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Abstract

Long-term effects of tightening immigration policy on native workers of the receiving country are analyzed in a small open overlapping generations model. Such a policy is intended to protect native workers from losing income and possibly jobs. Results demonstrate that a severer policy raises the unskilled wage rate as expected, but it lowers the skilled wage rate only if skilled and unskilled labor are strongly (technically) complementary. Such a policy also lowers the average education level of the country. If skilled labor and unskilled labor are sufficiently complementary, then the policy might instead increase immigration inflows to the country.

Keywords: education, immigration policy, skilled–unskilled labor complementarity
JEL Classification: D15, F22, F66, O24

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1. Introduction

Recently many economically developed countries have come to regard the receiving of immigrants, especially refugees from low-income countries, in a negative light. A major reason for such policy changes is a fear that decreased wage rates of native workers, especially unskilled workers, might be brought about by such a huge inflow of foreign workers, threatening their daily lives.[1] Do such policy changes against immigration bring about desirable consequences to these developed countries? This paper presents consideration of whether this argument is theoretically plausible or not by analyzing the consequences of inflows of immigrants on the domestic labor markets and the wage rates in the receiving countries.

In conventional trade theory, the gains from international factor mobility are generally sufficiently large to compensate the losses, i.e., they are potentially Pareto-improving (Kaldor–Hicks optimal). However, each high-income country might maximize its own national welfare rather than global welfare. As Sachs (2016) describes, public opinion in the USA and Europe is deeply divided in terms of whether migrants strengthen countries or burden them. Migration has also given rise to anti-immigrant politics running counter to EU commitments to open borders within the EU.[2] The USA tightened its immigration policy in 2017, although Japan moved in the opposite direction in 2018.[3] Therefore, the effects of immigration policy tightening in their respective countries should be analyzed to elucidate this issue entailing such divided opinion.[4] Sachs (2016), among others, proposes a global migration regime, which pays special attention to emigration from the world's most impoverished regions.[5]

Reports describing the effects of migration on sending economies have appeared mostly in the literature related to international labor mobility (e.g., Bhagwati and Hamada, 1974; Miyagiwa, 1991; Mountford, 1997). For instance, brain drain has been pointed out as leading to the possible decline of the average education level in poor

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[1] Especially regarding refugees, receiving countries are forced to bear huge burdens of expenditures such as jobs, housing costs, and social security. Nannestad (2007) also concludes that immigrants are rather a burden to Western welfare states because of the welfare programs.

[2] Peri (2016) reports that the population shares of foreign-born residents in both Europe and the U.S. were higher 15% in 2015.

[3] The U.S. President signed on the two executive actions on immigration and border policy in 2017, which make the policy stricter. The Japanese government has revised the Immigration Control and Refugee Recognition Act to relax the closed nature of its immigration policy in 2018.

[4] Recent empirical research has been conducted actively for Syrian refugees, the forced migration (Tumen, 2016).

[5] Sachs (2016) asserts that the regime should also devote attention to non-economic aspects such as cultural aspects.

economies, from which skilled or highly educated labor flows out. Immigrants are analyzed mostly as an exogenous increase in the supply of homogeneous (low-skill) workers in the labor force. The wage rate is determined by interaction with downward-sloping labor demand (Card, 2016).

However, in light of increases in inflow of refugees and low-skill immigrants into developed countries especially during the 1980s and after, recent empirical studies analyze the effects of immigration on the destination labor markets and wage rates from various perspectives. Borjas (2003), among others, concludes that the measured impact of 10 percent influx of immigrants of a skill group reduces the wage of that group at the national level by 3–4 percent. Dustmann et al. (2017) describe that an exogenous immigration leads to declines in native wages and in native employment. Card (2001) reports that immigrant inflows reduce the relative wages of unskilled workers in high-immigrant cities without offsetting mobility flows of native workers. By contrast, many empirical reports describe that immigration has only a negligible impact or a slight positive effect on the wage rates of competing native low-skilled workers because of the choice of production technology (Autor et al., 2003; Lewis, 2011), by pushing low-skilled natives to pursue less-manual-intensive occupations (Foged and Peri, 2015), because of immigrant clusters in cities or particular regions (Borjas, 2006; Docquier et al., 2013; Peri. 2016), and because of immigrants' downgrade at arrival (Dustmann et al., 2013).[6] Consequently, the empirical results remains mixed, depending on native-immigrant substitutability and on education-induced heterogeneity of labor (Ottaviano and Peri, 2012).[7]

Even in these empirical studies, inflows of immigrants are taken as exogenously given. The effects of immigration policy have been little argued explicitly.[8] Furthermore, most theoretical studies have not considered the technical relation between skilled and unskilled labor, i.e., between workers of different types distinguished by their education levels. This paper presents theoretical consideration of the effect of immigration policy on the wage rates of native unskilled workers.

