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Immigration policies, labor complementarities, population size and cultural frictions: Theory and evidence

Thomas Osang* and Shlomo Weber†

In this paper we consider a model of international migration due to Fujita and Weber, with two heterogeneous countries, and show that in equilibrium the larger country attracts more immigrants, while choosing a lower quota. Moreover, a higher degree of labor complementarity and lower degree of cultural friction between natives and immigrants yield a higher immigration quota. We test the empirical validity of the model by using time-series country-level data. Even in the absence of direct evidence of strategic and non-cooperative choice of countries' immigration quotas, both cross-section and panel data approaches indicate that cross-country immigration patterns are consistent with the majority of our theoretical findings.

Key words immigration quota, Nash equilibrium, labor complementarity, cultural friction, panel data, fixed effect.

JEL classification C72, F22, O3, R1

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1 Introduction

In describing an array of industries that require high-skilled labor, one immediately comes to the conclusion that different production technologies in different countries impose distinct requirements on the level and distribution of labor skills and the workers' interaction with each other. For example, over the years Japan has achieved a very high level of performance in manufacturing industries (cars, sophisticated consumer goods) that require a high level of precision and consistent quality control. These industries are characterized by a large number of production stages where technological progress is usually achieved through the series of small but incessant improvements, called *kaizen* (see Imai 1989). This type of production requires not only highly educated and able workers, but also a consistent and extensive level of interaction among them. These demands result in the emergence of a labor force that is relatively homogeneous in its educational, cultural, and linguistic background. On the other hand, the United States specializes in "knowledge," and especially software industries that rely on the talents and abilities of individuals from a wide range of educational and

* Department of Economics, SMU, Dallas, USA.

† Department of Economics, SMU, Dallas, USA, and Center for the Study of Diversity and Social Interactions, New Economic School, Moscow, Russia, and Lomonosov Moscow State University, Moscow, Russia. Email: sweber@smu.edu

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cultural environments. The success of Silicon Valley in the late 1990s is often attributed to the diverse backgrounds of the scientists, engineers and entrepreneurs who arrived from all corners of the world. However, the diversity did not prevent, and, in fact, even reinforced the commonality of workers' purpose and goals. Saxenian (1996) describes how workers in Silicon Valley enjoyed frequent and intensive exchange of information through a variety of formal and informal contacts. The exchange was facilitated by frequent moves of workers from one firm to another (the average time spent by an individual in one firm was about 2 years), and a flexible industry structure (it has often been claimed that in Silicon Valley "a firm is simply a vehicle allowing an individual to work.")

The nature of knowledge production indicates the importance of interaction between different workers and, especially, the complementarity of their talents and skills, that is quite different from the multi-stage technological process in high-precision manufacturing (see Milgrom and Roberts 1990; Kremer 1993). In general, the labor complementarity is based on two sources, internal heterogeneity, which describes the diversity of talents within the existing group of workers engaged in a given industry, and external heterogeneity, which captures the diversity between the existing group of workers and "newcomers" to the industry. The first type of heterogeneity has been the focus of the Grossman and Maggi (2000) two-country analysis, which introduced a model with a diverse talent pool within each country and examined, among other issues, an assignment of different individuals to complementary tasks, and its impact on trade patterns between two countries. Our goal is to examine an external labor complementarity between "native" population and immigrant workers in a given industry.

Following Fujita and Weber (2010), we consider two countries, A and B, and the world of immigrants, denoted by I. Each of the three groups, A, B, and I, is homogeneous and consists of identical individuals. The countries' heterogeneity comes from three sources: (i) a different degree of labor complementarity between countries' native population and immigrants; (ii) a variation in population size between countries; (iii) the magnitude of cultural friction between natives and immigrants. The cultural friction may manifest itself in language barriers caused by the difficulty of learning a local language, natives' bias toward to immigrants, and distinct cultural, religious and behavioral attitudes exhibited by natives and immigrants. Different attitudes toward immigrants across various countries can be explained by the web of historical, cultural, linguistic, ethnic, religious, geographic and economic reasons that are not examined here and we simply accept the fact that various countries exhibit different degrees of cultural friction between natives and immigrant population.

Fujita and Weber (2010) have shown the existence and uniqueness of Nash equilibrium in the non-cooperative quota game between two countries, where the spillover effect is introduced through the world immigrant wages. The goal of our paper is twofold. In the theoretical part we characterize the Fujita–Weber equilibrium and compare the equilibrium quotas in two countries. We show that the country with the higher labor complementarity and lower cultural friction admits a larger number of immigrants than its counterpart. It turns out that while the more populous country would attract a larger number of immigrants, its relative immigration quota would nevertheless be lower than in the smaller country. Second, we provide estimates for an empirical model that mimics the main features of the theoretical model. In addition to the explanatory variables identified by the theory, we include a number of control variables that are likely to matter for a country's share of immigrants. We estimate the empirical model within a cross-section, time-series framework that allows us to include country-specific dummies to control for unobserved, time-invariant country-specific variables. We also provide estimates from a basic cross-country regression as a robustness check. We show that, even in absence of direct evidence of strategic and non-cooperative choice of countries' immigration quotas, the observed cross-country patterns of immigration shares are consistent with the majority of our theoretical findings. In particular, we find strong support for the prediction that cultural frictions are inversely correlated with a country's immigrant share. There is tentative support for the hypothesis that greater labor complementarities between natives and immigrants should increase a country's share of immigrants, while the theoretical result that larger economies should have smaller immigrant shares is only partially supported.

The paper is organized as follows. In the next section we present the model. In Section 3 we introduce the Fujita–Weber immigration game and compare the levels of the immigration quotas chosen by the countries in equilibrium. Sections 4 and 5 describe the empirical model and the data, respectively. We discuss the empirical results in Section 6. Concluding remarks are provided in Section 7. The proofs of the theoretical results as well as the empirical findings are relegated to the Appendix.

