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MEDICAL BRAIN DRAIN: AN INDUSTRY SPECIFIC GRAVITY MODEL OF IMMIGRATION FLOWS

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Brain drain has important implications for economic development because it represents the loss of human capital, which is a significant determinant of long-term economic growth. Medical professionals are an important subset of migrants because their migration decisions may have significant immediate and long-term effects on economic development. This paper estimates the effect of public healthcare expenditures on immigration flows of medical physicians using a gravity model of 143 origin countries and 18 destination countries from 1995 to 2004. Controlling for various socio-economic and geographic variables, this paper finds that countries with a higher share of public healthcare expenditures attract fewer medical professionals. One of the explanations for this finding is that countries with a heavy role of government in the provision of healthcare may not be able to offer competitive compensation and career prospects to medical professionals seeking to emigrate.

JEL classifications: F22, J44, J61

Key words: medical migration, medical brain drain, immigration flows, human capital

Table of Contents

I. Skilled Migration

Migration has important implications for economic development, especially in the case of high-skilled workers, as it can result in a loss of human capital, often referred to as brain drain. MacPhee and Hassan (1990) originally defined brain drain as skilled worker outmigration from developing to developed countries. Docquier et al. (2007) and Beine et al. (2008) revised the definition to include the loss of skilled labor for any country. The majority of the literature examines microeconomic determinants of migration because these studies are based on individual level migration data, mostly gathered through surveys. Previous analyses of brain drain use an emigration rate based on stocks of migrants rather than flows. Recently, economists like Ashby (2007, 2010) and Gubert and Nordman (2009) started analyzing immigration flows in gravity models.

Much of the analyses focus on the overall level of brain drain. However, Bhargava and Docquier (2007) claim that general brain drain hides heterogeneity across sectors, citing concerns of nurse emigration in the Philippines versus concerns of information technology professionals in India. Inadequate domestic labor supplies can result from sector concentrated emigration, harming economic and social development. Mensah (2008) argues that extra emphasis should be placed on medical migration because of its disproportionate effects on society. The loss of one trained physicians can leave an entire village without access to healthcare in developing countries. Badwe et al. (2012) argue that medical brain drain (MBD) is an especially important element of skilled worker migration because of the strong connection between health and economic growth. For example, the scientific brain drain may slow down technological innovation in the long term, but medical brain drain can lower social and health outcomes in both the short and long term.

The relative importance of MBD motivates this analysis. Previous MBD literature follows the early path of the overall brain drain literature using emigration rates out of countries and not immigration flows into countries. Much of the literature is based on survey data from a handful of countries. Previous literature on MBD is largely based on country case studies and may not offer systematic or consistent conclusions on the determinants of medical migration. In contrast, I intend to analyze the determinants of MBD using immigration flows into a country on an aggregate (country) level, in a longitudinal panel of 143 origin and 18 destination countries over the 1995-2004 periods.

Gravity models explain bilateral flows between origin and destination countries based the corresponding country characteristics. The gravity model takes into account both “push” characteristics of the origin country and “pull” characteristics of the destination country. The empirical analysis of MBD could inform policymakers about the factors that determine the outmigration of medical professionals.

The main variable of interest in this study is the public share of total healthcare expenditure. This variable serves as a proxy for the extent of government involvement in healthcare provision. It could be argued that more private-based healthcare systems may offer migrants higher paying jobs and better benefits compared to more government controlled healthcare systems; illustrated by Barraclough and Phua’s (2011) case study of Malaysia where privatization of the country’s healthcare system resulted in a brain drain of specialist doctors from the public to private sector. For these reasons, countries with a higher share of government health expenditures may have a higher level of MBD, holding everything else constant. Controlling for numerous push and pull factors, I find that the share of public healthcare expenditures in the destination country can be a significant negative effect on medical immigration. The other significant determinants of medical immigration include health spending per capita, GDP per capita, population density, urban population growth, tertiary education levels, distance, linguistic relationships, colonial relationships, and island status.

II. Literature Review

Ashby (2007) asserts the decision to migrate is a form of utility maximization because "preferences are manifested through revealed actions." He argues individuals will choose to migrate if their perceived utility from doing so is higher than the perceived utility of not migrating. Douglas (1997) contends certain attributes improve utility and desirability for all when comparing destinations, but there are idiosyncratic characteristics that greatly differ in utility for individuals when choosing to migrate. The idiosyncratic characteristics will cancel themselves out while the attributes that attract the majority of migrants will be reflected in migration patterns.

