 0$ only if $\gamma < \gamma(\theta)$, then q_x is strictly convex in γ $\forall\, \gamma > \gamma(\theta)$ and q_x is strictly concave in γ $\forall\, \gamma < \gamma(\theta)$.

Proof of Lemma 2

Let's start by proofing the second part of Lemma 2. Let's suppose that the first part of Lemma 2 is true. Then, $\exists\, \gamma_0 \in [\gamma_{min}, \gamma_{max}]$, *such that* $q_x(\gamma_0) = q_y(\gamma_0)$. From equation 23 we know the optimal skill level of an individual working in the industrial sector. We also know that the optimal skill level of an individual working in the agriculture sector is $q_y = \frac{1}{2\sqrt{2}}(Rp)^2\sqrt{\gamma}$.

Hence, from setting q_x equal with q_y, I can write γ_0 as $\gamma_0 = 8\left(\frac{p}{R}\right)^4 \frac{1}{q_x^2}\frac{\left[q_x^2+(e^{1-\theta}-1)^2\right]^4}{\left[q_x^2+3(e^{1-\theta}-1)^2\right]^2}$.

I know from equation A-2 (See the proof of Corollary one) that $\gamma^* = 8\left(\frac{p^3}{R\Psi}\right)^4 \frac{1}{q_x^2}\frac{\left[q_x^2+(e^{1-\theta}-1)^2\right]^4}{\left[q_x^2+3(e^{1-\theta}-1)^2\right]^2}$.

Therefore, substituting the values of γ_0 *and* γ^*, the inequality $\gamma_0 < \gamma^*$ is equivalent to $\Psi^{12} < p^6$.

From A-1, we know that at $\gamma = \gamma^* \Rightarrow p^6 = \Psi^{\frac{5}{2}}\sqrt{\frac{q_x^2+3(e^{1-\theta}-1)^2}{\left[q_x^2+(e^{1-\theta}-1)^2\right]^2}}$. Hence, $\Psi^{12} < p^6$ can be written as $\sqrt{\frac{q_x^2+3\left(e^{1-\theta}-1\right)^2}{\left[q_x^2+\left(e^{1-\theta}-1\right)^2\right]^2}} > \Psi^{\frac{19}{2}}$ or $\frac{q_x^2+3\left(e^{1-\theta}-1\right)^2}{\left[q_x^2+\left(e^{1-\theta}-1\right)^2\right]^2} > \Psi^{19}$. We know that $\Psi = \frac{q_x^2}{q_x^2+\left(e^{1-\theta}-1\right)^2}$ by definition. Thus, the above inequality is equivalent with the following inequality:

$$\frac{q_x^2 + 3\left(e^{1-\theta} - 1\right)^2}{[q_x^2 + (e^{1-\theta} - 1)^2]^2} > \frac{q_x^2}{q_x^2 + (e^{1-\theta} - 1)^2} \qquad (B-1)$$

B-1 is always valid since the left hand side is always higher than one, while the left hand side is always lower than one $\forall\theta \in [0,1)$. This concludes the proof of the second part of Lemma 2.

Let now prove the first part of Lemma 2. This proof consists of two steps. In the first step, I prove the uniqueness of γ_0, and in the second step we proof the existence of γ_0.

Step 1.

If there exists a $\gamma_0 \in [\gamma_{min}, \gamma_{max}]$, such that $q_x(\gamma_0) = q_y(\gamma_0)$, then γ_0 is unique. The inequality $q_x(\gamma_0) \geq q_y(\gamma_0)$ can be written as $\frac{1}{2^{3/2}} R^6 \sqrt{\Psi\gamma \frac{q_x^2+3\left(e^{1-\theta}-1\right)^2}{\left[q_x^2+\left(e^{1-\theta}-1\right)^2\right]^2}} \geq \frac{1}{2^{3/2}} (pR)^6 \sqrt{\gamma}$. The left hand side of the above inequality comes from skill level first-order condition of utility optimization of individuals working in the industrial sector. The right hand side of the above inequality is the optimal skill level of an individual working in the agriculture sector. The above inequality is equivalent with the following

$$\sqrt{\Psi \frac{q_x^2 + 3(e^{1-\theta} - 1)^2}{[q_x^2 + (e^{1-\theta} - 1)^2]^2}} \geq p^6 \qquad (B-2)$$

