High Skilled Labor Force Brain Drain and Corruption: The Case of Colombia

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ABSTRACT. The country of Colombia has experienced growth in high-skilled brain drain rates and is perceived to be a country with moderately high levels of corruption. This article contributes to the literature by analyzing the effects of high-skilled brain drain by applying a Random Utilization Maximization (RUM) model to explain emigration flows from Colombia using cross-sectional and regional multivariate regression models. Findings indicate that greater transparency of regional institutions reduces emigration flows of the high-skilled working population. The regional multivariate regressions also show that lower corruption of regional institutions mitigates high-skilled brain drain in landlocked regions, but fuels high-skilled brain drain from non-landlocked regions and those regions that share an international border. Policies designed to reduce high-skilled brain drain should be conducted at the regional level depending on the expected net effects that high-skilled brain drain has on the local political and economic institutions. (O54, F22)

I. Introduction

Over the last half century, worldwide international migration flows have steadily grown. According to Meseguer and Burgess (2014), about 3 percent of the world's population now live in a different country than their nation of birth. The number of international migrants grew 50 percent between the years of 1990 to 2013 (United Nations 2013). The majority of the international migration growth, during the 1990 to 2013 period, came from migrants moving to more developed nations. In comparison, developing nations only gained 31 percent of the international migration growth (United Nations 2013).

International migration of high-skilled migrants has significantly increased in the world. For example, the growth in the number of skilled migrants in the Organization for Economic Co-operation and Development (OECD) countries between the years 1990 and 2000 has ranged from 32.5% to 91.3%, with Latin American countries experiencing the greatest growth (Meyer 2012; Docquier *et al.* 2009).

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The growth in the number of skilled migrants in the OECD countries has further increased after 1990, with the growth of skilled migrants in the OECD countries between 1990 and 2007 increasing to 155% in Latin America (Meyer 2012).

High-skilled migrants are responsive to the prevalence of corruption. In a study of 111 countries between 1985 and 2005, Dimant *et al.* (2013) find evidence that corruption is a significant push factor for skilled migrants. Besides fueling skilled migration, corruption generates inequality, introduces distortions into public and private sectors, and impacts productivity investment (Graf Lambsdorff 2006). The study of the effects of corruption on high-skilled migration flows has only recently been researched (Dimant *et al.* 2013; Cooray and Schneider 2016; Poprawe 2015).

Historically, Colombia has had negative net migration flows (Departamento Administrativo Nacional de Estadistica (DANE) 2008; Departamento Administrativo Nacional de Estadistica (DANE) 2009). According to Texido and Gurrieri (2012), Colombia has the greatest migrant outflow and the lowest migrant inflow of any South American country. The migration outflows have also grown over time in Colombia. The emigrant level was 391 percent higher in 2000-2005 than it was when measured in the 1970-1975 period (Ramírez *et al.* 2010). Colombia has also being identified among the top 30 countries with the highest number of high-skilled emigrants living in the OECD countries[1] (Docquier and Marfouk 2006). Data from the Institute for Employment Research (IAB) shows that Colombian emigration rates for those with tertiary education, to 20 countries from the OECD[2] went from 8.14% in 1980 to 13.44% in 2005 (Brücker *et al.* 2013). This suggests that the high-skilled Colombian brain drain to the OECD countries increased approximately by 65%, showing the large growth in high-skilled emigration rates in Colombia. This loss of the skilled labor population in Colombia is a classic example of "brain drain" that has been documented for many developing countries (Brücker *et al.* 2013). Given the growth in high-skilled migrants leaving Colombia, academic and government institutions created an initiative to encourage Colombians with masters and Ph.D. degrees to return to Colombia. The program is titled "Plan de Impacto e Intercambio de Conocimiento: Hoja de Ruta para el Retorno al País de Recurso Altamente Calificado."

In Colombia, corruption is perceived to be high. The Corruption Perception Index calculated by Transparency International for the year

2005 shows a picture of moderately high corruption perception[3]. Given the recent evidence of corruption being a push factor for high-skilled migrants (Dimant *et al.* 2013), the study of corruption in relation to high-skilled brain drain provides alternative policy solutions to mitigate the high-skilled brain in Colombia.

This paper focuses on the role of government institutional transparency in determining emigration flows of high-skilled[4] emigrants. Specifically, we focus on the effect of high-skilled worker population on international emigration from Colombia and how high-skilled workers respond to regional corruption levels, after controlling for migration cost, attractiveness of the destination country, and effects that alternative destinations have on international migration outflows in Colombia.

This paper adds to the international migration literature for Colombia. Particularly, there have been many different descriptive international and internal migration studies conducted in Colombia (Departamento Administrativo Nacional de Estadistica (DANE) 2008; Ramírez *et al.* 2010; Mejía Ochoa 2012; Cárdenas and Mejía 2006; Schultz 1969; Bermudez 2010; Guarnizo and Diaz 1999; Mejía *et al.* 2009). However, few studies have performed analytical migration studies (Fields 1979; Galvis 2002; Fields 1982; Udall 1981) in Colombia. Of the analytical migration research in Colombia, past studies have focused on factors that affect internal migration. Those studies have found that internal migration in Colombia is affected by regional income, distance, education, population density, and host regional security (Fields 1982; Galvis 2002).

In addition to adding to the international migration literature in Colombia, this paper also contributes to the empirical literature of corruption as either a push or pull factor for migration. Currently, there are no empirical studies in Colombia on how high-skilled workers respond to corruption, and the effects of corruption on emigration flows. This paper also adds to the literature by providing an analysis of the push and pull factors of Colombia's international regional emigration flows in a multivariate regression model framework. This study provides additional information on alternative policies to mitigate the effect of high-skilled workers brain drain in Colombia at the national and regional level.

The remainder of this paper is organized as follows. Section 2 provides a literature review on high-skilled brain drain in relation to corruption. Section 3 presents a description of the data. Section 4

outlines the theoretical model. Section 5 describes the variables used in the estimation and their expected effect on emigration flows. Section 6 outlies the empirical methodology. Section 7 provides a discussion of the results. The final section provides conclusions.

II. Literature Review

Brain drain has been defined as the migration of individuals with high levels of human capital (Beine, Docquier, and Rapoport 2008; Beine *et al.* 2001; Gibson and McKenzie 2011)[5].