The features of the model are two-hold: first, it incorporates workers' choices of education to be skilled workers, and second, it devotes explicit consideration of technical

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[6] Similar results are obtained for Europe countries, although the labor market in Europe is regarded as highly rigid (Zorlu and Hartog, 2005; Brücker and Jahn, 2011).

[7] Although presuming perfect substitutability between immigrants and natives of the same type such as Borjas (2003), the present model considers the (utility) cost of immigration, which includes costs of learning languages and psychic costs to be highly substitutable.

[8] Nevertheless, Peri (2016) describes that immigration policy changes aimed at opening the borders have not consistently reduced entry barriers to immigrants since about 1970.

complementarity between skilled and unskilled labor in domestic production rather than capital–skill complementarity.[9] A higher low-skill wage rate tends to deter workers from acquiring skill/education to be skilled; it also attracts low-skill immigration. We are concerned only with stationary states in the analyses presented in this paper, neglecting transition processes. The main results demonstrate that although a border-closing policy raises the wage rates of native low-skilled workers and lowers the average education level of the economy, such an immigration policy might raise the wage rates of native skilled workers depending on the degree of technical complementarity between skilled and unskilled labor. If the complementarity is sufficiently strong, then the skilled wage rate declines with adoption of the policy. If the complementarity is sufficiently strong, then the policy instead increases low-skilled immigration inflows. Therefore, closing of the borders might not always benefit all native workers in a plausible case of strong complementarity between skilled and unskilled labor.[10]

The paper is organized as follows. The next section introduces a small open overlapping generations model and then formalizes domestic labor market equilibrium. In section 3, we explain analysis of the long-term effects of tightening immigration policy on domestic wage rates, skilled and unskilled, and on the average education level in the receiving economy. Section 4 presents brief consideration of a case in which immigrants are ruled out from taking education. Section 5 gives conclusions derived from the analyses in the paper.

2. Model

To consider immigration from abroad, we extend a small open model economy with overlapping generations introduced by Andersen (2005) and Fan and Yakita (2011). We designate an economy receiving immigrants the home country. Although capital moves freely across the borders, immigration into the home country is controlled by the home government.[11] The aggregate production technology is represented by a production function that is constant returns to scale in capital, skilled labor, and unskilled labor. Because of the free movement of capital, the interest rate in the home country is equal

[9] Chassamboulli and Palivos (2013) is an exception that considers skilled and unskilled labor complementarity explicitly. For technical substitutability and complementarity, Hicks (1939, Chap 7) provides related explanations. It is also called 'Edgeworth complementarity' in the literature (Chassamboulli and Palivos, 2013).

[10] In this paper we assume that even illegal immigrants cannot be refused completely because of imperfection of the border check policy.

[11] The attitude of the source-country's governments might also affect the cost. For analytical purposes, we assume it away in this paper.

to the world interest rate, which is assumed to be given exogenously as a constant.

Individuals, both native workers and (potential) immigrants, live for two periods: young and old. Each individual determines whether to take education when young, working during the old period as a skilled worker, or to work throughout the two periods as an unskilled worker. We assume away native population growth and normalize the population size of young native individuals as unity in each period.[12] Immigrants come into the home country as non-educated workers at the beginning of their young period. Some immigrants might take education in the home country in their young period; the others do not. Workers originating from the outside the home country must pay various costs for immigration: both monetary and psychic. The immigration policy of the receiving country also affects the immigration cost.[13]

2.1 Production sector

The aggregate production function of the home country is assumed to be written as $Y = F(K, L^S, L^U)$, where Y denotes the aggregate output, K stands for aggregate capital stock, and L^S and L^U respectively express skilled and unskilled labor employed in goods production.[14] Assuming perfect competition in the factor markets, the production factors are paid their respective marginal products.

$$r = F_K(K, L^S, L^U), \tag{1a}$$

$$w^S = F_{L^S}(K, L^S, L^U), \tag{1b}$$

$$w^U = F_{L^U}(K, L^S, L^U). \tag{1c}$$

Subscripts of the function denote their partial derivatives. Variable r stands for the interest rate equal to the given world interest rate. Also, w^S and w^U respectively signify the wage rates for skilled and unskilled labor. From the profit-maximizing behavior of the production sector and the zero-profit condition in the output market, the