Let $L \equiv \sqrt{\Psi \frac{q_x^2+3\left(e^{1-\theta}-1\right)^2}{\left[q_x^2+\left(e^{1-\theta}-1\right)^2\right]^2}}$ and $D \equiv p^6$. Then, $\frac{\partial L}{\partial \gamma} > 0$ and $\frac{\partial D}{\partial \gamma} = 0$. This indicates that the left hand side of the inequality B-2 is increasing in γ, while the right hand side of B-2 is constant in γ. Consequently, γ_0 is unique.

In order to prove the existence of γ_0, let's assume that $\gamma^* < \gamma_{min}$. In terms of B-2, this implies that $q_x(\gamma_{min}) > q_y(\gamma_{min})\ \forall\ \gamma_0 \in [\gamma_{min},\ \gamma_{max}]$. Hence, no individual will invest to optimize her skills in the y sector. This shows that no individual will be employed in the agriculture sector, which implies that the relative price of the agriculture sector goes to infinity $(p \to \infty)$. This contradicts the assumption that $\gamma_0 < \gamma_{min}$. In an analogous way, one can show that $\gamma_0 < \gamma_{max}$.

Proof of the first and the second part of Proposition 2

Now, we are ready to provide t proof of part one and two of Proposition 2. We showed that, q_x is concave in γ only when $\gamma < \gamma(\theta)$. One can easily observe from the equation 23 that $\lim_{q_x \to 0} \frac{1}{8} R^4 q_x \frac{q_x^2 + 3\left(e^{1-\theta} - 1\right)^2}{\left[q_x^2 + \left(e^{1-\theta} - 1\right)^2\right]^2} \gamma = 0$. Hence, in the region where q_x is strictly concave in γ, q_x never intersects q_y. In Lemma 2, we showed the existence of γ_0 such that $q_x(\gamma_0) = q_y(\gamma_0)$. Thus, q_x must be convex in γ at γ_0. Moreover, we showed that q_x is convex in $\gamma\ \forall \gamma > \gamma_0$ Since, q_y is concave in $\gamma\ \forall \gamma > 0$, then $q_x > q_y\ \forall \gamma > \gamma_0$. We showed in the proof of the second part of Lemma 2 that $\gamma_0 < \gamma^*$. This implies that q_x is convex in $\gamma\ \forall \gamma > \gamma^*$ and $q_x > q_y\ \forall \gamma > \gamma^*$.

Proof of the third part of Proposition 2

We know that the optimal job training level of an individual working in the agriculture sector is linear to her skill level. The optimal training of an individual working in the industrial sector after the efficient matching process is strictly convex in her skill level. We can prove this by recalling that the optimal level of training for a worker is $t_w = \frac{1}{2}(Rw)^2 q_w \left[1 + \left(\frac{e^{1-\theta} - 1}{q_m}\right)^2\right]$. We also know that the wage after the efficient matching is $w = \Psi^{\frac{3}{4}}$ and that $q = q_y = q_x$. Hence the optimal level of training of a worker employed in the industrial sector is

$t_w = \frac{1}{2} R^2 \Psi^{\frac{3}{2}} q_x \left[1 + \left(\frac{e^{1-\theta} - 1}{q_x}\right)^2\right]$. One can easy show that $\frac{\partial t_w}{\partial q_x} > 0\ and\ \frac{\partial^2 t_w}{\partial q_x^2} > 0$.

