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Abstract

We consider two types of illegal migrants to a developed country based on the expected lifetime income: low-risk entrance with high risk of detection during their stay (type A) and high-risk entrance with low risk of detection (type B). Following Japan's new immigration policy introduced in 2019, we also consider two types of legal unskilled immigrants: those with a limited staying period without their families (Specific Skills #1) and those permitted permanent stay with their families (Specific Skills #2). We consider three possible cases for the co-existence of these types of migrants, resulting from each individual's choice. If all four types of immigrants exist, paradoxically, we found that policies encouraging the introduction of type B illegal immigrants would be the optimal policy for the host country that seeks to improve both foreign workers' quality and the economic welfare of domestic residents.

Keywords: Illegal immigration, border control, internal investigation, fake visa, technical intern

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1. Introduction

It is widely known that the gains of international factor mobility are generally sufficiently large to compensate losers. [1] Nevertheless, most developed countries experiencing decline in population do not always pursue foreign workers aggressively. Throughout the 2016 U.S. presidential campaign, Donald Trump called for the construction of a much larger and fortified border wall to prevent the illegal labor inflow from Mexico. Confronted with the large number of refugees and illegal immigrants from the Middle East and Africa after 2015, EU countries have abandoned their original generous immigration policies and introduced tighter border controls. These strategies are based on the same idea, that is, these developed countries never welcome the inflow of unskilled or lower-quality workers.

Japan has also shared this ideology and the Immigration Control and Refugee Recognition Act advocates that immigration to Japan be strictly restricted. Similar to the U.S. and the EU, Japan also welcomes the inflow of high-skilled labor, while unskilled foreigners are not officially permitted to work in the country. The number of unskilled foreign workers in Japan is therefore limited and can be categorized as the following four types: first, students with part-time jobs, who are permitted to be employed a maximum of 28 hours per week; second, technical interns or trainees who are allowed a maximum of 5 years of temporary work to gain skills on the job; third, foreign residents permitted by the Ministry of Justice, such as second- or third-generation Japanese-Brazilians; fourth, illegal workers. However, due to the accelerating population decline and the economic boom effected by the Shizo Abe Cabinet, labor shortage has become quite serious in the last 5–6 years, especially in nursing care, transport, construction, and guarding.

In this context, Japan decided to introduce a new residential status in 2018. Two new categories were introduced to acquire foreign workers for industries with labor shortage. The first category is Specific Skills #1. Although it is named *skill*, this category is meant mainly for unskilled workers who have completed technical training via internship as, contrary to the original purpose of the category, interns do not always obtain sufficient industrial technique or skill during their stay and some of them are only

[1] For example, see Wong (1995), who demonstrates the welfare gain of international factor mobility under multiple goods and factors.

treated as unskilled low-cost workers. The Japanese government intends to obtain a sufficient number of workers for industries with temporary labor shortage, for whom skilled workers are not necessary. The term "specific skill" seems to be aimed at maintaining an illusion of consistency with the historical Japanese immigration policies, which have never officially permitted the introduction of unskilled workers. Moreover, workers of this category can extend their stay by a maximum of 5 years but are strictly prohibited from bringing their family into the country.

The second new category is Specific Skills #2. This category is meant for medium-level skilled workers. Their period of stay can be extended, and they are assumed to be permanent residents with their families. In 2018, during parliamentary discussions, Japan's Cabinet presented the estimated number of immigrants under each new category. They estimated that in the year 2019 (April 2019 – March 2020), the number of immigrants would be 33,000~47,000, which does not cover the shortage of workers, estimated to be more than 600,000. Anyway, apart from the originally legal high-skilled workers such as medical doctors, lawyers, and so on, those without such high skills would now legally find job opportunities in Japan. This change is quite drastic and contrasts with U.S.A.'s exclusive immigration policies.

Moreover, according to the Ministry of Justice, the number of illegal residents in Japan is about 63,000 as of January 1, 2016.[2] Around two-thirds of those residents are those who entered Japan as short-term visitors such as tourists, who then overstayed. Ten percent of them entered as technical interns and 5.5% of them are non-Japanese spouses of Japanese nationals. Although cross-national marriage is a legal means to obtain residence status, some foreigners enter Japan by means of a fake marriage. In addition, around 5.5% of illegal residents entered Japan as students, then discontinued their studies and engaged in part-time jobs beyond the permitted number of hours, and continued to stay in Japan illegally after their visas expired.[3]

Following Kondoh (2018), we classify illegal residents in developed countries into two categories. Based on the expected lifetime income, some illegal immigrants to developed countries prefer a high-risk and high-cost entrance with a low risk of detection during their stay. Immigrants by fake marriage or disguised political refugees are included in this category. They spend a considerable amount of money to obtain fake documents that must be submitted at the border to the immigration bureau. Even when the quality of fake documentation is high, some of them are detected by border control,

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[2] A certain percentage of illegal residents are not captured in government data. For example, it is impossible to count the number of fake permanent residence visa holders (including fake refugees) unless their false status is uncovered.

[3] See Kondoh (2018) about the penalties imposed on detected illegal workers.

and in those cases, they need not pay penalty charges but must return to their home country immediately. However, if they successfully pass border control and enter as legal permanent residents, their risk of being detected during their stay is quite low, since opportunities to re-evaluate their status are quite limited.

Contrastingly, some illegal immigrants prefer a low-risk and low-cost entrance with a high risk of detection during their stay. Most overstaying residents are included in this category. As tourists, technical interns or students, their entrance is costless and completely legal, but after their visas expire, they face the risk of detection by internal investigation actions taken by the host country's government.

There are numerous studies on illegal immigration. Ethier (1986) was the pioneering theoretical study that introduced two common restriction policies to address illegal immigration, border control (border enforcement), and internal investigation (internal enforcement).[4] The author suggests that the combination of the two policies could reduce the cost of restriction. Ethier refers to two different types of restriction policies but does not distinguish between different groups of immigrants who are targeted by these two policies. Different policies are considered to be effective for all illegal immigrants.[5] We also note that previous studies sometimes assume that the host country's government adopts only one of the restriction policies. For example, Bond and Chen (1986) and Yoshida (1993) take only the internal investigation policy into consideration and focus on its effect on the economy of the host country and the global economy. Using an efficiency model, Carter (1999) also studies the economic effects of illegal immigration referring only to the internal investigation policy. Djajic (1987) presents an extended dynamic model based on Harris and Todaro (1970), and also implicitly considers the existence of internal enforcement.[6] As an example of a theoretical analysis of the border control policy, we refer to Yoshida (1998), who re-examines the Bond and Chen (1987) model using a different immigration policy. However, these studies ignore an important concern, that different policies may be more effective for different types of illegal immigrants. Border control may reduce only certain types of illegal immigrants such as those with fake visas, and internal investigation mainly

[4] Ethier concludes that by border control (and also by internal investigation, when employers can assess the immigration status of their employees), it is not possible to simultaneously accomplish two political targets (i.e., reduction of the volume of illegal immigrants and the improvement of the productivity of unskilled workers).

[5] One good example is Ethier (1986), in which the author considers the possible substitution between the two restriction policies.

[6] Djajic (1997) also studies illegal migration, but in that study, the difference between illegal and legal immigrants is that the former can only be employed in the informal sector.

detects illegal immigrants in another category, such as overstaying residents. Kondoh (2018) focuses on this aspect and investigates the best policies for the host country to combat both types of illegal immigration and to enhance the average quality of immigrants and/or exclude relatively lower-quality immigrants.[7]

Kondoh (2000) analyzes the worker's optimal choice of whether to be a legal migrant, an illegal migrant, or to continue to stay at home (in a developing country) considering the difference in the potential ability of each worker and the skill formation period required to be a legal skill holder, as seen in Djajic (1989). Additionally, Kondoh (2018) studies a potential illegal migrant's choice between high-risk and high-cost entry but low-risk stay, or low-risk and low-cost entry but high-risk stay. The most effective restriction policy for the former type would be border control, while for the latter, border control is meaningless, but internal investigation could more successfully contribute to their detection. Each of the above studies capture the current situation of Japan in a sense, although the effectiveness of restriction policies under the new circumstances, with various types of illegal and legal immigrants co-existing, still remain to be studied. Especially, not only the level of required skill to be legal immigrants as considered in Kondoh (2000), lifelong income also should be the key factor of decision making for potential immigrants. In case that several types of legal and illegal immigrants exist as a result of each individual choice, we need to consider the indirect effects of immigration policies for restricting entry of one type illegal immigrants on the optimal behavior of another type of illegal immigrants as well as legal immigrants. For example, relatively high productivity holders who formerly stay in their home country may choose legal migration due to the increased lifelong income in the host country. The change in average quality of foreign workers which is strongly attracted by domestic residents in the host country should be calculated under the consideration of above effects on the number and quality of foreign workers. We focus on this point and it is the novelty of this study.

In this study, following Kondoh (2018), we attribute the reason for the varied behavior of illegal immigrants to individuals' skill diversification; further, considering the new immigration policies adopted by Japan, we introduce the possibility of unskilled workers' legal migration under Specific Skills #1 and #2 depending on their inborn ability. We focus on the economy of the host country and analyze optimal policies to enhance both the income of domestic residents and the average quality of immigrants. Paradoxically, under certain reasonable condition, we found that policies encouraging the introduction of illegal immigrants with fake visa would be the optimal policy for the

[7] Kondoh (2018) also studies the effects of legalization of high-productivity illegal immigrants.

host country that seeks to improve both foreign workers' quality and the economic welfare of domestic residents.