The effects of brain drain can be positive to the country of origin. In a cross section of 127 countries, Beine *et al.* (2008) find that greater high-skilled emigration rates increase human capital formation in the native population of the migrant's origin country. Additionally, Beine *et al.* (2008) find that countries with beneficial brain drain are those countries with low levels of human capital and lower rates of high-skilled emigration rates. Other research points to the effect that emigration has on the migrant's origin country institutions. Specifically, Docquier *et al.* (2016) in an unbalanced panel study of 135 countries between 1985 and 2010, find that emigration promotes institutional development of the country of origin by promoting democratization. Li *et al.* (2016) indicate that high-skilled migrants positively affect political institutions in the country of origin. Li *et al.* (2016) argue that high-skilled migrants are the source of demand for better institutions and improve the political involvement of members of society. High-skilled migrants also increase the expected return to human capital investment by increasing expected income (Gibson and McKenzie 2011; Beine *et al.* 2001).

High-skilled brain drain can also hinder economic development of the origin country. Beine *et al.* (2008) find that the net effect of brain drain is negative[6] in countries where the migration rates of people with higher education are above 20% or the proportion of the population with higher education levels is above 5%. Li *et al.* (2016) indicate high-skilled migrants negatively affect economic institutions of the country of origin. High-skilled brain drain can also increase the unemployment of unskilled workers at the country of origin, if skilled and unskilled workers are viewed as complements in production (Gibson and McKenzie 2011).

Government institutional transparency is important for economic development. In particular, corruption affects economic development by affecting economic growth, lowering foreign investment, increasing

inequality and poverty, and decreasing productivity (Dimant and Schulte 2016; Gupta *et al.* 2002). Corruption has also been found to affect emigration rates depending on the migrant's educational attainment. Cooray and Schneider (2016) find evidence that emigration rates of migrants with lower levels of educational attainment decrease with higher levels of corruption in countries with greater income inequality. Cooray and Schneider (2016) also find evidence that emigration rates of high-skilled migrants are greater at higher levels of corruption. Dimant *et al.* (2013) find that corruption affects the rate at which high-skilled workers emigrate by affecting their return to human capital investment. In an study of bilateral migration for 230 countries, Poprawe (2015) finds evidence of corruption being a push factor of migration, as it lowers the return to labor.

III. Data

Colombia is divided into 32 administrative divisions or Departments. The data for each of Colombia's Departments and the country's capital city are taken from the national statistical system DANE (Departamento Administrativo National de Estadística) which includes: emigration flows, graduation rate at the secondary level, destination country's stock of migrants, unemployment, Gross Domestic Product (GDP), and population. The number of graduates with undergraduate, master, specialization, and Ph.D degrees are obtained from Colombia's Ministry of Education. Colombia's national fixed capital formation is used to estimate Colombia's capital stock following the methodology provided by Nehru and Dhareshwar (1993) and Berlemann and Wesselhöft (2014). Colombia's national fixed capital formation was obtained from the DANE. The official exchange rate provided by The World Bank's World Development Indicators is used to express data given in Colombian Pesos to constant 2005 U.S. dollars. The Transparency Index is taken from the Corporación Transparencia por Colombia (Corporación Transparencia por Colombia 2005).

The common language variable is obtained from the CIA World Factbook (Central Intelligence Agency 2013). The distances between each Departments' capital and destination countries' capital is taken from Google maps. Data for the common international border between each source Department and migrant's destination country is taken from Google Earth.

Destination countries' unemployment rate, GDP, and population data were obtained from The World Bank's World Development Indicators data base. Destination countries' capital stock were obtained from Berlemann and Wesselhöft (2014). The GDP deflator and the destination country's official exchange rate were taken from The World Bank's World Development Indicators and are used to express Berlemann and Wesselhöft (2014)'s destination countries' capital stock in constant 2005 U.S. dollars.

IV. Theoretical Model

Gravity models have been widely used to estimate the effects of economic variables on migration flows (Bergstrand and Egger 2011; Karemera *et al.* 2000; Cohen *et al.* 2008; Rodríguez González *et al.* 2011; Kim and Cohen 2010). However, the gravity model does not have a theoretical foundation which implies that the model suffers from omitted variable bias (Anderson and Van Wincoop 2003; Anderson 2011; Beine *et al.* 2016).

The microeconomics foundations of the gravity models have been represented by the Random Utility Maximization (RUM) model and have been used to explain migration flows (Ortega and Peri 2013; Beine and Parsons 2015; Beine *et al.* 2016; Bertoli and Fernández-Huertas Moraga 2013). The use of the RUM model allows an analysis to substantiate the use of variables such as the multilateral resistance to migration (Ramos 2016). The multilateral resistance to migration measures the effect that alternative destinations have on estimating the migration flows between two locations. Ignoring the multilateral resistance term to migration creates biased estimators (Bertoli *et al.* 2016; Bertoli and Fernández-Huertas Moraga 2013).

Beine *et al.* (2016) and Beine and Parsons (2015a) lay down the use of the RUM model as theoretical foundation of the gravity model for migration. Following, Beine *et al.* (2016) and Beine and Parsons (2015a) assume the emigration flow from the i^{th} source Department[7] to the j^{th} destination country, M_{ij}, is defined as

$$M_{ij} = p_{ij} S_i \tag{1}$$

where $p_{ij} \in [0,1]$ is the probability of individuals to migrate from the i^{th} source Department to the j^{th} destination country, and S_i is the source

Department's population. The probability of migrating from the i^{th} source Department to the j^{th} destination country depends on the utility of migrating. The utility of an individual of moving from the i^{th} source Department to the j^{th} destination country, among k choices is defined as,

$$U_{ij} = w_{ij} - c_{ij} + \varepsilon_j \tag{2}$$

where w_{ij} and c_{ij} are the benefit and cost of migrating from the i^{th} source Department to the j^{th} destination country, and ε_j is an error term. Assuming that the error term is independent and identically distributed with an extreme value distribution, we can write the probability of migrating from the i^{th} source Department to the j^{th} destination country as,

$$E\left[\Pr\left(U_{ij} = \max_k U_{ik}\right)\right] = \frac{\exp\left(w_{ij} - c_{ij}\right)}{\sum_k \exp\left(w_{ik} - c_{ik}\right)}. \tag{3}$$

After replacing equation (3) in equation (1), the expected migration flow from the i^{th} source Department to the j^{th} destination country is defined as,

$$E\left[M_{ij}\right] = \frac{\exp\left(w_{ij} - c_{ij}\right)}{\sum_k \exp\left(w_{ik} - c_{ik}\right)} S_i \,, \tag{4}$$

where the multilateral resistance term to migration is defined as $\Omega_{ij} = \sum_k \exp(w_{ik} - c_{ik})$. Thus, the expected migration flow is a positive function of the benefit from migration, $\exp(w_{ij})$, and the ability of the source Department to send migrants, S_i. Additionally, the migration flow is inversely related to the cost or accessibility of migrating, $\exp(c_{ij})$, and the multilateral resistance effect of alternative migration destinations, Ω_{ij}.

