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Mideksa, Torben

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Immigration, Wages, and Growth in the Host Nations[‡]

Torben K. Mideksa[§]

Abstract

This paper investigates the impact of skilled immigrants on the welfare the host natives. By employing the idea of induced technical change, and the skilled wage premium, this paper tries to link skilled immigration with observed rise in college enrolment, rise in skilled wages, and further acceleration of skilled wage premium. Through creation of demand for skill complimenting capital goods, skilled immigration raise the incentive for skill directed technical change which fuel up skilled wage in North, international wage differential, and the incentive for human capital formation. The results of the model are consistent with broad empirical regularities observed for three decades or more.

JEL Code: J61; J31; J41; O32; O41
Key Words: Skilled immigration; technical change; human capital; economic growth.

I. Introduction

International migration is an important phenomenon that affects the welfare of the sending and receiving countries. For a number of reasons, the economic performance of nations and respective factor payments differed very much across countries providing the incentive for people, goods, and resources to flow across countries. The magnitude of skilled workers' flow, from south to the western countries, has been increasing and has grabbed the attention of economists[1].

Economists have been interested in the issue for a number of reasons[2]. Some of the reasons are: strict control of international labor flow could be inefficient and reduce welfare. Moreover, the fact that the free market requires free flow of workers and it is essential to understand the dynamics from efficiency grounds. Further more, concerns relating to small rate of growth in developing countries and the importance of human capital as engine of growth lead economists to analyse its causes and effect on economic development, and the incentive for skill formation in sending countries. Some economists have also suggested that skilled immigration could help ameliorating the expected problem related to aging population and the sustainability of the welfare system.

Most of developed countries have a strict immigration controls in order to satisfy a number of political and social objectives. The objectives are related to the impacts of immigration on the welfare of the receiving natives that also have been subject of discussion[3]. For instance, the immediate impact of high volume of immigrants is to decrease the wage in the labor market, to raise the price of various commodities, and compete for different social services such as public transport, education, and health services. This effect has been a justification for many voters and politicians alike to impose strict restrictions. However, such restrictions are costly since the short run effects of immigration do not remain permanently. As firms adjust to the changes, wage increases due to increased demand for labor so as to meet the increased demand of consumption goods. As a result of demand induced rise in prices, producers also respond by expanding the outputs they produce over the long run to nullify the initial effect.

Empirical works have been less fruitful due to their failure to identify the short run and the long run effect in addition to the usual problems of simultaneity and measurement error. For instance, Borjas (2005) argued that excess skilled immigrants reduce the wage of skilled labor. However, the result has been challenged by Ottaviano and Peri (2006) and Peri (2006) who document the positive effect of immigrants on wage.

Efficiency considerations, in addition to the impact on wage, have also been important. According to Rodrik (2001) the price wedge of similar goods across countries is about two times but the wage gap of similarly qualified workers across countries is 10 folds or more. "*So the gains from liberalizing labor movements across countries are enormous, and much larger than the likely benefits from further liberalization in the traditional areas of goods and capital.*" The concern for efficiency has been largely neglected in international policy discussions due to the alleged negative impact of immigration on the natives; and, politicians in the north have little incentive to take short run painful measures that might possibly jeopardize their vote.

Moreover, the outflow of skilled professionals has been recognised as detrimental to the growth of sending countries. Bhagwati and Hamada (1974) saw outflow as "negative externality" on those left in the sending country. Ndulu (2004) analyzes the pattern of the flow of skilled professional from Africa. Collier, Hoefler, and Pattillo (2004) study human and physical capital flight out of Africa in the framework of portfolio decision. In line with standard theories of growth and development, many academicians and practitioners thought

that such outflow effectively reduces human capital and hence growth in the sending countries. However, recent research and evidence has resulted in some doubt on such theories.

In addition to efficiency based and growth based reasons, economists have also been interested in the issue due to the incentives it creates for the accumulation of skill in the south. Various authors report the possibility of beneficiary brain drain and point out that it has a positive effect for source, through higher incentive for skill formation[4]. Prospects for migration raise the expected return of skill accumulation thereby raising the proportion of the population that accumulates skill.

Concerns for public finance problem of the industrialized world lead Storesletten (2000) to use calibrated a general equilibrium model of overlapping generations to investigate the fiscal impact of skilled immigration. By giving due considerations for the differences of immigrants and natives ages and related characteristics, he argued that immigration of skilled professionals can sustain the fiscal policy problem associated with the baby boom generation. Storesletten (2003) also studied the effect of immigration on public finance accounts of Sweden.

The aim of this paper is to relate the broad empirical regularities to understand the effect of skilled immigrants on wage premium, human capital formation, and economic growth of the host nation. There are some attempts to address the issue, though not exactly like this paper. Barro and Sala-i-martin(2004) studied the impact of migration on per capita capital stock, speed of convergence, and economic growth using exogenous growth model while Kemnitz (2001) using the AK model. Lundborg and Segerstrom (2000) provide framework for international migration and economic growth *within* developed countries such as within the EU induced by trade and related policy distortions in a *similar developed countries* characterised by *free migration* policy but international trade barriers. This paper differs from Barro and Sala-i-martin(2004) and Kemnitz (2001) as it focuses on deliberate technical change as engine of immigration. It also differs from Lundborg and Segerstrom (2000) in two important respects. First, this paper focuses on costly immigration decision. Second, their mechanism is trade and policy distortions while ours is directed technical change. Hence, throughout this paper, the emphasis is how directed technical change and wage premium affect skilled immigration and human capital formation and affected by skilled immigration which is totally absent in the literature. Further more, this paper provides integrated

framework to understand the impact of costly immigration on directed technical change, growth, wage premium, and human capital formation in the host nations. To the best my knowledge, the hypothesis linking deliberate technical change and the impact of immigration on wage premium, human capital formation, and technical change has not been analysed so far.