Docquier and Marfouk (2006) note the topic of migration is increasing in importance as the world continues to globalize. More importantly, they reference the significance of skilled worker migration as a key debating point on the world's stage. Grubel and Scott (1966), Johnson (1967), Bhagwati and Hamada (1974), and Kwok and Leland (1982) all agree skilled migration is detrimental to those left in the origin country based on the notion that migrants' contributions to the destination economy are greater than their marginal product. Beine et al.'s (2001) conclusion that education level is a significant determinant of long-term economic growth, paired with empirical evidence that brain drain has negative economic effects on the origin country reveals the importance of analyzing its determinants.

As noted in the introduction, the definition of brain drain has changed overtime. MacPhee and Hassan (1990) asserted it as the emigration of skilled personnel from developing to developed countries. In particular, using a longitudinal panel from 1972-1987 periods, they analyzed brain drain rates from 18 developing countries to the United States. They claimed dynamic labor market shortages influence the brain drain flow and professional immigrants can respond to changing economic forces, resulting in an increase or decrease in brain drain for third world countries. Like Sen (1973), they concluded income is an insignificant determinant of brain drain and that education in the United States, the destination country, is significant.

Gani and Ward's (1995) similar analysis uses pooled data measuring the transfer of skilled labor from Fiji to New Zealand from 1982-1990. Contrary to MacPhee and Hassan (1990), they deemed income as well as various lagged economic incentives in New Zealand as significant determinants of brain drain. They conclude the demand for professionals in New Zealand does not have a significant impact on brain drain, countering MacPhee and Hassan's (1990) previous assertion. Both Gani and Ward (1995) and MacPhee and Hassan (1990) used analyses with one destination country leaving them unable to offer systematic conclusions for the determinants of medical brain drain on a broader country level basis.

Docquier et al. (2007) and Beine et al. (2008) provide a broader definition of brain drain; the international migration of skilled workers from one country to another. This assertion broadened data availability for the authors, allowing the use of brain drain rates from 150 countries. Docquier et al. (2007) analyzed a difference-in-difference model between 1990 and 2000, differentiating the countries by income levels. They reveal country size, religious fractionalization, political unstable countries, geographic proximity to major OECD countries, and colonial links as significant determinants of emigration. Using the same dataset, Beine et al.

(2008) use GDP per capita, geographical distance from OECD countries, colonial links, linguistic proximity, ethnic diversity, socio-political environment, country size, and various interaction terms. Both analyses attempt to account for destination country characteristics through linkages to OECD countries, but are not true gravity models. Thus, any conclusions made about migratory destinations are generalized preferences of a migrant. The difference-in-difference model also provides likelihood of discounting exogenous events that may have occurred over time.

The aforementioned studies all analyzed the overall level of brain drain. However, Bhargava and Docquier (2007) argue that industry-level brain drain is important to analyze because general brain drain hides heterogeneity across sectors. One country may focus on curbing scientific brain drain while another may focus on reducing information technology brain drain. Mensah (2008) and Badwe et al (2012) agree brain drain in medical personnel is perhaps most important because of the broader scope of people that medical migration affects. Badwe et al. (2012) argue medical migration's importance because of the interconnections between health and economic growth. Mensah (2008) argues that medical migration is very important despite its small comparison to the brain drain in other occupations because it affects a disproportionately large number of people.

Clemons (2007) and Bhargava et al. (2011) conducted empirical analyses regarding the effects of medical brain drain on host countries. Clemons (2007) finds the outmigration of health workers is unrelated to poor health and low staffing levels in the healthcare field. Moreover, he finds medical outmigration positively affects production of health workers in origin countries. Bhargava et al. (2011) does however find medical outmigration as a significant determinant of higher disease prevalence. The two countering analyses are important to the research because of their claims on the position of medical brain drain. The controversy on the topic lends to more in-depth research.

Rutten (2009), Eastwood et al. (2005), and Clark et al (2006) all recognize not only that medical migration has increased worldwide, but it is also more often permanent now. Eastwood et al. introduce the idea of an incomplete carousel of medical personnel that does not fully turn. Medical personnel move from developing countries to more developed countries to higher developed countries. However, Rutten (2009) and Eastwood et al (2005) argue the carousel never fully turns, leaving the developing countries with a shortage of medical personnel, a large MBD, and a permanent loss of scarce human capital.

Omaswa (2008) and Rutten (2009) assert push and pull scenarios that are two types of determinants of the brain drain. Push scenarios including inadequate compensation, poor-working conditions, lack of career opportunities, and lack of career security are characteristics of origin countries. Pull scenarios including better compensation, safer environment, political stability, and increased career security are characteristics of destination countries.