V. Definition of Variables

Table 1 presents each variable used in the econometric specification and a description of those variables. The first set of variables described in Table 1, describes the dependent variables used in the estimation. Note that Departments at the interior of the country (i.e. Landlocked) experience the greater average permanent emigration flows.

The second set of variables shown in Table 1 capture the cost of migrating from the i^{th} source Department to the j^{th} destination country. The cost of migrating is captured by time-variant and time-invariant variables. The time-variant variables include the source Department's high-skilled graduation rates, Transparency Index, graduation rates at the secondary level of education, and stock of migrants. The time-invariant variables that affect the cost of migrating from the i^{th} source Department to the j^{th} destination country are captured by language, distance, and common border variables.

The source's Department high-skilled graduation rates are defined at the undergraduate, and tertiary educational level. The source Department's high-skilled graduation rates are defined as the number of graduates for each educational level as a percentage of the source Department's population working age population (i.e. between 25 and 64 years old). High-skilled graduation rates are defined as a percentage of the working age population to capture the effect that working age high-skilled workers have on the source Department's emigration. The definition of high-skilled graduate rates closely follows the definition of skilled emigration rates offered by Docquier *et al.* (2007), Docquier and Marfouk (2006), and Brücker *et al.* (2013). The national average high-skilled worker graduation rate for Colombia is 0.38% for the tertiary educational level. Less than one percent of the working age population has any post-secondary education. High-skilled graduation is assumed to capture the cost of migration as it estimates the transferability of human capital from the source Department to the destination country. Thus, it is assumed that at higher education levels, greater transferability of human capital which decreases the cost of emigration and increases migration outflows. Evidence of brain drain is interpreted as a positive effect of high-skilled worker graduation rates on emigration flows.

The Transparency Index measured by the Corporación Transparencia por Colombia (2005), measures the risk of corruption of institutions at the Department's level. Higher values for the Transparency Index are associated with lower risk of corruption in the local institutions. The institutions used for evaluation of the index were selected based on their political and administrative responsibility, and their participation in the use of the Department's resources.

TABLE 1–Descriptive Statistics

Variable (No. Obs. 363)	Description	Mean	Std. Dev.
M_{ij}	Migration flow from source Department to destination country (number of people; 2001-2005)	506.157	1932.271
M_{ij} (Atlantic Coast)[a]	Migration flow for the Atlantic Coast region from source Department to destination country (number of people; 2001-2005)	143.298	843.212
M_{ij} (Pacific Coast)[b]	Migration flow for the Pacific Coast region from source Department to destination country (number of people; 2001-2005)	134.534	1420.331
M_{ij} (Landlocked)[c]	Migration flow for the Landlocked region from source Department to destination country (number of people; 2001-2005)	198.435	1053.559
M_{ij} (International Border)[d]	Migration flow for the International Border region from source Department to destination country (number of people; 2001-2005)	29.890	270.403
High-Skilled Worker Grad. Rate-Undergraduate	Number of graduates from the source Department at the undergraduate level of education as percentage of the working age population (percentage; 2005; working age population is defined as those individuals between 25-64 years)	0.327	0.293
High-Skilled Worker Grad. Rate-Tertiary	Number of graduates from the source Department at the tertiary level of education as percentage of the working age population. Individuals with tertiary level of education is defined as those individuals with a master, specialization, or Ph.D. degree (percentage; 2005; working age population defined as those individuals between 25-64 years)	0.388	0.361
Transparency Index	Source Department's Transparency Index (index range is from 0 to 100 points; average of the 2003-2004 and the 2004-2005 indices values)	50.657	8.644

TABLE 1–Descriptive Statistics (continued)

Variable (No. Obs. 363)	Description	Mean	Std. Dev.
Secondary Level Graduation Rate	Number of graduates from the source Department at the secondary level of education as a percentage of the enrolled students at the same educational level (percentage; 2005)	84.348	5.194
Stock of Migrants	Migration flow before 1996 (number of people)	604.530	2489.101
Language	Source Department and destination country share common language (=1)	0.727	0.446
Distance	Distance between the source Department's capital and the destination country's capital (kilometers)	3847.804	3933.779
Common Border	Source Department and destination country share an international border (=1)	0.033	0.179
Relative Unemployment Rate	Destination country's unemployment rate relative to the unemployment rate at the source Department (percentage; 2005)	115.378	63.427
Relative Capital Stock	Destination country's capital stock relative to the Colombian capital stock (percentage; 2005)	817.054	1834.434
Relative GDP per Capita	Destination country's Gross Domestic Product relative to the source Department Gross Domestic Product (percentage; 2005)	753.965	930.527
Population	Population in the source Department (number of people; 2005)	1299654.000	1525123.000

[a] Atlantic Coast Region - the Departments in this region are: Atlántico, La Guajira, Magdalena, Bolivar, Córdoba, Antioquia, San Andrés, and Sucre.
[b] Pacific Coast Region - the Departments in this region are Cauca, Chocó, Nariño, and Valle del Cauca.
[c] Landlocked Region - the Departments in this region are: Risaralda, Caldas, Quindío, Huila, Tolima, Cundinamarca, Santander, Casanare, Meta, Guaviare, and Caquetá.
[d] International Border Region - The Departments in this region are: Putumayo, Vaupés, Vichada, Boyacá, Arauca, Norte de Santander, Cesar, Amazonas, and Guainia.