2 The model

Our basic setup is as in Fujita and Weber (2010). The model contains two "industrialized" countries, A and B, each facing an unlimited source of immigrants from the "rest of the world." One of the main features of the model is that we allow for intra-country heterogeneity of levels of labor complementarity between native population (natives) and immigrants in two countries. Thus, the two countries may face different effects of immigrants' contribution to their production capabilities. The countries produce a homogenous product that is sold at the same "world" price and can freely traded everywhere. More specifically, the production function of country $j = A, B$ is given by

$$Q_j = (N_j^{\alpha_j} + I_j^{\alpha_j})^{\frac{1}{\alpha_j}}, \tag{1}$$

where N_j is the country population of natives and I_j is the number of immigrants to country j. The parameter α_j represents the reverse measure of labor complementarity between natives and immigrants in j. We assume that $0 < \alpha_j < 1$, and within this range, the smaller values of α_j reflect a higher degree of labor complementarity. Note also that when $\alpha_j \leq 0$, the complementarity is so strong that the output Q_j tends to zero when the number of immigrants I_j approaches zero. This would imply that the country is unable to survive without the influx of immigrants. In order to avoid this unrealistic situation, we rule out all non-positive values of α_j. On the other hand, when α_j exceeds 1, the isoquant curves of country j are strictly concave, so that the mix of natives and immigrants is actually harmful for production purposes. This may happen if the cultural gap between two populations is too wide to allow a successful integration of the heterogeneous population into production process. In the case where $\alpha_j = 1$, the mix of two populations has the neutral effect and has neither positive nor negative benefit in production. Summarizing all these arguments, our analysis is focused on the interesting and meaningful case of $0 < \alpha_j < 1$, where natives and immigrants possess a sufficient degree of diversity to enhance the productivity of the industry they engage in. At the same time, the degree of diversity is sufficiently small to allow beneficial integration of two populations into the production process.

The real immigrant wage, w_I, is the same in both countries. It is determined via the supply function given by

$$w_I = c + \gamma I, \tag{2}$$

where c and γ are positive constants, and $I = I_A + I_B$ is the total number of immigrants in countries A and B. The high-skilled professionals are a scarce resource and we assume that intense world competition for their services drives up their wages which are increasing in the number of high-skilled immigrants I. Also, the decreasing marginal productivity in the immigrants' country of origin implies that a larger immigration flow to countries A and B leads to a smaller number of workers employed in the country of their origin, and a rise in their world wage w_I. As alluded to above, in addition to their size and labor complementarity parameters, the two countries differ in the magnitude of cultural friction between their native populations and immigrants. This type of intra-country heterogeneity plays an important role in our analysis. In spite of the fact that immigrant real wages are identical in both countries, the actual wages should take into account different cultural environments in the two countries. Indeed, if the linguistic, cultural or religious obstacles faced by immigrants in country B are substantially higher than in country A, then the actual wages that are necessary to attract immigrants into country B should be higher than those needed in country A. Formally, we introduce a degree of cultural friction in both countries, f_A and f_B, such that the actual wages to be paid to immigrants in country $j = A, B$ are given by

$$w_j = w_I + f_j. \tag{3}$$

Then the welfare of country $j = A, B$ is[1]

$$W_j = Q_j - w_j I_j = Q_j - w_I I_j - f_j I_j. \tag{4}$$

The immigration quota of country $j = A, B$, given by

$$x_j = \frac{I_j}{N_j}, \tag{5}$$

represents the ratio of immigrants to the native population. The production levels of the final (homogenous) good in the two countries can be rewritten as

$$Q_A = N_A(1 + x_A^{\alpha})^{\frac{1}{\alpha}}, \quad Q_B = N_B(1 + x_B^{\beta})^{\frac{1}{\beta}}, \tag{6}$$

where, for simplicity of notation, the degrees of complementarity, α_A and α_B, are replaced by α and β, respectively. It is convenient to express the real immigrant wage and country j's welfare level in terms of immigration quotas:

$$w_I = c + \gamma(N_A x_A + N_B x_B) \tag{7}$$

and

$$W_j = Q_j - w_I N_j x_j - f_j N_j x_j. \tag{8}$$

[1] Here we implicitly assume a circular flow of migration between country j and the rest of the world (called "temporary migration" (Wong 1995)), when immigrants do not stay in j for "too long." Thus, the welfare of country j is that of its natives only. More generally, we may replace the term $w_I I_j$ by $\theta_j w_I I_j$, where $\theta_j \in [0, 1]$ is a parameter reflecting the degree of integration of immigrants in country j's society. $\theta = 1$ corresponds to our model, whereas the other extreme case $\theta = 0$ represents the case of the complete integration of immigrants where their earnings are fully accounted in the country welfare.

To illustrate the features of our model, consider the following examples discussed in Fujita and Weber (2010).

Example 1 Let country A be the USA and B be Japan. Suppose that all immigrants are from China. Given their different cultural background, Chinese immigrants do not easily integrate into the production process in Japan that requires a high degree of cultural homogeneity and an intensive level of interaction and communication within the labor force. Thus, the degree of labor complementarity of Chinese immigrants in Japan is relatively low. The situation is different in the USA, where, after receiving appropriate training, Chinese immigrants exhibit a relatively high degree of labor complementarity. Thus, the reverse degree of complementarity of "natives" and immigrants in the USA, α, is lower than β, the corresponding value in Japan.

As far as cultural friction is concerned, it is commonly recognized that the USA is more open to immigration than Japan. In addition, there are also linguistic and historical challenges for Chinese immigrants in Japan. Even though Chinese characters are used in both China and Japan, their pronunciation in the two countries is completely different. More importantly, the structure of the Chinese language is very similar to that of English, while being quite distinct from that of Japanese. In addition, given the lingering memories of painful historical events and the relationship between the two countries, one may assume a higher degree of cultural friction faced by Chinese immigrants in Japan than in the USA, implying $f_A < f_B$.

Finally, a larger population in the USA yields $N_A > N_B$. To summarize, this example satisfies the following relationship between the parameters of the model:

$$\alpha < \beta, \quad f_A < f_B, \quad N_A > N_B. \tag{9}$$

Example 2 The relationship indicated by (9) can be derived from a slightly different story, where the degree of complementarity of two populations in production depends not only on their cultural heterogeneity but also on the industry in which they are employed. As in Example 1, let country A be the USA and B be Japan, but now suppose that all the immigrants come from India. One can assume that while Japan specializes in high-quality manufacturing, the US specialization lies in software development. Then the mix of heterogeneous populations of Japanese and Indians may be rather harmful in refining the high-quality manufacturing through incessant *kaizen* in the production process. In contrast, mixing appropriately heterogeneous populations of Americans and Indians generates higher complementarity in software development. Thus, the *reverse* degree of complementarity α in the USA would be lower than the corresponding value β in Japan. We may also assume that, in terms of cultural differences, Hindu is equally distant from Christianity and Buddhism. But, given the Indian colonial past, a large number of educated people in India speak English, so that the degree of cultural friction in the USA is lower than in Japan. Thus, inequalities (9) hold in this example as well.