[12] This assumption implies that variables in a period are represented in terms of per young worker terms in that period.
[13] Beam et al. (2016) suggest that only unilateral facilitation of sending countries might not promote international labor mobility.
[14] Variables are represented in per young native worker terms. To analyze the policy effects, we assume away machinery uses in production in this study.

factor demands can be written as the functions of (r, w^S, w^U).[15] By definition, the skilled wage rate is higher than the unskilled wage rate, i.e., $w^S > w^U$.[16]

2.2 Education and immigration decisions

The problem of a worker is to choose whether to take education/skill when young and work as a skilled worker during old age or to work as an unskilled worker throughout two periods. Individuals are characterized in terms of index $i \in [0,1]$ which is attributed in related to the individual's level of skill acquisition. We assume that the utility cost of acquiring a certain level of skill is represented by $e(i)$, where $e'(i) > 0$. An individual with $i = 0$ can become educated/skilled with the lowest cost; an individual with $i = 1$ must pay the highest cost to acquire the skill. The acquired skill level is assumed to be the same for all individuals.

The lifetime utility of individuals depends on consumption during two periods: young and old. Individuals face the same rate of interest. For that reason, assuming the same preference for all individuals, the lifetime utility of an individual depends on the discounted sum of wage incomes of the two periods. Therefore, following Andersen (2005), we assume the (semi-indirect) utility function of a domestic individual as $U(i) = V(i) - \phi e(i)$, where $\phi = 1$ if the individual is educated in the young period and $\phi = 0$ if uneducated.[17] Function $V(i)$ represents the utility of lifetime consumption. An individual with index i chooses to take education/skill during the young period and work as a skilled worker in the old period if

$$\frac{w^S}{1+r} - e(i) \geq w^U + \frac{w^U}{1+r}. \qquad (2)$$

The left-hand side of (2) is the net wage income discounted to the beginning of the young period if this individual takes education/skill. The right-hand side is the discounted sum of wage income during two periods if working as an unskilled worker. Defining an index satisfying condition (2) with equality as $\hat{i}$, then individuals with $i \in [0, \hat{i}]$ will take education to acquire the skill, although those with $i \in (\hat{i}, 1]$ will not.

Individuals outside the home country choose whether to immigrate into the home

[15] In this paper, we assume away the issue of geographic clustering of immigration.
[16] We assume that capital and each type of labor are technical complements, as in the literature, although both types of labor are not necessarily so.
[17] The utility cost of skill acquisition is measured in consumption-equivalence terms.

country or not. We assume that the preference of immigrants for consumption is the same as that of native workers in the home country. Individuals outside the home country are characterized by index j that attributes related to the attitude toward immigration. The utility cost of migration of an individual with index j is defined as $c(j,\beta)$ where β denotes the home government's stance toward immigration. Notionally, the cost depends on various factors such as travel cost (i.e., monetary cost) and psychic cost. The psychic cost reflects the individual's anxiety about unfamiliar life in a foreign country, which might entail unfamiliar customs and social rules, and a foreign language. Although monetary cost might be almost identical for all immigrants, the psychic cost might be inversely related to attitude related to migration. The greater an individual's anxiety is, the higher that person's psychic cost becomes. More restrictive attitude of the receiving country' government toward immigration might also increase the psychic cost of potential immigrants. Therefore, we assume here that $c_j(j,\beta) < 0$ and $c_\beta(j,\beta) > 0$.[18]

For analytical simplicity in considering the difficulty of individuals outside the home, the wage rate outside the home country is given as w^* in each period, which is assumed to be given exogenously.[19] Given an immigration policy of the home country as described by parameter β, an individual outside the home country chooses to immigrate if the following inequality holds.[20]

$$w^u - c(j,\beta) \geq w^*. \tag{3}$$

In other words, if the wage rate outside the home country less immigration cost is lower than the unskilled wage rate in the home country, then the individual moves into the home country. With constant w^*, the individual can enjoy higher consumption in the

[18] We do not consider the possibility that individuals must return to the original country. Galor and Stark (1990) show that the possibility of return migration might increase savings and economic performance.