The remainder of this paper is organized as follows. In Section 2, we present our model. Section 3 is devoted to the analysis, and concluding remarks are presented in Section 4.

2. The Model

2.1 Individuals and Wage Rates

Let us consider a world with two countries. Country Q has a large population and is a source country of international migration and Country R is a host country with a small population. To focus the analysis on the effects of international migration, let us assume, as in MacDougall (1960), that both countries produce the same one good and thus there is no international trade.[8] We take the price of the good as numeraire. The primary factors of production are capital and labor. We assume that free capital mobility and the rental price of capital equal the given world interest rate.[9] In this study, we consider the diversification of skill in each worker of both countries, which directly reflects his/her productivity and wage rate in the home country. We use an approach similar to that of Djajic (1989), where individuals differ in productivity, θ, and are uniformly distributed between $[0,1]$. In addition, following Katz and Stark (1984) and Stark (1991), the number of workers in each country is considered sufficiently large to

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[8] The one-good no-trade model is ordinarily introduced in past studies on international factor mobility to sharpen the focus of the analyses on the problem of international factor mobility. On the other hand, between two countries like China and Japan or Mexico and U.S.A., the existence of large magnitudes of factor mobility is also accompanied by a large magnitude of trade. Therefore, it might be possible to consider a two-good two-country model with different production technologies. Under free trade, the relative prices of the two goods should be equalized between two countries; however, the factor price equalization theorem is not realized due to an assumed technological difference. The wage rate in a capital-abundant country with superior technology to produce the capital intensive good should be higher than that of another country.

[9] For example, we consider production function of country R to be $Y = F(K,L) = 3K^{\frac{1}{3}}L^{\frac{1}{3}}$, where K and L denote capital and labor input considering efficiency, respectively. Under the assumption of free capital mobility, the value of marginal products of capital is exogenously given. In this case, capital inflow occurs following the inflow of labor, and the wage rate of one efficient unit of labor, $\overline{w}_R$, will decrease.

make it possible to express the wage rate of each worker in each country as a continuous function of his/her productivity:

$$w_R(\theta) = \overline{w}_R + r\theta \,, \tag{1}$$

$$w_Q(\theta) = \overline{w}_Q + q\theta \,, \tag{2}$$

where w_R and w_Q are, respectively, the wage rates of an individual in Countries R and Q.[10] $\overline{w}_R$ and $\overline{w}_Q$ are, respectively, the basic wage rate of a worker in Countries R and Q whose productivity is at the lowest level. The basic wage rate in country R is the function of the size of the efficiency unit of migrants, while we assume that of the large country Q remains constant regardless of the amount of capital/labor flow.[11] Each domestic worker's wage rate increases depending on his/her productivity by rates r and q, in Countries R and Q, respectively. On the other hand, because of insufficient communication skills, unskilled (including medium-level skilled) immigrants are treated as the lowest-quality workers regardless of their inborn abilities. Thus, their wage rate in country R is $\overline{w}_R$. Additionally, we reasonably assume that because of the inconvenience of the uncertain illegal status or loneliness without family, the welfare of both unskilled illegal immigrants and immigrants under the Specific Skills #1 status should be discounted by $k, (k < 1)$.[12] On the other hand, Specific Skills #2-type immigrants can enjoy their life in the host country with their family without any uncertainty. Thus, the model does not include any factor to discount their welfare.

We assume that $k\overline{w}_R > \overline{w}_Q$, which implies that at least the lowest productivity

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10 We assume that employers in Country R perfectly know the productivity level of workers. Following Katz and Stark (1984), considering asymmetric information and introduction of expected quality of workers are subjects for future work.

11 We assume that both the area and labor market of Country Q are sufficiently large. Because of low trip costs, limited workers who live near the border intend to migrate as it is considered beneficial, while most workers who live inland of Country Q do not consider migration. Assuming free and zero cost capital movement in Country Q, we can assume an integrated labor market where there is no wage gap between the workers of same productivity all over the country.

12 As this is one-good model, each worker's welfare level can be measured by his income level. Moreover under the assumption of constant rental price of capital, domestic residents' welfare level also can be measured by $\overline{w}_R$.

holder prefers to be an unskilled immigrant regardless of the discount factor k. We also assume $k\overline{w}_R > w_Q$ if $\theta = [0, \theta^*]$ and $k\overline{w}_R < w_Q$ if $\theta = [\theta^*, 1]$, which implies that high-productivity workers avoid migrating without their families and, as a result, unskilled immigrants are essentially lower-productivity workers.

2.2 Legal migration

Under Japan's old immigration policy, the period of legal stay for unskilled technical interns was 5 years. In this case, we can express the lifelong income of unskilled legal immigrants as,

$$w_0 = \tau k\overline{w}_R + (T - \tau) w_Q, \tag{3}$$

where τ denotes the period of legal stay.

Unskilled workers can migrate to Japan legally under better conditions after April 2019. The new category Specific Skills #1 is, as mentioned in the introduction, for those who have completed a technical internship. Their treatment is essentially unchanged but staying for more 5 years is permitted. Thus, the lifelong income of unskilled legal Specific Skills #1-immigrants can be expressed as follows,

$$w_1 = tk\overline{w}_R + (T - t) w_Q, \tag{4}$$

where t denotes the period of legal stay in Country R under the new immigration policy, that is, 10 years.

In contrast, also as mentioned in the introduction, the new category, Specific Skills #2, involves much better treatment. During the first 5 years as technical interns, these immigrants need to make great effort to satisfy the necessary conditions for their stay—their qualifications in the fields of construction, shipbuilding, automotive aviation, or lodging.[13] If they succeed, they can work in Japan permanently, and also bring along their families. We assume that the necessary costs to obtain sufficient skills or

[13] The Cabinet of Japan estimates that around 45% of Specific Skills #1 and #2 will be occupied by those who have completed a technical internship. In this study, we consider those workers' case.

qualifications are different depending on their potential productivity or ability and here, we reasonably consider that the aggregate costs, Φ, is a convex decreasing function of θ and to simplify our analysis, we assume a quadratic function, $\Phi = a(1-\theta)^2$. We can express the lifelong income of unskilled legal Specific Skills #2-immigrants as follows,

$$w_2 = [\tau k + (T-\tau)]\overline{w}_R - \Phi . \quad (5)$$

Figure 1 shows unskilled workers' decision-making process to migrate under the new immigration policy. Individuals whose indexes are $\theta = [0, \bar{\bar{\theta}}]$, $\theta = [\bar{\bar{\theta}}, \tilde{\theta}]$, and $\theta = [\tilde{\theta}, 1]$ choose to migrate to country R as Specific Skills #1, Specific Skills #2, and choose to stay in country Q (no migration), respectively.[14]

----FIGURE 1 is around here----

2.3 Illegal migration

As mentioned in the introduction, each worker aims to maximize his/her expected lifetime income. As a result, some workers prefer to adopt a low-risk and low-cost entrance with a high risk of detection. Let us call them type A migrants. They enter as tourists, technical interns, or language-school students and overstay their visas. We assume that there is no special cost or inspection associated with crossing the border. However, because they do not have work permits, they live in constant fear of being discovered. Further, employers must pay penalty charges in case of detection. Thus, following Yoshida (1993), immigrants' wage rates should be discounted to account for this probability. As in Kondoh (2018), we express the expected income of a type-A migrant, w_A, with their innate productivity θ as follows:

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[14] As it is not realistic, we exclude the possibility of $\bar{\bar{\theta}} > \theta^*$ where medium ability holders, lower than those to be Specific Skills #2 but higher than Specific Skills #1, do not choose migration.

$$w_A(\theta) = \gamma k(\overline{w}_R - p\varepsilon) + (T - \gamma)w_Q(\theta)\,, \tag{6}$$

where p denotes the probability of detection in each period of their illegal stay, ε denotes the penalty charge that employers must pay in case of detection, and T denotes the immigrant's survival period.[15] Additionally, γ denotes the expected or average period of illegal stay, and we reasonably assume that it is a decreasing function of p, that is, $\gamma = \gamma(p)$ and $\gamma' < 0$.

On the other hand, some workers in Country Q prefer to migrate to a developed country by choosing a high-risk and high-cost entrance with a low-risk of detection during their stay. Let us call them type B migrants. They disguise themselves as married with domestic people, refugees or legal skilled workers. Unlike with type-A migrants, we assume that it is necessary for these migrants to pay a special cost to obtain fake documents or visas. Moreover, if their illegal status is discovered, they must pay penalty charges themselves.[16] However, once they successfully pass border control, they face a fairly low risk of detection during their stay. Also as in Kondoh (2018), we express the expected income of a type B immigrant, w_B, with innate productivity θ as follows,

$$w_B(\theta) = T[\eta k\overline{w}_R + (1-\eta)w_Q(\theta)] - \mu\,, \tag{7}$$

where η denotes the probability of success in crossing the border, and μ denotes the necessary cost to obtain the fake document or visa.

