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Open borders

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ABSTRACT

There is a large body of evidence indicating that cross-country differences in income levels are associated with differences in productivity. If workers are much more productive in one country than in another, restrictions on immigration lead to large efficiency losses. The paper quantifies these losses, using a model in which efficiency differences are labor-augmenting, and free trade in product markets leads to factor price equalization, so that wages are equal across countries when measured in efficiency units of labor. The estimated gains from removing immigration restrictions are huge. Using a simple static model of migration costs, the estimated net gains from open borders are about the same as the gains from a growth miracle that more than doubles the income level in less-developed countries.

1. Introduction

Imagine there's no countries
It isn't hard to do
[John Lennon]

Citizens of Zimbabwe or Somalia who would prefer to respond to the enormous problems in their home countries by simply moving to a country that does not have such problems are generally prohibited from doing so by the governments of these destination countries. One could well argue that prohibitions of this kind constitute a very serious violation of human rights.[2] More prosaically, one can ask what would happen if such prohibitions were eliminated.

Before proceeding to analyze a world economy with open borders, the first question that must be answered is whether restrictions on factor mobility have any real effects. If product prices are the same across countries (because there is free trade and transportation is not costly, for example), and if there are two goods that are produced in two different countries, and if the production technologies (for these two goods) are the same across the two countries, then the factor price equalization theorem applies. That is, real wages and other factor prices are equalized across countries even though factors are immobile, because differences in factor prices are implicitly arbitraged through the product market. The theoretical

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2 See Hanson (2010).

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argument is beautiful, but of course the facts are otherwise. For example, wages in the U.S. are about 2.5 times the Mexican wage, for comparable workers.[3]

Empirical studies that attempt to account for the observed differences in average incomes across countries have repeatedly shown that large differences remain after adjusting for differences in physical and human capital endowments. In other words, there are large differences in productivity.[4] This paper considers a model with labor-augmenting differences in productivity across countries. In this model, the factor price equalization theorem holds (under the usual assumptions) if wages are measured in terms of efficiency units of labor. This means that the rental rate of capital is equalized across countries, but a Mexican worker in the U.S. has more efficiency units of labor (and therefore higher earnings) than the same worker in Mexico.

In the standard (Heckscher–Ohlin) model, factor price equalization means that there is no economic incentive to migrate from one country to another. But when the model is extended to allow for labor-augmenting productivity differences, there are potentially large gains from migration, because a worker who moves to a more productive place acquires more efficiency units of labor. There are also potentially large costs, since people tend to be strongly attached to the place where they were born and raised.[5] Using a very simple specification of migration costs, the net gains from open borders can be roughly estimated. The main conclusion of the paper is that these gains are huge.

Given that immigration is heavily restricted in developed countries, it is clear that the gains accruing to immigrants are offset to some extent by perceived losses imposed on the residents of these countries. These losses may be associated with changes in the wage structure, or with the costs of including immigrants in social insurance schemes (net of the additional tax revenue collected), or with the dilution of a country's cultural identity. The effects of immigration on wages are analyzed below, but no attempt is made to quantify the public finance implications of open borders, and of course the cultural implications are far beyond the scope of the paper.[6]

The gains from open borders have also been stressed in recent work by Freeman (2006), Klein and Ventura (2007, 2009) and Clemens (2011). In the Klein–Ventura model, cross-country income differences are attributed to differences in total factor productivity, and there are large gains when capital and labor are moved to more productive countries. The main novelty in this paper is that the gains from open borders are analyzed in an environment in which income differences are attributed to differences in labor productivity, and the factor price equalization theorem holds, as in Trefler (1993). In contrast to the Klein–Ventura model, the gains have nothing to do with reallocating capital across countries, because it is assumed, in line with the evidence presented by Caselli and Feyrer (2007), that there are no differences in the productivity of capital, and factor price equalization implies that the return to capital is the same in all countries.

2. Data

Clemens et al. (2008) compare the wages of foreign-born, foreign-educated workers in the 2000 U.S. Census with the wages of similar workers in 42 home countries. The relative wage data are shown in Fig. 1, along with data on GDP per person from the Penn World Table.[7]

These relative wages are used below to measure cross-country differences in labor efficiency – that is, differences in the productivity of a given stock of human capital, when moved from one country to another. For example, the wage of a Mexican worker in Mexico is about 40% of the wage of a worker with the same education and experience who was born and educated in Mexico but who was working in the U.S. in the 2000 Census. This is taken to mean that Mexican workers have 0.4 efficiency units of labor (per unit of human capital), so that a Mexican worker who crosses the U.S. border becomes as productive as 2.5 Mexican workers who stayed at home. The assumption here is that the variables that reduce labor productivity in Mexico (whatever they might be) are specific to the location, and not to the people who work in that location. This is obviously a strong assumption, given that there is no theory of what the relevant variables are. The main concern is that the workers who migrate are selected from the upper tail of the individual-specific productivity distribution (conditional on observables).

Clemens et al. (2008) reviewed the empirical literature on migrant selection, and concluded that although the typical migrant is probably somewhat more productive than the typical non-migrant (conditional on observables), it is quite unlikely that the typical migrant is drawn from a point above the 70th percentile of the individual-specific productivity distribution (in the home country). In Fig. 2, the wage at the 70th percentile in the sending country relative to the mean U.S. wage (for

[3] See Clemens et al. (2008).

[4] See Hall and Jones (1999), Hendricks (2002) and Caselli (2005), for example. Schoellman (2011) shows that cross-country differences in the quality of education are important, but even after accounting for these differences, the remaining differences in labor productivity are very large.