Empirical analysis of MBD is relatively young in comparison to the literature chain of overall migration. Brown and Connell (2003) analyzed a survey of 251 doctors from Fiji, Samoa, and Tonga using various socio-economic indicators as push and pull scenarios based on origin and destination countries. Bhargava and Docquier (2008) conducted a macro-economic model analyzing MBD on an aggregate country level using a longitudinal panel of 181 countries from 1991-2004 periods. They determined lower wages and higher HIV prevalence as significant determinants. However their model is brief because the majority of their analysis uses MBD rates as a dependent variable in various social health indicators whence it is a significant determinant of HIV prevalence.

Similar to Brown and Connell (2003), Gibson and McKenzie (2009) conducted a panel analysis of survey data. They analyze three Pacific island countries in which migrants are defined as having worked or studied abroad after finishing secondary school. Their analysis concludes marginal changes in income or tax rates do not cause migration decisions and career opportunity is more important to migration decisions than salary levels.

Ashby (2007, 2010) and Gubert and Nordman (2009) acknowledged problems with using brain drain rates. They instead use immigration flows into a country to determine an immigration rate and estimate a gravity model. Gubert and Nordman (2009) assert that a gravity model explains migratory flows from one country to another using various socio-economic characteristics and bilateral geographic characteristics of the origin and destination countries. Both analyses analyze overall migration, not an industry-specific migration. However, their models more thoroughly account for destination country characteristics (pull), contrary to previous literature, which focused more on the origin country characteristics (push). Gubert and Nordman's (2009) model contains demographic variables, macroeconomic variables, and bilateral geographic data for each country pair. Because their model is the most complete model in migration literature, I intend to apply the basis of it to MBD. MBD literature lacks any account for industry specific indicators. This paper intends to account for industry specific indicators for MBD while analyzing it with a gravity model, something the previous literature has not done.

III. Methodology

A. Data

Data for this model are a longitudinal panel of dyads (country-pairs) consisting of 18 migration destination countries and 143 migration origin countries from 1995-2004 periods. The dataset consists of 2573 unique origin/destination country pairs. The dependent variable in this study is the immigration rate (IMRATE) of medical physicians calculated as follows:

$$IMRATE_{ijt} = \frac{Inflows_{ijt}}{Population_{jt}} \quad (1)$$

where *i* is the destination country, *j* is the origin country, and *t* is time. Both the number of medical physicians coming into a destination country (*Inflows*) and the population are taken from Bhargava and Docquier's (2007) dataset. In order to provide more meaningful coefficient estimates the population is measured in 100,000's. Bhargava and Docquier compile the inflow of medical migrants using annual databases from the most important host countries, while interpolating 10 or 5 year intervals for the remaining host countries (20 percent of medical migrant flows). A migrant is defined as a skilled physician who was trained in their home country. Bhargava and Docquier's definition dismisses migrants who migrated for schooling purposes and focuses on decisions to migrate based on career paths.

Table 1 describes the variables used in this analysis, their unit measurement, and their sources.

Table 1: Variables

Variable	Definition	Unit	Source
IMRATE[1]	Immigration rate into destination country.	Emigration rate per 100,000 people	Bhargava et al. (2010)
DIST	Distance between origin and destination country	Kilometers	Centre d'Etudes Prospectives et d'Informations Internationales (CEPII)
BRDR	Destination and origin country share a border	1 if Yes, 0 if No	CEPII
LANG	Destination and origin country share a language	1 if Yes, 0 if No	CEPII
COL	Destination and origin country have a colonial link	1 if Yes, 0 if No	CEPII
ISL	Destination or origin country are islands or both are islands	0 if neither, 1 if one, 2 if both	United States Department of State
POPDENS[2]	Population density	Per square kilometer of land	The World Bank
URBPOP[3]	Urban population growth	Growth rate % of urban population	The World Bank
TERT[4]	Labor force with tertiary education	% of labor force	The World Bank
GDPPC	Gross Domestic Product per capita	Constant US $	The World Bank
POLRT	Political rights	Scale 1-7[5]	Freedom House's *Freedom in the World* indicators
CIVLIB	Civil liberties	Scale 1-7[6]	Freedom House's *Freedom in the World* indicators
%PUBHLTH[7]	Percentage of total health expenditure that is public	% of total expenditure	The World Bank
HLTHEXPC[8]	Health expenditure per capita, PPP	Constant US $	The World Bank