2.4 Choice of migration style

Workers will choose to be type A illegal migrants if profit is positive, that is,

$$f(\theta) \equiv w_A(\theta) - Max\{w_1(\theta), w_2(\theta)\} > 0\,. \tag{8}$$

Also workers will choose to be type B illegal migrants if profit is positive, that is,

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[15] To simplify our analysis, we ignore the ordinary discount rate caused by time preference.

[16] In this study, to simplify our analysis, we assume this penalty charge is null.

$$g(\theta) \equiv w_B(\theta) - Max\{w_1(\theta), w_2(\theta)\} > 0 . \tag{9}$$

This now presents three possible cases. If $f > 0$ and $f > g$, workers will be type A migrants. If $g > 0$ and $g > f$, workers will be type B migrants. Finally, if $f < 0, g < 0$, then workers will not be illegal migrants and will migrate legally under the Specific Skills #1 or #2 category, and otherwise choose to not migrate.

In case $\bar{\bar{\theta}} < \theta < \tilde{\theta}$, $w_1 < w_2$ holds but we easily can find that for any $\theta\ (\theta > \bar{\bar{\theta}})$, $f < 0$ and $g < 0$ which implies that workers would migrate under Specific Skills #2 status. Whereas, in case $\theta < \bar{\bar{\theta}}$, considering $w_1 > w_2$, to guarantee the possibility of illegal migration, we assume both $\gamma > t$ and $\eta T > t$, which implies that $f' < 0$ and $g' < 0$.[17] Let us define θ_F, θ_G, and $\hat{\theta}$, which satisfy $f(\theta_F) = 0$, $g(\theta_G) = 0$, and $f(\hat{\theta}) = g(\hat{\theta})$, respectively.[18] Now we have three possible cases.

Case 1 is where $f(0) > g(0)$ and $\theta_F > \theta_G$. As $f(0) - g(0) = (k\bar{w}_R - q_0)(\gamma - \eta T) - \gamma kp\varepsilon + \mu$, $\gamma > \eta T$ and $\mu > \gamma kp\varepsilon$ are sufficient conditions to realize this case, where type A migration dominates and there is no possibility of type B migration. In this case, an individual whose index is $\theta = [0, \theta_F]$ will be a type A illegal migrant, whose index is $\theta = [\theta_F, \bar{\bar{\theta}}]$ will be a legal migrant under the Specific Skills #1 status, and whose index is $\theta = [\bar{\bar{\theta}}, \tilde{\theta}]$ will be a legal migrant under the Specific Skills #2 status, and those whose index is $\theta = [\tilde{\theta}, 1]$ will not migrate.

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[17] Otherwise, $w_1 > w_A$ and $w_1 > w_B$ for all θ, which implies no possibility of illegal migration.

[18] We can calculate that $\theta_F = \dfrac{k\bar{w}_R - q_0}{q} - \dfrac{\gamma kp\varepsilon}{q(\gamma - t)}$, $\theta_G = \dfrac{k\bar{w}_R - q_0}{q} - \dfrac{\mu}{q(\eta T - t)}$, and $\hat{\theta} = \dfrac{(k\bar{w}_R - q_0)(\gamma - T\eta)}{q} + \dfrac{\mu - \gamma kp\varepsilon}{q(\gamma - T\eta)} = \dfrac{1}{q}[f(0) - g(0)]$.

In Case 2, $f(0) < g(0)$ and $\theta_F < \theta_G$. $\gamma < \eta T$ and $\mu < \gamma kp\varepsilon$ are sufficient conditions to realize this case where type B migration dominates and there is no possibility of type A migration. In this case, an individual whose index is $\theta = [0, \theta_G]$ will be a type B illegal migrant, whose index is $\theta = [\theta_G, \bar{\bar{\theta}}]$ will be a legal migrant under the Specific Skills #1 status, whose index is $\theta = [\bar{\bar{\theta}}, \tilde{\theta}]$ will be a legal migrant under the Specific Skills #2 status, and those whose index is $\theta = [\tilde{\theta}, 1]$ will not migrate.

In Case 3, $f(0) > g(0)$ and $\theta_F < \theta_G$. As $f' < g' < 0$, that is $\gamma > \eta T$, the necessary condition is $\mu < \gamma kp\varepsilon$.[19] This is the co-existing case of two types of illegal immigrants and the abilities or productivity of type A immigrants are lower than those of type B immigrants. In this case, an individual whose index is $\theta = [0, \hat{\theta}]$ will be a type A illegal migrant, $\theta = [\hat{\theta}, \theta_G]$ will be a type B illegal migrant, $\theta = [\theta_G, \bar{\bar{\theta}}]$ will be a legal migrant under the Specific Skills #1 status, $\theta = [\bar{\bar{\theta}}, \tilde{\theta}]$ will be a legal migrant under the Specific Skills #2 status, and $\theta = [\tilde{\theta}, 1]$ will not migrate. Figure 2 summarizes the above three cases.

----FIGURE 2 is around here----

3. Analysis

Generally, labor inflow causes positive effects on the economy of the host

[19] $\hat{\theta} > 0$ implies $f(0) > g(0)$; therefore, there is no possibility of another case with two types of illegal migration co-existing, as abilities of type B immigrants are lower than those of type A immigrants, for which both $f(0) < g(0)$ and $\theta_F > \theta_G$ are necessary conditions.

(recipient) country. However, despite this fact, unskilled labor inflow might not be welcomed due to security concerns from increased crime, or to protect those whose jobs may be taken away by immigrants. Thus, we assume that Country R, the host country of illegal immigration, aims to realize two policy targets in addressing the issue of illegal immigrants; that is, first, to enhance the income of native inhabitants by reducing the total number of immigrants and enhancing the wage rate. Second, to improve the average productivity of these immigrants, that is, reduce the staying period of those with lower ability. Thus, we stipulate that welfare improvement should involve an increase in both the wage rate and the quality of foreign workers.

3.1 Case 1 – type A with Specific Skills #1 & #2

In Case 1, we obtain the following four equations which determine four endogenous variables, $(\overline{w}_R, \theta_F, \overline{\overline{\theta}}, \tilde{\theta})$.

$$\theta_F = \frac{k\overline{w}_R - q_0}{q} - \frac{\gamma k p \varepsilon}{q(\gamma - t)}, \tag{10}$$

$$\begin{aligned}\Psi(\overline{\overline{\theta}}) &= w_1(\overline{\overline{\theta}}) - w_2(\overline{\overline{\theta}}) \\ &= [(t-\tau)k - (T-\tau)]\overline{w}_R + (T-t)(q_0 + q\overline{\overline{\theta}}) + a(1-\overline{\overline{\theta}})^2 = 0,\end{aligned} \tag{11}$$

$$\begin{aligned}\Gamma(\tilde{\theta}) &= w_2(\tilde{\theta}) - T(q_0 + q\tilde{\theta}) \\ &= [\tau k + (T-\tau)]\overline{w}_R - T(q_0 + q\tilde{\theta}) - a(1-\tilde{\theta})^2 = 0,\end{aligned} \tag{12}$$

$$\overline{w}_R = \overline{w}_R(\gamma\theta_F, t(\overline{\overline{\theta}} - \theta_F), T(\tilde{\theta} - \overline{\overline{\theta}})), \tag{13}$$

where $\Psi' < 0$ and $\Gamma' < 0$.

As mentioned in the introduction, two possible restriction policies are available to Country R, border control and internal investigation. Similar to Kondoh (2018) and unlike Ethier (1986) and most other studies, in our model, the targets of these two policies are distinct. Stricter border control implies stricter visa inspection at the border, which will directly reduce type A immigrants' probability of success in crossing the border, while stricter internal investigation will likely reduce the expected duration of type B immigrants' stay in the host country.

To restrict the inflow of type A immigrants, the government of Country R can adopt two policies, increasing the probability of detection in each period of their illegal stay, p, and increasing the penalty charge in the case of detection, ε. The results of the comparative static analyses are as follows:

$$d\overline{w}_R/dp > 0,\ d\theta_F/dp < 0^*,\ d\overline{\overline{\theta}}/dp < 0,\ d\tilde{\theta}/dp > 0 \text{ ,}^{20} \tag{14}$$

$$d\overline{w}_R/d\varepsilon > 0,\ d\theta_F/d\varepsilon < 0,\ d\overline{\overline{\theta}}/d\varepsilon < 0,\ d\tilde{\theta}/d\varepsilon > 0\ . \tag{15}$$

Alternatively, to improve the average quality of immigrants, we can consider extending Specific Skills #1 workers' legal staying period. The results of this policy are:

$$d\overline{w}_R/dt > 0,\ d\theta_F/dt < 0,\ d\overline{\overline{\theta}}/dt > 0,\ d\tilde{\theta}/dt > 0\ .^{21} \tag{16}$$

Because of the difference of expected staying periods, the average quality of foreign workers will increase if both θ_F and $\overline{\overline{\theta}}$ decrease while $\tilde{\theta}$ increases. From (14)–(16), we can make the following proposition.

Proposition 1

Consider the case with the co-existence of type A illegal migrants and Specific Skills #1 and #2 legal migrants.