The Transparency Index measures the risk of corruption based on three different factors: visibility, compliance, and sanctions. The visibility of the institution measures availability of information to the public regarding the management of local government institutions. The visibility factor measures how the public can judge and discuss the management of the local institutions. The second factor measured in the Transparency Index, compliance, evaluates compliance of procedures established by the institutional mission. Procedural compliance limits the institutions' employees, political representatives, and government employees from acting at their own discretion and therefore limits potential corruption. Thus, the greater the visibility and compliance of the local institutions the lower the risk of corruption. The third factor, sanctions, measures disciplinary, lottery, and perk sanctions to the local institutions. The greater the number of sanctions the greater the risk of corruption.

The effect of the Transparency Index on emigration flows is expected to be positive. Corruption (i.e. lower values for the Transparency Index) is interpreted as an economic and social cost that can be avoided by moving (Poprawe 2015). Higher levels of corruption are associated with greater levels of income inequality and poverty (Gupta *et al.* 2002). In the dataset used for this paper, the correlation between the Transparency Index and a Department's poverty index[8] is -0.71. Poverty is a constraint to migration as the cost of migrating are proportionally higher for the poorest population. For example, in Colombia the cost of a student or tourist visa in 2016 was 160 US Dollars and the monthly minimum wage salary was approximately 226 US Dollars[9]. Given the visa cost and the minimum wage salary for 2016, the cost of the visa is approximately 70% of the monthly income for a person who makes the minimum wage salary in Colombia, without including other costs of migration. Thus, lower values for the Transparency Index (i.e. higher risk of corruption) are associated with lower emigration flows.

The responsiveness of high-skilled workers to institutional corruption is measured by the interaction of the Transparency Index with the high-skilled worker graduation rates at the undergraduate and tertiary levels of education. Evidence suggest that high-skilled migrants tend to emigrate more with higher levels of corruption (Cooray and Schneider 2016). The latter result implies that high-skilled workers are more aware of domestic corruption, which suggests that the interaction effect of the Transparency Index and high-skilled worker graduation rates on

emigration flows is negative.

The Department's graduation rate at the secondary level of education is defined as the number of graduates at the secondary level of education as a percentage of students enrolled at the same level of education. The expected effect of the graduation rate at the secondary level of education on emigration flows is expected to be positive. The graduation rate at the secondary level of education is assumed to measure the transferability of human capital for low-skilled migrants, which captures the low-skilled migrant's assimilation cost. Evidence shows that the cost of assimilation decreases with time in the destination country, as the earnings gap between immigrants and natives decreases (Dustmann and Glitz 2011). Thus, it is expected that graduation rates at the secondary level of education will have a positive but smaller effect on emigration flows when compared to high-skilled workers graduation rates. Lewer and Van den Berg (2008) find evidence that migrants with secondary levels of education positively affect the host country immigration flows.

The stock of migrants measures the migrant's networks and is measured by the number of migrants before the year 2000 from the i^{th} source Department already living in the j^{th} destination country. Migrant networks have been found to have a positive effect on bilateral migration (Beine *et al.* 2016). The stock of migrants is expected to have a positive effect on emigration because migration costs decrease as the potential social network of the migrant in the destination country is larger. In other words, if network effects exist, a large migrant stock in the destination country will encourage more migrants from the source Department (Kahan 1978; Murayama 1991; Rephann and Vencatasawmy 2000; Pedersen *et al.* 2008; Zavodny 1997).

Time-invariant variables that affect the cost of migrating from the i^{th} source Department to the j^{th} destination country are captured by linguistic, physical, and cultural proximity. The linguistic proximity is measured by language. Language is defined as a binary variable that takes a value of one (and zero otherwise) if both the source Department and destination country share a common language. The language variable captures the cost of migration as it proxies the cost of assimilation of migrants in the host labor market. Evidence shows that proficiency in the host country language results in higher earnings and positively affects the host country immigration (Lewer and Van den Berg 2008; Daneshvary *et al.* 1992). Thus, the effect of language similarity on emigration flows is expected to be positive.

The effect of distance on emigration flows is expected to be negative. Evidence shows that greater distances to the destination country increases the cost of migration (Cattaneo 2009; Levy and Wadycki 1974). The cultural proximity is measured by a common border variable that takes a value of one (zero otherwise) if the source Department has a common border with the destination country. The common border variable is assumed to capture cultural proximity as countries neighboring Colombia as culturally similar. Cultural proximity reduces migrants cost of assimilation. Thus, the common border variable is expected to have a positive effect on emigration flows in Colombia.

The third set of variables described in Table 1 captures the attractiveness to migrants of the destination country. The attractiveness of the destination country is proxied by the relative unemployment rates, capital stock, and GDP per capita. The relative unemployment rate variable is measured as the unemployment rate in the destination country as a percentage of the source Department's unemployment rate. The expected effect of the relative unemployment rate variable on emigration flows is negative. Greater unemployment rate in the destination country, *ceteris paribus*, is a detriment to emigration flows (Levy and Wadycki 1974; Pedersen *et al.* 2008). Popular studies of immigration, such as Sjaastad (1962), Friedberg and Hunt (1995), Card (2001), and Borjas (2003) use a standard labor market model in which immigrant workers are assumed to respond to differences in wages and employment opportunities between countries. Greater employment opportunities and higher relative wages in the destination country, *ceteris paribus*, encourage greater immigration. Thus, the higher unemployment rate in the destination country relative the source Department's unemployment rate, the lower the migration flows to that country.

The relative national capital stock proxies the relatively availability of public services and infrastructure. The relative capital stock is measured as the destination country's capital stock as a percentage of the Colombian capital stock. Borjas (1999) finds evidence of "welfare magnets," given that immigrants select to pay the cost of immigration, they will tend to migrate toward the country which offers the greatest public assistance. Thus, the greater relative capital stock in the destination country in comparison to Colombia's national capital stock, the greater the emigration flows.

The relative GDP per capita variable is measured as GDP per capita in the destination country as a percentage of the GDP per capita in the

source Department. The effect of the relative GDP per capita variable on emigration flows is expected to be positive. The greater relative GDP per capita in the destination country makes migrating more attractive to migrants.

Finally, the population level in the source Department measures the ability of the source Department to send migrants. The source Department has greater capacity to send migrants, the larger the source Department's population. The source Department's population is expected to have a positive effect on emigration flows.