As is commonly known, the number of immigrants in the USA is larger than that in Japan. In Section 3 we shall re-examine the relationship described in (9) and demonstrate that our theoretical conclusions are consistent with the existing immigration gap between the two countries.

3 The quota game

Formally, we consider the Fujita–Weber game between two countries, A and B, whose strategic choices are their relative immigration quotas, x_A and x_B, respectively. The payoff of country $j = A, B$

is represented by its welfare level, $W_j(x_A, x_B)$, which depends on the production, immigrant wages, and cultural friction between the native population and immigrants in country j:

$$W_j(x_A, x_B) = Q_j - w_I N_j x_j - f_j N_j x_j. \tag{10}$$

The existence and uniqueness of a pure strategies Nash equilibrium in this game have been shown in Fujita and Weber (2010). Our goal is to examine how differences in population size, degree of complementarity and cultural friction impact the variance in the equilibrium immigration quotas and welfare levels in the two countries.

In the first proposition we consider countries with the same population and examine two cases. One is where the two countries have an identical degree of labor complementarity but differ with respect to the magnitude of the friction between natives and immigrants. The second case deals with two countries that are distinguished only on the basis of the labor complementarity between the native and immigrant population.

Proposition 1 *Assume that* $N_A = N_B$.

(i) *Let* $f_A = f_B$, *whereas* $\alpha < \beta$, *that is, the degree of labor complementarity in country A is higher than in country B. (Recall that* α *and* β *are the reverse measures of complementarity in countries A and B, respectively.) Then* $x_A^e(p) > x_B^e(p)$.

(ii) *Let* $\alpha = \beta$, $f_A < f_B$, *whereas* $f_A < f_B$, *that is, country A exhibits a lower degree of cultural friction than country B. Then country A would accept more immigrants, that is,* $x_A^e(p) > x_B^e(p)$.

The intuition here is quite clear. If the countries are distinguished only on the basis of labor complementarity, they both pay identical wages to immigrants. However, since the marginal productivity is higher in the country with a higher degree of labor complementarity, assertion (i) states that country A would choose a higher immigration quota. In the case where countries differ with respect to their degree of cultural friction, the gross wages paid to immigrants are lower in A. The declining marginal productivity implies that country A should accept a larger number of immigrants.

Let us now turn to the impact of population size in the two countries on their strategic choice of immigration quotas. If the population of two countries is the same, there is no need, as Proposition 1 shows, to provide a separate examination of relative and absolute number of immigrants in A and B. However, for countries with heterogeneous population sizes, a distinction between absolute and relative number of immigrants is essential. In Proposition 2 we consider two countries with identical degrees of labor complementarity and cultural friction, but different population sizes. We will compare both the immigration quotas (the relative number of immigrants with respect to the native population) and the (absolute) number of immigrants in the two countries.

Proposition 2 *Assume that* $\alpha = \beta$, $N_A > N_B$, $f_A = f_B$.

(i) *Then the immigration quota is lower in the more populous country A, i.e.,* $x_A^e(p) < x_B^e(p)$.

(ii) *However, the larger country would accept a larger number of immigrants, that is,* $I_A > I_B$, *or* $N_A x_A^e(p) > N_B x_B^e(p)$.

Indeed, consider country A. Under identical degrees of labor complementarity in the two countries, the higher population size and declining marginal product imply (see Equations (A6) and (A7) in the Appendix) that country A will have a lower immigration quota. At the same time, a lower immigration quota in A yields a higher per-capita marginal productivity in that country. Since the difference between the per-capita marginal product and the weighted number of immigrants is equal in both countries, it immediately implies that the number of immigrants into A is larger than into B.

The next corollary examines the aggregate effect of differences in population size, degree of complementarity and cultural friction. We consider the case where, as in Examples 1 and 2, country A is more populous, has a higher degree of labor complementarity and a lower degree of cultural friction than country B. Then the number of immigrants to country A exceeds the number of immigrants to country B, which is consistent with the fact that the number of immigrants in the USA is larger than in Japan.

Corollary 1 *Assume that $p \in P$ is such that $\alpha < \beta$, $f_A < f_B$ and $N_A > N_B$. Then $I_A > I_B$.*

Now let us turn to the welfare comparison between countries that are distinct in their labor complementarity, population size and degree of cultural friction. We show that the country with the higher degree of complementarity between two groups has a welfare advantage over its counterpart. The same is true with regard to the country that exhibits the lower degree of cultural friction. It is also demonstrated that the more populous country, which accepts a larger number of immigrants, has higher total output, and, thus, higher total welfare than the smaller country. Consider a point $p \in P$. The welfare levels of the two countries in the equilibrium of the game $\Gamma(p)$, $W_A(x_A^e(p), x_B^e(p))$ and $W_B(x_A^e(p), x_B^e(p))$, will be denoted simply by $W_A^e(p)$ and $W_B^e(p)$, respectively.

Proposition 3

(i) *Assume that $p = (\alpha, \beta, N_A, N_B, f_A, f_B) \in P$ is such that $\alpha < \beta$, $N_A = N_B$, and $f_A = f_B$. Then the country with the higher degree of complementarity attains the higher level of welfare, that is, $W_A^e(p) > W_B^e(p)$.*

(ii) *Let $p \in P$ be such that $\alpha = \beta$, $N_A > N_B$, and $f_A = f_B$. That is, the countries differ only with respect to their population size. Then the more populous country is better off relative to its smaller counterpart: $W_A^e(p) > W_B^e(p)$.*

(iii) *Assume that $p \in P$ is such that $\alpha = \beta$, $N_A = N_B$ but $f_A < f_B$. Then the country with the lower cultural friction attains the higher level of welfare, that is, $W_A^e(p) > W_B^e(p)$.*

Proposition 3 allows us to examine some possible policy implications of the results stated here. Among the three parameters, labor complementarity, the size of the native population, and the degree of cultural friction between natives and immigrants, it seems that the first two are unlikely to change in the short or medium run. However, the last, cultural friction, should become the subject of active public policy debate and action. Indeed, in order to enhance the national welfare, it is important to undertake concrete measures aimed at reducing the cultural friction between natives and immigrants.