[1] Immigration flow into the destination country (*i*) from the origin country (*j*) / Population of origin country (*j*)
[2] "Population density is midyear population divided by land area in square kilometers." (The World Bank)
[3] "Urban population refers to people living in urban areas as defined by national statistical offices." (The World Bank) Measured as the % change from the previous year.
[4] "Labor force with tertiary education is the proportion of labor force that has a tertiary education, as a percentage of the total labor force." (The World Bank: Data Indicators)
[5,6] 1 represents the highest degree of rights or freedom, 7 the lowest degree.
[7] "Public health expenditure consists of recurrent and capital spending from government (central and local) budgets, external borrowings and grants (including donations from international agencies and nongovernmental organizations), and social (or compulsory) health insurance funds." (The World Bank)
[8] "Total health expenditure is the sum of public and private health expenditures as a ratio of total population." (The World Bank)

My independent variables of focus are indicators of the healthcare system in the origin and destination countries. I use the public share of total healthcare expenditure as a proxy for the degree of government involvement in the provision of healthcare. This and other percentage variables in this paper are measured on the 0-100 scale to provide more meaningful coefficient estimates.

I use overall health expenditure per capita in constant US dollars to control for migrants' preferences towards better healthcare systems, regardless if it is more private or public. This controls for countries that may have extremely high percentages of public healthcare spending, but in fact may have very low healthcare spending as a whole.

The remaining independent variables follow Gubert and Nordman's (2009) model. Bilateral geographic variables measure ease of migration and include distance between the origin and destination countries' most populated cities, a dummy variable if the two countries in a dyad share a border, a dummy variable if the countries have a linguistic link, a dummy variable if the countries have a colonial relationship, and an island integer variable. The island variable is set equal to zero if neither of the countries in a dyad are an island nation, 1 if one of them is an island nation, and 2 if both countries are an island nation.

Socio-economic variables meant to measure protection and opportunity include GDP per capita and political and civil liberties. Civil liberties are defined as freedom of religion, freedom of assembly, rule of law, freedom of the press, and personal autonomy (Freedom House 2004). Political liberties are freedom from coercion of individuals or groups through voting and freedom from the influence of special interest groups that obtain special favors at the expense of others (Ashby 2010).

Country demographic variables include population density, urban population growth and tertiary education levels. The tertiary education level is the percentage of the population older than 22 with tertiary education. This subset of variables is included as measures of migratory pressures. Expected arguments for inclusion, coefficient estimates, and preliminary data analysis are discussed in the expected results section of this paper.

B. Expected Results

As indicated in the literature review, career opportunities are an important determinant of migration. Previous MBD literature has not looked at industry specific indicators as push or pull factors. This paper seeks to filll that void by analyzing health expenditure data which can act as proxies for measurements that minimize economic risk by providing career security. The share of public healthcare expenditure for a country acts as a proxy for the degree of government control of the healthcare sector.

Dewenter and Malatesta (2001) argue that government owned firms tend towards pursuing social and political objectives instead of maximizing profitability. They also claim that public firms display greater labor intensity traits, meaning more work for the same salary levels as privatized firms. D'Souza and Megginson (1999) found that privatized firms have increased profitability, real sales, and operating efficiency over government-owned firms. Thus it can be argues that public healthcare systems, like various other government-owned industries, would provide lower wages and fewer benefits than private healthcare systems. Public healthcare systems have to provide for all citizens while operating on smaller budgets and lower efficiency levels than private systems. The OECD (2010) assertion that governments not only care about health status but also budget sustainability lends to claims that facilities and equipment can be outdated in many hospitals. Budgets may not allow for important upgrades in safety for not only patients, but for physician protection as well, providing a higher risk work environment. The budgets also do not allow for regular raises or as much room for career advancement as private industries do. Medical professionals will intuitively choose career paths that provide greater financial compensation for themselves and their family.

Public healthcare systems in origin countries providing lower compensation through fewer benefits, lower salaries, and higher health risks will cause migrants to choose to leave. For these reasons it is expected that the more public a country's healthcare system is, the less likely it is to attract medical migrants. Thus, the expected coefficient estimate for the share of public healthcare spending in the origin countries is positive and negative for the share of public healthcare spending in the destination countries. Preliminary data analysis supports this hypothesis as demonstrated by the scatter plot in Figure 1.