Recall that the optimal level of training for a manager who operates her own firm in the industrial sector is equal to $t_m = \frac{1}{2} R^2 w^{\frac{6}{5}} (q_m^3 q_w^2)^{\frac{1}{5}} \left[1 + \left(\frac{e^{1-\theta}-1}{q_m}\right)^2\right]^{\frac{2}{5}}$. Using the same logic as we did in the above case of the worker, we can show that the optimal training of a manager running her own firm in the industrial sector after the efficient matching process is

$t_m = \frac{1}{2} R^2 \Psi^{\frac{8}{5}} \left[1 + \left(\frac{e^{1-\theta}-1}{q_x}\right)^2\right]^{\frac{2}{5}}$. Thus, $\frac{\partial t_m}{\partial q_x} > 0 \; and \; \frac{\partial^2 t_m}{\partial q_x^2} > 0$.

Hence, we know that t_x is strictly convex in q_x, while t_y is strictly linearly increasing in q_y. We proved in the first and second part of proposition two that $q_x > q_y \; \forall \gamma > \gamma^*$. Consequently, it is straightforward that $t_x > t_y \; \forall \gamma > \gamma^*$.

Appendix C

Proof of Proposition 3.

We have to prove that $I_x(\gamma) \geq I_y(\gamma) \; \forall \gamma > \gamma^*$. Let's first find $I_y(\gamma) \; and \; I_x(\gamma)$

In the agriculture sector we assumed that each firm consists of one individual. Therefore, in the agriculture sector, the income of each individual is equal to her firm's profit $I_y(a) = pa$. In the fifth stage, we found the optimal profits for a firm operating in the agriculture sector. Substituting the optimal effort levels as indicated in the fifth stage into $I_y(a)$ we obtain $I_y(t) = p^2 Rt$. In the fourth stage we found the optimal training levels of an individual working in the agriculture sector. Substituting it into $I_y(t)$, we obtain $I_y(q) = \frac{1}{2} p^4 R^3 q$. In the first stage we found the optimal skill level for an individual working in the agriculture sector. Substituting it into $I_y(q)$, we can obtain the income of an individual working in the agriculture sector

$$I_y(\gamma) = \frac{1}{4\sqrt{2}} p^6 R^5 \sqrt{\gamma} \qquad (C-1)$$

In the industrial sector we assumed that firms are created by an efficient matching process between workers and managers. We showed that a worker's income is determined from her wage as stated in the contract. Thus, the worker income is $I_w(a) = wK = w\left[a_w + \left(\frac{e^{1-\theta}-1}{q_m}\right)d_w\right]$. In the fifth stage, we found the optimal effort and distortion levels exerted from a worker employed in the industrial sector. Substituting the optimal effort and distortion levels as indicated in the fifth stage into $I_w(a)$ we obtain $I_w(t) = w^2Rt_w\left[1 + \left(\frac{e^{1-\theta}-1}{q_m}\right)^2\right]^2$. In the fourth stage, we determined the optimal level of training obtained by a worker employed in the industrial sector. Substituting it into $I_w(t)$ we obtain $I_w(q) = \frac{1}{2}R^3\Psi q_w$. In the third stage, we showed that the most skilled managers match with the most skilled workers creating firms. Hence, $q = q_w = q_m$. This implies that $I_w(q) = \frac{1}{2}R^3\Psi\mathrm{q}$. A manager's income is determined from the profits of her firm. Therefore, $I_m(a) = \pi = 2\sqrt{a_m a_w} - R^2\mathrm{wt_w}\Psi^{-1}$. Substituting the optimal effort, distortion and training levels for a manager who runs her own firm in the industrial sector (in a analogous way with the worker's case as described above), we can establish that the income of a manager with optimal skill levels after the efficient matching process is $I_m(q) = \frac{1}{2}R^3\Psi\mathrm{q}$. As one can easy observe, $I_w(q) = I_m(q) = I_x(q) = \frac{1}{2}R^3\Psi\mathrm{q}$. In the first stage we determined the optimal skill level of an individual working in the industrial sector. Substituting it into $I_x(q)$ we get

$$I_x(\gamma) = \frac{1}{16}R^7\Psi q_x \frac{q_x^2 + 3\left(e^{1-\theta}-1\right)^2}{[q_x^2 + (e^{1-\theta}-1)^2]^2}\gamma \qquad (C-2)$$