4 Empirical model

The above analysis makes distinct predictions about the relationship between immigration quotas and a number of their determinants. In particular, Propositions 1–3 and Corollary 1 state that a country's immigrant quota should be positively correlated with the degree of labor complementarity between native and immigrant workers and negatively correlated with the degree of cultural friction between immigrants and natives. Furthermore, more populous countries should have smaller immigrant quotas than smaller countries. Such distinct predictions lend themselves to an empirical investigation which is the subject of the rest of this paper. To test the theoretical predictions, we first derive an empirical model that captures the main features of the theoretical investigation:

$$x_{it} = \mu_i + \gamma_1 LC_{it} + \gamma_2 CF_{it} + \gamma_3 N_{it} + \boldsymbol{\gamma}'\mathbf{X}_{it} + \epsilon_{it}, \tag{11}$$

where x_{it} is the ratio of immigrants to native workers in country i at time t, LC_{it} is a measure of labor complementarities between immigrants and natives, CF_{it} is a measure of cultural frictions between immigrants and natives, N_{it} is the size of the population and $\mathbf{X}_{it}$ is a vector of additional time-varying covariates that matter in determining a country's immigrant ratio. The term μ_i captures all time-invariant, unobserved heterogeneity between countries, and ϵ_{it} is an idiosyncratic random disturbance to be assumed independent and identically normally distributed. If the theoretical predictions are borne out by the empirical estimates, we expected the parameter estimates to have the following signs:

$$\gamma_1, \gamma_2 > 0, \quad \gamma_3 < 0. \tag{12}$$

We estimate the above model by applying the standard fixed-effect (FE) estimator to our panel data set. We also report results from two robustness checks: first, we show FE estimates for a number of alternative model specifications; second, we report cross-section estimates where all time-varying variables have been replaced by their time averages.

5 Data

Various data sources are used to construct the variables needed to estimate Equation (11). The immigrant ratio, x_{it}, is approximated by the foreign born ratio available from the UN migration statistics website. The level of complementarity between immigrants and native workers is approximated by a series of variables measuring the attitudes of natives toward immigrants. These variables, discussed in more detail in Table 1, are obtained from various waves of the World Values Survey.[2] We use two measures as proxies for cultural friction between immigrants and native workers: language and cultural proximity. Language proximity is the linguistic distance between a country's main language(s), obtained from the CIA *World Factbook*, and English. The metric for the linguistic distance measure was first introduced by Hart-Gonzalez and Lindemann (1993), extended to more languages in Grimes and Grimes (1993) and further discussed in Chiswick and Miller (2004, table 1). The idea here is that the closer a country's main language is linguistically to English, the less friction we would expect between native and immigrant workers in terms of language barriers, regardless of the immigrant's native language. For example, Japanese, with a score of 1, is considered to be the most distant language to English and thus the hardest to learn for immigrants. On the other hand, Norwegian and Swedish, with a score of 3, are the least distant languages and hence are easiest to learn. If a country has more than one official language (e.g. English and French in Canada), we used the weighted average of the language scores using the fraction of that population that speaks a given language as weights (from the *World Factbook*).

[2] Previous empirical studies that have used World Values Survey data on attitudes toward immigrants in a cross-section context include Mayda (2005) and Facchini and Mayda (2009).

Table 1 Variable definitions and sources

Variable	Definition	Source
Foreign Born Ratio$_{it}$	Ratio of foreign born to total population	United Nation
Population$_{it}$	Total population, in millions	World Bank
CIM$_{it}$	Contract-intensive money: the ratio of non-currency to total money	IMF, own calculations
Openness$_{it}$	Trade share: ratio of exports and imports to GDP	World Bank
Law and Order$_i$	Quality of contract enforcement, police and courts, as well as likelihood of crime and violence	Kaufmann and Mastruzzi (2003)
Cultural Prox$_{it}$	Cultural proximity to the West: # of McDonald's branches, # of IKEA (per capita) branches, trade in books (% of GDP)	KOF Index of Globalization
Language Prox$_i$	Country's main language proximity to English	Various
Job$_i$	Employers should not give job priority to native workers	World Value Survey
Neighbors$_i$	Would not like to have immigrants as neighbors	World Value Survey
Immigration Policy$_i$	Government policies should limit immigration	World Value Survey
Help$_i$	Do you refuse to help immigrants?	World Value Survey
Assist$_i$	No need to do something in return for immigrants	World Value Survey
Moral Duty$_i$	No moral duty to help immigrants	World Value Survey
Sympathise$_i$	No sympathy for immigrants	World Value Survey

We use the KOF Index of Globalization as the second proxy for cultural friction. The KOF Index is a weighted average of the number of McDonald's restaurants and the number of IKEA stores per capita, as well as the trade in books (as a percentage of GDP). Here, the idea is that the higher the KOF Index, the more open the economy is to foreign (i.e., Western) culture and the lower the frictions between immigrants and natives.

Finally, the size of a country's native population is approximated by the size of the country's total population (Pop).

In addition, we include a set of control variables comprised of the total trade share in GDP (Openness) and two variables that measure the quality of government institutions: the amount of contract-intensive money (CIM) in circulation and the quality of contract enforcement, police and courts (Law and Order).

Summary statistics as well as the expected sign for each variable are given in Table 2.