This rest of the paper is organized as follows. Section two describes the broad empirical regularities related to immigration, wage premium, and human capital in the host nations. The research hypothesis and the mechanisms are also forwarded. Section three presents a simple framework to understand facts and the last section concludes.

II. Facts

This section presents the broad empirical patterns that have been observed during past decades. First I describe the share of immigrants in host nations and how strong impact they are likely to have. Next, I will briefly touch on the patterns of skill premiums which are observed in the literature followed by natives' college enrolment. Then, an attempt is made to link the pattern of wage premiums with pattern of high skill accumulation and skilled immigration using time series data.

Fact 1: *Skilled immigrants account sizable fraction of the labor force of the host nations.* Immigrants account large fraction of the labor force in many of the host countries. The share of foreign born individuals in the labor force of OECD country has been increasing since 1950s and currently it is expected to be large. For instance, Lalonde and Topel (1997) reported that in Australia, it was only 10% of the population that was foreign born in 1950 but in 1980 the share increased to 22%. In 1980 alone, for instance the share of foreign born individuals in Canada and US is 16% and 7% respectively. This is also the case in some European countries. For example the 45% of the labor force of Luxembourg is foreign workers[5].

According to Ndulu (2004), the share of immigrants is more than 20% of the labor force with both secondary and tertiary level of education in various OECD countries. As can also be seen from the table below, the educational profile of immigrants indicates that immigrants to Australia and Canada are more skilled than the natives on average compared to the US in 1980.

Table 1: Educational Attainment of natives and immigrants in US, Canada, and Australia in 1980[6]

	Australia	Canada	US
Natives	11.6	11.3	12.7
All immigrants	11.7	11.7	11.7
By area of birth			
Asia	12.9	13.6	14.6
Africa	13.1	14.0	15.3
Europe	11.4	10.9	12.1
Latin America	12.1	12.1	9.4

Source: Borjas (1991b: p. 64, Table 1.10).

The skill level immigrants and their country of origin vis-à-vis destination reported above have a pattern that has natural economic interpretation. The top, in terms of educational attainment, comes from continent of Africa, followed by Asia, Latin America, and Europe in all the three OECD countries of US, Australia, and Canada. Comparing the wage differential between the sending and the receiving countries, highest wage differential is observed in Africa, then Asia, followed by Latin America, and Europe which provides the strongest incentive according the wage differential.

Fact 2: *The skill premium has increased in western countries over the past three decades.* Hecker (1992) presents evidence of the sharp rise in skilled wage premium in US beginning from 1997(see Figure 1 in the appendix). Fruitful explanation of this pattern has been given by Daron Acemoglu in a number of productive research such as Acemoglu (1998), Acemoglu (2002a), Acemoglu (2002b), Acemoglu (2003), and recently well formalized in Acemoglu (2007).

Daron argues that technological progress is directed so that firms invent new technologies from which they are likely to obtain greater profit. Profits from new innovations are dependent on market size and prices. In the event where the market size effect dominates, innovators produce technologies that are biased towards the abundant factor, in this case skilled labor. As wage is proportional to technological progress, the wage of skilled workers

rises at a rate of biased technical progress which is greater than that of unskilled workers' and directed technical change explains the patterns of skill premiums observed in the data.

The greater gap between wage of skilled and less skilled workers has a number of implications. First and foremost, the wage differential between skilled workers at destination and host countries widens and skilled immigration is likely to accelerate following the rise in wage premiums in the host countries. Moreover, the proportion of natives who choose to accumulate skill increases as the return from accumulation of skill rises by greater rate compared to the return from not accumulating skill.

Fact 3: *The flow of skilled immigrants has increased over time and accelerated recently.* Figure2 shows that skilled migration, from different continents to USA, has been increasing overtime and sharply accelerated since 1980s. The variations in the intensity of migration can be explained by the affordable cost of mobility, which more or less proportional to per capita income of countries. For example, the reason for large numbers of migrants are from Latin America, mainly from Mexico, has to do with geographical proximity when compared with Asia and Sub-Saharan Africa. The Lowest intensity in Sub-Saharan Africa can also be accounted by the cost of mobility.

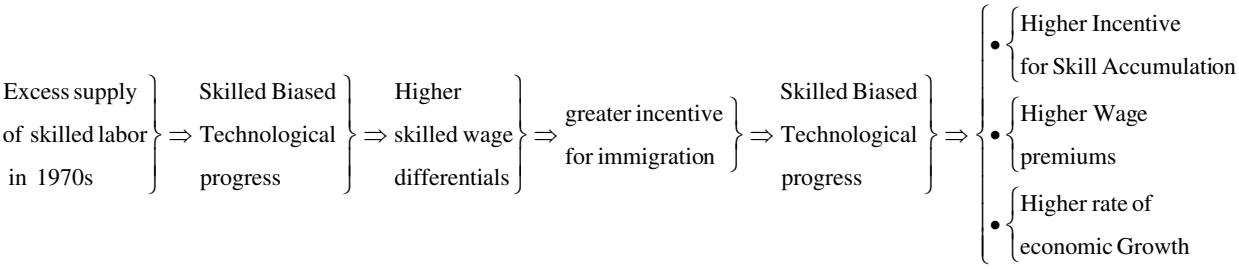
The same pattern is also consistent with the data reported in table -1. Since the recent rise in skill premiums have been observed in most industrialized countries, the wage differential increased by largest in Africa, then Asia, and then in Latin America. The least increase in wage differential is likely to occur between Europe and USA and hence one can see the educational attainment pattern reported in the above table.