Thus, using C-1 and C-2 the inequality $I_x(\gamma) \geq I_y(\gamma)\ \forall\gamma > \gamma^*$ now can be written as

$$\gamma > 8\left(\frac{p^3}{\mathrm{R}}\right)^4\left(\frac{1}{\Psi q_x}\right)^2\frac{\left[q_x^2 + \left(e^{1-\theta}-1\right)^2\right]^4}{[q_x^2 + 3(e^{1-\theta}-1)^2]^2}$$

Since we need to show that the above inequality stands for all $\gamma > \gamma^*$, we can substitute γ^* from equation A-2 (see the proof of Corollary one).

Hence, $\left(\frac{1}{\Psi}\right)^2 > 1 \Rightarrow \frac{1}{\Psi} > 1 \Rightarrow 1 > \Psi \Rightarrow 1 > \frac{q_x^2}{q_x^2+\left(e^{1-\theta}-1\right)^2} \Rightarrow \left(e^{1-\theta}-1\right)^2 > 0.$

Appendix D

In this appendix, we provide the proof of propositions 4, 5 and Corollary 2.

Proof of Proposition 4.

The proof of uniqueness and existence of $(\gamma^*)^j$, is exactly the same as the proof of uniqueness and existence of γ^*in a closed economy of Proposition 1 (see the first and second steps of the proof of Proposition 1 in appendix A).

The proof of the second part of Proposition 4 is simple. $(\gamma^*)^H < (\gamma^*)^O$ since $\frac{\partial \gamma^*}{\partial q} < 0$ regardless of the country index (see equation A-2 in the proof of Corollary 1) . But, $\gamma^H > \gamma^O$, by assumption. This implies that $q^H > q^O \; \forall \gamma > (\gamma^*)^H$. The argument for the existence of the latter inequality comes directly from the first and second part of Proposition 2.

Proof of the third part of Proposition 5.

I start with the proof of the inequality $(\gamma^*)^O \geq \gamma_{min}$. Assume that $(\gamma^*)^O < \gamma_{min}$. In the above paragraph we proved that $(\gamma^*)^H < (\gamma^*)^O$. This implies that $(\gamma^*)^O < \gamma_{min}$ & $(\gamma^*)^H < (\gamma^*)^O$. But, if both $(\gamma^*)^H$ and $(\gamma^*)^O$ are strictly lower than γ_{min}, then no one enters into the agriculture sector, which implies that the relative price of the agriculture good (p) goes to infinity. Thus, $(\gamma^*)^H$ and $(\gamma^*)^O$must be strictly higher than γ_{min}. But we assumed that $(\gamma^*)^O < \gamma_{min}$. Consequently, $(\gamma^*)^O \geq \gamma_{min}$. In an analogous way $(\gamma^*)^H \leq \gamma_{max}$.

Proof of Proposition 5.

The proof of uniqueness and existence of $(\gamma^*)^j$, is analogous to γ^* (see Appendix A).

Proof of the second part of Proposition 5.

$(\gamma^*)^H < (\gamma^*)^O$ since $\frac{\partial \gamma^*}{\partial \theta} < 0$ regardless of the country index. But, we assumed that $\theta^H > \theta^O$. Hence, $(\gamma^*)^H < (\gamma^*)^O$. The proof of the third part of Proposition 5 is exactly the same as the one of the third part of proposition 7.

Proof of Corollary 2.

The proofs of all inequalities of Corollary 2 are exactly analogous with the proofs of Propositions 2 and 3 (see Appendix B and C).

Appendix E

In this appendix, we provide the proof of propositions 6, 7 and Corollary 3.

Proof of Proposition 6.

The proof of part 1 and 2 of Proposition 6 is analogous to that of Proposition 5, and the proof of part 3 of Proposition 6 is analogous to that of Corollary 2 (Appendix D).

The proof of part 4 of Proposition 6:

We drop the superscript (j) when necessary for notation simplicity. We first prove that γ^* exists. Then, we show that also $\exists \tilde{\gamma}$ such that $I_x(\tilde{\gamma})^H > [I_x(\tilde{\gamma})^O - c] \; \forall \gamma > \tilde{\gamma}$.