Table 2 shows descriptive statistics by different regions in Colombia. Departments located in the interior of the country (i.e. landlocked group) have the greatest proportion of high-skilled worker population. On the other hand, Departments sharing an international border have the lowest proportion of high-skilled worker population. It is expected the largest high-skilled brain drain to occur at the interior of the country and the smallest from Departments sharing an international border. Table 2 also indicates that Departments located at the interior of the country have the greatest government institutional transparency and GDP per capita. Departments sharing an international border show the greatest level of government institutional corruption. Departments located on the coast have the greatest graduation rates at the secondary level of education and the largest stock of migrants internationally. The latter result indicates that most of the low-skilled migrants come from Departments on the coast that see their cost of migration being reduced due to the network effect.

Table 3 shows the population of urban agglomerations with 300,000 inhabitants or more provided by the United Nations, Department of Economic and Social Affairs. Table 3 indicates the two most populated cities are located in the interior of the country (i.e. landlocked group) and the Atlantic Coast group.

VI. Econometric Estimation

The migration model in equation (4) is estimated using the Poisson Pseudo-Maximum-Likelihood (PPML) estimator proposed by Santos Silva and Tenreyro (2006). Estimation of the migration flows using the PPML estimator allows us to take into account zero values for the dependent variable. The PPML estimator also gives consistent estimators based on the theoretical specification of the migration flows derived from the RUM model.

TABLE 2–Descriptive Statistics by Region

	Coastal Border (Atlantic)[a]		Coastal Border (Pacific)[b]		Landlocked[c]		International Border[d]	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev	Mean	Std. Dev.
High-Skilled Worker Grad. Rate - Undergraduate	0.364056	0.2538911	0.2619312	0.1135855	0.4419147	0.347332	0.1728073	0.2214173
High-Skilled Worker Grad. Rate - Tertiary	0.4047683	0.2767859	0.3109739	0.1444964	0.5239038	0.4445429	0.2295853	0.294653
Transparency Index	50.82362	8.234232	52.21938	8.419537	54.0626	4.755211	45.41135	10.43011
Secondary Level Graduation Rate	87.65767	1.436262	87.16768	1.354381	83.81813	3.682052	80.86675	7.275386
Stock of Migrants	852.1839	2770.205	1217.523	4434.839	585.803	2224.907	139.4242	631.8721
Unemployment Rate	5.478748	2.136293	6.744111	1.103409	7.534517	1.713623	6.271975	1.193463
GDP per capita[e]	0.0025306	0.0007084	0.0019882	0.0009478	0.0035285	0.0023892	0.0023511	0.0015075
Population	1745769	1635279	1856587	1405649	1454159	1744603	460324.7	496099.3

[a] Atlantic Coast Region - the Departments in this region are: Atlántico, La Guajira, Magdalena, Bolivar, Córdoba, Antioquia, San Andrés, and Sucre.

[b] Pacific Coast Region - the Departments in this region are Cauca, Chocó, Nariño, and Valle del Cauca.

[c] Landlocked Region - the Departments in this region are: Risaralda, Caldas, Quindío, Huila, Tolima, Cundinamarca, Santander, Casanare, Meta, Guaviare, and Caquetá.

[d] International Border Region - The Departments in this region are: Putumayo, Vaupés, Vichada, Boyacá, Arauca, Norte de Santander, Cesar, Amazonas, and Guainia.

[e] GDP is given in Constant 2005 USD (millions)

TABLE 3–Population of Urban Agglomerations [a] with 300,000 Inhabitants or More (Thousands)[b]

City	Department	Region	Year 2000	Year 2005	Average
Bogotá	Cundinamarca	Landlocked	5494	6356	5925
Medellin	Antioquia	Atlantic Coast	2372	2724	2548
Cali	Valle del Cauca	Pacific Coast	1757	1950	1854
Barranquilla	Atlántico	Atlantic Coast	1363	1531	1447
Bucaramanga	Santander	Landlocked	759	855	807
Cartagena	Bolívar	Atlantic Coast	645	737	691
Cúcuta	Norte de Santander	Int'l Border	571	632	601
Pereira	Risaralda	Landlocked	486	513	500
Ibagué	Tolima	Landlocked	356	409	382
Manizales	Caldas	Landlocked	336	362	349
Santa Marta	Magdalena	Atlantic Coast	284	331	308
Armenia	Quindío	Landlocked	269	298	284
Pasto	Nariño	Pacific Coast	268	290	279
Villavicencio	Meta	Landlocked	236	293	265
Neiva	Huila	Landlocked	245	269	257
Monteria	Córdoba	Atlantic Coast	220	251	235
Valledupar	Cesar	Int'l Border	214	253	234
Buenaventura	Valle del Cauca	Pacific Coast	207	246	226

[a] Urban Agglomeration: it "refers to the de facto population contained within the contours of a contiguous territory inhabited at urban density levels without regard to administrative boundaries. It usually incorporates the population in a city or town plus that in the sub-urban areas lying outside of but being adjacent to the city boundaries." (United Nations - Department of Economic and Social Affairs: Population Division 2017)

[b] Data obtained from the World Urbanization Prospects, the 2014 revision at https://esa.un.org/unpd/wup/cd-Rom/. Accessed February 3, 2017

Specifically, estimation is done using the PPML estimator as it takes into account cases where the dependent variable M_{ij} takes zero values. The PPML estimator also gives consistent estimators assuming the specification of the conditional mean is of the form $E\left[M_{ij}|X\right]=\exp\left(X_{ij}\underline{\beta}\right)$ for the continuous variable M_{ij}. The PPML estimator is also robust to heteroskedasticity if using a robust covariance estimator (Santos Silva and Tenreyro 2006).

After taking the natural log of equation (4), the conditional expectation of migration flow from the i^{th} source Department to the j^{th} destination country is defined as,

$$\begin{aligned}\ln\left(E\left[M_{ij}|w_{ij};c_{ij};S_i\right]\right)&=w_{ij}-c_{ij}-\ln\left(\Omega_{ij}\right)+\ln\left(S_i\right)\\ E\left[M_{ij}|w_{ij};c_{ij};S_i\right]&=\exp\left(w_{ij}-c_{ij}-\ln\left(\Omega_{ij}\right)+\ln\left(S_i\right)\right)\end{aligned} \tag{5}$$

The cost of migrating from the i^{th} source Department to the j^{th} destination country, c_{ij} , is modeled as a linear combination of the time-variant cost variables (i.e. source's Department's high-skilled graduation rates, Transparency Index, graduation rates at the secondary level of education, and stock of migrants) and time-invariant cost variables (i.e. language, distance, and a common border). The attractiveness or desirability of the destination country, w_{ij} , is modeled as a linear combination of the relative unemployment rates, capital stock, and GDP per capita. The multilateral resistance of migration is controlled by destination country dummies. Destination dummies are included to account for 84% of the emigration flows in order to avoid multicollinearity problems. The multilateral resistance to migration captures the heterogeneity in the migration preference. Beine and Parsons (2015) also use destination dummies to account for the resistance term of migration.