Fact 4: *Following skilled immigration, the proportion of people who accumulate skill has increased.* Skilled immigration raises the skilled wage premium through induced technical change. Skilled wage premiums raises the returns to schooling as the simple model of schooling decision presented in section III implies that the proportion of individuals that accumulate skill increases. Recently, Murray (2007) reported that larger fraction of Americans are going to college[7]. More informative picture is shown by Figure-3. The graph is drawn using data from US census in 2000[8]. The data is also fitted using forth degree Spline. As can be observed from the fit, the proportion of high school graduates that choose to join

colleges and universities has sharply increased since 1979, the year at which the skilled wage premium has started to rise. See figure 3 for details.

These four broad patterns lead to the hypothesis that factor abundance lead wage premium which in turn raises the demand for the abundant factor which further attracts that factor from anywhere. Skilled immigration to the western world has been increasing after the World War II and it sharply increased in 1980s. The same time, skilled wage premium, and the supply of skilled workers has also increased.

The hypothesis of this paper is, therefore, the higher supply of skilled workers in US around 1970s has biased the technological progress which in turn has raised the wage differential between skilled workers in USA and abroad. As a result of greater wage differential, rational individuals who managed to cover the cost of mobility responded by migrating to USA which in turn has created further incentive for technical change to be skilled biased and raise the wage of skilled workers. The final consequence would be higher incentive for skill accumulation due to higher skilled wage premiums, and greater growth due to the availability of more input and concomitant involvement in production of final goods and innovation. The schematic form of the hypothesis of this paper is:



The hypothesis linking the supply of skilled workers to biased technical change has been in the literature and this paper further adds the implication for immigration and its consequences. The next section presents an integrated framework to analyse the hypothesis using the idea of horizontal innovations of intermediate capital goods along the theory of rational immigration and skill formation.

III. Simple Model

In order to analyse the implication of skilled migration for wage premiums, human capital formation, growth, and evolution of income in the North, a simple framework is presented. First, I analyse the decision to migrate by skilled workers in south. Once migration decision is

analysed, I investigate its implication for the long term macroeconomic variables within the framework of horizontal innovation described in Romer (1991).

Rational individuals make decision where to supply their labor service based on its net relative returns. Although, unlike goods and services, individuals have different preferences and costs for geographical mobility, basically goods and services, factors of production and labor follow the same fundamental economic principle, resources respond to incentives! Like any other factors of production, labor tends to flow to the areas where it obtains greater price for its services than otherwise. Thus, present values of income across different countries are among the key variable for individuals' mobility decision.

Focusing on skilled workers, it is assumed that workers face wage of $w(H^S)$ if they remain at source country and $w(H^N)$ at destination country. Let us suppose that a given labor get more return in north than south. There is some evidence of skill premium that is an incentive for skilled workers to migrate. Rodrik (2001) pointed out that the international wage premium for equally qualified people is about 10 times or so. Easterly and Levine (2001) document that skilled wages premium is 24 times between US and India. Such premium, for instance, could be due to property right problems as in Acemoglu, Robinson and Johnson (2001), variations in technical change as in Acemoglu and Zilibotti (2001), or lack of complimentary inputs as in Kremer (1993). Thus for a zero cost of travel, assuming that agent's utility is linear in their income, agents choose to supply their labour in the North than in south.

(1) $$w(H^S) < w(H^N)$$

For variety of reasons described earlier, it is frequently observed that most destination countries impose some form of regulation to control the quantity and the quality of labor flow. Such regulations raise the cost of mobility. Moreover, spatial mobility involves other costs. Let the cost of mobility, M has two components depending on the agents facing the cost. Let E be the component that is constant across all agents, for instance it includes immigration laws in the host country, transportation cost, while $M(\ell_i)$ is a component associated with an individual "i" which depends up on ℓ_i which is a set of individual specific factors such as family background, preference to dislocate, marital status, cultural attachment, etc . Without

loss of generality, the paper assumes that $\ell_i \sim f(\ell_i)$ where $f(\ell_i)$ is any density function which has the standard properties of piecewise continuity, monotonicity, and boundedness with cumulative density function of $F(\bullet)$. Thus the heterogeneity variable ranks cost of individuals in a systematic order. For illustrative simplicity, the domain is restricted to $\ell \in [0,1]$. Thus, the cost function is given by,

$$M = M(\ell_i) + E \,. \tag{2}$$

The additional cost of individual heterogeneity factor is assumed to be positive, $M'(\ell_i) > 0$ and it satisfies $\lim_{\ell_i \to 1} M'(\ell_i) = \infty$, $\lim_{\ell_i \to 0} M'(\ell_i) = 0$ and let the inverse of $M'(\bullet) = Q(\bullet)$. These assumptions on the cost function ensure interior optimal solution. It is also assumed that any individual that affords to pay the cost M can migrate to north without any additional requirement.

Suppose that the total skilled labor in south is H^s and grows exogenously at a rate of v. This is not a bad assumption. As the decision to accumulate skill is analysed in section three, it can be seen that the agents that accumulate are fixed proportion of population which is more or less grows exogenously. Individual skilled worker with ℓ_i decides to travel to north incurring cost if the present value of the sum of all future earnings in the north covers the present value of the sum of all earnings in south adjusted for the degree of diversion and cost of travel and vice versa.

However, individuals also consider the risk associated with the return of their investment when deciding when to supply their service. Risks related to diversion of returns have been traditionally affected the decision to investment. Policy uncertainties might force risk avers agents to choose the optimal location under which they can reap the return of their investment. For instance, Rodrik (1991) presents a story where relatively minor fraction of policy uncertainty has unduly large impact on private investment. More recently, Collier, Hoeffler, & Pattillo (2004) presented evidence that uncertainties associated with the earnings at home countries forced skilled Africans to what they call the "African Exodus." This effect is mainly related to institutional failures.

The institutional setup in many developing and transitional countries is characterised by weaker property rights. Consequently, radical and virulent form of institutions that share the profit of firms and wage of workers by creating and solving "problems" that government can not technically solve. In the nations where such agents have become stronger, they have managed to create grabber friendly institutions. For instance, local gangs receive a percentage of earnings of firms and residents to protect them from extortion by other gangs in many cities of developing countries. Skilled workers in many developing countries are also victims of such "problem solvers". Without going into further details, let $1-\theta \in (0,1)$ be the extent to which "parasites" in south can tax the return of skilled agents in south and assume that it is common for all skilled workers in the south[9].