[5] For empirical evidence on the importance of attachment to place see Kennan and Walker (2011) (for migration within the U.S.), and Lessem (2011) (for migration between Mexico and the U.S.).

[6] See Storesletten (2000) for a detailed analysis of the fiscal effects of immigration, showing that, at least in some realistic cases, the present value of the additional retirement benefits paid to immigrants is actually more than offset by the present value of the additional tax revenue. Freeman (2006) discusses ways of transferring some of the gains from immigration to residents of the host country, including the idea of simply selling entry permits, as suggested by Becker and Becker (1998).

[7] The GDP data are from PWT version 7.1; see Heston et al. (2012). The relative wage estimate for Puerto Rico is taken from Table 9 in Clemens et al. (2008). A relative wage estimate for China has been added, using data from Shi (2009). In the figure, countries are identified by internet domain names.

Fig. 1. Cross-country differences in wages relative to wages of similar workers in the U.S., using data from Clemens et al. (2008), and differences in income per worker from the Penn World Table.

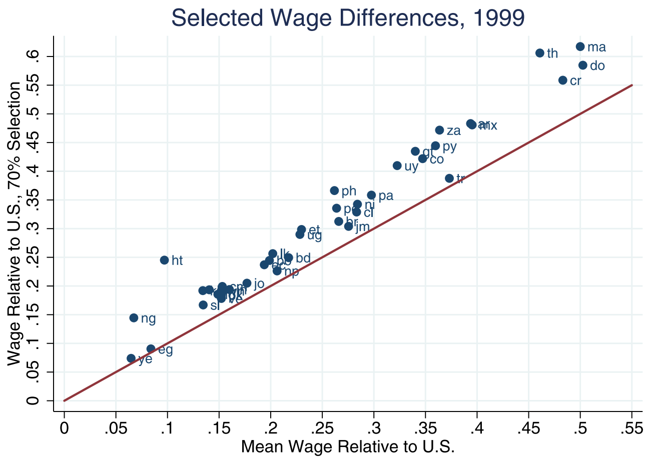

Fig. 2. Wages at the 70th percentile and at the mean of the domestic distribution, both relative to mean U.S. wage; data from Clemens et al. (2008).

a worker with the same observables), is plotted against the relative wage at the mean. The result is that the selection effect is not large.

Income per worker varies across countries not only because of differences in labor efficiency, but also because of differences in human capital endowments. Income per worker can be computed from data on GDP per worker and labor share. The labor share in country j can be written as

$$\lambda_j = \frac{wa_j h_j N_j}{Y_j}$$

where w is the real wage, a_j represents efficiency units of labor per worker in country j, h_j is the human capital of the average worker, N_j is the labor force, and Y_j is total GDP. So if data are available on λ_j and Y_j, income per worker can be computed as

$$y_j = wa_j h_j = \frac{\lambda_j Y_j}{N_j}$$

Bernanke and Gurkaynak (2002) and Gollin (2002) report labor shares for 20 countries that are also in the Clemens et al. (2008) data. The relationship between relative incomes and relative wages is illustrated in Fig. 3.

A country that has the same level of human capital per worker as the U.S. should lie on the 45-degree line in this plot. For most countries, the data lie well below the 45-degree line, indicating that the average worker in these countries has considerably less human capital than the average worker in the U.S. But the data for Egypt and Venezuela are implausible: for example, the average worker in Egypt surely does not have more human capital than the average worker in the U.S.

Fig. 4 shows factor price data for 17 countries. The vertical axis shows measures of the marginal product of capital, taken from Caselli and Feyrer (2007). The horizontal axis shows the relative wage data from Clemens et al. (2008). There are big

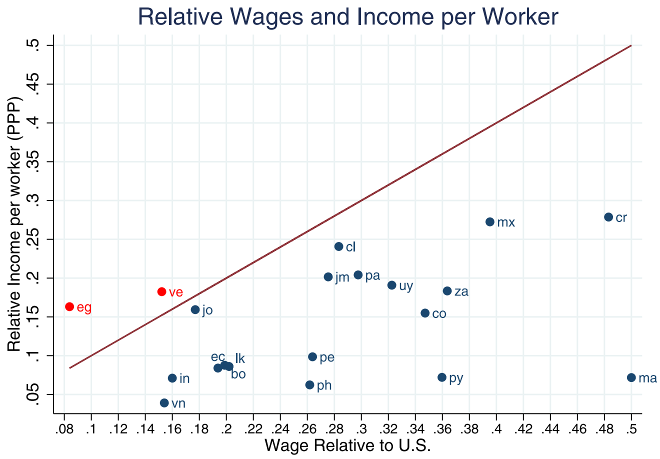

Fig. 3. Relative wages from Clemens et al. (2008) and real GDP per worker from Penn World Table, multiplied by labor shares from Bernanke and Gurkaynak (2002) and Gollin (2002).