The expected emigration flows are first estimated for the entire data set for each of the high-skilled worker graduation rates. The estimation of the emigration flows from the i^{th} source Department to the j^{th} destination country for each high-skilled graduation rate is defined as,

$$M_{ij}\left|w_{ij};c_{ij};S_i\right.=\exp\left(w_{ij}-c_{ij}-\ln\left(\Omega_{ij}\right)+\ln\left(S_i\right)\right)\eta_{ij} \tag{6}$$

where η_{ij} is a well-behave error term with $E\left[\eta_{ij}\right]=1$.

Estimation of the cross-sectional migration outflows for each of the high-skilled worker graduation rates is estimated using the PPML with the Eicker-White robust covariance estimator to take into account the heteroskedasticity in the model (Santos Silva and Tenreyro 2006). The Pearson goodness-of-fit test for the Poisson distribution is rejected for each of the cross-sectional estimations suggesting than the Negative Binomial distribution is a more appropriate model to estimate emigration flows.

Next, a multivariate estimation of the emigration flows by regions is estimated for each of the high-skilled worker graduation rates. The regions are groups of Departments based on their geographical location. The Atlantic Coast and Pacific Coast groups are Departments who share border with the Atlantic Ocean or Pacific Ocean, respectively. The Landlocked group are Departments that are not on the coast and do not share an international border. Lastly, the International Border group, are Departments that share an international border, but do not have a coast on the Atlantic or Pacific oceans. Specifically, the regional emigration flows specification in the multivariate regression model for each high-skilled worker graduation rate is defined as,

$$M_{i-1ij}\left|w_{1ij};c_{1ij};S_{1i}\right. = \exp\left(w_{1ij} - c_{1ij} = \ln\left(\Omega_{1ij}\right) + \ln\left(S_{1i}\right)\right)\eta_{1ij}, \quad (7)$$

$$M_{i-2ij}\left|w_{2ij};c_{2ij};S_{2i}\right. = \exp\left(w_{2ij} - c_{2ij} = \ln\left(\Omega_{2ij}\right) + \ln\left(S_{2i}\right)\right)\eta_{2ij}, \quad (8)$$

$$M_{i-3ij}\left|w_{3ij};c_{3ij};S_{3i}\right. = \exp\left(w_{3ij} - c_{3ij} = \ln\left(\Omega_{3ij}\right) + \ln\left(S_{3i}\right)\right)\eta_{3ij}, \quad (9)$$

$$M_{i-4ij}\left|w_{4ij};c_{4ij};S_{4i}\right. = \exp\left(w_{4ij} - c_{4ij} = \ln\left(\Omega_{4ij}\right) + \ln\left(S_{4i}\right)\right)\eta_{4ij}, \quad (10)$$

where the unobserved disturbances are defined as η_{lij} for $l = 1$ (i.e. Atlantic Coast group), $l = 2$ (i.e. Pacific Coast group), $l = 3$ (i.e. Landlocked group), and $l = 4$ (i.e. International Border group) and $E[\eta_{lij}] = 1$. The multivariate estimation of the emigration flows for the four different groups takes into account the correlation among each group. A likelihood ratio test is used to test the fit of the Poisson group distribution. The likelihood ratio test is rejected suggesting the Negative Binomial better accounts for the

dispersion of the data.

VII. Results

Tables 4 through 6 report the results on the factors affecting emigration flows. Table 4 shows the results of the Negative Binomial regression estimates of the factors affecting emigration flows from Colombia. Regression estimates are obtained by testing the high-skilled worker graduation rate for the undergraduate, and tertiary levels of education, and their interaction with the Transparency Index. The estimates of all independent variables have the expected sign, with the exception of the language variable.

Results in Table 4 show that higher high-skilled worker graduation rates are expected to generate greater migration outflows. A one percentage point increase in the high-skilled worker population rate is expected to increase emigration flows by a factor of 80.16[10] for the undergraduate skill level and 129.41[11] for the tertiary level of education after controlling for other costs of emigrating, the attractiveness of the destination country, and the effect of alternative destinations on the emigration decision. To put in perspective the significant results for the high-skilled worker population, note that the average national high-skilled worker population rate is 0.33% at the undergraduate level and 0.39% at the tertiary level (i.e. approximately 0.33% and 0.39% of the working age population has undergraduate and tertiary education, respectively). Thus, if the national average high-skilled working age population increases by 0.1 percentage point at the undergraduate and tertiary levels of education (i.e. high-skilled worker graduation rate increases to 0.43% and 0.49% for the undergraduate and tertiary levels of education, respectively) permanent migration outflows are expected to increase on average by about 8 individuals with an undergraduate degree and 12 individuals with any post-secondary level of education. Significant results for the graduation rate at the secondary level of education in comparison to the high-skilled worker graduation rates indicates that lower-skilled migrants significantly emigrate to other countries but at a lower rate than individuals with tertiary education.

TABLE 4–Factors Affecting Emigration Flows (Negative Binomial Regression)

Variable	Coeff.[a]	p-value[a]	Coeff.[b]	p-value[b]
High-Skilled Worker Grad. Rate-Undergraduate	4.384**	0.019		
High-Skilled Worker Grad. Rate - Tertiary			4.863*	0.001
Transparency Index	0.074*	<0.001	0.085*	<0.001
High-Skilled Worker Grad. Rate (Undergraduate) by Transparency Index Interaction	-0.067***	0.059		
High-Skilled Worker Grad. Rate (Tertiary) by Transparency Index Interaction			-0.080*	0.006
Secondary Level Graduation Rate	0.051**	0.010	0.044**	0.031
Stock of Migrants	0.0002*	0.002	0.0002*	0.002
Language	-5.114*	0.005	-5.167*	0.004
Distance	-0.001*	0.001	-0.001*	0.001
Common Border	1.907*	<0.001	1.917*	<0.001
Relative Unemployment Rate	-0.003**	0.020	-0.002**	0.037
Relative Capital Stock	0.003*	<0.001	0.003*	<0.001
Relative GDP per Capita	0.0001	0.230	0.0001	0.184
Ln (Population)	0.693*	<0.001	0.704*	<0.001

*, **, *** indicates significant effects at the 1%, 5%, and 10% level, respectively.