Figure 1: Immigration Rate v. Percentage of Total Health Expenditure that is Public (Destination Country)

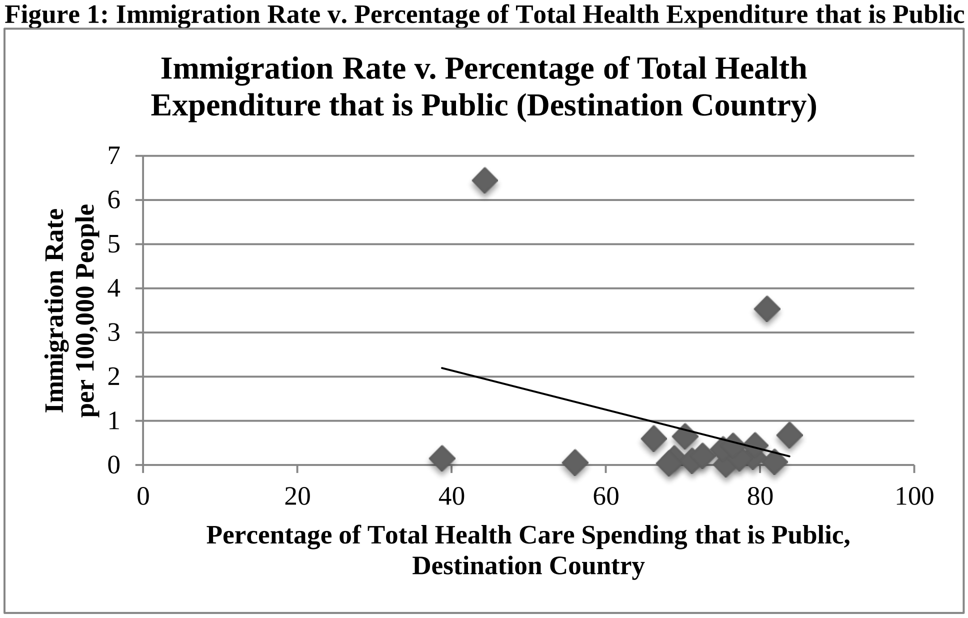

Figure 1 shows as the percentage of total health expenditure that is public increases, the immigration rate into that country decreases. The data points in Figure 1 represent the 18 developed destination countries in the analysis. The development status of the countries is pertinent because a migrant is likely to move from a lower developed country to a higher developed country.

I use total health expenditure per capita to control for migrants' preferences towards a better overall healthcare system. Increased per capita health expenditure is related to better healthcare systems, regardless if spending is public or private. As origin countries spend more per capita on healthcare, immigration rates are expected to decrease, having a negative coefficient estimate. Contrarily, as destination countries spend more per capita on healthcare, immigration rates into the country are expected to increase, having a positive coefficient estimate. This specification is supported by preliminary data analysis for the 18 destination countries, as shown in Figure 2.

Figure 2: Immigration Rates v. Total Health Expenditure per capita (Destination Country)

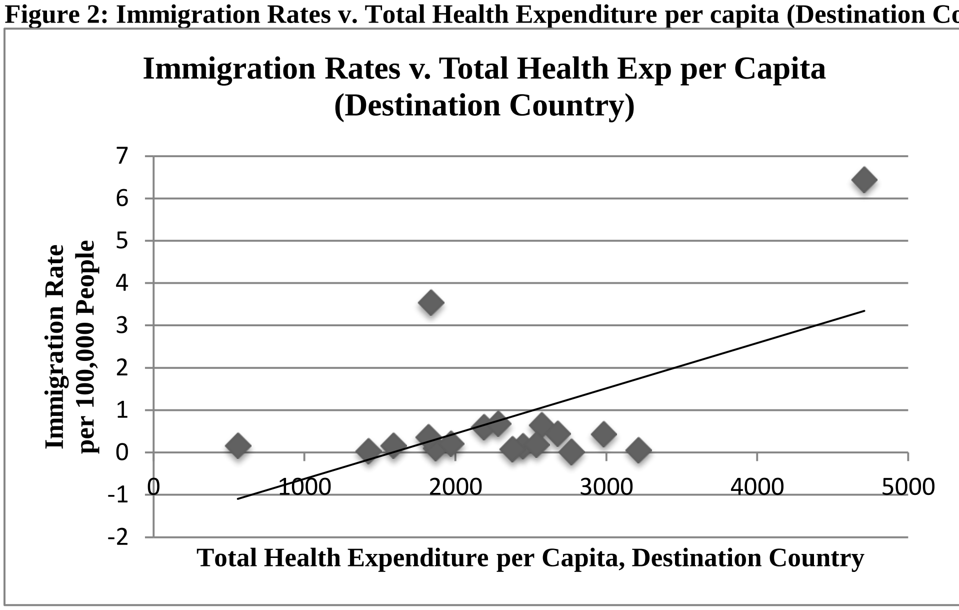

Figure 2 supports the claim that migrants will be drawn to areas with higher per capita total health expenditure. As destination countries spend more on healthcare per capita, the immigration rate into those countries increases.