ⅰ)An increase in the penalty charges from illegal migrant detection will cause positive effects on the economic welfare of the host country by increasing the wage rate and improving the average quality of immigrant workers.

ⅱ) Under certain conditions, similar results are obtained for both cases through an increase in the probability of detection of illegal immigrants and an increase in the legal staying period of Specific Skills #1-immigrants.

3.2 Case 2 – type B with Specific Skills #1 and #2

In Case 2, we obtain the following four equations which determine four

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[20] The sign of * is under the condition that γ' is sufficiently small.

[21] See Appendix 1 for the derivation of (14)-(16).

endogenous variables, $(\bar{w}_R, \theta_G, \bar{\bar{\theta}}, \tilde{\theta})$.

$$\theta_G = \frac{k\bar{w}_R - q_0}{q} - \frac{\mu}{q(\eta T - t)}, \tag{17}$$

$$\begin{aligned}\Psi(\bar{\bar{\theta}}) &= w_1(\bar{\bar{\theta}}) - w_2(\bar{\bar{\theta}}) \\ &= [(t-\tau)k - (T-\tau)]\bar{w}_R + (T-t)(q_0 + q\bar{\bar{\theta}}) + a(1-\bar{\bar{\theta}})^2 = 0,\end{aligned} \tag{11}$$

$$\begin{aligned}\Gamma(\tilde{\theta}) &= w_2(\tilde{\theta}) - T(q_0 + q\tilde{\theta}) \\ &= [\tau k + (T-\tau)]\bar{w}_R - T(q_0 + q\tilde{\theta}) - a(1-\tilde{\theta})^2 = 0,\end{aligned} \tag{12}$$

$$\bar{w}_R = \bar{w}_R(\eta T \theta_G, t(\bar{\bar{\theta}} - \theta_G), T(\tilde{\theta} - \bar{\bar{\theta}})), \tag{18}$$

where $\Psi' < 0$ and $\Gamma' < 0$.

As in section 3.1, to restrict the inflow of type B immigrants, the government of Country R can adopt two policies, reducing the probability of success in crossing the border, η, and increasing the necessary cost to obtaining fake visas, μ. The results of the comparative static analyses are as follows:

$$d\bar{w}_R/d\eta < 0, d\theta_G/d\mu \gtrless 0, d\bar{\bar{\theta}}/d\eta > 0, d\tilde{\theta}/d\eta < 0, \tag{19}$$

$$d\bar{w}_R/d\mu > 0, d\theta_G/d\mu < 0, d\bar{\bar{\theta}}/d\mu < 0, d\tilde{\theta}/d\mu > 0. \tag{20}$$

The results of extending the legal staying period of Specific Skills #1 workers are as follows:

$$d\bar{w}_R/dt > 0, d\theta_G/dt \gtrless 0, d\bar{\bar{\theta}}/dt \gtrless 0, d\tilde{\theta}/dt > 0. \tag{21}$$ [22]

Because of the difference of expected staying periods, the average quality of foreign workers will increase if both θ_G and $\bar{\bar{\theta}}$ decrease while $\tilde{\theta}$ increases. From (19) - (21), we can state the following proposition.

[22] See Appendix 2 for derivation of (19)-(21).

Proposition 2

Consider the case with co-existence of type B illegal migrants and Specific Skills #1 & 2 legal migrants.

ⅰ)The effects on the economic welfare of the host country caused by an increase in fake visa costs for illegal immigrants will cause positive effects on the economic welfare of the host country by increasing wage rate and improving the average quality of foreign workers.

ⅱ) Both a decrease inthe probability of successful border crossing and an increase in the legal staying period of Specific Skills #1 will have positive effects on the wage rate of domestic workers, but the average quality of foreign workers may decrease.

3.3 Case 3– type A & B with Specific Skills #1 & #2

In Case 3, we obtain the following five equations which determine five endogenous variables, $(\overline{w}_R, \hat{\theta}, \theta_G, \overline{\overline{\theta}}, \tilde{\theta})$:

$$\hat{\theta} = \frac{(k\overline{w}_R - q_0)(\gamma - T\eta)}{q} + \frac{\mu - \gamma k p \varepsilon}{q(\gamma - T\eta)}, \tag{22}$$

$$\theta_G = \frac{k\overline{w}_R - q_0}{q} - \frac{\mu}{q(\eta T - t)}, \tag{17}$$

$$\begin{aligned}\Psi(\overline{\overline{\theta}}) &= w_1(\overline{\overline{\theta}}) - w_2(\overline{\overline{\theta}}) \\ &= [(t-\tau)k - (T-\tau)]\overline{w}_R + (T-t)(q_0 + q\overline{\overline{\theta}}) + a(1-\overline{\overline{\theta}})^2 = 0,\end{aligned} \tag{11}$$

$$\begin{aligned}\Gamma(\tilde{\theta}) &= w_2(\tilde{\theta}) - T(q_0 + q\tilde{\theta}) \\ &= [\tau k + (T-\tau)]\overline{w}_R - T(q_0 + q\tilde{\theta}) - a(1-\tilde{\theta})^2 = 0,\end{aligned} \tag{12}$$

$$\overline{w}_R = \overline{w}_R(\gamma\hat{\theta}, \eta T(\theta_G - \hat{\theta}), t(\overline{\overline{\theta}} - \theta_G), T(\tilde{\theta} - \overline{\overline{\theta}})), \tag{23}$$

where $\Psi' < 0$ and $\Gamma' < 0$.

As in 3.1 and 3.2, to restrict the inflow of type A and B immigrants, the government of Country R can adopt two policies for each: for type A immigrants, increasing the probability of detection in each period of their illegal stay, p, and increasing the penalty charge in the case of detection, ε; and for type B immigrants, reducing the probability of success in crossing the border, η, and increasing the necessary cost to obtaining fake visas, μ. However, in this case, due to the connected indirect effects, some of the restriction policies have unexpected outcomes. The results of the comparative static analyses are as follows:

$$d\overline{w}_R/dp > 0, d\hat{\theta}/dp \gtrless 0, d\theta_G/dp > 0, d\bar{\bar{\theta}}/dp < 0, d\tilde{\theta}/dp > 0, \tag{24}$$

$$d\overline{w}_R/d\varepsilon > 0, d\hat{\theta}/d\varepsilon < 0, d\theta_G/d\varepsilon > 0, d\bar{\bar{\theta}}/d\varepsilon < 0, d\tilde{\theta}/d\varepsilon > 0, \tag{25}$$

$$d\overline{w}_R/d\eta > 0, d\hat{\theta}/d\eta < 0, d\theta_G/d\eta > 0, d\bar{\bar{\theta}}/d\eta < 0, d\tilde{\theta}/d\eta > 0, \tag{26}$$

$$d\overline{w}_R/d\mu = 0, d\hat{\theta}/d\mu > 0, d\theta_G/d\mu < 0, d\bar{\bar{\theta}}/d\mu = 0, d\tilde{\theta}/d\mu = 0. \tag{27}$$

The results of extending the legal staying period of Specific Skills #1 workers are as follows:

$$d\overline{w}_R/dt > 0, d\hat{\theta}/dt > 0, d\theta_G/dt < 0, d\bar{\bar{\theta}}/dt > 0, d\tilde{\theta}/dt > 0. \tag{28}$$ [23]

Because of the difference in the expected staying periods, the average quality of foreign workers will increase if both $\hat{\theta}$ and $\bar{\bar{\theta}}$ decrease while $\tilde{\theta}$ increases.[24] From (25) - (28), we present the following proposition.

Proposition 3

Consider the case of the co-existence of type A & B illegal migrants and Specific Skills #1 & 2 legal migrants.

i) An increase in penalty chargeon detected illegal migrants will have positive effects on the economic welfare of the host country by increasing wage rate and improving the

[23] See Appendix 3 for derivation of (24)-(28).

[24] The effect on the average quality of foreign workers caused by an increase in θ_G may or may not positive depending on parameters. We consider the magnitude of this effects is not sufficiently large to dominate the effects caused by changes in $\hat{\theta}, \bar{\bar{\theta}}$ and $\tilde{\theta}$.

average quality of foreign workers.

ii) An increase in the probability of detection of illegal immigrants, a decrease in the probability of successful border crossing, and an increase in the legal period of stay of Specific Skills #1 workers will improve the wage rate but the effects on average quality of foreign workers are not always positive.

iii) Paradoxically, **a decrease in fake visa cost may enhance the economic welfare of the host country** due to the reduced number of lower-quality foreign workers and the unchanged wage rate.

iv) Also paradoxically, **an increase in the probability of successful border crossing with a fake visa will have positive effects on the welfare of the host country** by increasing the wage rate and the average quality of foreign workers.

The paradoxical results, iii) and iv) of proposition 3 can be intuitively comprehended as follows. Due to the increase of type B illegal migrants, individuals just less than index $\hat{\theta}$ will change their behavior from type A to type B. This implies that the total number of lower-quality immigrants will decrease because of $\gamma > \eta T$. Moreover, we find that by this effect, in iv. (iii.), the total the number of foreign workers will decrease (remain unchanged), which enhances (keeps constant) $\overline{w}_R$ in equilibrium and also results in increased (constant) $\hat{\theta}$. This result is the opposite of Case 2, with no type A illegal immigrants.