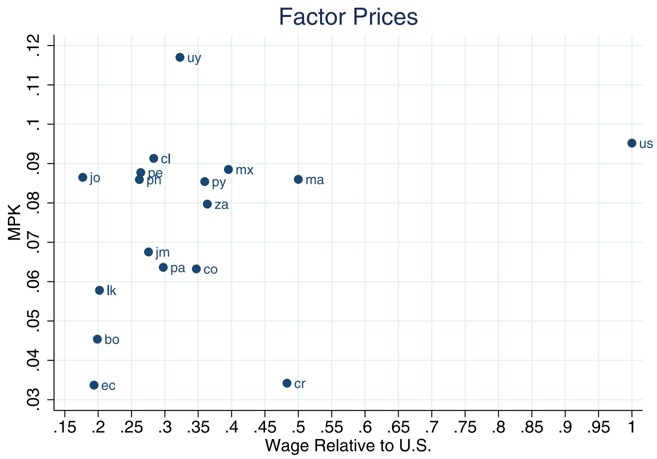

Fig. 4. Marginal product of capital, from Caselli and Feyrer (2007), compared with relative wages.

wage differences, but the return on capital is roughly equal across countries, as Caselli and Feyrer (2007) point out. This is consistent with factor price equalization, given labor-augmenting technology differences across countries.

3. Model

3.1. The Heckscher–Ohlin model

The Heckscher–Ohlin theorem says that each country exports factors in which it is abundant. Trefler (1993) shows that data on imports and exports can always be made to satisfy the Heckscher–Ohlin theorem if suitable productivity adjustments are made. Let $\Omega^*_{fj} = a_{fj}\Omega_{fj}$ be the effective endowment of factor f in country j, where Ω denotes physical units, and a represents factor-augmenting productivity differences, so that Ω^* is measured in efficiency units. Then f is abundant in j if

$$\Omega^*_{fj} - s_j \sum_{\tau} \Omega^*_{f\tau} > 0$$

where s_j is j's share in world consumption.

If there are I produced goods, and T is the vector of net exports of these goods, then $\mathfrak{F}^*_j = A^* T_j$ is the factor content of trade, where A^* is the matrix of cost-minimizing factor quantities for each good (at a given factor–price vector), and it is assumed that this matrix is the same for all countries. That is, it is assumed that technology differences across countries are confined to factor-augmenting productivity differences (as opposed to differences in elasticities of substitution between factors, for example). Then the (modified) Heckscher–Ohlin theorem is

$$\mathfrak{F}^*_{fc} = \Omega^*_{fc} - s_c \sum_j \Omega^*_{fj}$$

There are a lot of free parameters in this model. The issue is whether the productivity adjustments match the data on relative factor prices across countries – whether the adjustments needed to match the trade flow data are consistent with factor price equalization. For capital and labor, and for a sample of 33 countries, Trefler (1993) shows that the match is quite good; moreover, the labor adjustments are bigger than the capital adjustments. The next section develops a version of this model in which cross-country differences in technology are purely labor-augmenting. This model is used in the subsequent sections to analyze the implications of open borders.

3.2. Factor price equalization with labor-augmenting technology differences

Suppose there are J countries, with different productivity levels. If the productivity differences are labor-augmenting (i.e. Harrod-neutral), then the technology for product s in country j can be specified as

$$Q^j_s = F_s\left(K^j_s, a_j L^j_s\right)$$

where a_j represents efficiency units of labor per worker in country j.

Let c^0_s be the unit cost function for product s when the labor input is measured in efficiency units, so that the production function is $Q_s = F_s(K_s, L_s)$. Then it is easy to see that the cost function for product s in country j is

$$c^j_s(v, w) = c^0_s\left(v, \frac{w}{a_j}\right)$$

where w is the wage per efficiency unit of labor, and v is the price of capital.

If there is free trade in the product markets, with no transportation costs, then the zero-profit condition implies

$$p_s = c^0_s\left(v_j, \frac{w_j}{a_j}\right)$$

If two products r and s are produced in country j, then

$$c^0_r\left(v_j, \frac{w_j}{a_j}\right) = p_r$$

$$c^0_s\left(v_j, \frac{w_j}{a_j}\right) = p_s$$

These equations determine the factor prices in country j. If the marginal rates of technical substitution satisfy a single-crossing condition, the factor prices are uniquely determined. Then if country ℓ also produces these same two products, the same equations determine factor prices in country ℓ, with a_ℓ in place of a_j. This implies $v_j = v_\ell$, and

$$\frac{w_j}{a_j} = \frac{w_\ell}{a_\ell}$$

Thus

$$w_j = a_j w_0$$

where w_0 is a reference wage level that can be normalized to 1.

In this model, migration has no effect on relative wages. Thus if 30 million workers move from Mexico to the U.S., it will still be true that the wage in the U.S. is 2.5 times the wage in Mexico. In particular, it is not the case that migration reduces the wage in the receiving country while increasing the wage in the sending country, as would be the case in a single-product model where migration involves opposing movements along the marginal product of labor curve. But migration affects wage levels (this is analyzed in Section 3.4 below).[8]

[8] See Borjas (2009) for an analysis of the effects of immigration on wages in a setting where the domestic and foreign economies produce distinct goods, so that the factor price equalization theorem doesn't apply.

3.3. General equilibrium

Given the factor prices, the prices of consumer goods are determined by the cost functions. Then the quantities are determined by these goods prices, and by preferences and total income (where income depends on factor prices). Given the quantities to be produced, and the factor prices, producers determine the profit-maximizing factor quantities. This gives demand curves for the factors, and factor prices are determined so as to clear the factor markets.