[a] Factors affecting emigration flows for high-skilled workers with undergraduate level of education

[b] Factors affecting emigration flows for high-skilled workers with tertiary level of education

TABLE 5–Multivariate Regression for the Regional Emigration Flows for High-Skilled Workers at the Undergraduate Level of Education (Negative Binomial Regression)

	Coastal Border (Atlantic)		Coastal Border (Pacific)		Landlocked		International Border	
	Coeff.	p-value	Coeff.	p-value	Coeff.	p-value	Coeff.	p-value
High-Skilled Worker Grad. Rate - Undergraduate	-23.224*	<0.001	-11.638	0.293	40.676*	<0.001	44.539*	<0.001
Transparency Index	-0.154*	<0.001	-0.027	0.672	0.296*	<0.001	-0.164	<0.001
High-Skilled Worker Grad. (Undergraduate) by Transparency Index Interaction	0.431*	<0.001	0.082	0.679	-0.718	<0.001	0.794*	<0.001
Secondary Level Graduation Rate	0.454*	<0.001	0.437*	<0.001	-0.310*	<0.001	0.151*	<0.001
Stock of Migrants	0.00004	0.312	0.0003*	<0.001	0.0001**	0.010	-0.0005***	0.050
Language	-0.318	0.882	3.334	0.454	-0.792	0.748	-1.177	0.619
Distance	-0.0001	0.764	0.00003	0.944	-0.0001	0.748	-0.0001	0.704
Common Border	-2.285**	0.029	1.118	0.160	-25.305	1.000	1.840*	<0.001
Relative Unemployment Rate	0.009*	<0.001	-0.022*	<0.001	-0.012*	0.003	0.005***	0.093
Relative Capital Stock	0.001	0.191	-0.003***	0.066	0.0002	0.819	0.0005	0.668
Relative GDP per Capita	0.00005	0.882	0.002*	<0.001	0.0001	0.655	-0.0003	0.230
ln (Population)	0.362***	0.077	1.132*	<0.001	-0.060	0.767	-0.242	0.131

*, **, *** indicates significant effects at the 1%, 5%, and 10% level, respectively.

TABLE 6–Multivariate Regression for the Regional Emigration Flows for High-Skilled Workers at the Tertiary Level of Education

	Coastal Border (Atlantic)		Coastal Border (Pacific)		Landlocked		International Border	
Variable	Coeff.	p-value	Coeff.	p-value	Coeff.	p-value	Coeff.	p-value
High-Skilled Worker Grad. Rate - Tertiary	-19.606*	<0.001	-14.247	0.138	31.965*	<0.001	-40.545*	<0.001
Transparency Index	-0.150*	<0.001	-0.045	0.467	0.287*	<0.001	-0.228*	<0.001
High-Skilled Worker Grad. Rate (Tertiary) by Trans-parency Index Interaction	0.360*	<0.001	0.145	0.385	-0.572*	<0.001	0.752*	<0.001
Secondary Level Graduation Rate	0.518*	<0.001	0.443*	<0.001	-0.3312*	<0.001	0.223*	<0.001
Stock of Migrants	0.00004	0.248	0.0003*	<0.001	0.00005**	0.026	-0.0004	0.188
Language	-0.678	0.756	3.515	0.428	-0.757	0.747	-1.191	0.630
Distance	-0.0001	0.671	0.0001	0.852	-0.0001	0.751	-0.0001	0.706
Common Border	-2.346**	0.026	1.337***	0.094	-26.854	1.000	1.927*	<0.001
Relative Unemployment Rate	0.008*	<0.001	-0.022*	<0.001	-0.012*	0.005	0.002	0.535
Relative Capital Stock	0.001	0.215	-0.002***	0.070	0.0002	0.765	0.0002	0.844
Relative GDP per Capita	0.000005	0.988	0.002*	<0.001	0.00003	0.793	-0.0003	0.313
ln (Population)	0.269	0.154	1.102*	<0.001	0.082	0.701	-0.521*	0.001

*, **, *** indicates significant effects at the 1%, 5%, and 10% level respectively.

Table 4 also shows that the Transparency Index and its interaction with the high-skilled graduation rate significantly affects emigration flows for Colombia. The effect of the Transparency Index on emigration flows have the expected effect. The higher institutional transparency (and lower risk of government institutional corruption) the greater the emigration flows. The interaction of the Transparency Index with the high-skilled graduation rates is significantly negative: the higher the transparency of the regional institutions, the smaller the effect that the high-skilled working population has on emigration flows. Greater institutional transparency of the regional institutions implies lower risk of corruption, which decreases the high-skilled brain drain. Results indicate that with one percentage point increase in the Transparency Index, emigration flows are expected to decrease by a factor of 0.93[12] and 0.92[13] for high-skilled workers with an undergraduate and tertiary education, respectively. This means that emigration of high-skilled worker with any post-secondary level of education is expected to decrease by 8% for every percentage point increase in the Transparency Index. Greater institutional transparency facilitates migration outflows but it also helps to lower the rate of high-skilled brain drain rates in Colombia.

Other results shown in Table 4 show that migrations outflows are expected to be higher to neighboring countries with lower relative unemployment rates, and higher capital stock. As expected, the positive effect of the destination country's capital stock indicates that countries with greater public assistance and infrastructure are more attractive to Colombian migrants. Furthermore, emigration flows are greater to countries where the stock of Colombian migrants is larger. Contrary to what we expected the effect of linguistic proximity negatively affects emigration flows. Sharing a common language does not reduce the cost of migration.

Tables 5 and 6 show the factors affecting regional emigration flows when testing the undergraduate and tertiary levels of education. Results show that the effect of high-skilled worker graduation rates, the Transparency Index, and its interaction with the high-skilled worker graduation rates has opposite effects in the regional migration outflows from Departments located on the Atlantic coast and Departments sharing an international border, in comparison to the Departments located at the interior of the country. Higher high-skilled graduation rates are expected to decrease migration outflows for the region on the Atlantic coast and

Departments sharing a border with other countries. Higher high-skilled graduation rates are expected to increase emigration flows for the landlocked region. High-skilled brain drain is greater for Departments located at the interior of the country.