The proof of the existence of γ^*:

We know from Proposition 1 (see Appendix A) that $V_x(\gamma) \geq V_y(\gamma)$ only if:

$$\Psi^{\frac{5}{2}} \sqrt{\frac{q_x^2 + 3(e^{1-\theta} - 1)^2}{[q_x^2 + (e^{1-\theta} - 1)^2]^2}} \geq p^6 \qquad (E-1)$$

We also know that the left hand side of (E-1) is strictly increasing in γ and approaches zero when γ approaches zero, while the left hand side of (E-1) is constant when γ changes.

Let's suppose that γ^* does not exist. This implies that the right hand side of (E-1) is strictly higher than one. This implies that no one enters into the industrial sector in each country. Thus, the relative price of the agriculture good approaches zero. Hence, the right hand side of (E-1) is strictly less than one. This fact contradicts our assumption that $p > 1$. Thus, γ^* must exist.

Since γ^* exists, then according to Proposition 3 (see Appendix C) $I_x(\gamma)^H \geq I_x(\gamma)^O \; \forall\gamma > (\gamma^*)^O$.

Since γ^* exists, then $\tilde{\gamma}$ must also exist for low enough values of c.

We know that $I_x(\gamma)^H \geq I_x(\gamma)^O \; \forall\gamma > (\gamma^*)^O$. Since $V_x(\gamma)^j$ is positive, then there must exist a $\tilde{\gamma}$ such that for any positive value of c, $V_x(\tilde{\gamma})^H = [V_x(\tilde{\gamma})^O - c]$, where $\tilde{\gamma} > \gamma^*$. Consequently, $V_x(\gamma)^H > [V_x(\gamma)^O - c] \; \forall\gamma > \tilde{\gamma}$ From Proposition 3, $I_x(\gamma) \geq I_y(\gamma) \; \forall\gamma > \gamma^*$. Hence, there exists a $\tilde{\gamma}$ such that $I_x(\gamma)^H > [I_x(\gamma)^O - c] \; \forall\gamma > \tilde{\gamma}$ and $I_x(\gamma) \geq I_y(\gamma) \; \forall\gamma > \tilde{\gamma}$. Since country *H* is exporting *Y* and country *O* is exporting *X*, then the individuals who obtain the highest level of income are those who work in the industrial industry from *H*. Thus, the flow of labor movement will be from *O* to *H*.

Proof of Proposition 7.

Proof of part 1) of Proposition 7:

From Proposition 6, $I_x(\gamma)^H > [I_x(\gamma)^O - c] \; \forall\gamma > \tilde{\gamma}$ since $\theta^H > \theta^O$. Hence, only those individuals of *O* with $\gamma > \tilde{\gamma}$ have an incentive to seek employment in *H*. No one who works *y* has an incentive to emigrate in either country since $I_y(\gamma)^H = I_y(\gamma)^O \; \forall\gamma > 0$. This is related to the fact that $\frac{\partial (V_y)^j}{\partial \theta^j} = 0 \Rightarrow \frac{\partial (I_y)^j}{\partial \theta^j} = 0$. Therefore, only individuals who work in the industrial sector have an incentive to emigrate in *H* because $\frac{\partial (V_x)^j}{\partial \theta^j} > 0 \Rightarrow \frac{\partial (I_y)^j}{\partial \theta^j} > 0$. However, not all individuals of *O* that work or will seek employment in the industrial sector will emigrate to *H*. There would be some of them whose income difference because of immigration is lower than the fixed costs of immigration. These individuals will work in the industrial sector in *O*. The early education level of such individuals is $\gamma^* < \gamma^O < \tilde{\gamma}$. Hence, all individuals of *O* with $\gamma > \tilde{\gamma}$ will emigrate in *H*. These are the most talented individuals of *O* will choose to emigrate in *H* because $\frac{\partial \gamma}{\partial q_x} > 0 \Rightarrow \frac{\partial \gamma}{\partial t_x} > 0 \ \forall \gamma > \gamma^*$ and moreover $\forall \gamma > \tilde{\gamma}$.