The remaining independent variables follow Gubert and Nordman (2009) and will be discussed with their expected coefficient estimates in the remainder of this section:

Using the CEPII dataset I use the distance in kilometers between the destination and origin countries' two most populated cities. Distance is incorporated in the analysis because it acts as a measure of costs of migrating (Ashby 2007). Docquier et al. (2007) claim distance as a proxy for monetary and psychic costs of migration. Likewise, sharing a border, linguistic relationships, and colonial relationships are all linked to costs of migration as well. These relationships can also act as a proxies to account for differences in schooling requirements between origin and destination countries. Because of the breadth of regulatory requirements, it would be impossible to account for country-to-country differences as push or pull factors. Though it is important to acknowledge these differences can help to ease or hinder decisions to migrate. This paper attempts to account for those through bilateral geographic relationships. The coefficient estimate for distance is expected to be negative because of the higher costs of traveling further and being further from family. The dummy variables for border sharing, linguistic relationships, and colonial relationships are expected to have positive coefficient estimates because the relationships reduce the costs of migrating.

The islands independent variable is an integer variable meant to account for if either none, one, or both of the countries is an island. Traveling to and from islands are more difficult than contiguous travel arrangements. For that reason, it is expected that if either one or both of the countries is an island the coefficient estimate is expected to be negative.

Population density and urban population growth are included as measures of migration pressure. Overall population density measures the amount of people per square kilometer of land. More densely populated countries are often correllated with higher levels of disease prevalence. It is expected that the coefficient estimate for origin countries will be positive, while the coefficient estimate for the destination country will be negative. Gubert and Nordman (2009) argue the higher relative population growth will result in larger migration pressure because of more job-seekers. Ashby (2010) argues that younger people have a higher propensity to migrate also. Thus, urban population growth is expected to have a positive coefficient estimate for the origin country and a negative coefficient estimate for the destination country.

GDP per capita, tertiary education levels are included as indicators that will alleviate risk. GDP per capita is an important independent variable. It provides a measure for economic opportunity in a country, in particular a measure of income. Medical physician incomes are not readily available for the majority of the countries in this dataset. I use GDP per capita to account for differences in income between countries. Origin countries that have high GDP per capita and high tertiary education levels reduce the need for a migrant to emigrate. Thus they are expected to have negative coefficient estimates. The opposite coefficient estimates are expected for the destination country variables with GDP per capita and tertiary education levels having positive coefficient.

The remaining two variables are political rights and civil liberties. Ashby (2010) asserts that levels of freedom are correlated with greater economic opportunities. The levels of freedom are differentiated between political and civil because political freedom results in freedom from coercion through voting and interest groups, while civil freedom protects the civil rights of a citizen, like the right to own land. The measures used in this analysis range from 1-7 with 1 being the most free. For the origin countries the coefficient estimates are expected to be postive and the destination countries are expected to be negative.

C. Model Specification

The baseline empirical model in this paper is based on Gubert and Nordman's (2009) dyadic gravity model and takes the following form:

$$IMFLOW_{ijt} = \alpha + \beta_1 log(DIST)_{ij} + \beta_2(BRDR)_{ij} + \beta_3(LANG)_{ij} + \beta_4(COL)_{ij} + \beta_5(ISL)_{ij} + \beta_6 log(GDPPC)_{it-1} + \beta_7 log(GDPPC)_{jt-1}$$
$$+ \beta_8(POPDENS)_{it-1} + \beta_9(POPDENS)_{ij-1} + +\beta_{10}(URBPOP)_{it-1} + \beta_{11}(URBPOP)_{jt-1} + \beta_{12}(TERT)_{it-1}$$
$$+ +\beta_{13}(POLRT)_{jt-1} + \beta_{14}(CIVLIB)_{jt-1} + \beta_{15}(\%PUBHLTH)_{it-1} + \beta_{16}(\%PUBHLTH)_{jt-1} + \beta_{17}(HLTHEXPC)_{it-1}$$
$$+ \beta_{18}(HLTHEXPC)_{jt-1} + u_{it} \quad (2)$$

Where subscripts *i* and *j* denote the destination and origin countries, respectively, in year *t*. The variables in the model are described inTable 2. The time-variant variables in the model are lagged by one year as in Gubert and Nordman to account for migration decisions being based on the observed socio-economic performance of the origin and destination countries.