6 Empirical results

The results for the baseline panel data estimation with fixed effects are given in Table 3. In terms of theory predictions, we find no evidence that larger countries have smaller immigrant shares. On the contrary, larger countries tend to have larger immigrant shares, with all point estimates significant

Table 2 Summary statistics and expected sign of coefficient estimate

Variable	Obs.	Mean	Min.	Max.	Expected sign
Foreign Born Ratio$_{it}$	469	0.073	0.0003	0.724	n/a
Population$_{it}$	515	40.01	0.156	1280	–
Openness$_{it}$	487	75.48	2.57	404.78	n/a
CIM$_{it}$	287	0.815	0.196	0.98	+
Law and Order$_i$	478	32.505	1	96.823	+
Cultural Prox$_{it}$	312	7.072	1.67	10	+
Language Prox$_i$	508	0.3937	0	1	+
Job$_i$	92	1.58	0	2.458	+
Neighbors$_i$	92	0.115	0	0.356	–
Immigration Policy$_i$	92	2.359	0	2.705	–
Help$_i$	92	1.67	0	3.337	–
Assist$_i$	92	1.73	0	4.333	–
Moral Duty$_i$	92	1.34	0	2.647	–
Sympathise$_i$	92	1.269	0	2.896	–

at the 10% level. Both cultural friction variables, language and cultural proximity, have the expected positive signs, except for language proximity in column 5. While cultural proximity is not statistically significant, language proximity is significant at the 10% level except for columns 1 and 5. With regard to labor complementarity, we introduce the seven measures one at a time. With the exception of Jobs (employers should give priority to native workers), all labor complementarity measures demonstrate the expected sign. Among those, measures 3 and 4 (neighbors and immigrant policy) are highly statistically significant, while the other four measures are not statistically significant. The control variables for institutional quality display the expected positive sign in all specifications. While CIM is not statistically significant, Law and Order is highly significant at the 1% level. Trade openness has the wrong sign, but is not statistically significant and hence does not appear to affect a country's immigrant share.

We test the robustness of the estimation results given in Table 3 in two ways. In Table 4 we show another set of panel data FE estimates, but this time for different combinations of labor complementarity measures, ranging from two (column 1) to all seven variables (column 8). We find that in addition to Job, both Assist and Moral Duty display the wrong positive signs. However, only Moral Duty is statistically significant at the 10% level, while Job is statistically insignificant in the first three specifications and only moderately significant in the others. Among the complementarity variables with the correct sign, Immigration Policy is strongly significant (at the 1% level), while both Sympathy and Help vary in significance, though most of their estimates are significant at the 15% level. Only Neighbors is not statistically significant in any specification.

In terms of the cultural friction variables, Cultural Prox continues to have the expected positive sign, but once again the estimates are not statistically significant. Surprisingly, Language Prox now shows the wrong (negative) sign, but none of the estimates are significant except for column 8. The

Table 3 Panel data estimates with fixed effects

	Dependent variable: foreign born share						
Variable	1	2	3	4	5	6	7
Population$_{it}$	8.15E-02*	8.15E-02*	8.15E-02*	8.15E-02*	8.15E-02*	8.15E-02*	8.15E-02*
	(0.091)	(0.091)	(0.091)	(0.091)	(0.091)	(0.091)	(0.091)
Openness$_{it}$	−5.46E-07	−5.46E-07	−5.46E-07	−5.46E-07	−5.46E-07	−5.46E-07	−5.46E-07
	(0.999)	(0.999)	(0.999)	(0.999)	(0.999)	(0.999)	(0.999)
CIM$_{it}$	0.119	0.119	0.119	0.119	0.119	0.119	0.119
	(0.209)	(0.209)	(0.209)	(0.209)	(0.209)	(0.209)	(0.209)
Law and Order$_i$	0.028**	0.027**	0.027**	0.019**	0.017**	0.028**	0.027**
	(0)	(0)	(0)	(0.004)	(0.001)	(0)	(0)
Cultural Prox$_{it}$	4.6E-05	4.6E-05	4.6E-05	4.6E-05	4.6E-05	4.6E-05	4.6E-05
	(0.769)	(0.769)	(0.769)	(0.769)	(0.769)	(0.769)	(0.769)
Language Prox$_i$	0.007	0.05*	0.054*	0.072**	−0.014	0.056**	0.053*
	(0.811)	(.085)	(0.058)	(0.007)	(0.584)	(0.049)	(0.059)
Job$_i$	−0.09**						
	(0.001)						
Neighbors$_i$				−0.519**			
				(0.002)			
Immigration Policy$_i$					−0.116**		
					(0.0)		
Help$_i$		−0.008					
		(0.296)					
			−0.007				
			(0.3)				
Moral Duty$_i$						−0.009	
						(0.316)	
Sympathise$_i$							−0.013
							(0.198)
Constant	−0.081	−0.213**	−0.215**	−0.107*	0.147**	−0.218**	−0.211**
	(0.199)	(0.0)	(0.0)	(0.089)	(0.047)	(0.0)	(0.0)
Number of obs	66	66	66	66	66	66	66
Number of countries	22	22	22	22	22	22	22
R-squared	0.497	0.285	0.284	0.374	0.554	0.284	0.291

p-values in parentheses; **/* indicates statistical significance at 5%/10% level.
Note: The coefficient estimates for the time-invariant variables are obtained from a second-stage regression of the first-stage residuals on the time-invariant regressors. See Kripfganz and Schwartz (2014) for a similar approach in the context of dynamic panel data models.

controls for institutional quality continue to display the correct positive sign. As in the previous table, the level of significance of Law and Order exceeds that of CIM in all specifications.

For our second robustness check, we time-average all time-varying variables (Foreign Born, Pop, CIM, Openness, and Cultural Prox) and re-estimate Equation (10) as a cross-section equation. This

Table 4 Robustness check I: panel data estimates with fixed effects (alternative model specifications)