4. Concluding Remarks

The main findings of this study are summarized as follows.

The most acceptable policy in Case 1 (low-risk entrance–high-risk detection illegal immigrants with Specific Skills #1 & #2) is increasing the penalty for detected illegal migrants. Under certain conditions, increasing the probability of detection of illegal immigrants and extending the legal period of stay of Specific Skills #1 workers are also positive for the economy of the host country. In Case 2 (low-high entrance–low-risk detection illegal immigrants with Specific Skills #1 & #2), increasing the cost of fake visas is a effective policy but the policy to reduce the probability of successful entry is not always preferable for the host country. Finally, in Case 3 (both types of illegal immigrants with Specific Skills #1 & #2), the most acceptable policies are paradoxical. Increasing the penalty charged on detected illegal migrants is a good policy for type A illegal immigrants, which is an expected result. However, for type B illegal immigrants, decreasing fake visa costs and enhancing the probability of successful entry are good policies for domestic residents. In other words, encouraging illegal immigration with fake visas might be welfare improving.

In Case 3, where type A illegal immigrants also co-exist, the optimal policy to type B illegal immigrants is completely opposite to that is in Case 2 without type A immigrants. Our results suggest that the direct effects of restriction policies to one type of illegal immigrants might be dominated by the indirect effects on the behavior of another type of illegal immigrants and legal immigrants. As a result, we can assert the possibility that the estimated results might be reversed.

Future studies must consider financially neutral conditions. In reality, the aggregate costs of restriction policies must be within the total financial resource that is equal to the penalty charges paid by the detected type A illegal immigrants. Moreover, we need to try to relax assumptions by, for example, introduction asymmetric information about the productivity of illegal immigrants, introducing wage difference in the host country between different productivity holders, and introducing highly skilled workers who can migrate legally without any training period and investigating the effects of the extension of this required skill. Finally, real-world examples must be investigated to test which case is the most realistic.

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Appendix 1

Totally differentiating (7), (8), (9) and (10), we have,

$$\begin{bmatrix} -(\gamma-t)k & q(\gamma-t) & 0 & 0 \\ (t-\tau)k-(T-\tau) & 0 & \Sigma & 0 \\ \tau k+(T-\tau) & 0 & 0 & \Xi \\ -1 & (\gamma-t)\overline{w}_R^L & (t-T)\overline{w}_R^L & T\overline{w}_R^L \end{bmatrix} \begin{bmatrix} d\overline{w}_R \\ d\theta_F \\ d\overline{\overline{\theta}} \\ d\tilde{\theta} \end{bmatrix} = \begin{bmatrix} \Psi \\ 0 \\ 0 \\ -\overline{w}_R^L\theta_F\gamma' \end{bmatrix} dp + \begin{bmatrix} -\gamma kp \\ 0 \\ 0 \\ 0 \end{bmatrix} d\varepsilon + \begin{bmatrix} -[k\overline{w}_R-(\overline{w}_Q+q\theta_F)] \\ -[k\overline{w}_R-(\overline{w}_Q+q\overline{\overline{\theta}})] \\ 0 \\ -w_R^L(\overline{\overline{\theta}}-\theta_F) \end{bmatrix} dt, \quad \text{(A1)}$$

where $\overline{w}_R^L \equiv \partial\overline{w}_R / \partial L < 0,\ L \equiv \gamma\theta_F + t(\overline{\overline{\theta}}-\theta_F) + T(\tilde{\theta}-\overline{\overline{\theta}})$, $\Sigma = (T-t)q + 2a(\overline{\overline{\theta}}-1) < 0$, $\Xi = -[Tq + 2a(\tilde{\theta}-1)] < 0$, and $\Psi = [(k\overline{w}_R - (w_Q + q\theta_F)]\gamma' - k\varepsilon(\gamma + \gamma' p) < 0$. The determinant of LHS of (A1), Δ_1, can be expressed as,

$$\begin{aligned} \Delta_1 &= (\gamma-t)\Sigma\Xi[-(\gamma-t)k\overline{w}_R^L + q] + \Xi q[(t-\tau)k-(T-\tau)](t-T)\overline{w}_R^L \\ &+\Sigma q[\tau k + (T-\tau)]T\overline{w}_R^L > 0 \end{aligned} . \quad \text{(A2)}$$

The results of the comparative static analyses are,

$$\frac{d\overline{w}_R}{dp} = \frac{1}{\Delta_1}(\gamma-t)\overline{w}_R^L\Sigma\Xi[\Psi\gamma + q\theta_F\gamma'] > 0, \quad \text{(A3)}$$

$$\frac{d\theta_F}{dp} = \frac{1}{\Delta_1}\{-\Psi[\Xi q(\gamma - t)[(t-\tau)k - (T-\tau)](t-T)\overline{w}_R^L$$
$$+\Sigma q(\gamma - t)[\tau k + (T-\tau)]T\overline{w}_R^L - \Sigma\Xi] + \Sigma\Xi(\gamma - t)k\overline{w}_R^L\theta_F\gamma', \tag{A4}$$

$$\frac{d\overline{\overline{\theta}}}{dp} = -\frac{1}{\Delta_1}\Xi\Psi(\gamma - t)[(t-\tau)k - (T-\tau)] < 0, \tag{A5}$$

$$\frac{d\tilde{\theta}}{dp} = \frac{-1}{\Delta_1}\Sigma[\tau k + (T-\tau)[\Psi(\gamma - t)\overline{w}_R^L + q(\gamma - t)\overline{w}_R^L\theta_F\gamma'] > 0, \tag{A6}$$

$$\frac{d\overline{w}_R}{d\varepsilon} = \frac{-1}{\Delta_1}\Sigma\Xi\gamma kp(\gamma - t)\overline{w}_R^L > 0, \tag{A7}$$

$$\frac{d\theta_F}{d\varepsilon} = \frac{-1}{\Delta_1}\gamma kp\{\Sigma\Xi + \Sigma[\tau k + (T-\tau)]T\overline{w}_R^L + \Xi[(t-\tau)k - (T-\tau)](t-T)\overline{w}_R^L\} < 0, \tag{A8}$$

$$\frac{d\overline{\overline{\theta}}}{d\varepsilon} = \frac{1}{\Delta_1}\Xi\gamma kp[(t-\tau)k - (T-\tau)](\gamma - t)\overline{w}_R^L < 0, \tag{A9}$$

$$\frac{d\tilde{\theta}}{d\varepsilon} = \frac{1}{\Delta_1}\Sigma\gamma kp[(\tau k + (T-\tau)](\gamma - t)\overline{w}_R^L > 0, \tag{A10}$$

$$\frac{d\overline{w}_R}{dt} = \frac{-1}{\Delta_1}\Xi(\gamma - t)\overline{w}_R^L[\Sigma + q(t-T)][k\overline{w}_R - (\overline{w}_Q + q\overline{\overline{\theta}})] > 0, \tag{A11}$$

$$\frac{d\theta_F}{dt} = \frac{1}{\Delta_1}\Xi(\gamma - t)k\overline{w}_R^L\{\Sigma(\overline{\overline{\theta}} - \theta_F) - (t-T)[k\overline{w}_R - (\overline{w}_Q + q\overline{\overline{\theta}})]\}$$
$$-[k\overline{w}_R - (\overline{w}_Q + q\theta_F)]\{\Xi\Sigma + \Sigma[\tau k + (T-\tau)]T\overline{w}_R^L + \Xi(t-T)[(t-\tau)k - (T-\tau)]\overline{w}_R^L\} < 0, \tag{A12}$$

$$\frac{d\overline{\overline{\theta}}}{dt} = \frac{1}{\Delta_1}(-\Xi)(\gamma - t)\{q[k\overline{w}_R - (\overline{w}_Q + q\overline{\overline{\theta}})] + [(t-\tau)k - (T-\tau)]\overline{w}_R^L[k\overline{w}_R - (\overline{w}_Q + q\theta_F)]\}$$
$$+q(\gamma - t)\overline{w}_R^L(\overline{\overline{\theta}} - \theta_F)[(t-\tau)k - (T-\tau)] - k(\gamma - t)^2\overline{w}_R^L[k\overline{w}_R - (\overline{w}_Q + q\overline{\overline{\theta}})] > 0, \tag{A13}$$

$$\frac{d\tilde{\theta}}{dt} = \frac{1}{\Delta_1}(\gamma - t)[\tau k + (T-\tau)][k\overline{w}_R - (\overline{w}_Q + q\overline{\overline{\theta}})]\overline{w}_R^L[\Sigma + q(t-T)] > 0, \tag{A14}$$

Appendix 2

Totally differentiating (14), (8), (9) and (15), we have,

$$\begin{bmatrix} -(\eta T-t)k & q(\eta T-t) & 0 & 0 \\ (t-\tau)k-(T-\tau) & 0 & \Sigma & 0 \\ \tau k+(T-\tau) & 0 & 0 & \Xi \\ -1 & (\eta T-t)\overline{w}_R^L & (t-T)\overline{w}_R^L & T\overline{w}_R^L \end{bmatrix} \begin{bmatrix} d\overline{w}_R \\ d\theta_G \\ d\overline{\overline{\theta}} \\ d\tilde{\theta} \end{bmatrix}$$
$$= \begin{bmatrix} T(k\overline{w}_R^L-(\overline{w}_Q+q\theta_G)) \\ 0 \\ 0 \\ -\overline{w}_R^L\theta_G T \end{bmatrix} d\eta + \begin{bmatrix} -1 \\ 0 \\ 0 \\ 0 \end{bmatrix} d\mu + \begin{bmatrix} -[k\overline{w}_R-(\overline{w}_Q+q\theta_G)] \\ -[k\overline{w}_R-(\overline{w}_Q+q\overline{\overline{\theta}})] \\ 0 \\ -w_R^L(\overline{\overline{\theta}}-\theta_G) \end{bmatrix} dt, \tag{A15}$$