Table 2: Variable Definitions

Variable	Definition
$IMRATE_{ijt}$	Immigration flows from country *j* to country *i* at time *t*
$logDIST_{ij}$	Log of the distance from country *j* to country *i*
$BRDR_{ij}$	Country *j* and country *i* share a border
$LANG_{ij}$	Country *j* and country *i* share a language
COL_{ij}	Country *j* and country *i* share a colonial link
ISL_{ij}	Country *j* and/or country *i* is/are an island [0,1,2]
$logGDPPC_{nt-1}$	Log of GDP per capita for country *n* at time *t-1*
$POPDENS_{nt-1}$	Population density for country *n* at time *t-1*
$URBPOP_{nt-1}$	Urban population growth for country *n* at time *t-1*
$logTERT_{nt-1}$	Log of the Labor force with tertiary education for country *n* at time *t-1*
$POLRT_{nt-1}$	Political rights for country *n* at time *t-1*
$CIVLIB_{nt-1}$	Civil liberties for country *n* at time *t-1*
$\%PUBHLTH_{nt-1}$	Public % of total health expenditure for country *n* at time *t-1*
$HLTHEXPC_{nt-1}$	Health expenditure per capita, PPP for country *n* at time *t-1*
u_{it}	Error term

n=[*i*, *j*]

Five different regression models will be estimated. The first model is a pooled OLS regression as shown in equation 2. The second model is a random effects regression estimated via GLS. The third model is estimate via OLS with dyad and year fixed effects. The last two models are estimated via a dynamic (lagged dependent variable) system GMM.

The Breusch-Pagan test in Table 6 finds the pooled OLS model to be heteroskedastic in the error term. Thus, robust standard errors will be estimated and reported in the regression table. The Wooldridge test for autocorrelation in panel data in Table 7 finds autocorrelation in the error terms across panel data for fixed effects and random effects. The modified Wald test for groupwise heteroskedasticity in Table 8 finds heteroskedasticity in the error term. Therefore, standard errors robust to these anomalies will be estimated and listed in the regression table. Two tests shown in Table 9 indicate that the fixed effects model should be preferred over the random effects model.

The first GMM model assumes the healthcare variables as exogenous. In the second GMM model, the healthcare variables are instrumented with their own lagged values and first-differences. The reason for estimating GMM models is that there might be a momentum in the migration rates, which is accounted for by the inclusion of the lagged dependent variable. Past migration rates may also proxy for existing migrant communities in the destination countries that act as a pull factor. Furthermore, healthcare expenditures might be endogenous, necessitating the use of instrumental variables. In this case, the system GMM can be very useful.

The Arellano-Bond autocorrelation tests in Table 10 indicate that the GMM models estimated in this paper satisfy the assumption of no second order autocorrelation. The Sargan test in Table 11 fails to reject the validity of the GMM instruments used for the healthcare variables in the second GMM model.

IV. Results

Table 3: The Effect of Healthcare Expenditures on Medical Worker Migration (1995-2004)

Estimation (model)	Pooled OLS (1)	RE (2)	FE (3)	GMM (4)	GMM (5)
Health spending/capita (i)	**0.00123*** **	**0.000169*** **	0.000153	0.000915	**-0.000224** **
	(0.0003)	(0.0001)	(0.0001)	(0.0008)	(0.0001)
Health spending/capita (j)	0.0000748	-0.000117	-0.000124	-0.000381	-0.000265
	(0.0003)	(0.0001)	(0.0001)	(0.0005)	(0.0002)
Public health spending share (i)	**-0.0545*** **	**-0.0125***	0.00374	-0.0728	**-0.0176** **
	(0.0116)	(0.0066)	(0.0089)	(0.0450)	(0.0086)
Public health spending share (j)	-0.0111*	-0.000602	-0.00138	-0.00151	0.000991
	(0.0057)	(0.0012)	(0.0013)	(0.0027)	(0.0052)
Log GDP/capita (i)	**-1.073*** **	-0.15	0.365	**3.984***	0.106
	(0.3310)	(0.2820)	(1.3300)	(2.4120)	(0.2520)
Log GDP/capita (j)	**0.244** **	**0.177** **	0.0011	0.999	0.067
	(0.1120)	(0.0730)	(0.1220)	(1.3280)	(0.1080)
Population density (i)	**-0.00266** **	**-0.00196** **	0.0185	0.0169	0.000123
	(0.0010)	(0.0010)	(0.0444)	(0.0259)	(0.0007)
Population density (j)	-0.000196	-0.00043	-0.000902	0.0105	0.000862
	(0.0002)	(0.0003)	(0.0011)	(0.0067)	(0.0006)
Urban population growth (i)	**-0.462*** **	**-0.0781** **	**-0.115** **	0.087	-0.0365
	(0.1190)	(0.0348)	(0.0576)	(0.1370)	(0.0848)
Urban population growth (j)	0.0596	-0.0036	-0.00498	-0.00012	0.0123
	(0.0373)	(0.0044)	(0.0058)	(0.0229)	(0.0205)
Log Tertiary education (i)	**0.407*** **	**0.138*** **	0.0884	0.0388	0.0731
	(0.1020)	(0.0535)	(0.0538)	(0.0709)	(0.1540)
Political rights (j)	-0.0204	-0.0151	-0.0096	-0.00489	0.00166
	(0.0729)	(0.0110)	(0.0119)	(0.0162)	(0.0145)
Civil liberties (j)	-0.0712	0.0477	0.0476	-0.0751	-0.0753
	(0.0997)	(0.0331)	(0.0365)	(0.0566)	(0.0498)
Log Distance	**-0.696*** **	**-0.601*** **	-	-	-
	(0.1940)	(0.1610)			
Common border	1.385	3.372	-	-	-
	(1.8850)	(3.1930)			
Common language	0.444	**1.062*** **	-	-	-
	(0.3960)	(0.4030)			
Colony	**3.333*** **	**3.461** **	-	-	-
	(1.0710)	(1.6070)			
Island nation	**1.671*** **	**1.250*** **	-	-	-
	(0.4220)	(0.4620)			
Lagged Dep. Var.	-	-	-	**0.897*** **	**1.062*** **
				(0.0621)	(0.0418)
Constant	**15.99*** **	**5.684** **	-5.36	**-46.16** **	0.137
	(4.4710)	(2.5910)	(16.5300)	(19.7600)	(2.8450)
R-squared	0.1138	0.0694	0.0004	-	-
Year fixed effects	No	No	Yes	Yes	Yes
Dyad fixed effects	No	No	Yes	Yes	Yes