	Dependent variable: foreign-born share							
Variable	1	2	3	4	5	6	7	8
Population$_{it}$	8.2E-02*	8.2E-02*	8.2E-02*	8.2E-02*	8.2E-02*	8.2E-02*	8.2E-02*	8.2E-02*
	(0.091)	(0.091)	(0.091)	(0.091)	(0.091)	(0.091)	(0.091)	(0.091)
Openness$_{it}$	−5.46E-07	−5.46E-07	−5.46E-07	−5.46E-07	−5.46E-07	−5.46E-07	−5.46E-07	−5.46E-07
	(0.999)	(0.999)	(0.999)	(0.999)	(0.999)	(0.999)	(0.999)	(0.999)
CIM$_{it}$	0.119	0.119	0.119	0.119	0.119	0.119	0.119	0.119
	(0.209)	(0.209)	(0.209)	(0.209)	(0.209)	(0.209)	(0.209)	(0.209)
Law and Order$_i$	0.015**	0.014**	0.014**	0.012**	0.012**	0.01*	0.012**	0.009**
	(0.009)	(.0120)	(0.017)	(0.03)	(0.041)	(0.089)	(0.04)	(0.012)
Cultural Prox$_{it}$	4.6E-05	4.6E-05	4.6E-05	4.6E-05	4.6E-05	4.6E-05	4.6E-05	4.6E-05
	(0.769)	(0.769)	(0.769)	(0.769)	(0.769)	(0.769)	(0.769)	(0.769)
Language Prox$_i$	−0.008	−0.0095	−0.002	−0.019	−0.035	−0.035	−0.022	−0.0488*
	(0.751)	(.713)	(0.931)	(0.472)	(0.253)	(0.253)	(0.447)	(0.07)
Job$_i$	0.0309	0.033	0.026	0.061	0.057	0.05	0.062	0.557
	(0.354)	(0.33)	(0.453)	(0.121)	(0.172)	(0.219)	(0.13)	(0.16)
Neighbors$_i$			−0.099		−0.061	−0.123	−0.005	−0.062
			(0.549)		(0.715)	(0.466)	(0.977)	(0.707)
Immigration Policy$_i$	−0.14**	−0.14**	−0.13**	−0.16**	−0.15**	−0.16**	−0.16**	−0.17**
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Help$_i$		−0.0025		−0.0303	−0.029	−0.056**	−0.032	−0.067**
		(0.691)		(0.144)	(0.17)	(0.029)	(0.124)	(0.01)
Assist$_i$				0.0247	0.0234	0.028	0.04*	0.05**
				(0.159)	(0.192)	(0.114)	(0.057)	(0.015)
Moral Duty$_i$						0.031*		0.038**
						(0.066)		(0.024)
Sympathise$_i$							−0.021	−0.028**
							(0.127)	(0.044)
Constant	0.16**	0.164**	0.163**	0.193**	0.192**	0.236**	0.208**	0.266**
	(0.034)	(0.033)	(0.034)	(0.015)	(0.016)	(0.004)	(0.01)	(0.001)
Number of obs.	66	66	66	66	66	66	66	66
Number of countries	22	22	22	22	22	22	22	22
Adj. R-squared	0.561	0.5612	0.563	0.576	0.577	0.602	0.594	0.63

p-values in parentheses; **/* indicates statistical significance at 5%/10% level.
Note: The coefficient estimates for the time-invariant variables are obtained from a second-stage regression of the first-stage residuals on the time-invariant regressors. See Kripfganz and Schwartz (2014) for a similar approach in the context of dynamic panel data models.

change increases the sample size by 30% since the sparsity of some of the time-varying variables is now less of an issue. The cross-section estimation results are shown in Table 5. The estimates mirror those of Table 3. Except for Job, the labor complementarity measures have the expected

Table 5 Robustness check II: cross-section estimates

	Dependent variable: foreign-born share						
Variable	1	2	3	4	5	6	7
Population$_{it}$	−2.4E+00** (0.021)	−3.9E-02** (0.038)	−3.7E-02** (0.047)	−3.7E-02 (0.934)	−8.9E-03 (0.383)	−3.6E-03** (0.036)	−3.8E-02** (0.035)
Openness$_{it}$	−1.3E-02** (0.006)	−1.4E-03 (0.93)	−5.5E-07 (0.999)	1.9E-02 (0.184)	−1.1E-02 (0.212)	1.6E-02 (0.312)	−1.3E-04 (0.993)
CIM$_{it}$	0.0003 (0.444)	−0.0002 (0.858)	−0.0003 (0.834)	−0.002* (0.087)	−0.001 (0.324)	−0.001 (0.475)	−0.0004 (0.757)
Law and Order$_i$	−0.027** (0.0)	0.024** (0.0)	0.025** (0.0)	0.018** (0.0)	0.008** (0.02)	0.024** (0.0)	0.026** (0.0)
Cultural Prox$_{it}$	0.002 (0.778)	0.001 (0.349)	0.0004 (0.769)	0.0002 (0.62)	0.002** (0.0)	0.001 (0.272)	0.0002 (0.7)
Language Prox$_i$	−0.004** (0.0)	0.04* (0.07)	0.045** (0.045)	0.072** (0.0)	−0.003 (0.809)	0.05** (0.02)	0.04* (0.062)
Job$_i$	−0.206** (0.0)						
Neighbors$_i$				0.072** (0.0)			
Immigration Policy$_i$					−0.135** (0.0)		
Help$_i$		−0.015** (0.015)					
Assist$_i$			−0.01** (0.03)				
Moral Duty$_i$						−0.029** (0.0)	
Sympathise$_i$							−0.02** (0.003)
Constant	0.255** (0.0)	−0.062 (0.54)	−0.06 (0.55)	0.102 (0.278)	0.38** (0.0)	−0.065 (0.485)	−0.05 (0.61)
Number of obs.	86	86	86	86	86	86	66
Adj. R-squared	0.79	0.49	0.44	0.575	0.82	0.513	0.47

p-values in parentheses; **/* indicates statistical significance at 5%/10% level.

sign and all of them are now highly significant. Cultural Prox has the expected positive sign and is statistically significant at the 10% level in two of the seven specifications. Language Prox too shows the expected positive sign (except for column 1) and is statistically significant at the 10% level in all but one specification. For the first time, Population displays the expected negative sign in all seven specifications and is statistically significant at the 5% level in five of them.

The controls for institutional quality have the anticipated positive signs (except for Law and Order in column 1), as in the previous tables. While CIM is not statistically significant, Law and Order is highly significant at the 1% level.

7 Concluding remarks

The purpose of this paper is twofold. First, we provide a characterization of the equilibrium introduced in the model of Fujita and Weber (2010), which links a country's immigrant quota to a number of country-specific variables such as the country's population size, the complementarity between native and immigrant workers, and the cultural frictions that exist between native and immigrant workers. For each of these conditioning variables, the model makes precise predictions about the expected correlation with the country's immigrant quota. Second, in the empirical part of the paper, we provide estimates for an empirical model that mimics the main features of the theoretical model. In addition to the explanatory variables identified by the theory, we include a number of additional control variables that are likely to matter for a country's share of immigrants. While the theoretical model is static, we estimate the empirical model within a cross-section, time-series framework that allows us to include country-specific dummies to control for all unobserved, time-invariant country-specific variables. We find that many, but not all, of the theoretical predictions are supported by the empirical results. Our main conclusion is that, even in absence of direct evidence of strategic and non-cooperative choice of countries' immigration quotas, the observed cross-country patterns of immigration shares are consistent with the majority of our theoretical findings. In general, we find the strongest support for the prediction that cultural frictions are inversely correlated with a country's immigrant share. We find mixed support for the hypothesis that greater labor complementarities between natives and immigrants should increase a country's share of immigrants. We find the least support for the theoretical claim that larger economies should have smaller immigrant shares.