Proof of part 2) of Proposition 7:

We know from part 3) of Proposition 6 that $(\gamma^*)^H < (\gamma^*)^O$. Thus, $\gamma^* < (\gamma^*)^O$. This in turn implies that $I_x(\gamma)^H > I_x(\gamma)^O \ \forall \gamma > \gamma^*$. Also from part 4) of Proposition 6, we know that $\gamma^* < \tilde{\gamma}$ and $I_x(\gamma)^H > [I_x(\gamma)^O - c] \ \forall \gamma > \tilde{\gamma}$. But, when c approaches zero then $I_x(\gamma)^H > I_x(\gamma)^O \ \forall \gamma > \gamma^*$, which also is true for $\forall (\gamma^*)^O$. Hence, there must exist a threshold $\bar{c}$, such that $I_x(\gamma)^H > [I_x(\gamma)^O - \bar{c}] \ \forall \gamma > \bar{\gamma}$, where $(\gamma^*)^O < \bar{\gamma} > \tilde{\gamma}$.

Proof of Corollary 3.

In Proposition 7 I showed that $I_x(\gamma)^H > [I_x(\gamma)^O - \bar{c}] \ \forall \gamma > \bar{\gamma}$. Then according to figure 4 the relative price of the agriculture good increases from the world increase in production of the industrial good because of emigration of individuals of *O*, with $\gamma > \tilde{\gamma}$, towards *H*. Assuming that the following inequality $\Psi^{\frac{5}{2}} \sqrt{\frac{q_x^2 + 3\beta^2 (e^{1-\theta} - 1)^2}{\left[q_x^2 + \beta^2 (e^{1-\theta} - 1)^2\right]^2}} \geq p^6$ is still valid after immigration, then $\frac{\partial I_y(\gamma)^j}{\partial p} > 0$ because $\frac{\partial V_y(\gamma)^j}{\partial p} > 0$. Since $I_y(\gamma)^j = I_y(\gamma)^H = I_y(\gamma)^O$ and most of the individuals who already work or seek employment in the agriculture sector are in O and no one of them has an incentive to emigrate in H, then their income will keep increasing as their government improves the early education system.

References

Abowd, J., Freeman R., 1991. Immigration, trade and the labor market. University of Chicago Press, Chicago.

Acemoglu, D., Antras, P., Helpman, E., 2007. Contracts and technology adaption. American Economic Review vol. 97 (no. 3), 916-943 June.

Acemoglu, D., Johnson, S., Robinson, J., 2001. Colonial origins of comparative development: an empirical investigation. American Economic Review vol. 91 (no. 5), 1369-140 December.

Acemoglu, D., Johnson, S., Robinson, J., 2002. Reversal of fortune: geography and institutions in the making of the modern world income distribution. Quarterly Journal of Economics vol. 117 (no. 4), 1231-1294 November.

Beine, M., Docquier, F., Rapoport, H., 2001. Brain drain and economic growth: theory and evidence. Journal of Development Economics vol. 64 (no. 1), 275-289 February.

Beine, M., Docquier, F., Rapoport, H., 2008. Brain drain and human capital formation in developing countries winners and losers. The Economic Journal vol. 118 (no. 528), 631-652 April.

Bhagwati, N., Hamada, K., 1974. The brain drain, international integration of markets for professionals and unemployment: a theoretical analysis. Journal of Development Economics 1 (1), 19-42 August.

Blanchard, O., Katz, L., 1992. Regional Evolutions. Brooking Papers on Economic Activity 1992 (1), 21-41.

Borjas, G., 1987. Self-selection and the earnings of immigrants. American Economic Review vol. 77 (no. 4), 531-553 September.

Borjas, G., 1992. National origin and the skills of immigrants in the postwar period. In: George J. Borjas and Richard B. Freeman, (Eds.), Immigration and the Workforce: Economic Consequences for the United States and Source Areas. University of Chicago Press, Chicago.