Definition 1: *Equilibrium with regard to mobility decision occurs when no one has incentive to migrate from south to north.*

At equilibrium, there is a critical value of the heterogeneous variable ℓ_i^* with which a skilled labor in south with individual heterogeneous value below the critical level chooses to migrate while those with greater value decide to remain at home. It is found by equalizing the present value of earnings in the north less cost of travel to the effective present value of earnings in south.

Proposition 2: *A positive fraction of skilled professionals migrate to North at time "t". Moreover, the proportion of skilled workers that emigrate from sending countries is increasing in earnings in the host countries and decreasing in θ and earnings in the sending countries.*

Proof:

The critical value ℓ_i^* that satisfies the equilibrium condition is given by

$$\ell_i^* = Q\left(\int_0^{\infty} e^{-rt}\left[w(H^N) - \theta w(H^s)\right]dt - E\right). \tag{3}$$

The proportion of skilled workers that choose to migrate to the north is given by the cumulative distribution function evaluated at the critical threshold level. Thus, the total skilled

workers that migrate to north $H_m(t)$, and skilled workers remaining in the source economy $H_{-m}(t)$ is given by equations (4) and (5).

(4) $$H_m(t,\ell_i) = F(\ell_i^*)H^S(t)$$

Unlike the model by Kwok and Leland (1982) and Miyagiwa (1991), in this model immigrants are not necessarily very skilled compared to those remaining at home. Rather skilled immigrants have lower costs than the one who chosen to remain in the sending country.

(5) $$H_{-m}(t,\ell_i) = (1 - F(\ell_i^*))H^S(t)\,.$$

Equation (3) provides consistent pro-intuitive interpretation. Greater earnings differentials or greater earnings in the north raises the proportion of people migrating since the total cost of mobility is decreasing in wage differential. On the other hand, larger discount rate, lower expropriation, and greater earnings in south decrease the proportion of labor that chooses migrating to the north. As it can also be seen from equation (4) the proportion of migrating workers is increasing in the critical threshold. Thus, lower wage differential and lower diversions at south raise the proportion of skilled workers remaining at home.

(6) $$\frac{d}{d\ell_i^*}H_m(t,\ell_i) = f(\ell_i^*)H^S > 0$$

At each time "t" firms in the north have $H_m(t)$ of additional skilled labor flowing in to the labor market. This portion of labor may engage in the production of final goods or intermediaries that compliment labor in the production of final goods. QED

Suppose that there are two categories of firms in the North. One set of firms produce final goods using skilled labor and intermediaries at competitive market taking the price of intermediaries and wage given. The other set of firms, which are individual monopolist, produce intermediate goods by buying patents from firms engaged in R&D.

At a given time, the total skilled supplied in the economy, where $H^N(t)$ is skilled labor available in the north, is $H(t)$ which is given by the equation,

$$(7) \qquad H(t) = \left[H^N(t)^{\frac{s-1}{s}} + H_m(t)^{\frac{s-1}{s}} \right]^{\frac{s}{s-1}} \text{ for } s \in \Re_+$$

Depending on the values of s natives and immigrants could be complimentary or substitute or independent to each other in the labor market. Other things being the same, when $s = 1$, immigrants and natives are independent while when $s < 1$, they are substitutes.

The technology of final goods uses skilled labor, and a set of intermediate goods to produce final goods and services for consumption.

$$(8) \qquad Y_H(t) = H_Y(t)^{1-\alpha} \int_0^{A_H(t)} (x_{H,j}(t))^{\alpha} dj \quad \forall j \in [0, A_H(t)]$$

The number of intermediaries responds to profits associated to the production of intermediaries. It is assumed that additional unit number of intermediate goods requires skilled labor $H_x(t)$ of $\frac{1}{\theta A_H(t)}$ units. Thus, the endogenously growing technical changes are given by,

$$(9) \qquad \dot{A}_H(t) = \theta A_H(t) H_x(t)$$

Moreover, fixed supply of skilled workers at a point of time requires that the sum of skilled labor engaged in the production of final goods and ideas satisfies,

$$(10) \qquad H(t) \geq H_Y(t) + H_x(t)$$

Definition 3: *Equilibrium in production occurs when* $\left\{A_H(t), H_Y(t), \left\{x_{H,j}(t)\right\}_{j=0}^{A_H}\right\}_{t=0}^{\infty}$ *satisfies the problem* $\max_{H_Y, \{x_H\}_{j=0}^{A_H}} H_Y(t)^{1-\alpha} \int_0^{A_H(t)} (x_{H,j}(t))^{\alpha} dj - w_H(t) H_Y(t) - \varphi_j \int_0^{A_H(t)} x_{H,j}(t) dj$ *and* $\left\{\left\{x_{H,j}(t)\right\}_{j=0}^{A_H}\right\}_{t=0}^{\infty}$ *satisfies the problem* $\max_{x_{H,j}} \varphi_j x_{H,j} - x_{H,j}$ *given the demand constraint from final goods sector.*

Each firm producing final goods chooses the quantity of labor and intermediaries used in production of final goods for a given wage of skilled workers and price of intermediaries.

$$w_H(t) = (1-\alpha) H_Y(t)^{-\alpha} \int_0^{A_H(t)} (x_{H,j}(t))^{\alpha} dj \quad \forall j \in \left[0, A_H(t)\right] \text{ and } \alpha \in (0,1) \tag{11}$$

Equation (11) shows both the static and the dynamic effects of immigration. Noting that $H_Y(t) = \left[H^N(t)^{\frac{s-1}{s}} + H_m(t)^{\frac{s-1}{s}} \right]^{\frac{s}{s-1}} - H_x(t)$, for a given set of intermediate goods, wage is decreasing in the number of skilled migrants. The evidence for such a static effect is ample in the literature. For instance Borjas (2005) reported that for every 1% increase in the supply of immigrant skilled workers in the US, earnings decrease by 0.3%. Thus, in the extreme case where immigrants are perfect substitutes, in short run skilled migrants may crowd out natives in the labor market.