For simplicity, it is assumed that: (1) preferences are identical in all countries, and are described by a loglinear utility function with expenditure share parameters θ_s; and (2) the production function for each good is a CES, and is the same in all countries, with an elasticity of substitution σ that is the same for all goods (and with the understanding that the labor input is measured in efficiency units). It is also assumed that each worker supplies one time-unit of labor (inelastically). This time-unit implies different amounts of effective labor in different countries, for two reasons: human capital endowments h_j may differ across countries, and each unit of human capital in country j means a_j efficiency units of labor.[9]

Given that the production function for each good is a CES, the price of good s is given by

$$p_s^{1-\sigma} = \alpha_s \left(\frac{v}{\alpha_s}\right)^{1-\sigma} + \beta_s \left(\frac{w}{\beta_s}\right)^{1-\sigma}$$

where w is the wage in efficiency units, and where $\alpha_s + \beta_s = 1$. The quantities to be produced are determined by the expenditure shares θ_s applied to total income

$$p_s Q_s = \theta_s (w\bar{L} + v\bar{K})$$

where $\bar{L}$ is the aggregate amount of labor in the world (in efficiency units), and $\bar{K}$ is the aggregate amount of capital.

The conditional factor demand functions are the derivatives of the cost functions, by Shephard's lemma. The derivatives are determined by

$$c_s^{-\sigma} \frac{\partial c_s}{\partial v} = \left(\frac{v}{\alpha_s}\right)^{-\sigma}$$
$$c_s^{-\sigma} \frac{\partial c_s}{\partial w} = \left(\frac{w}{\beta_s}\right)^{-\sigma}$$

Thus the factor demands are given by

$$K_s = Q_s c_s^{\sigma} \left(\frac{v}{\alpha_s}\right)^{-\sigma}$$
$$L_s = Q_s c_s^{\sigma} \left(\frac{w}{\beta_s}\right)^{-\sigma}$$

Finally, the factor market clearing equations are

$$\sum_s Q_s c_s^{\sigma} \left(\frac{v}{\alpha_s}\right)^{-\sigma} = \bar{K}$$
$$\sum_s Q_s c_s^{\sigma} \left(\frac{w}{\beta_s}\right)^{-\sigma} = \bar{L}$$

One of these equations is redundant, by Walras Law. Write the capital market equation as

$$\sum_s p_s Q_s c_s^{\sigma-1} \left(\frac{v}{\alpha_s}\right)^{-\sigma} = \bar{K}$$

and define ξ_s as the capital share for good s:

$$\begin{aligned}\xi_s &= \frac{vK_s}{vK_s + wL_s} \\ &= \frac{\alpha_s \left(\frac{v}{\alpha_s}\right)^{1-\sigma}}{\alpha_s \left(\frac{v}{\alpha_s}\right)^{1-\sigma} + \beta_s \left(\frac{w}{\beta_s}\right)^{1-\sigma}}\end{aligned}$$

[9] These are obviously strong assumptions. When there are more than two factors of production, with variable elasticities of substitution (for different pairs of factors, or for different goods), the analysis becomes much more complicated. But there is no reason to believe that these complications would seriously undermine the main argument regarding the gains from open borders, so it is useful to develop the argument in the context of a simple and relatively transparent model.

Then the market-clearing equation for capital can be expressed as

$$\sum_s \frac{1}{\alpha_s}\left(\frac{v}{\alpha_s}\right)^{-1}\theta_s\xi_s = \frac{\bar{K}}{w\bar{L}+v\bar{K}}$$

which reduces to

$$\sum_s \theta_s\xi_s = \frac{v\bar{K}}{v\bar{K}+w\bar{L}}$$

The point here is that ξ_s is the capital share for product s, and θ_s is the share of product s in total consumer expenditure, so the equilibrium condition is that the weighted average of the capital shares has to match the capital share of total income (implying that the corresponding equality holds for labor).

Note that ξ_s may be an increasing or decreasing function of the factor–price ratio, depending on the elasticity of substitution. But in the case of Cobb–Douglas production functions ($\sigma = 1$), $\xi_s = \alpha_s$ is just a technological parameter, and the equilibrium factor–price ratio is then determined by

$$\sum_s \theta_s\alpha_s = \frac{1}{1+\frac{w}{v}\frac{\bar{L}}{\bar{K}}}$$

implying that the elasticity of the factor–price ratio with respect to the capital–labor ratio is unity.

3.3.1. *Goods prices*

The price ratio between any two consumer goods is given by

$$\frac{p_s^{1-\sigma}}{p_t^{1-\sigma}} = \frac{\alpha_s^{\sigma}\left(\frac{v}{w}\right)^{1-\sigma}+\beta_s^{\sigma}}{\alpha_t^{\sigma}\left(\frac{v}{w}\right)^{1-\sigma}+\beta_t^{\sigma}}$$

Thus an increase in the price of capital relative to labor implies an increase in the relative price of capital-intensive goods. For example, in the limit, when σ approaches 1,

$$\log\left(\frac{p_s}{p_t}\right) = (\alpha_s-\alpha_t)\log\left(\frac{v}{w}\right)$$

3.4. *Immigration and wages*

The effective total supply of labor aggregated over countries is

$$\bar{L} = \sum_j a_j h_j N_j$$

where N_j is the labor force in country j. When workers move to countries where labor is more efficient, the effective supply of labor increases, and if the world capital stock is taken as fixed, this reduces the capital–labor ratio. Thus if M_{jk} workers migrate from j to k, the change in the effective labor supply is

$$\Delta\bar{L} = \sum_j\sum_k (a_k h_k - a_j h_j)M_{jk}$$

The amount of effective labor time needed to earn enough to buy one unit of good s is $\frac{p_s}{w}$. This is determined by

$$\left(\frac{p_s}{w}\right)^{1-\sigma} = \alpha_s^{\sigma}\left(\frac{v}{w}\right)^{1-\sigma}+\beta_s^{\sigma}$$

and in the Cobb–Douglas case this reduces to

$$\log\left(\frac{p_s}{w}\right) = \alpha_s\log\left(\frac{v}{w}\right) - \alpha_s\log(\alpha_s) - \beta_s\log(\beta_s)$$