[19] We assume away education/skill acquisition outside the home country. Alternatively, we can assume that only uneducated individuals immigrate into the home country. However, Docquier et al. (2013), among others, report that the share of college educated immigrants is four to five times as large as their share among non-migrant natives in OECD countries. Clements et al. (2008) report that the ratio of wages earned by workers in the U.S. to those of 'observably identical' workers abroad is considerably large, e.g., 3.8 for a Peruvian-born worker.

[20] This is the immigrant self-selection model described by Borjas (1994). In the present setting, immigrants will be accepted as workers. Beam et al. (2016) emphasize the importance of both demand-side and supply-side for international labor mobility.

home country even if she works as an unskilled worker. Defining index j satisfying (3) with equality as $\bar{j}$, it can be said that individuals with index $j \geq \bar{j}$ immigrate into the home country; those with $j < \bar{j}$ do not.

An immigrant might also be able to receive education in the recipient home country. If so, then it is quite plausible that the attitude about immigration of an individual has some relation to the skill acquisition cost of the individual. Following Fan and Yakita (2011), we assume here that the cost of skill acquisition of an individual with a more positive attitude of immigration lowers the cost of skill acquisition, i.e., $di/dj = -a < 0$.[21] Letting $\hat{j}$ be the minimum attitude toward immigration of the individual who takes education, it can be said that the index related to skill acquisition of this individual is equal to $\hat{i} = i(\hat{j})$. Letting $j_{\max}$ be the maximum positive attitude related to migration, an immigrant with attitude toward immigration $j \in [\hat{j}, j_{\max}]$ chooses to take education and become a skilled worker during the immigrant's old period. We assume that index $j_{\max}$ is given exogenously. Individuals with $j \in [\bar{j}, \hat{j})$ remain unskilled throughout life. If the cost of skill acquisition is sufficiently high, then all immigrants work as unskilled workers during two periods.[22] These two cases are presented respectively in Figures 1(a) and 1(b), in which the vertical line measures the index related to the cost of acquiring education/skill whereas the horizontal line is the index related to attitudes toward immigration. Relation $j = j(i)$ is shown as thick lines in Figure 1.

2.3 Labor market equilibrium

We consider only stationary equilibria in this paper. Each individual economically behaves for two periods, young and old: individuals who do not acquire education work as unskilled laborers during young and old period, although individuals educated when they are young as skilled laborers only in their old period. If skilled labor and unskilled

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[21] The cost of skill acquisition can be considered to be in inverse relation to the (innate) ability of an individual. The cost of immigration might be lower for foreigners with higher abilities, for instance, in language. For instance, Japan requires a certain level of Japanese language skill for immigrants in principle.

[22] The (semi-indirect) utility function of an immigrant indexed j can be written as $U(j) = V(j) - \phi e(i(j)) - \theta c(j, \beta)$ where $\phi = 0$ if she does not take education in the recipient country and $\theta = 0$ if she does not immigrate.

labor are not perfect substitutes, then the two markets are segmented. We assume that this is the case. The labor markets being under full employment in each period, two generations of uneducated individuals, young and old, are employed in the unskilled labor market and educated, old, individuals are employed as skilled workers. The labor market equilibrium conditions for unskilled and skilled labor can be written respectively as[23]

$$L^u(w^S, w^u, r) = 2[(1 - \int_0^{\hat{i}} f(i)di) + \alpha \int_{\bar{j}}^{\hat{j}} h(j)dj] \quad \text{and} \tag{4}$$

$$L^S(w^S, w^u, r) = \int_0^{\hat{i}} f(i)di + \alpha \int_{\hat{j}}^{j_{\max}} h(j)dj\,. \tag{5}$$

Parameter α is a scale parameter representing the relative population size outside the home country. Function $f(i)$ stands for the density of the population across index i, satisfying $\int_0^1 f(i)di = 1$, whereas function $h(j)$ is the density of the immigrants across characteristic j, satisfying $\int_{j_{\min}}^{j_{\max}} h(j)dj = 1$ where $j_{\min}$ is the exogenously given minimum level of j. The right-hand side of condition (5) includes educated immigrants as the second term.

From (2) and (3) with equalities, we obtain $\bar{j} = j(w^u, w^*)$ and $\hat{i} = i(w^S, w^u, r)$, while by definition $\hat{j} = j(\hat{i}(w^S, w^u, r))$. Therefore, we can solve these equilibrium conditions for wage rates (w^S, w^u) from (4) and (5), assuming the stability of the labor market.[24] From the assumption of a small open economy, capital moves across borders to equate the domestic interest rate with the world interest rate, i.e., K is determined to satisfy (1a) at the equilibrium for given r.