Borjas, G., 1993. Immigration policy, national origin, and immigrant skills: a comparison of Canada and the United States. In: David Card and Richard B. Freeman (Eds.), Small differences that matter: labor markets and income maintenance in Canada and the United States. University of Chicago Press, Chicago.

Costinot, A., 2009. On the origins of comparative advantage. Journal of International Economics vol. 77 (no. 2), 255-264 April.

Cunat, A., Melitz, M., 2007. Volatility, labor market flexibility and comparative advantage. NBER Working Paper No. 13062 April.

Di Maria, C., Stryszowski, P., 2009. Migration, human capital accumulation and economic development. Journal of Development Economics Vol. 90 (no. 2), 306-313 November.

Freeman, R., 1993. Immigration from poor to wealthy countries: Experience of the United States. European Economics Review 37 (2-3), 443-451.

Galor, O., Tsiddon, D., 1997. The distribution of human capital and economic growth. Journal of Economic Growth vol. 2 (no. 1), 93-124 March.

Grossman, G., 2004. The distribution of talent and the pattern and consequences of international trade. Journal of Political Economy vol. 112 (no. 1), 209-239 February.

Grossman, G., Maggi G., 2000. Diversity and trade. American Economic Review vol. 90 (no. 5), 1255-1275 December.

Hatton, T. J. and Williamson, J. G. (2005). Global Migration and the World Economy: Two Centuries of Policy and Performance. MIT Press, Cambridge.

Jensen, L., 1988. Patterns of immigration and public assistance utilization, 1970-1980. International Migration Review vol. 22 (no. 1), 51-83 Spring.

Kremer, M., 1993. The O-Ring theory of economic development. Quarterly Journal of Economics, vol. 108 (no. 3), 551-575 August.

Levchenko, A., 2007. Institutional quality and international trade. Review of Economic Studies vol. 74 (no. 3), 791-819 June.

Lucas, R., 1978. On the size distribution of business firms. Bell Journal of Economics vol. 9 (no. 2), 551-575 Autumn.

Lucas, R., 1988. On the mechanics of economic development. Journal of Monetary Economics vol. 22 (no. 1), 3-42 July.

Matsuyama, K., 2005. Credit market imperfections and patterns of international trade and capital flows. Journal of the European Economic Association 3 (2-3), 714-723.

Miyagiwa, K., 1991. Scale economics in education and the brain drain problem. International Economic Review vol. 32 (no. 3), 743-759 August.

Mountford, A., 1997. Can a brain drain be good for growth in the source economy? Journal of Development Economics vol. 53 (no. 2), 287-303 August.

Murphy, K., Shleifer, A., Vishny, R., 1991. The allocations of talent: implications for growth. The Quarterly Journal of Economics vol. 106 (no. 2), 503-530 May.

Nunn, N., 2007. Relation-specificity, incomplete contracts, and the pattern of trade. The Quarterly Journal of Economics vol. 112 (no. 2), 569-600 May.

Ohnsorge, F., Trefler, D., 2007. Sorting it out: international trade and protection with heterogeneous workers. Journal of Political Economy vol. 115 (no. 5), 868-892 October.

Rosen, S., 1981. The Economics of Superstars. American Economic Review vol. 71 (no. 5), 845-858 December.

Stark, O., Helmenstein, C., Prskawetz, A., 1997. A brain gain with a brain drain. Economics Letters vol. 55 (no. 2), 227-234 August.

Stark, O., Helmenstein, C., Prskawetz, A., 1998. Human capital formation, human capital depletion, and migration: a blessing or a "curse"? Economics Letters vol. 60 (no. 3), 363-267 September.

United Nations 2006. International Migration Levels, trends and policies. International Migration Report 2006: A global assessment. Part One.

Vidal, P., 1998. The effect of emigration on human capital formation. Journal of Population Economics vol. 11 (no. 4), 589-600 July.

Vogel, J., 2007. Institutions and moral hazard in open economies. Journal of International Economics vol. 71 (no. 2), 495-514 April.