On the other hand, equation (11) also implies that immigrants may have a differing effect on the market wage depending on their effect on the size and the number of intermediaries. For instance, Mideksa (2007) argues that migrants raise the number of intermediaries as the market for intermediate goods used in final goods is greater and monopolists have greater incentive to innovate new intermediaries. This effect is also illustrated in equation (12). The price of a specific intermediate good is increasing in the amount of total labor that compliments the intermediate good in the production of final goods and services.

$$\varphi_j(t) = \alpha H_Y(t)^{1-\alpha} x_{H,j}(t)^{\alpha-1} \quad \forall j \in \left[0, A_H(t)\right] \tag{12}$$

Equation (12) shows that the price of intermediate goods is increasing in the number of migrants and decreasing in the supply of a given intermediate good.

Proposition 4: *At equilibrium, the price of intermediate goods is a constant which is the ratio of marginal cost to one minus the share of labor in the production of final goods. The wage of skilled workers is proportional to the total number of intermediate goods produced and the profit of each intermediate good producer is increasing in the volume of immigrants.*

Proof:

Firms in the intermediate goods sector maximize profit from the production of intermediate goods. The production of each intermediate goods requires τ units of intermediate good. Maximizing profit subject to the demand constraint imposed by final goods sector (12), the price of each intermediary is given by

$$\varphi_j(t) = \frac{\tau}{\alpha}. \tag{13}$$

The right hand side of equation (13) is constant and it implies that each intermediate good faces the same price regardless of its type. That is $\varphi_j(t) = \varphi$ which amounts to marginal cost over one minus the share of labor in the final output.

Substituting (13) into (12), using the fact $H_Y(t) = H(t) = \left[H^N(t)^{\frac{s-1}{s}} + H_m(t)^{\frac{s-1}{s}} \right]^{\frac{s}{s-1}} - H_x(t)$, and rearranging, results in equation (14). The demand for each intermediate is increasing in the number immigrant skilled workers and decreasing in the marginal cost of producing additional unit of a given intermediary.

$$x_{H,j}(t) = x_H(t) = \alpha^{\frac{2}{1-\alpha}} \left(\frac{1}{\tau} \right)^{\frac{1}{1-\alpha}} \left(\left[H^N(t)^{\frac{s-1}{s}} + H_m(t)^{\frac{s-1}{s}} \right]^{\frac{s}{s-1}} - H_x(t) \right) \tag{14}$$

Moreover, using equation (13) and (14), the profit from each intermediate good is given by,

(15) $$\pi(t) = (1-\alpha)\alpha^{\frac{1+\alpha}{1-\alpha}}\left(\frac{1}{\tau}\right)^{\frac{\alpha}{1-\alpha}}\left(\left[H^N(t)^{\frac{s-1}{s}} + H_m(t)^{\frac{s-1}{s}}\right]^{\frac{s}{s-1}} - H_x(t)\right)$$

The profit from each type of intermediate good is increasing in the total number of workers engaged in the production of final goods and services and decreasing with the number of skilled workers engaged in the production of new intermediate goods and marginal cost of producing the intermediate good. The fact that higher rate of skilled immigrants entails greater profit implies that there is greater incentive for innovators to produce new innovations. Hence, the number of intermediate goods in the presence of skilled migrants is greater than the number of intermediate goods in the absence of skilled migrants.

Using equations (11) and (14), it is easy to identify the dynamic effect of immigration on the average wage of skilled workers. The wage of skilled workers is increasing in the number of intermediate goods and decreasing in the marginal cost of intermediate good.

(16) $$w_H(t) = (1-\alpha)\left(\frac{\alpha^2}{\tau}\right)^{\frac{\alpha}{1-\alpha}} A_H(t)$$

Given the fact that more immigration involves greater number of intermediate goods, over the long run, greater supply of immigrants raise the wage of skilled labor in contrast to the static effect emphasised in equation (11). Over the long run, the static effect of increase in the supply of skilled labor is cancelled by increased demand for labor due to higher demand for the existing intermediate goods. In addition to raising the demand for the existing intermediate goods, immigration raises also the incentive for innovating new technologies and hence the number of intermediaries. QED.

Proposition 5: *Growth rate is increasing in the volume of immigrants regardless of the amount of physical capital immigrants posses. Moreover, higher volume of immigration raises the stock of capital in the economy by raising the interest rate.*

Proof:

Free entry into the business of innovation provides the mechanism to allocate skilled workers into the innovation of new intermediate goods and the production of final goods. Each labor engaged in the business of innovation gets the discounted value of profit $\frac{\pi(t)}{r}$. On the other hand, the opportunity cost of each unit of labor engaged in innovation is $\frac{w_H(t)}{\theta A_H(t)}$. At equilibrium, the optimal amount of labor engaged in innovation is given by

$$H_X(t) = \left[H^N(t)^{\frac{s-1}{s}} + H_m(t)^{\frac{s-1}{s}} \right]^{\frac{s}{s-1}} - \frac{r}{\theta\alpha}. \tag{17}$$

Since the number of intermediate goods is increasing in the number of skilled workers engaged in research, (9), and the number of skilled workers engaged in research is increasing in skilled immigrants, immigrants raise the number of intermediate goods available in the economy.