3. Effects of immigration policy

Next we analyze the effects of immigration policy changes on the labor markets and the size of immigration. Policy changes can be represented by changes in parameter β. Presumably, a severer stance of the home country's government is denoted by a greater β, and *vice versa*.

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[23] Labor demand functions are explained in Appendix A1.

[24] For system stability, Samuelson (1983), for instance, provides a useful explanation.

Differentiating (4) and (5), and using (2) and (3) with equalities, we obtain the following linearly approximated equations around the equilibrium as

$$\begin{pmatrix} A_s^s & A_u^s \\ A_s^u & A_u^u \end{pmatrix}\begin{pmatrix} dw^s / d\beta \\ dw^u / d\beta \end{pmatrix}=\begin{pmatrix} 0 \\ B \end{pmatrix}, \tag{6}$$

where

$$A_s^s \equiv L_s^s - \frac{f(\hat{i})+a\alpha h(\hat{j})}{(1+r)e'(\hat{i})} < 0, \tag{7a}$$

$$A_u^s \equiv L_u^s + (1+\frac{1}{1+r})\frac{f(\hat{i})+a\alpha h(\hat{j})}{e'(\hat{i})}, \tag{7b}$$

$$A_s^u \equiv L_s^u + 2\frac{f(\hat{i})+a\alpha h(\hat{j})}{(1+r)e'(\hat{i})}, \tag{7c}$$

$$A_u^u \equiv L_u^u - 2(1+\frac{1}{1+r})\frac{f(\hat{i})+a\alpha h(\hat{j})}{e'(\hat{i})} + 2\frac{\alpha h(\bar{j})}{c_j(\bar{j},\beta)} < 0, \tag{7d}$$

$$B \equiv 2\frac{\alpha h(\bar{j})c_\beta(\bar{j},\beta)}{c_j(\bar{j},\beta)} < 0, \tag{8}$$

and $dj / di = -a < 0$.

From (6) we can obtain the following results.

$$dw^s / d\beta = -BA_u^s / D, \tag{9}$$

$$dw^u / d\beta = BA_s^s / D. \tag{10}$$

Therein, $D \equiv A_s^s A_u^u - A_u^s A_s^u$. From the stability condition, we have $D > 0$.

Result (10) implies that tightening immigration policy, i.e., raising β, invariably increases the unskilled wage rate w^u, i.e., $dw^u / d\beta > 0$. In (9), the effect on the skilled wage rate cannot be determined *a priori*, depending on the sign of A_u^s, i.e., the sign of (7b). Although the second term on the right-hand side of (7b) is positive, the sign of the first term depends on the technical relation between skilled and unskilled labor in

production. If $L_u^S \geq 0$, i.e., if a rise in the unskilled wage rate does not decrease the demand for skilled labor, or if skilled labor and unskilled labor are technically independent or substitutable, then we have $A_u^S > 0$. In this case, the tightened immigration policy also raises the skilled wage rate, i.e., $dw^S / d\beta > 0$. Domestic workers, irrespective of whether they are skilled or unskilled, benefits from the tightening of immigration policy. The underlying intuition is simple. Decreases in unskilled labor supply raise the low-skilled wage rate. Because of substitutability (and even weak complementarity) between skilled and unskilled labor, the decreased unskilled labor employment increases demand for skilled labor. Therefore, the skilled wage rate rises.

By contrast, one can demonstrate that $L_u^S < 0$ holds if skilled labor and unskilled labor are technically complementary, i.e., if $F_{L^S L^u} > 0$, and that if the complementarity is sufficiently strong to satisfy $L_u^S < -(1+\frac{1}{1+r})\frac{f(\hat{i})+a\alpha h(\hat{j})}{e'(\hat{i})} (<0)$, then we have $A_u^S < 0$.[25] In this case, the severer immigration policy lowers the skilled wage rate, i.e., $dw^S / d\beta < 0$. If the production sector actually employs both skilled and unskilled labor simultaneously because of their mutual complementarity, then this case is apparently highly plausible. In this case, because of strong complementarity between skilled and unskilled labor, the decreased low-skilled employment lowers the marginal productivity of skilled labor and therefore its associated wage rate. Therefore, when the home-country's government closes the border, native skilled workers are plausibly adversely affected by a lower wage rate, although unskilled workers benefit from the policy change. However, it is noteworthy that such a negative effect can derive only when the technical complementarity is sufficiently strong; otherwise, the tightening immigration policy benefits all the native workers: skilled and unskilled.