Similarly, higher transparency of the regional institutions is expected to decrease permanent migration outflows from the region on the Atlantic coast and Departments sharing a border with other countries, but it is expected to increase migration outflows in the landlocked region. The unexpected sign for the Transparency Index for the Atlantic coast region and Departments sharing an international border is an indication that institutional corruption facilitates emigration as legal migration becomes expensive. A possible explanation is the higher GDP per capita in Departments located at the interior of the country in comparison to the rest of the country.

When taking into account how responsive high-skilled workers are to corruption levels, the interaction effect indicates that at higher institutional transparency (and lower risk of corruption), the smaller the effect of the high-skilled working population on the permanent emigration flows in the landlocked region of the country. However, for the rest of the country at higher institutional transparency, the greater the effect of the high-skilled working population on the emigration flows. Thus, for the interior of the country greater institutional transparency mitigates the high-skilled brain drain. However for Departments with a coast on the Atlantic Ocean or sharing an international border, institutional transparency fuels the high-skilled brain drain. The latter result may be interpreted as a beneficial effect that emigration has on the institutional quality in the source Department (Docquier *et al.* 2016), reducing thereof, the cost of migration to other countries. The greater effects that the high-skilled working population has on emigration flows at higher institutional transparency can also explain high-skilled brain drain as a method to reduce income disparities. Other results from Tables 5 and 6 indicate that the lower-skilled population is emigrating mostly from Departments located on the coast and those Departments that share an international border.

VIII. Conclusion

In this paper, a RUM model is applied to explain the effect of high-skilled brain drain and its responsiveness to regional government

corruption risk in relation to emigration flows. The cross-sectional estimation results show the significant impact of high-skilled brain drain. When taking into account how responsive the high-skilled working population is to government institutional corruption, results indicate that greater institutional transparency mitigates the effects of high-skilled brain drain. A lower risk of corruption helps to retain to working-age individuals with higher educational attainment.

Regional estimation of emigration flows show that high-skilled brain drain is occurring mainly from Departments located in the interior of the country. For Departments located in the interior of the country, high-skilled brain drain is smaller at lower risk levels of local government institutional corruption. The unexpected effect of high-skilled working population, institutional transparency, and its interaction with the high-skilled working population lead us to conclude that institutional transparency facilitates high-skilled brain drain in Departments located on the Atlantic Ocean and those Departments sharing an international border.

In terms of policy, if the high-skilled brain drain is viewed as a way to reduce income inequality for those regions located on the Atlantic Coast and regions that share an international border, then greater institutional public visibility and institutional accountability will encourage high-skilled brain drain. At the same time, given the large effects of the high-skilled working population at the interior of the country, the greater institutional transparency could mitigate some of the negative effects of high-skilled brain drain such as high-skilled human capital flight. High-skilled brain drain positively affects the political institutions and negatively affects economic institutions of the migrant's origin country (Li *et al.* 2016). The net effect of high-skilled brain drain for the source Department will depend on its expected effects on the Department's political and economic institutions. Docquier and Rapoport (2012) suggest that high-skilled brain drain could be reduced by adjusting the public supply of higher education. In particular, Docquier and Rapoport (2012) indicate that cutting subsidies in particular fields could be a policy response if the goal is to mitigate the effects of high-skilled brain drain.

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Endnotes

1. Stock of high-skilled emigrants is defined as the stock of emigrants with tertiary education living in OECD countries. The stock of high-skilled emigrants from Colombia living in OECD countries in 2000 was 233,536 individuals.
2. The 20 OECD countries included in the data base are: Australia, Austria, Canada, Chile, Denmark, Finland, France, Germany, Greece, Ireland, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, and United States.
3. The Corruption Perception Index for Colombia in 2005 is 4. The Corruption Perception Index ranges between 10 (least corrupt) and 0 (highly corrupt).
4. We refer to high-skilled workers are those individuals with any post-secondary level of education.
5. In this research high-skilled is defined as those individuals with post-secondary education. Specifically, those individuals with an undergraduate level of education, and individuals with any tertiary level of education.
6. Beine *et al.* (2008) define negative net brain drain as the reduction of gross human capital levels among native population (i.e. both residents and emigrants) as a result of greater high-skilled emigration rates.
7. For estimation purposes, Departments are any of the 32 administrative regions in Colombia or the capital city.
8. The poverty index is measured by the Index of Unsatisfied Necessities and controls for the incidence of poverty at the i^{th} source Department. The poverty index captures household's dimensions such as economic dependency, school attendance, household structure and space, and adequate public services (Departamento Administrativo Nacional de Estadistica (DANE) 2005).
9. Reported tourist and student visa application fee from the Embassy of the United States in Colombia is used (see https://bogota.usembassy.gov/scvaf.html). The minimum wage salary for the year 2016 reported by the Banco de la República is 689,455 Colombian pesos. Both the visa application fee and minimum wage salary were accessed on November 21, 2016. The average exchange rate for the year 2016 up to November 21^{st} of the same year reported by the Banco de la República was 3,052 Colombian Pesos/US Dollars. The average exchange rate of 3,052 Colombian Pesos/US Dollars is used to express the visa application fee in US Dollars.
10. For the Negative Binomial the coefficients allow us to interpret the direction of the relationship between the emigration flows and the independent variables. The Incidence Rate Ratios (IRR) quantifies the direction and strength of a unit increase in the independent variable. The IRR is defined as $IRR = \exp(coefficient)$. Thus,

IRR = exp (4.384) = 80.158. For more information about derivation and interpretation of IRR see UCLA: Statistical Consulting Group (2015) and Rabe-Hesketh and Skrondal (2012).

11. *IRR* = exp (4.863) = 129.41.
12. *IRR* = exp (-0.067) = 0.935 is the Incidence Rate Ratio for the high-skilled graduate rate at the undergraduate level. This means that one percentage point increase in the Transparency Index is expected to decrease emigration flows of high-skilled workers with an undergraduate degree by about 7%.
13. *IRR* = exp (-0.08) = 0.923 is the Incidence Rate Ratio for the high-skilled graduate rate at the tertiary level of education. This means that one percentage point increase in the Transparency Index is expected to decrease emigration flows of high-skilled workers with tertiary education by about 8%.