The determinant of LHS of (A15), Δ_2, can be expressed as,

$$\Delta_2 = (\eta T-t)\Sigma\Xi[-(\eta T-t)k\overline{w}_R^L+q]+\Xi q[(t-\tau)k-(T-\tau)](t-T)\overline{w}_R^L$$
$$+\Sigma q[\tau k+(T-\tau)]T\overline{w}_R^L>0. \tag{A16}$$

The results of the comparative static analyses are,

$$\frac{d\overline{w}_R}{d\eta} = \frac{1}{\Delta_2}\Sigma\Xi(\eta T-t)T\overline{w}_R^L(k\overline{w}_R-\overline{w}_Q)<0, \tag{A17}$$

$$\frac{d\theta_G}{d\eta} = \frac{1}{\Delta_2}\Sigma\Xi T\{k(\eta T-t)\overline{w}_R^L\theta_G-[k\overline{w}_R-(\overline{w}_Q+q\theta_G)]\}$$
$$+\frac{1}{\Delta_2}T[k\overline{w}_R-(\overline{w}_Q+q\theta_G)]\overline{w}_R^L\{\Sigma T[\tau k+(T-\tau)]+\Xi(t-T)[(t-\tau)k-(T-\tau)]\}, \tag{A18}$$

$$\frac{d\overline{\overline{\theta}}}{d\eta} = \frac{-1}{\Delta_2}\Xi[(t-\tau)k-(T-\tau)](\eta T-t)T\overline{w}_R^L(k\overline{w}_R-\overline{w}_Q)>0, \tag{A18}$$

$$\frac{d\tilde{\theta}}{d\eta} = \frac{-1}{\Delta_2}\Sigma[\tau k+(T-\tau)](\eta T-t)T\overline{w}_R^L(k\overline{w}_R-\overline{w}_Q)<0, \tag{A19}$$

$$\frac{d\overline{w}_R}{d\mu} = \frac{-1}{\Delta_2}\Sigma\Xi(\eta T - t)\overline{w}_R^L > 0, \tag{A20}$$

$$\frac{d\theta_G}{d\mu} = \frac{-1}{\Delta_2}\{\Sigma\Xi + \Sigma[\tau k + (T-\tau)]T\overline{w}_R^L + \Xi(t-T)\overline{w}_R^L[(t-\tau)k - (T-\tau)]\} < 0, \tag{A21}$$

$$\frac{d\overline{\overline{\theta}}}{d\mu} = \frac{1}{\Delta_2}\Xi(\eta T - t)[(t-\tau)k - (T-\tau)]\overline{w}_R^L < 0, \tag{A22}$$

$$\frac{d\tilde{\theta}}{d\mu} = \frac{1}{\Delta_2}\Sigma[\tau k + (T-\tau)](\eta T - t)\overline{w}_R^L > 0, \tag{A23}$$

$$\frac{d\overline{w}_R}{dt} = \frac{-1}{\Delta_2}\Xi\overline{w}_R^L(\eta T - t)[k\overline{w}_R - (\overline{w}_Q + q\overline{\overline{\theta}})]\{\Sigma + (t-T)q\} > 0, \tag{A24}$$

$$\begin{aligned}\frac{d\theta_G}{dt} &= \frac{-1}{\Delta_2}\Sigma T\overline{w}_R^L[\tau k + (T-\tau)](\eta T - t)[k\overline{w}_R - (\overline{w}_Q + q\theta_G)] \\ &- \frac{1}{\Delta_2}\Xi\Sigma k(\eta T - t)\overline{w}_R^L(\overline{\overline{\theta}} - \theta_G) - \Xi\Sigma[k\overline{w}_R - (\overline{w}_Q + q\theta_G)] \\ &- \frac{1}{\Delta_2}\Xi(t-T)\overline{w}_R^L\{k(\eta T - t)[k\overline{w}_R - (\overline{w}_Q + q\overline{\overline{\theta}})] \\ &-[(t-\tau)k - (T-\tau)][k\overline{w}_R - (\overline{w}_Q + q\theta_G)]\},\end{aligned} \tag{A25}$$

$$\begin{aligned}\frac{d\overline{\overline{\theta}}}{dt} &= \frac{1}{\Delta_2}qT\overline{w}_R^L[\tau k + (T-\tau)](\eta T - t)[k\overline{w}_R - (\overline{w}_Q + q\overline{\overline{\theta}})] \\ &+ \frac{1}{\Delta_2}\Xi(\eta T - t)[k\overline{w}_R - (\overline{w}_Q + q\overline{\overline{\theta}})]\{[(\eta T - \tau)k - (T-\tau)]\overline{w}_R^L - q\},\end{aligned} \tag{A26}$$

$$\frac{d\tilde{\theta}}{dt} = \frac{1}{\Delta_2}\Sigma\overline{w}_R^L(\eta T - t)[\tau k + (T-\tau)][k\overline{w}_R - (\overline{w}_Q + q\overline{\overline{\theta}})]\{\Sigma + (t-T)q\} > 0, \tag{A27}$$

Appendix 3

Totally differentiating (19), (14), (8), (9), and (20), we have,

$$\begin{bmatrix} k(\gamma-\eta T) & -q(\gamma-\eta T) & 0 & 0 & 0 \\ -k(\eta T-t) & 0 & q(\eta T-t) & 0 & 0 \\ (t-\tau)k-(T-\tau) & 0 & 0 & \Sigma & 0 \\ \tau k+(T-\tau) & 0 & 0 & 0 & \Xi \\ -1 & (\gamma-\eta T)w_R^L & (\eta T-t)w_R^L & (t-T)w_R^L & Tw_R^L \end{bmatrix} \begin{bmatrix} d\overline{w}_R \\ d\hat{\theta} \\ d\theta_G \\ d\overline{\overline{\theta}} \\ d\tilde{\theta} \end{bmatrix}$$

$$= \begin{bmatrix} \Upsilon \\ 0 \\ 0 \\ 0 \\ -\gamma'\hat{\theta}w_R^L \end{bmatrix} dp + \begin{bmatrix} \gamma kp \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} d\varepsilon + \begin{bmatrix} (k\overline{w}_R-\overline{w}_Q)T \\ [k\overline{w}_R-(\overline{w}_Q+q\theta_G)]T \\ 0 \\ 0 \\ -(\theta_G-\hat{\theta})w_R^L \end{bmatrix} d\eta + \begin{bmatrix} -1 \\ -1 \\ 0 \\ 0 \\ 0 \end{bmatrix} d\mu$$

$$+ \begin{bmatrix} 0 \\ -[k\overline{w}_R-(\overline{w}_Q+q\theta_G)] \\ -[k\overline{w}_R-(\overline{w}_Q+q\overline{\overline{\theta}})] \\ 0 \\ -(\overline{\overline{\theta}}-\theta_G)w_R^L \end{bmatrix} dt, \quad , \qquad \text{(A28)}$$

where $\Upsilon = kp\varepsilon\gamma' + k\varepsilon\gamma - (k\overline{w}_R - \overline{w}_Q)\gamma' > 0$. Remembering that $\gamma > \eta T > t$, the determinant of LHS of (A28), Δ_3, can be expressed as,

$$\Delta_3 = -\Sigma\Xi kq(\gamma-\eta T)^2(\eta T-t)\overline{w}_R^L + q\Delta_2 > 0. \qquad \text{(A29)}$$