Next, the policy effects on the skill-acquisition decisions are considered. From (2) we obtain

[25] The proof is presented in Appendix A1.

$$\frac{d\hat{i}}{d\beta} = \frac{1}{e'(\hat{i})}[\frac{1}{1+r}\frac{dw^S}{d\beta} - (1+\frac{1}{1+r})\frac{dw^u}{d\beta}]$$

$$= (-\frac{B}{e'(\hat{i})D})[L_S^S + \frac{1}{1+r}(L_S^S + L_u^S)]. \qquad (11)$$

When $L_S^S + L_u^S < 0$, as is standard in the literature, we have $d\hat{i}/d\beta < 0$. Tightening the immigration policy invariably reduces the proportion of individuals who choose to pursue education. When the immigration index is linked negatively to the skill-acquisition index, the tightening policy also decreases the proportion of immigrants who acquire skills. Therefore, the severer immigration policy lowers the average education/skill level of the home country. This effect is apparently analogous to a phenomenon of so-called brain drain, although it is not the source economy. Although the border-closing policy might raise the skilled-wage rate, it lowers the benefits from education investment because the policy raises the unskilled wage rate.

Finally, the effect on the immigration decision of individuals outside the home country is obtained from (3).[26] Differentiating (3) with respect to β gives

$$\frac{d\bar{j}}{d\beta} = \frac{1}{c_j(\bar{j},\beta)}[\frac{dw^u}{d\beta} - c_\beta(\bar{j},\beta)]. \qquad (12)$$

Because $c_j(\bar{j},\beta) < 0$, the effect depends on the sign of the terms in the square brackets. From (7), (8), and (10), one can obtain the following:

$$\frac{dw^u}{d\beta} - c_\beta(\bar{j},\beta) = \frac{1}{D}[A_S^S(B - c_\beta(\bar{j},\beta)A_u^u) + c_\beta(\bar{j},\beta)A_u^S A_S^u]. \qquad (13)$$

Although the first term in the square brackets on the right-hand side of (13) can be shown to be positive, the sign of the second term depends on the sign of $L_u^S (= L_S^u)$, as might be readily apparent from (7c) and (7d). If $L_u^S \geq 0$, then the second term is positive and therefore $d\bar{j}/d\beta > 0$. The tightened immigration policy induces only individuals with higher indexes related to immigration to flow into the home country. Thereby, the quantity of immigration becomes smaller.

[26] Immigration quota policy is assumed to be ruled out in this paper.

By contrast, if there is a strong technical complementarity, i.e., if $F_{L^s L^u} > 0$, then the second term on the right-hand side of (13) might be negative. If this negative term dominates over the first positive term, then we have $d\bar{j} / d\beta < 0$. In this case, the tightened immigration policy eventually increases immigrants. This counter-intuitive result is explainable as follows. Decreases in immigrants might raise the unskilled wage rate considerably. It might increase the demand for skilled labor through changes in the relative wage. With the strong complementarity, however, increases in the skilled labor raise the unskilled labor demand, thereby raising the unskilled wage rate more than without it. Consequently, on balance, the rise in the wage rates might attract more immigration to the home country even with the tightened immigration policy. We can summarize the argument in the following proposition:

Proposition 1: *A severer immigration policy raises the unskilled wage rate but strong complementarity between skilled and unskilled labor might lower the skilled wage rate. A tightening immigration policy also lowers the average education level in the home country. If the complementarity between skilled and unskilled labor is sufficiently strong, it might induce more immigrants to flow into the home country.*

This prediction might run counter to conventional theory that restricting immigration raises the wage rates of competing workers *and* lowers the wage rates of complements in the receiving country (e.g., Borjas, 2006). Unless the complementarity between skilled and unskilled labor are sufficiently strong, a severer immigration policy might raise both the skilled and the unskilled wage rate because the education decisions of natives and the immigration decisions of foreigners are affected by the policy. The intuition underpinning the results is simple: A tightening immigration policy decreases the inflow of low-skill immigrants, which tend to raise the low-skill wage rate. High low-skill wage rates deter workers from education for being skilled, thereby decreasing the number of skilled workers. It in turn raises the skilled wage rate and makes the rises in the low-skill wage rates moderate. By contrast, complementarity between skilled and unskilled labor tends to lower the skilled wage rate. The decreased low-skilled labor lowers the marginal productivity of skilled labor. The net effect of the policy on the skilled wage rate depends on the relative magnitudes of these two effects. Without immigration quotas, higher low-skill wages attract immigrants if it is sufficiently high to offset increases in costs. The policy effect on the average education level of native workers has not been explained in the literature. The result, that a border-closing policy might increase

immigration inflows, is also novel.