When immigration restrictions are relaxed, the capital–labor ratio $\frac{\bar{K}}{\bar{L}}$ falls, so the factor–price ratio $\frac{v}{w}$ rises, and this leads to a fall in the real wage, $\frac{w}{p_s}$, measured in terms of good s.[10] The reduction in the real wage is the same in all countries

[10] In the CES case, the elasticity of the real wage with respect to the factor–price ratio is $\alpha_s(\frac{p_s}{v})^{\sigma-1}$.

(regardless of whether they are sending or receiving countries). Factor price equalization holds both before and after the migration of labor, but migration reduces the wage per efficiency unit of labor (and therefore also reduces the wages of all workers who do not migrate).

Even though migration reduces the prices of labor-intensive goods relative to capital-intensive goods, there is a reduction in the real wage regardless of whether the real wage is defined in terms of labor-intensive or capital-intensive goods. But the magnitude of the effect depends on the composition of the consumption bundle. For example, in the Cobb–Douglas case, the elasticity of the factor–price ratio with respect to the capital labor ratio is unity, so if the effective labor supply doubles, the factor–price ratio is cut in half. Then if the capital share for good s is $\alpha_s = \frac{1}{3}$, the real wage falls by about 20% when measured in terms of good s.

3.5. *Wages in the long run*

Migration increases the return on capital, since the effective capital–labor ratio decreases. In steady state equilibrium with a constant returns technology

$$f'(k^*) = \rho + \delta$$

where f' is the marginal product of capital, ρ is the rate of time preference, δ is the depreciation rate and k^* is the effective capital–labor ratio. In the short run, migration increases the effective labor supply, so the capital–labor ratio falls below k^*, and the marginal product of capital rises above $\rho + \delta$. The investment rate therefore increases, and this continues until the effective capital–labor ratio returns to k^*, and the real wage returns to its original level. Thus migration does not reduce wages in the long run. And if immigration restrictions are removed gradually, in such a way that the effective labor supply grows at the same rate as the capital stock, then wages do not fall even in the short run.

3.6. *Migration decisions*

One might initially expect that in a world with open borders, everyone would move to the most productive location. But this ignores the strong attachment to home locations that is evident in the data.[11]

Let $a_j = \frac{y_j}{y_0} \leqslant 1$ be the level of income in the home location (y_j), relative to the highest income available elsewhere (y_0), and assume that migration involves a utility cost δ, which is drawn from a distribution F. Since the utility function is loglinear, the indirect utility function can be expressed as $\log(y)$. Then it is optimal to stay in the home location if

$$\log(y_0) - \delta \leqslant \log(y_j)$$

If the distribution of δ is the unit exponential, $F(t) = 1 - e^{-t}$, then the probability of staying is[12]

$$\text{Prob}\left(\delta \geqslant \log\left(\frac{y_0}{y_j}\right)\right) = e^{-\log(\frac{y_0}{y_j})} = a_j$$

This model is of course oversimplified in many respects.[13] But it is consistent with the data on migration between Puerto Rico and the U.S. According to Clemens et al. (2008), the relative wage in Puerto Rico is approximately $\frac{2}{3}$ of the U.S. wage, and according to the 2000 Census, the proportion of adults born in Puerto Rico who were living in Puerto Rico is also approximately $\frac{2}{3}$. Moreover, Lessem (2011) estimates that a 10% increase in the Mexican/U.S. wage ratio would decrease migration by 11.6%, which is roughly consistent with the unit elasticity of the migration rate predicted by the simple model.

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11 For example, Kennan and Walker (2011) show that attachment to home is an important determinant of internal migration decisions in the U.S.

12 Klein and Ventura (2009) use a similar specification of the disutility of living away from home. More generally, it is reasonable to suppose that this disutility varies from one country to another. For example, if δ is exponentially distributed with scale parameter ν_j in country j, $F(t) = 1 - e^{-\nu_j t}$, then the probability of staying is

$$\text{Prob}\left(\delta \geqslant \log\left(\frac{y_0}{y_j}\right)\right) = a_j^{\nu_j}$$

13 For example, if skilled and unskilled labor are not perfect substitutes, interesting questions arise. Are the differences in efficiency more important for skilled labor or for unskilled labor? Internal migration data for the U.S. show much higher migration rates for skilled workers, suggesting that the attachment to home may be weaker for skilled workers. Thus if the efficiency differences are similar, one might expect that the flow of skilled workers would be larger with open borders. Open borders also affect the incentive to invest in human capital; in a more general treatment, one would not take the numbers of skilled and unskilled workers as given.