Given the severe data limitations that constrained our empirical investigation, we are not surprised that our main results as well as our robustness checks are not as strong and clear-cut as we would have liked. Nevertheless, the majority of the results presented here confirm the main predictions of the theoretical model. Furthermore, based on the cross-section approach, we find evidence in support of all three predictions of the theoretical model, including the inverse correlation between population size and immigrant share.

Appendix A

Before proceeding with the proofs of our results, notice that the welfare of two countries in terms of immigration quotas can be presented as[3]

$$W_A(x_A, x_B) = N_A(1 + x_A^{\alpha})^{\frac{1}{\alpha}} - [c + \gamma(N_A x_A + N_B x_B)]N_A x_A - f_A N_A x_A, \tag{A1}$$

$$W_B(x_A, x_B) = N_B(1 + x_B^{\alpha})^{\frac{1}{\alpha}} - [c + \gamma(N_A x_A + N_B x_B)]N_B x_B - f_B N_B x_B. \tag{A2}$$

It would be also useful to note that

$$\frac{\partial W_A(x_A, x_B)}{\partial x_A} = N_A\left(g(\alpha, x_A) - c - \gamma(2N_A x_A + N_B x_B) - f_A\right) = 0 \tag{A3}$$

and

$$\frac{\partial W_B(x_A, x_B)}{\partial x_B} = N_B\left(g(\beta, x_B) - c - \gamma(2N_B x_B + N_A x_A) - f_B\right) = 0, \tag{A4}$$

[3] Since the welfare of each country is decreasing in the immigration quota of the other country, it follows that the immigration quotas are, in fact, *strategic substitutes* (Bulow *et al*. 1985).

where the function $g : (0, 1) \times \Re_{++} \to \Re_{++}$ is defined by

$$g(\delta, x) \equiv (1 + x^{\delta})^{\frac{1}{\delta}-1} x^{\delta-1} = (1 + x^{-\delta})^{\frac{1}{\delta}-1}. \tag{A5}$$

The following lemma summarizes some properties of the function g that will be utilized to prove our results:

Lemma 1

(i) *For every* $\delta \in (0, 1)$, *the function* $g(\delta, \cdot)$ *is decreasing on* $\Re_{++}$.
(ii) *For every* $\delta \in (0, 1)$, *the function* $g(\delta, x) \cdot x$ *is increasing in* x *on* $\Re_{++}$.
(iii) *For every positive* x, *the function* $g(\cdot, x)$ *is decreasing on* $(0, 1)$.
(iv) *For every* $\delta \in (0, 1)$, $\lim_{x\to 0} g(\delta, x) = +\infty$.
(v) *For every* $\delta \in (0, 1)$, $\lim_{x\to +\infty} g(\delta, x) = 1$.

Assertion (i) states that the marginal product declines in the number of immigrants. Assertion (ii) implies, however, that the rate of decline is not "very steep." Assertion (iii) states that the marginal product is positively correlated with the value of labor complementarity. Assertions (iv) and (v) describe the limit value of marginal product at corner points zero and infinity.

Note that the function g satisfies the conditions

$$g(\alpha, x_A) = \frac{1}{N_A} \frac{\partial Q_A}{\partial x_A} \tag{A6}$$

and

$$g(\beta, x_B) = \frac{1}{N_B} \frac{\partial Q_B}{\partial x_B}. \tag{A7}$$

That is, the values of the function $g(\delta, x)$ for $\delta = \alpha$, $x = x_A$ and $\delta = \beta$, $x = x_B$ represent per-capita marginal product induced by changing the immigration quota in countries A and B, respectively. Since the conditions in Equations(A3) and (A4) can be rewritten as:

$$g(\alpha, x_A) - \gamma N_A x_A = c + \gamma(N_A x_A + N_B x_B) + f_A = w_I + f_A = w_A, \tag{A8}$$

$$g(\beta, x_B) - \gamma N_B x_B = c + \gamma(N_A x_A + N_B x_B) + f_B = w_I + f_B = w_B, \tag{A9}$$

the difference between the per-capita marginal product and the weighted number of immigrants is equal to the actual immigrant wages paid in the country.

Proof of Lemma A1

Assertions (i), (iv) and (v) are straightforward. For (ii), note that

$$\frac{\partial[g(\delta, x)x]}{\partial x} = (1 + x^{-\delta})^{\frac{1}{\delta}-2}[-(1 - \delta)x^{-\delta} + 1 + x^{-\delta}] = (1 + x^{-\delta})^{\frac{1}{\delta}-2}[\delta x^{-\delta} + 1] > 0. \tag{A10}$$

Finally, to prove (iii), we have

$$g(\delta, x) = e^{(\frac{1}{\delta}-1)\log(1+x^{-\delta})}. \tag{A11}$$

Then

$$\frac{\partial g(\delta, x)}{\partial \delta} = g(\delta, x) \left[-\frac{1}{\delta^2} \log(1 + x^{-\delta}) - \frac{(\frac{1}{\delta} - 1)x^{-\delta} \log x}{1 + x^{-\delta}} \right]. \tag{A12}$$

This expression is obviously negative when $x \geq 1$. If $0 < x < 1$, we have

$$\frac{\partial g(\delta, x)}{\partial \delta} = -\frac{g(\delta, x)x^{-\delta}}{\delta^2(1 + x^{-\delta})} \left[x^{\delta} \log(1 + x^{-\delta}) + \log(1 + x^{-\delta}) + \delta \log x - \delta^2 \log x\right] \tag{A13}$$

$$= -\frac{g(\delta, x)x^{-\delta}}{\delta^2(1 + x^{-\delta})} \left[x^{\delta} \log(1 + x^{-\delta}) + \log(1 + x^{\delta}) - \delta^2 \log x\right] < 0.$$

□

Proof of Proposition 1

(i) Let $\alpha < \beta$, $N_A = N_B$, $f_A = f_B$. From Equations (A6) and (A7)

$$[g(\alpha, x_A^e(p)) - \gamma N_A x_A^e(p)] - [g(\beta, x_B^e(p)) - \gamma N_A x_B^e(p)] = 0. \tag{A14}$$

Since, by Lemma A1, $g(\alpha, x_A^e(p)) > g(\beta, x_A^e(p))$, we have

$$[g(\beta, x_A^e(p)) - \gamma N_A x_A^e(p)] - [g(\beta, x_B^e(p)) - \gamma N_A x_B^e(p)] < 0. \tag{A15}$$

Invoking Lemma A1 again, we conclude that the function $g(\beta, x) - \gamma N x$ is declining in x, yielding $x_A^e(p) > x_B^e(p)$.