$$g_{A_H}(t) = g = \theta H(t) - \frac{r}{\alpha} \tag{18}$$

The number of intermediate inputs is increasing in the number of total skilled workers and one minus the share of labor in the production function and decreasing in the rate of discount. Each consumer in chose consumption plans subject to the intertemporal budget constraint and non-Ponzi game condition. As shown elsewhere, for a constant relative risk aversion utility function, the optimal consumption path satisfies the equation,

$$\frac{\dot{c}(t)}{c(t)} = g = \frac{r-\rho}{\upsilon} \tag{19}$$

Where ρ the subjective discount is rate and υ is the relative rate of risk aversion. The equilibrium rate of growth is obtained by solving (18) and (19). By using the two equations, the equilibrium rate of economic growth given as,

(20) $$g^* = \frac{\alpha\theta\left(\left[H^N(t)^{\frac{s-1}{s}} + H_m(t)^{\frac{s-1}{s}}\right]^{\frac{s}{s-1}} - \rho\right)}{\alpha + \upsilon}$$

As can be seen from (20), growth is increasing in the number of skilled immigrants. The graph below, which is drawn based on the assumption of perfect substitution, indicates the effect on growth of increase in the rate of skilled immigration. Thus, the rate of growth would be permanently higher for a higher but also permanent rate of skilled immigration. QED

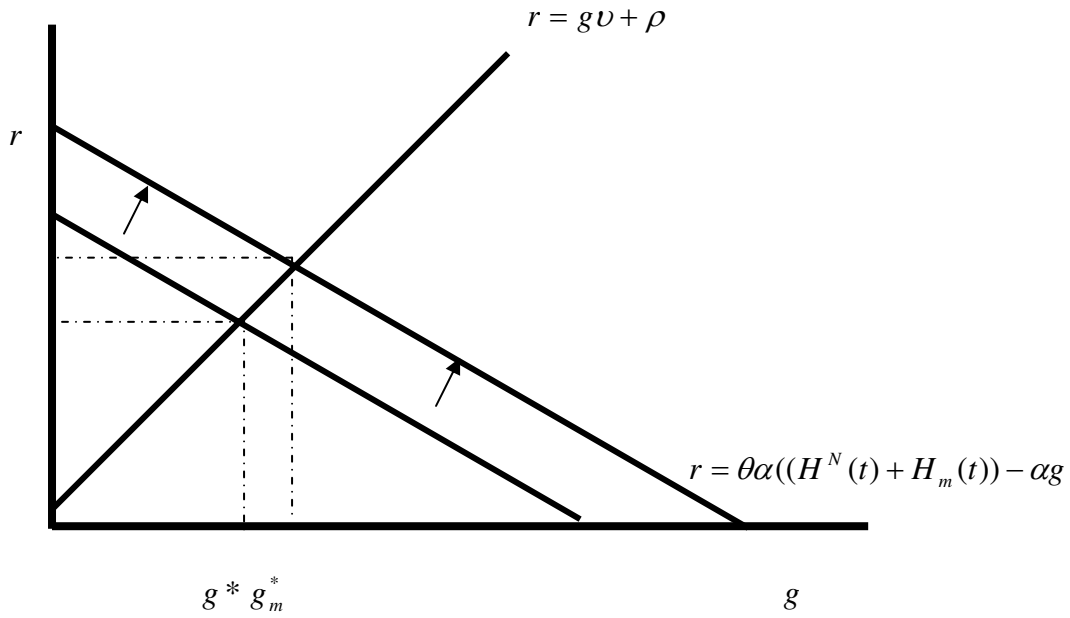


Figure 4: Volume of Skilled Immigration and Economic Growth

Proposition 6: *The inflow of migrants raises the proportion of natives that accumulate skill over the long run.*

Proof:

As discussed previously, higher supply of skilled migrants reduce wage in the short run but raise wage in the long run and the number of intermediate goods produced by providing greater supply of skilled for innovation and greater market for each intermediate goods complimenting labor in the production of final goods and services. Since the supply of immigrants affect the return to investments in skill in the North, potentially immigration has another effect through skilled wage premium.

Individuals decide whether to accumulate skill, for our case join college and universities, or not to accumulate skill based on the relative present values of earnings, and cost of accumulating skill. Let $H^N(t)$ be the number of workers that choose to accumulate skill as before and $L(t)$ be the number unskilled workers with any form of skill which associated with unskilled workers. Suppose there is a technology that uses unskilled workers to produce another set of final goods, $Y_L(t)$ at time "t". The output produced by unskilled workers is given by,

(21) $$Y_L(t) = mL(t)^{1-\alpha} \quad m \in \Re_+ .$$

Firms producing $Y_L(t)$ face a wage of $w_L(t)$ and the quantity of labor they hire is given by equation (22). Like the standard demand for labor, demand for unskilled workers is decreasing in wage and increasing in labor productivity, m and the share of labor in output $(1-\alpha)$.

(22) $$w_L(t) = mL(t)^{-\alpha}$$

Suppose that education increases productivity and hence wage. Thus, the wage of skilled workers is greater than the wage of unskilled workers in the economy.

(23) $$w(H^N) > w(L)$$

However, skill is scarce resource that can only acquired by incurring costs. The cost of education $C(a_i, b)$ depends up on college fees b, and the exogenously given ability a_i of individuals.

(24) $$C(a_i, b) = c(a_i) + b$$

Without loss of generality, let the cost function satisfies the properties of $c'(a_i) < 0, c''(a_i) > 0, a_i \sim N(\mu_a, \sigma_a^2)$, $\lim_{a_i \to 0} c'(a_i) = \infty$, and $\lim_{a_i \to \infty} c'(a_i) = 0$. Suppose also

the endowment of ability of individuals follows some density function whose cumulative distribution is given by $\Phi(\bullet)$. Moreover, assume that $c^{-1}(\bullet) = h(\bullet)$. Let the population in the north grows exogenously at a rate of n and its evolution is given by,

(25) $$N(t) = N_0 e^{nt}$$

The decision to accumulate skill is determined by its relative earning and cost of acquiring skill. If an individual, in North, is skilled it gets present value of wage for skilled workers $\int_0^\infty e^{-rt} w(H^N)dt$, and $\int_0^\infty e^{-rt} w(L)dt$ if she decides not to accumulate skill. Accumulation of skill costs every individual a constant cost, b and a component that is decreasing with innate ability and assumed to be distributed according to some density function. When $\int_0^\infty e^{-rt}\left[w(H^N) - w(L)\right]dt > C(a_i, b)$, an individual with ability a_i chooses to accumulate skill and vice versa.