The results of the comparative static analyses are,

$$\frac{d\overline{w}_R}{dp} = \frac{-1}{\Delta_3} q(\eta T-t)\Sigma\Xi\overline{w}_R^L[\Upsilon(\gamma-\eta T) - q\hat{\theta}\gamma'] > 0, \qquad \text{(A30)}$$

$$\frac{d\hat{\theta}}{dp} = \frac{1}{\Delta_3}\{qk(\eta T-t)(\gamma-\eta T)\Sigma\Xi\overline{w}_R^L\hat{\theta}\gamma' - \Upsilon\Delta_2\}, \qquad \text{(A31)}$$

$$\frac{d\theta_G}{dp} = \frac{1}{\Delta_3} k(\eta T-t)\Sigma\Xi\overline{w}_R^L[q\hat{\theta}\gamma' - \Upsilon(\gamma-\eta T)] > 0, \qquad \text{(A32)}$$

$$\frac{d\overline{\overline{\theta}}}{dp}=\frac{-1}{\Delta_3}q(\eta T-t)[(t-\tau)k-(T-\tau)]\Xi\overline{w}_R^L[q\hat{\theta}\gamma'-\Upsilon(\gamma-\eta T)]<0, \tag{A33}$$

$$\frac{d\tilde{\theta}}{dp}=\frac{1}{\Delta_3}q(\eta T-t)\Sigma[\tau k+(T-\tau)]\overline{w}_R^L[q\hat{\theta}\gamma'-\Upsilon(\gamma-\eta T)]>0, \tag{A34}$$

$$\frac{d\overline{w}_R}{d\varepsilon}=\frac{-1}{\Delta_3}\gamma kpq(\eta T-t)(\gamma-\eta T)\Sigma\Xi\overline{w}_R^L>0, \tag{A35}$$

$$\frac{d\hat{\theta}}{d\varepsilon}=\frac{-1}{\Delta_3}\gamma kp\Delta_2<0, \tag{A36}$$

$$\frac{d\theta_G}{d\varepsilon}=\frac{-1}{\Delta_3}\gamma k^2p(\eta T-t)(\gamma-\eta T)\Sigma\Xi\overline{w}_R^L>0, \tag{A37}$$

$$\frac{d\overline{\overline{\theta}}}{d\varepsilon}=\frac{1}{\Delta_3}\gamma kpq(\eta T-t)(\gamma-\eta T)[(t-\tau)k-(T-\tau)]\Xi\overline{w}_R^L<0, \tag{A38}$$

$$\frac{d\tilde{\theta}}{d\varepsilon}=\frac{1}{\Delta_3}\gamma kpq(\eta T-t)(\gamma-\eta T)[\tau k+(T-\tau)]\Sigma\overline{w}_R^L>0, \tag{A39}$$

$$\frac{d\overline{w}_R}{d\eta}=\frac{-1}{\Delta_3}q^2\hat{\theta}(\eta T-t)(\gamma-\eta T)T\Xi\Sigma\overline{w}_R^L>0, \tag{A40}$$

$$\frac{d\hat{\theta}}{d\eta}=\frac{1}{\Delta_3}\{kT\Sigma\Xi(\eta T-t)(\gamma-\eta T)[k\overline{w}_R-(\overline{w}_Q+q\hat{\theta})]\overline{w}_R^L-(k\overline{w}_R-\overline{w}_Q)T\Delta_2\}<0, \tag{A41}$$

$$\begin{aligned}\frac{d\theta_G}{d\eta}&=\frac{1}{\Delta_3}qT^2\Sigma(\gamma-\eta T)[\tau k+(T-\tau)][k\overline{w}_R-(\overline{w}_Q+q\theta_G)]\overline{w}_R^L\\&+\frac{1}{\Delta_3}qT\Xi(t-T)(\gamma-\eta T)[(t-\tau)k-(T-\tau)][k\overline{w}_R-(\overline{w}_Q+q\theta_G)]\overline{w}_R^L\\&+\frac{1}{\Delta_3}\Sigma\Xi(\gamma-\eta T)[k\overline{w}_R-(\overline{w}_Q+q\theta_G)](qT-k(\gamma-\eta T)\overline{w}_R^L)\\&-\frac{1}{\Delta_3}kT\Sigma\Xi(\gamma-\eta T)(\eta T-t)[k\overline{w}_R-(\overline{w}_Q+q\theta_G)+(1-k)\overline{w}_Q+q\hat{\theta}]\overline{w}_R^L>0,\end{aligned} \tag{A42}$$

$$\frac{d\overline{\overline{\theta}}}{d\eta}=\frac{1}{\Delta_3}q^2\hat{\theta}T\Xi(\eta T-t)(\gamma-\eta T)[(t-\tau)k-(T-\tau)]\overline{w}_R^L<0, \tag{A43}$$

$$\frac{d\tilde{\theta}}{d\eta} = \frac{1}{\Delta_3} q^2 \hat{\theta} T \Sigma(\eta T - t)(\gamma - \eta T)[\tau k + (T - \tau)]\overline{w}_R^L > 0, \tag{A44}$$

$$\frac{d\overline{w}_R}{d\mu} = 0, \tag{A45}$$

$$\frac{d\hat{\theta}}{d\mu} = \frac{1}{\Delta_3}\{-k\Sigma\Xi(\eta T - t)(\gamma - \eta T)\overline{w}_R^L + \Delta_2\} > 0, \tag{A46}$$

$$\begin{aligned} \frac{d\theta_G}{d\mu} = \frac{-1}{\Delta_3}\{& qT\Sigma(\gamma - \eta T)[\tau k + (T - \tau)]\overline{w}_R^L + q(t - T)\Xi(\gamma - \eta T)[(t - \tau)k - (T - \tau)]\overline{w}_R^L \\ & + \Sigma\Xi(\gamma - \eta T)[k(\gamma - t)\overline{w}_R^L - q]\} < 0, \end{aligned} \tag{A47}$$

$$\frac{d\overline{\overline{\theta}}}{d\mu} = 0, \tag{A48}$$

$$\frac{d\tilde{\theta}}{d\mu} = 0, \tag{A49}$$

$$\frac{d\overline{w}_R}{dt} = \frac{-1}{\Delta_3}(\gamma - \eta T)(\eta T - t)[k\overline{w}_R - (\overline{w}_Q + q\overline{\overline{\theta}})]q\Xi\overline{w}_R^L[q(t - T) + \Sigma] > 0, \tag{A50}$$

$$\frac{d\hat{\theta}}{dt} = \frac{-1}{\Delta_3}(\gamma - \eta T)(\eta T - t)[k\overline{w}_R - (\overline{w}_Q + q\overline{\overline{\theta}})]k\Xi\overline{w}_R^L[q(t - T) + \Sigma] > 0, \tag{A51}$$

$$\begin{aligned} \frac{d\theta_G}{dt} = & \frac{1}{\Delta_3}\{\Sigma\Xi(\gamma - \eta T)^2[k\overline{w}_R - (\overline{w}_Q + q\theta_G)]\overline{w}_R^L - \Sigma T[\tau k + (T - \tau)][k\overline{w}_R - (\overline{w}_Q + q\theta_G)]\} \\ & - \frac{1}{\Delta_3}\Sigma\Xi\{[k\overline{w}_R - (\overline{w}_Q + q\theta_G)] + (\eta T - t)\overline{w}_R^L(\overline{\overline{\theta}} - \theta_G)\} \\ & - \frac{1}{\Delta_3}\Xi(t - T)\overline{w}_R^L\{k(\eta T - t)[k\overline{w}_R - (\overline{w}_Q + q\overline{\overline{\theta}})] \\ & + [(t - \tau)k - (T - \tau)][k\overline{w}_R - (\overline{w}_Q + q\theta_G)]\} < 0, \end{aligned} \tag{A52}$$

$$
\begin{aligned}
\frac{d\bar{\bar{\theta}}}{dt} &= \frac{1}{\Delta_3}\Xi qk(\gamma-\eta T)^2[k\bar{w}_R-(\bar{w}_Q+q\bar{\bar{\theta}})]\bar{w}_R^L \\
&+\frac{1}{\Delta_3}qT(\gamma-\eta T)(\eta T-t)[\tau k+(T-\tau)]\bar{w}_R^L \\
&-\frac{1}{\Delta_3}q^2(\gamma-\eta T)^2\Xi[k\bar{w}_R-(\bar{w}_Q+q\bar{\bar{\theta}})] \\
&+\frac{1}{\Delta_3}q(\gamma-\eta T)\Xi\{[(t-\tau)k-(T-\tau)][k\bar{w}_R-(\bar{w}_Q+q\theta_G)] \\
&+k(\eta T-t)[k\bar{w}_R-(\bar{w}_Q+q\bar{\bar{\theta}})]\} \\
&-\frac{1}{\Delta_3}q^2(\gamma-\eta T)(\eta T-t)\Xi[(t-\tau)k-(T-\tau)](\bar{\bar{\theta}}-\theta_G)\bar{w}_R^L>0,
\end{aligned}
\tag{A53}
$$

$$
\frac{d\tilde{\theta}}{dt}=\frac{1}{\Delta_3}[\tau k+(T-\tau)](\gamma-\eta T)(\eta T-t)[k\bar{w}_R-(\bar{w}_Q+q\bar{\bar{\theta}})]q\bar{w}_R^L[q(t-T)+\Sigma]>0. \tag{A54}
$$