The strength of the complementarity between skilled and unskilled labor is crucially important for the result, although it is an empirical issue.[27] Most models in the literature assume complementarity between skilled and unskilled labor (Caselli and Coleman, 2002; Unel, 2010). If the complementarity is not strong, then a tightening policy raises both skilled and unskilled wage rates and decreases the number of immigrants in the receiving economy. Using Greek data for 2000–2007, Chassamboulli and Palivos (2013) present a calibration result by which skilled native workers actually gained in terms of wages and employment because of complementarity between native skilled labor and low-skill immigrants.

4. Restriction on immigrants' opportunities for education

In the preceding section, we assume that immigrants can also acquire education/skill if the education costs are sufficiently lower. However, it might actually be difficult for immigrants to take education unless they are received by the destination country as skilled workers. Therefore, we briefly consider a case in which no immigrant receives education. This case is presented in Figure 1b.

The analysis is fundamentally the same as that used in the preceding section. The equilibrium conditions in the labor market become

$$L^u(w^s, w^u, r) = 2[(1 - \int_0^{\hat{i}} f(i)di) + \alpha \int_{\bar{j}}^{j\max} h(j)dj] \quad \text{and} \tag{14}$$

$$L^s(w^s, w^u, r) = \int_0^{\hat{i}} f(i)di\,. \tag{15}$$

Because conditions (2) and (3) are the same as those in the preceding section, the analysis can be simplified. From these conditions, one can demonstrate that the results are qualitatively equivalent.

5. Concluding remarks

We have analyzed the effects of a border-closing policy on immigration and education decisions of individuals as well as skilled and unskilled wage rates in the receiving country. Our main concern is international mobility of unskilled workers and probably

[27] Dustmann et al. (2016) describe that the elasticity of substitution between unskilled and skilled workers is unambiguously negative. However, empirical studies report that $F_{L^sL^u}$ can be positive or negative. See Appendix A2.

refugees in the world. Our setting shows that severer immigration policies raise the unskilled wage rate and lower the average education level in the home country. In an apparently plausible case in which unskilled and skilled labor are complementary, the policy change might lower the skilled wage rate and might increase immigrant inflows. Therefore, a border-closing policy might not make all workers in the receiving home country happier.

Relaxing simplifying assumptions and reflecting real factors into the model are subjects of future research. First, unemployment has been assumed away in this paper. This point might be more important for European countries. With imperfect labor markets, increases in the wage rate in this paper might be reinterpreted by increases in employment (or decreases in unemployment). Second, the cultural and institutional differences brought along with poor immigrants are not considered in these analyses. Clements and Prichett (2018) as well as Borjas (2015) point out the importance of such factors' effects on production efficiency. Tabellini (2019) suggests that political discontent among natives is unlikely to have economic roots even if immigrants bring economic prosperity. Sachs (2016) also emphasizes the importance of the pace of immigration and its assimilation.[28] Finally, we have not considered demographic factors such as aging, education, and migration simultaneously. Docquier et al. (2018) empirically analyze interaction among these factors in industrialized countries.

Appendix

A1. Complementarity and substitutability between skilled and unskilled labor

In a small open economy, capital internationally moves to keep the domestic interest rate equal to the world interest rate, satisfying (1a). Therefore, we have

$$dw^S = [F_{L^sL^s} - F_{KL^s}(F_{L^sK} / F_{KK})]dL^S + [F_{L^uL^s} - F_{KL^s}(F_{L^uK} / F_{KK})]dL^u , \tag{A1}$$

$$dw^u = [F_{L^sL^u} - F_{KL^u}(F_{L^sK} / F_{KK})]dL^S + [F_{L^uL^u} - F_{KL^u}(F_{L^uK} / F_{KK})]dL^u . \tag{A2}$$

From these equations, we obtain

[28] By contrast, Iranzo and Peri (2009) show with a simulation analysis that international skilled-labor movements and trade improve global welfare through improvements of productive efficiency even under monopolistic competition.