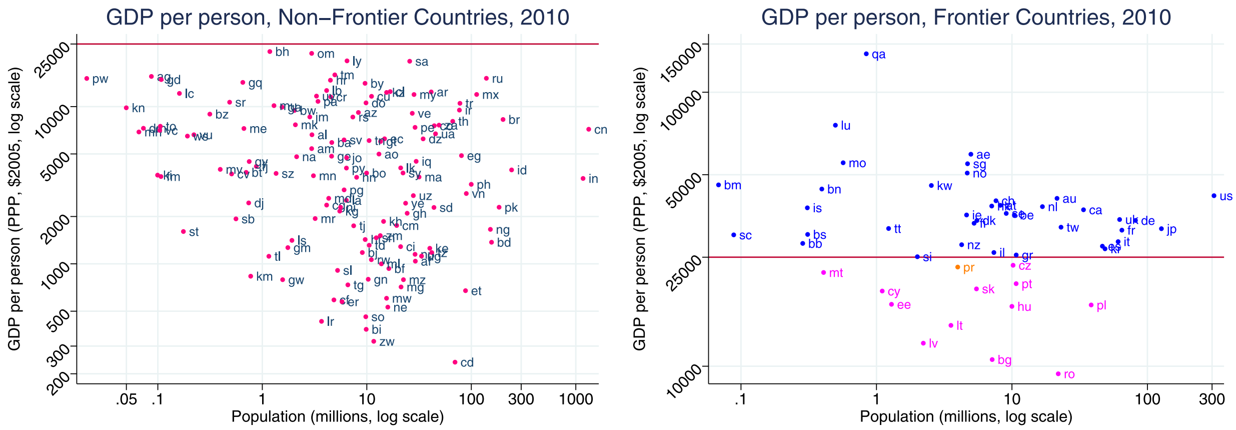

Fig. 5. Cross-country differences in real GDP per person (Penn World Table, 7.1).

4. Labor supply and wages with open borders: magnitudes

4.1. The effective supply of labor

Given that each person starts with ah units of effective labor, and that the proportion of stayers is a, the average supply of effective labor after migration (to the most productive location, where the efficiency level is normalized to 1) is

$$a \times ah + (1-a) \times h = \left(1 - a + a^2\right)h$$

Thus the increase in effective labor per person is $(1 - a + a^2 - a)h = (1-a)^2 h$, and the aggregate increase in effective labor due to migration is

$$\Delta \bar{L} = \sum_{j=1}^{J} (1 - a_j)^2 h_j N_j$$

The increase in the supply of labor is proportional to the increase in gross income (since income is just effective labor multiplied by the wage, and the wage is the same everywhere). Since total labor income can be written as $wa_j h_j N_j = \lambda_j Y_j$, the proportional increase in effective labor can be restated in terms of income as

$$\frac{\Delta \bar{L}}{\bar{L}^0} = \frac{\sum_{j=1}^{J} \frac{(1-a_j)^2}{a_j} \lambda_j Y_j}{\sum_{j=1}^{J} \lambda_j Y_j}$$

In order to estimate this increase in the effective labor supply, it is necessary to have data on labor incomes and relative wages for all countries. The available data include measures of real GDP per capita for almost all countries (i.e. all 189 countries in the Penn World Table), real GDP per worker for all but 11 of these countries, together with labor shares and relative wage estimates for a limited set of countries.

The first step is to define a set of countries at the productivity frontier. This involves choosing a cutoff productivity level above which the gains from migration are negligible. The most recent data on GDP per person in PWT7.1 are for 2010. These data are displayed in Fig. 5, with a proposed cutoff point at $25,000. This cutoff is of course arbitrary to some extent, but the results are not sensitive to the precise number chosen. The $25,000 cutoff gives a reasonable classification: the frontier set contains 38 countries, including all of Western Europe except for Portugal, as well as Japan and South Korea (which is just above the cutoff). The set is then expanded to include countries that already share open borders with the frontier countries. This adds 12 relatively poor countries that are in the European Union (which has open borders); Puerto Rico is also added, since the border between the U.S. and Puerto Rico is open. Thus defined, the frontier set includes 51 countries in all.

4.1.1. Labor income and relative wages

Gollin (2002) analyzed the available data on labor shares and concluded that the variation across countries is quite limited, and in particular that labor shares do not vary systematically with the level of income. Based on this, labor share is taken to be a constant for countries not included in Gollin (2002)'s data, or in the data analyzed by Bernanke and

Gurkaynak (2002); thus $\lambda_j = \frac{2}{3}$ for these countries, this value being very close to the average labor shares reported in both papers (0.675 and 0.650).

There remains the problem of estimating a_j for countries without relative wage data. This is done by regressing relative wages in 1999 on real GDP per worker in 1999, for the 40 countries for which the relevant data are available, and using the estimated regression function to predict the missing relative wage data.[14] The results are adjusted for changes in real GDP per worker between 1999 and 2010.[15]

4.2. *Effective world labor supply estimates*

Using the above approximations, the effective world labor supply, before allowing for migration, is estimated as 764.1 million workers, taking one U.S. worker as the efficiency unit; this is just total world labor income divided by income per worker in the U.S.[16] With open borders, the supply increases to 1507.7 million. Thus the effective labor supply doubles. The number of workers in frontier countries increases by much more than 100%, but this greatly overstates the increase in the effective labor supply, since the labor supplied by each worker who migrates is proportional to the amount of human capital the worker has, and the relative wage and income data imply that human capital levels in the sending countries are much lower than in the frontier countries.

A surprising conclusion from this analysis is that the effect of open borders on real wage rates is small (even in the short run, with capital held fixed). For example (as was mentioned in Section 3.4), if the technology is Cobb–Douglas, and the real wage is computed in terms of goods for which the capital share is $\frac{1}{3}$, the real wage would fall by only about 20% if everyone moved immediately, with no time for adjustment of the capital stock. In a dynamic model, the effect on real wages would be very much attenuated, even in the short run. For example, in the Kennan and Walker (2011) model of internal migration within the U.S., it takes about 10 years before the response to a simulated (permanent) increase in the real wage in one location is more or less complete.