At equilibrium, there will be a threshold of ability, a_i* at which all individuals with ability below which decide not to accumulate skill. It is given by

(26) $$a_i * \left(w(H^N), w(L^N), r, b\right) = h\left(\int_0^\infty e^{-rt}\left[w(H^N) - w(L)\right]dt - b\right).$$

Equation (26) implies that the threshold ability is increasing in r, wage of unskilled labor, and cost of schooling and decreasing in the wage of skilled labor and the excess wage of skilled labor. Equation (26) also provides the equation of skilled and unskilled workers for a given cumulative density of ability, $\Phi(a_i)$ with the usual properties of any cumulative density function. The number of natives who choose to accumulate skill and decline to accumulate skill are in the North are given by,

(27) $$H^N(t) = (1 - \Phi(a_i*))N_0 e^{nt}$$

(28) $$L(t) = \Phi(a_i*)N_0 e^{nt}$$

As equation (27) makes it clear, the share of individuals that choose to accumulate skill is a decreasing function of threshold ability. The threshold ability in turn is decreasing in wage of skilled workers.

$$\frac{d}{dH_m(t)} H^N(t) = -\Phi'(a_i^*) \frac{\partial}{\partial w_H(t)} a_i^* \frac{\partial}{\partial H_m(t)} w_H(t) N_0 e^{nt} > 0 \tag{29}$$

Equation (29) or alternatively from (16) and (20), it is shown that skilled immigrants raise the wage of skilled workers in the north. Hence, skilled immigrants also raise the proportion of individuals in the north who choose to accumulate skill by raising the incentive to accumulate skill. QED

Conclusion

The impact of immigrants on the welfare of natives has been a center of discussion. There has also been fierce discussion on various Mass Medias and huge rallies. Unlike the frequent allegations that immigrants hurt natives, the result from endogenous technical change implies that the inflow skilled immigration has overwhelmingly positive gains for the natives in the host nations in the areas of wage, technical change, long run growth, and human capital formation.

First, the profit from intermediate goods positively depends on the quantity of labor complimenting intermediate goods in the production of final consumption good. Higher volume of immigrants raises the profit of each intermediate good producer and provides greater incentive to innovators to innovate new intermediate goods thereby raising the number of intermediate goods.

Although there is some short run decrease in wage, as the rest of the economy responds to the inflow of skilled immigrants, over the long run the dynamic gains from skilled immigrants raises the productivity through directed technical change which responds to factor abundance. Since long run wage is proportional to technical change, inflow of immigrants raises the long run average wage unlike the implication of exogenous technical change.

The growing wage for skilled workers raises the wage differential between skilled and unskilled workers. As the return to skill increases, more individuals decide to accumulate skill than otherwise in the absence of such increase.

Change in technology also affects the welfare of citizens, in addition to wage, as it is the source of the single most important variable over the long run-economic growth. Finally, although this paper has abstracted from capital stock and fiscal policy, there is an important implication for capital stock, fiscal policy, and level of income. The higher profit associated with skilled immigration has an important consequence for capital formation as capitalists respond to greater rate of return from investment, higher volume of immigration raises the capital stock and hence the level of income in the host economy.

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Appendices

A-1: Graphs

Figure 1: The Skilled wage premiums of College and High-school graduates in 1967 – 1990[10]

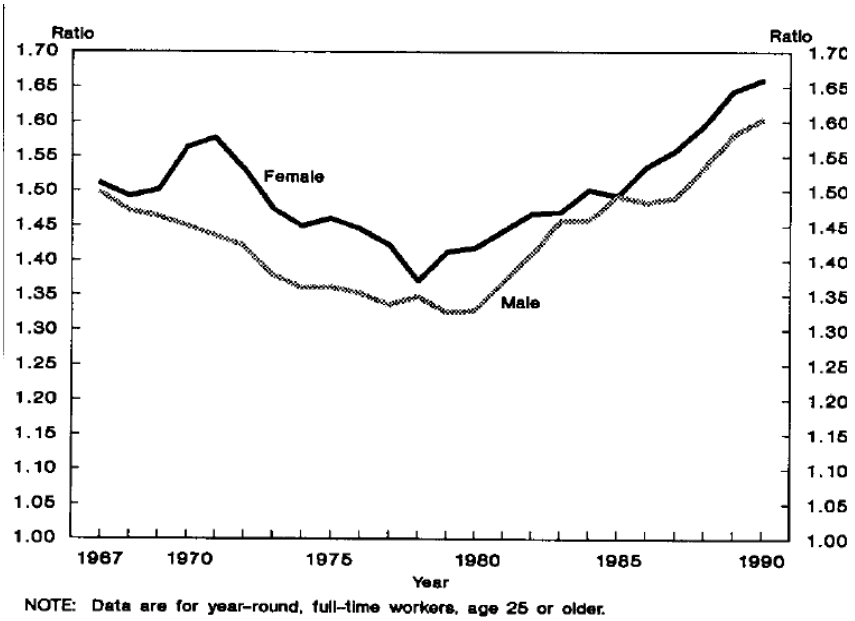


Figure 2: Immigrants to USA from SSA, SASIA, EASIA, and Latin America[11]