$$\frac{dL^s}{dw^u}(:=L_u^s)=G^{-1}[-\frac{F_{L^uL^s}-F_{KL^s}(F_{L^uK}/F_{KK})}{F_{L^sL^s}-F_{KL^s}(F_{L^sK}/F_{KK})}] \text{ and} \tag{A3}$$

$$\frac{dL^u}{dw^u}(:=L_u^u)=G^{-1}, \tag{A4}$$

where, by assumption,

$$G\equiv[F_{L^uL^u}-F_{KL^u}(F_{L^uK}/F_{KK})]$$

$$-\frac{F_{L^sL^u}-F_{KL^u}(F_{L^sK}/F_{KK})}{F_{L^sL^s}-F_{KL^s}(F_{L^sK}/F_{KK})}[F_{L^uL^s}-F_{KL^s}(F_{L^uK}/F_{KK})]<0. \tag{A5}$$

Therefore, if $F_{L^uL^s}>0$, i.e., technically complementary, then we have $L_u^S<0$ from (A3), where we assume that $F_{KL^x}>0$ ($x=s,u$) and $F_{KK}<0$ in this study. Condition (A4) implies that the demand curve of low-skilled labor is downward sloping. A more detailed explanation is given in Fan and Yakita (2011).

A2. Complementarity between skilled and unskilled workers

Presuming a production function $Y=AK^{\alpha}L^{1-\alpha}$ in which the labor aggregate is a nested constant-elasticity-of-substitution (CES) aggregation of skilled and unskilled labor $L=[\theta^u(L^u)^{\sigma}+\theta^s(L^s)^{\sigma}]^{1/\sigma}$, the elasticity of substitution between skilled and unskilled labor is given as $1/(1-\sigma)$. From the production function, we obtain

$$F_{L^uL^s}=AK^{\alpha}(1-\alpha)\theta^u(L^u)^{\sigma-1}\theta^s(L^s)^{\sigma-1}L^{(1-\alpha)-2\sigma}(1-\alpha-\sigma).$$

Therefore, we have

$$F_{L^uL^s}\begin{matrix}>\\=\\<\end{matrix}0 \text{ as } 1-\sigma\begin{matrix}>\\=\\<\end{matrix}\alpha. \tag{A6}$$

The parameter of the wage change of natives with respect to immigration shock corresponds to $\sigma-1$, as described in Dustmann et al. (2016). They report that the parameter estimated in various studies ranges from -0.42 in Card (2009) to -0.04 in Card and Lewis (2007) in the Mixed Approach (presuming here that $\sigma<1$). Therefore, assuming as many reports in the literature do that $\alpha=0.33$, we can have a case of

$F_{L^u L^s} > 0$, i.e., technical complementarity. In a small open economy with free capital mobility, skilled and unskilled labor are (gross) complements only when their technical complementarity is sufficiently strong. This paper describes that skilled native workers can gain from immigration inflows in terms of wages only when technical complementarity between skilled and unskilled labor is sufficiently strong.

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Conflict of interest

The author has no conflict of interest, financial or otherwise, related to this study.

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Figure 1(a). Education of immigrants.

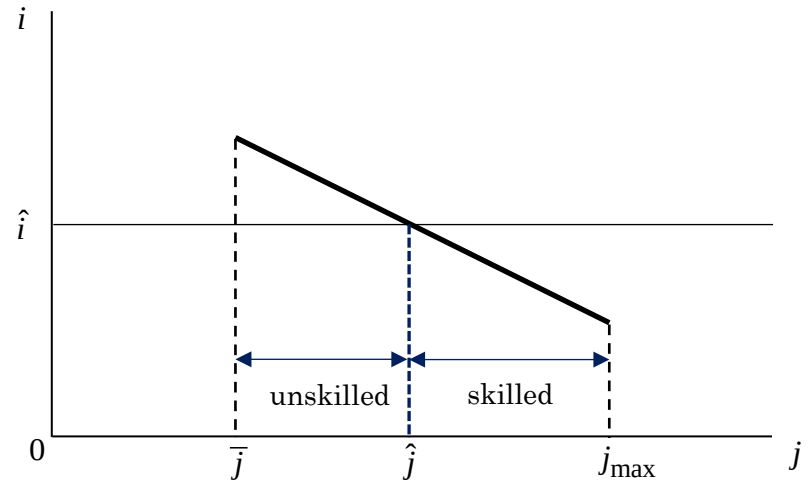

Figure 1(b). Without education of immigrants.