5. Net gains from migration

Given factor price equalization, average income per worker in country j is $y_j = a_j h_j w$, where h_j is the human capital of the average worker.[17] Both h and a are measured in efficiency units of labor; the difference between them is that h is embodied in the worker, and is carried from one country to another when the worker migrates, while a is embodied in the country. Thus when a worker moves from j to a frontier country (where $a = 1$), the (gross) income gain is

$$\begin{aligned}\Delta y &= (1 - a_j)h_j w \\ &= \frac{1 - a_j}{a_j} y_j\end{aligned}$$

The net gains from migration differ from one individual to another. The net gain for the marginal migrant is zero, and of course there is no gain for those who do not migrate. If the lowest migration cost is zero then the first person who moves gains the full income difference, $\frac{1-a_j}{a_j} y_j$. For the average migrant, the gain is roughly the average of these: $\frac{1-a_j}{2a_j} y_j$.[18] The proportion of people who do not migrate is a_j (according to the simple model of migration decisions described in Section 3.6), so the income gain for the average person (including non-migrants) is

$$\bar{g}_j = \frac{1}{2} \frac{(1 - a_j)^2}{a_j} y_j$$

[14] For most countries, the most recent data on GDP per worker in PWT7.1 refer to 2010. There are 11 (small, non-frontier) countries with missing observations on GDP per worker in 2010. Predictions for these countries are made by using real GDP per person in place of real GDP per worker.

[15] In the case of countries that are included in the regression, $\hat{a}_j(t+s) = a_j(t) + [Y_j(t+s) - Y_j(t)]\hat{\beta}$; for the countries that do not have relative wage data, $\hat{a}_j(t+s) = \hat{\alpha} + Y_j(t+s)\hat{\beta}$. Here Y denotes real GDP per worker, $\hat{\alpha}, \hat{\beta}$ are estimated regression coefficients, $t = 1999$ and $t + s = 2010$.

[16] An even simpler calculation, assuming equal labor shares for all countries, divides total world GDP by GDP per worker in the U.S.; the result of this calculation is 813 million workers (using data for 2010). Since the U.S. labor force is 155.8 million, this means that the U.S. supplies about 20% of the (effective) labor in the world market. This illustrates the Leontief (1953) explanation for why the U.S. exports labor-intensive goods in exchange for capital-intensive goods: when differences in labor productivity are taken into account, the U.S. has a relative abundance of labor.

[17] Note that a country's endowment of physical capital has no effect on income per worker. Factor price equalization means that endowments do not change factor prices, so low wages cannot be explained by low physical capital endowments. On the other hand, two countries with the same (country-specific) productivity level can have quite different levels of income per worker (as is evident from Fig. 3), if the average levels of human capital per worker are different.

[18] This is not exact for the exponential cost distribution assumed in Section 3.6, but it is not far off.

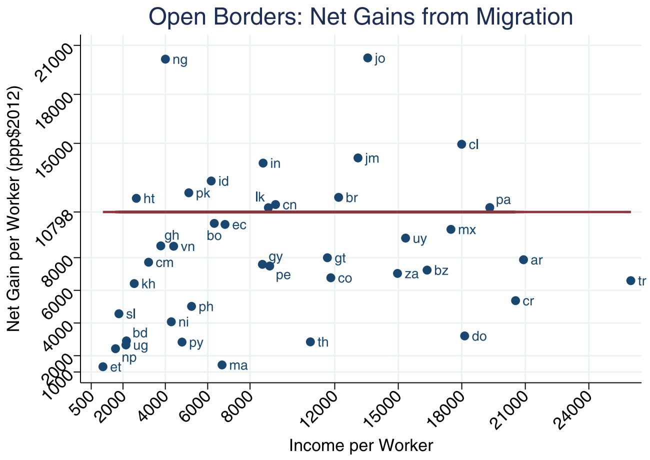

Fig. 6. Net gains per worker; computed using simple migration model.

After deleting three countries (Egypt, Yemen and Venezuela) with anomalous relative wage data, net gains from migration ($\bar{g}_j$) can be estimated for a sample of 40 countries. This includes 18 countries for which labor share estimates are available either from Bernanke and Gurkaynak (2002) or from Gollin (2002), with income per worker computed as $y_j = \frac{\lambda_j Y_j}{N_j}$, and 22 countries for which labor share is fixed at $\bar{\lambda} = \frac{2}{3}$, with income per worker computed as $y_j = \frac{\bar{\lambda} Y_j}{N_j}$. The results of this calculation are shown in Fig. 6; some details are shown in Tables 1 and 2 in Appendix A.[19]

The average net gain over all countries is given by

$$\bar{g} = \frac{\sum_j N_j \bar{g}_j}{\sum_j N_j}$$

For the 40 countries in Fig. 6 this gives an estimate of \$10,798, per worker (including non-migrants), per year (in 2012 dollars, adjusted for purchasing power parity). This is a very large number: the average income per worker in these countries is \$8633, so the gain in (net) income is 125%. For all of the countries in the Penn World Table that are not at the productivity frontier (as defined above), using GDP data to estimate relative wages, the estimated gain is \$10,135, relative to an average income of \$9079, so the gain is 112%. These are of course just rough estimates, relying on a number of strong simplifying assumptions. But unless these assumptions are extremely far off the mark, the results indicate that the gains from open borders would be enormous.