(ii) Let $\alpha = \beta$, $N_A = N_B$, $f_A < f_B$. Note that the substraction of (A7) from (A6) implies that for every $p \in P$,

$$[g(\alpha, x_A^e(p)) - \gamma N_A x_A^e(p)] - [g(\beta, x_B^e(p)) - \gamma N_B x_B^e(p)] = f_A - f_B. \tag{A16}$$

Let $\alpha = \beta$, $N_A = N_B$ and $f_A < f_B$. Then (A22) yields

$$[g(\alpha, x_A^e(p)) - \gamma N_A x_A^e(p)] - [g(\alpha, x_B^e(p)) - \gamma N_A x_B^e(p)] < 0. \tag{A17}$$

Since, by Lemma A1, the function $g(\alpha, x) - \gamma N_A x$ is declining in x, it follows that $x_A^e(p) > x_B^e(p)$. □

Proof of Proposition 2

Let $\alpha = \beta$, $N_A > N_B$ and $f_A = f_B$.

(i) Invoking (A14), we obtain

$$[g(\alpha, x_A^e(p)) - \gamma N_A x_A^e(p)] - [g(\alpha, x_B^e(p)) - \gamma N_B x_B^e(p)] = 0, \tag{A18}$$

and, since $N_A > N_B$,

$$[g(\alpha, x_A^e(p)) - \gamma N_A x_A^e(p)] - [g(\alpha, x_B^e(p)) - \gamma N_A x_B^e(p)] > 0. \tag{A19}$$

Since, by Lemma A1 the function $g(\alpha, x) - \gamma N_A x$ is decreasing in x, it immediately follows that $x_A^e(p) < x_B^e(p)$.

(ii) Since $x_A^e(p) < x_B^e(p)$, by Lemma A1 and (A16), we have

$$[g(\alpha, x_A^e(p)) - g(\alpha, x_B^e(p))] = [\gamma N_A x_A^e(p) - \gamma N_B x_B^e(p)] > 0. \tag{A20}$$

Moreover, since, by Lemma A1, $g(\alpha, x_A^e(p)) > g(\alpha, x_B^e(p))$, it follows that $N_A x_A^e(p) > N_B x_B^e(p)$. □

Proof of Corollary 1

Let $\alpha < \beta$, $N_A > N_B$ and $f_A < f_B$. If $x_A^e(p) \geq x_B^e(p)$, the statement is straightforward. Let $x_A^e(p) < x_B^e(p)$. Since $f_A < f_B$, (A14) implies that

$$[g(\alpha, x_A^e(p)) - \gamma N_A x_A^e(p)] - [g(\beta, x_B^e(p)) - \gamma N_B x_B^e(p)] < 0. \tag{A21}$$

By Lemma A1, $g(\alpha, x_A^e(p)) > g(\beta, x_A^e(p))$, and we have

$$[g(\beta, x_A^e(p)) - g(\beta, x_B^e(p))] - [\gamma N_A x_A^e(p) - \gamma N_B x_B^e(p)] < 0. \tag{A22}$$

Since, by Lemma A1, $g(\beta, x_A^e(p)) > g(\beta, x_B^e(p))$, it immediately yields $N_A x_A^e(p) > N_B x_B^e(p)$. □

Proof of Proposition 3

Equations (11) and (12) imply that the equilibrium welfare levels of the two countries, $W_A^e(p)$ and $W_A^e(p)$, respectively, are given by

$$W_A^e(p) = N_A(1 + (x_A^e(p))^{\alpha})^{\frac{1}{\alpha}-1} + \gamma N_A^2(x_A^e(p))^2 = N_A\ g\left(\alpha, \frac{1}{x_A^e(p)}\right) + \gamma N_A^2(x_A^e(p))^2, \tag{A23}$$

$$W_B^e(p) = N_B(1 + (x_B^e(p))^{\beta})^{\frac{1}{\beta}-1} + \gamma N_B^2(x_B^e(p))^2 = N_B\ g\left(\beta, \frac{1}{x_B^e(p)}\right) + \gamma N_B^2(x_B^e(p))^2. \tag{A24}$$

(i) Let $\alpha < \beta$, $N_A = N_B$, and $f_A = f_B$. By assertion (i) of Proposition 1, $x_A^e(p) > x_B^e(p)$. Since, by Lemma A1, the function $g(\alpha, \frac{1}{x})$ is increasing in x, Equations (A23) and (A24) imply that $W_A^e(p) > W_B^e(p)$.

(ii) Let $\alpha = \beta$, $N_A > N_B$ and $f_A = f_B$. By assertion (i) of Proposition 2, $x_A^e(p) < x_B^e(p)$. By Lemma A1, the function $g(\alpha, x)x$ is increasing in x. Thus

$$g\left(\alpha, \frac{1}{x_A^e(p)}\right)\frac{1}{x_A^e(p)} > g\left(\alpha, \frac{1}{x_B^e(p)}\right)\frac{1}{x_B^e(p)} \tag{A25}$$

or

$$\frac{g\left(\alpha, 1/x_A^e(p)\right)}{g\left(\alpha, 1/x_B^e(p)\right)} > \frac{x_A^e(p)}{x_B^e(p)}. \tag{A26}$$

Since, by assertion (ii) of Proposition 2, $\frac{x_A^e(p)}{x_B^e(p)} > \frac{N_B}{N_A}$, (A23) and (A24) imply that $W_A^e(p) > W_B^e(p)$.

(iii) Let $\alpha = \beta$, $N_A = N_B$ and $f_A < f_B$. By assertion (ii) of Proposition 1, $x_A^e(p) > x_B^e(p)$. Thus, $N_A x_A^e(p) > N_B x_B^e(p)$, and (A23) and (A24) guarantee that $W_A^e(p) > W_B^e(p)$. □

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