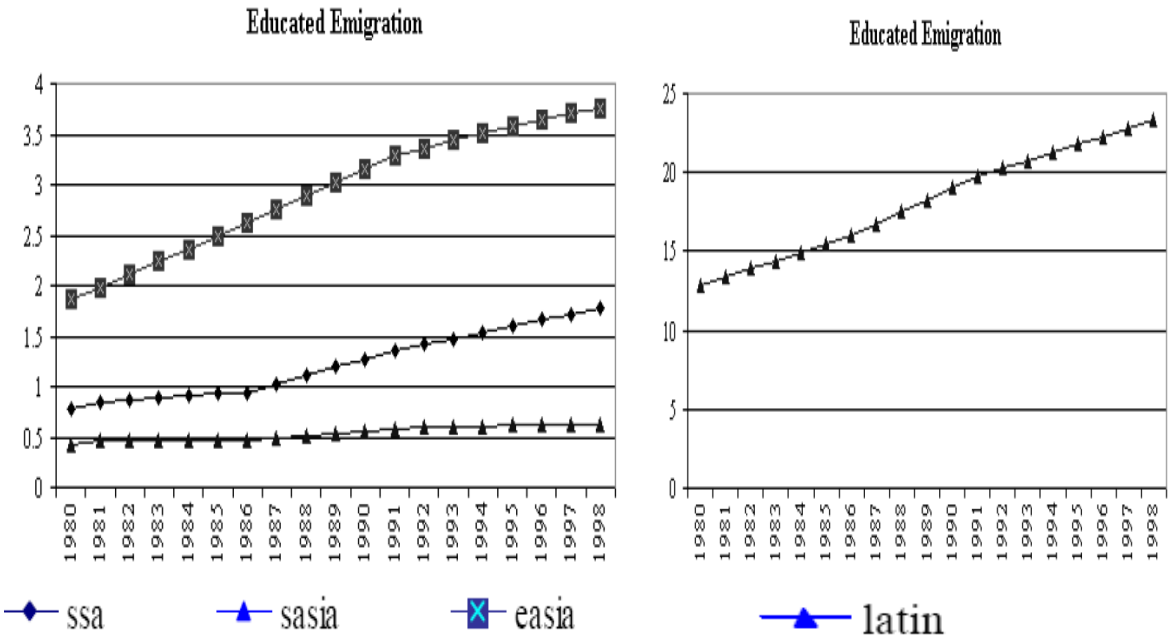
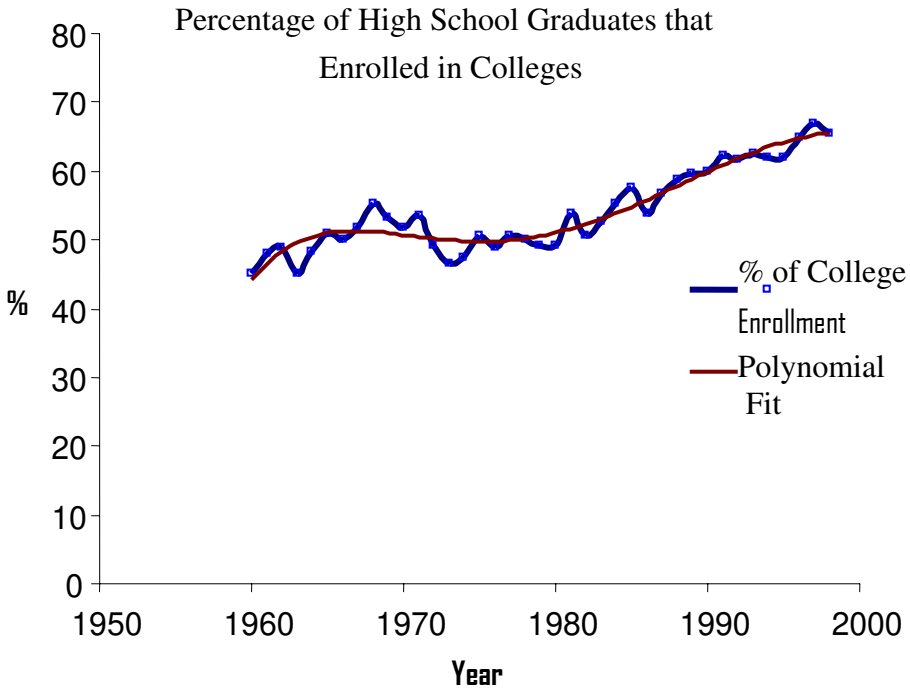


Figure 3: The Proportion of High School Graduates that are enrolled in colleges (1960 -1998)



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§ CICERO P.O. Box 1129 Blindern, N-0318 Oslo, Norway

1 The issue has been on the center of academic discussion, for instance beginning from the publication of the first issue of Journal of Development Economics. It has also attracted the attention of politicians in many countries. It is widely believed that immigration issue has affected the 2001 election in Denmark and raised huge support for virulent anti-immigration parties such as National Alliance-Italy, National Front – France, and the Republikaner – Germany. Immigration has also been center of debate in the US economic policy.

[2] For instance Lalonde and Topel (1997) provide a considerable survey of the research on the issue.

[3] Borjas (1989), and Friedberg and Hunt (1995) also discuss the impact of immigrants on the wellbeing of receiving country.

[4] Beine et al. (2001), Chau and Stark (1999), Davenport (2004), Docquier and Rapoport (2003), Hemmi (2005), Lien (2006), Stark (2004), Stark et al. (1997) and Stark et al. (1998)

[5] http://en.wikipedia.org/wiki/Immigration

[6] Table-1 is reproduced from Lalonde and Topel (1997)

[7] http://www.opinionjournal.com/extra/?id=110009535

[8] http://www.allcountries.org/uscensus/295_college_enrollment_of_high_school_graduates.html#2

[9] Mehlum, Moene, and Trovik (2006) show that equilibrium $\theta \in (0,1)$.

[10] Reproduced from Hecker(1992)

[11] Reproduced from Collier, Hoeffler, & Pattillo (2004)