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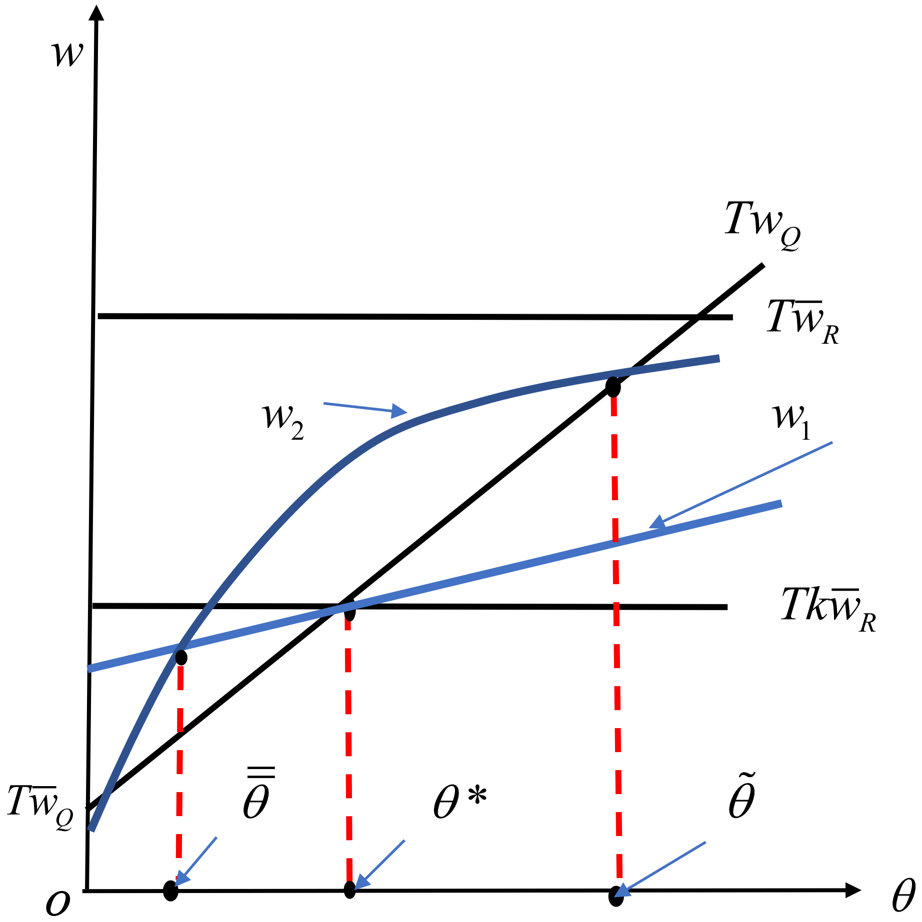

Figure 1: Lifelong income of Specific Skills #1 & #2 legal unskilled immigrants

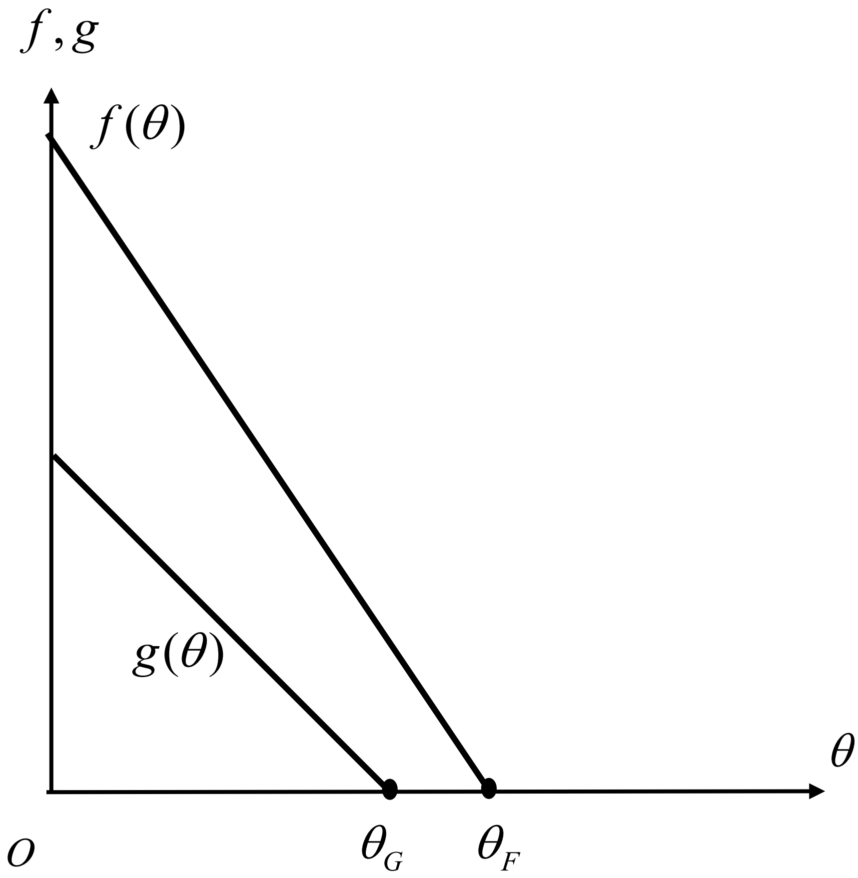

Figure 2-1: Case 1

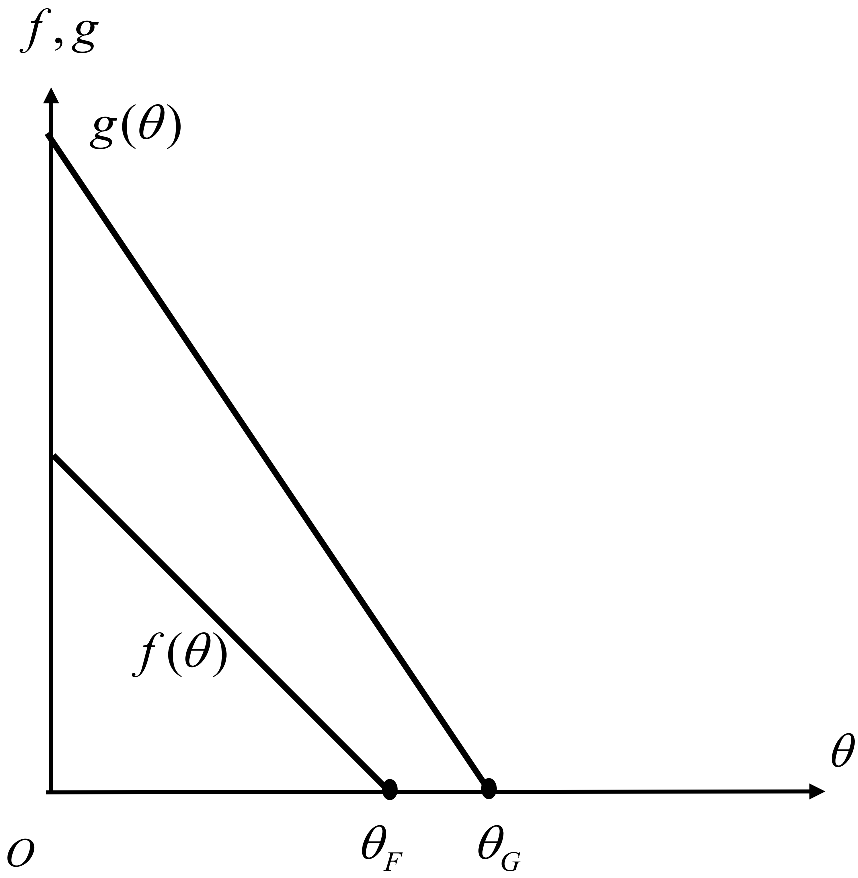

Figure 2-2: Case 2

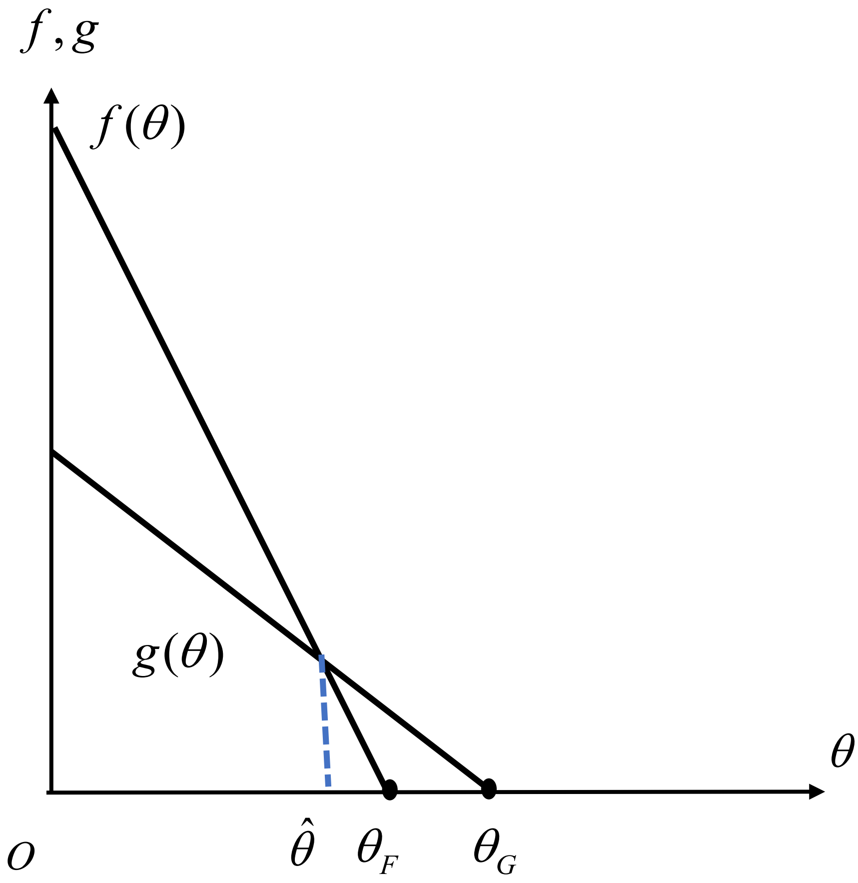

Figure 2-3: Case 3