6. Conclusion

Liberal immigration policies are politically unpopular. To a large extent, this is because the beneficiaries of these policies are not allowed to vote. It is also true, however, that the enormous benefits associated with open borders have not received much attention in the economics literature.[20] Economists are generally enthusiastic about free trade. But if free movement of goods is important, then surely free movement of people is even more important.

One conclusion of this paper is that open borders could yield huge welfare gains: more than \$10,000 a year for a randomly selected worker from a less-developed country (including non-migrants). Another is that these gains are associated with a relatively small reduction in the real wage in developed countries, and even this effect disappears as the capital–labor ratio adjusts over time; indeed if immigration restrictions are relaxed gradually, allowing time for investment in physical capital to keep pace, there is no implied reduction in real wages.

[19] Although the results are noisy, Fig. 6 shows a hump-shaped relationship between income and migration gains across countries. In the case of very poor countries, the gains are small because h is low; for relatively rich countries, the gains are small because a is relatively high.

[20] See Clemens (2011) for a recent review of the relevant literature.

Appendix A. Migration gains

Table 1
Migration gains, using labor share data.

Country	Code	Labor share		Relative wage		Workers millions	GDP per worker	Income per worker	Gain per worker
				1999	2010				
Bolivia	bo	0.67	0.627	0.199	0.200	4.6	9421	6312	10,099
Chile	cl	0.59		0.283	0.297	7.9	30,499	17,994	14,944
Colombia	co	0.65		0.347	0.359	21.1	18,176	11,815	6770
Costa Rica	cr	0.73		0.483	0.493	2.1	28,136	20,539	5370
Ecuador	ec	0.45	0.571	0.194	0.211	7.0	15,153	6819	10,037
India	in		0.828	0.160	0.200	452.7	10,407	8617	13,791
Jamaica	jm	0.6	0.566	0.275	0.257	1.3	21,828	13,097	14,108
Jordan	jo	0.64		0.177	0.209	1.6	21,184	13,558	20,232
Sri Lanka	lk	0.78		0.202	0.235	8.7	11,366	8866	11,061
Morocco	ma	0.58		0.500	0.525	11.3	11,515	6679	1433
Mexico	mx	0.55		0.395	0.364	48.6	31,795	17,487	9734
Panama	pa	0.73		0.298	0.359	1.6	26,470	19,323	11,069
Peru	pe	0.56		0.264	0.296	15.4	15,944	8929	7488
Philippines	ph	0.59	0.661	0.262	0.275	41.5	8877	5237	5021
Paraguay	py	0.49		0.360	0.353	3.1	9771	4788	2831
Uruguay	uy	0.58		0.323	0.351	1.7	26,458	15,345	9199
Vietnam	vn		0.802	0.154	0.173	52.7	5476	4392	8700
South Africa	za	0.62		0.364	0.393	17.8	24,137	14,965	7035
Total						700.7			
Average		0.61	0.676	0.291	0.308		18,145	11,376	9385
Average (weighted)		0.59	0.808	0.206	0.235		12,603	9103	11,729

Notes: The codes in the second column are the domain names used in the figures. The labor share data are from Bernanke and Gurkaynak (2002) and Gollin (2002). The relative wage estimates for 1999 are from Clemens et al. (2008); the estimates for 2010 are estimated using changes in GDP per worker. Labor force and GDP data are from the Penn World Table (v.7.1). Net gains are computed using the simple migration model described in the text. The averages in the last row use labor force weights.

Table 2
Migration gains, using fixed labor share.

Country	Code	Relative wage		Workers millions	GDP per worker	Income per worker	Gain per worker
		1999	2010				
Argentina	ar	0.394	0.431	18.8	31,373	20,915	7875
Bangladesh	bd	0.217	0.224	75.9	3244	2162	2907
Brazil	br	0.266	0.274	104.8	18,274	12,183	11,694
Belize	bz	0.412	0.403	0.1	24,542	16,361	7240
Cameroon	cm	0.153	0.150	8.1	4814	3209	7721
China	cn	0.163	0.238	794.9	13,809	9206	11,253
Dominican Republic	do	0.503	0.556	4.4	27,205	18,136	3209
Ethiopia	et	0.230	0.234	43.3	1580	1054	1323
Ghana	gh	0.140	0.155	10.3	5677	3785	8722
Guatemala	gt	0.340	0.329	5.4	17,481	11,654	7996
Guyana	gy	0.258	0.287	0.3	12,875	8584	7590
Haiti	ht	0.097	0.093	4.0	3944	2629	11,634
Indonesia	id	0.149	0.168	119.5	9251	6167	12,696
Cambodia	kh	0.134	0.144	8.1	3796	2531	6412
Nigeria	ng	0.067	0.083	48.3	6006	4004	20,155
Nicaragua	ni	0.284	0.276	2.3	6421	4281	4074
Nepal	np	0.206	0.211	15.5	2470	1647	2427
Pakistan	pk	0.152	0.153	63.4	7663	5109	11,973
Sierra Leone	sl	0.135	0.145	2.0	2712	1808	4567
Thailand	th	0.461	0.492	37.8	16,275	10,850	2846
Turkey	tr	0.373	0.498	24.1	38,974	25,982	6592
Uganda	ug	0.228	0.235	13.4	3209	2139	2658
Total				1404.8			
Average		0.244	0.263		11,891	7927	7435
Average (weighted)		0.188	0.237		12,598	8399	10,334

Note: Labor share data not being available, the labor share for these countries is fixed at $\frac{2}{3}$, as discussed in the text.

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