Dependent variable: migrants inflow/origin population 100,000's. i: destination country for migrants. j: origin country of migrants. Observations: 18,793. Country pairs or dyads: 2,536. Receiving (destination) countries: 18. Robust standard errors are in parentheses. Significance levels: * p<0.10, ** p<0.05, *** p<0.01. Monetary variables are in constant dollars. Models 4 and 5 are estimated using a dynamic, system generalized method of moments (GMM). In model 5, lagged values and first-differences of the dependent variable and health expenditures (public and total) are used as instruments for health expenditures (public and total).

Table 4: Elasticities of Random Effects Output

Variable	RE	Variable	RE
Health spending/ capita (i)	0.520***	Urban population growth (j)	-0.010
	(0.199)		(0.012)
Health spending/capita (j)	-0.091	Log Tertiary Education (i)	0.563***
	(0.079)		(0.221)
Public health spending share (i)	-1.161*	Political rights (j)	-0.069
	(0.587)		(0.051)
Public health spending share (j)	-0.039	Civil liberties (j)	0.224
	(0.080)		(0.159)
Log GDP/capita (i)	-1.878	Log Distance	-6.676***
	(3.667)		(1.324)
Log GDP/capita (j)	1.736**	Common border	0.088
	(0.722)		(0.078)
Population Density (i)	-0.262**	Common language	0.165***
	(0.135)		(0.064)
Population Density (j)	-0.086	Colony	0.192**
	(0.070)		(0.075)
Urban population growth (i)	-0.084**	Island Nation	0.571***
	(0.038)		(0.162)

i: destionation country for migrants. j: origin country for migrants. Robust standard errors are in parentheses.
Significance levels: * p<0.10, ** p<0.05, *** p<0.01

The estimates shown in Table 3 vary significantly across models, particularly between fixed effects and random effects models. The pooled and random effects models suggest that higher healthcare spending per capita in destination countries attracts medical migrants, while a higher share of public health expenditures in destination countries discourages medical migrants. However, in the fixed effects model, the healthcare and many other variables are not statistically significant. Although the Hausman Random Effects Test favors the fixed effects model, I believe that the fixed effects model might be inappropriate in this case because a small number of annual observations coupled with slowly changing variables may result in country fixed effects capturing most of the variation in the variables of interest. Additionally, as previously indicated, Bhargava and Docquier (2007) interpolated the dependent variable for twenty percent of the immigrant inflows. As a result, the interpolated data may be relatively time-invariant; making the dyadic fixed effects draw away significance from other variables in the model which means that the random effects model might be a better fit than the fixed effects model, in theory.

Removing the interpolated data leaves 1001 dyads for analysis. The outcome of those regressions showed similarities with the complete dataset regressions, with the fixed effects model having little significance again. Because of the similarities in results, I used the entire dataset so that the available data was not greatly minimized.

The first GMM model (regression 4) in Table 3 also yields results that are similar to the fixed effects model in the lack of statistical significance for the majority of regressors. However, the second GMM model (regression 5) that instruments for the healthcare variables indicates that both total healthcare spending per capita and its public share in destination countries are negatively and statistically significantly related to immigration rates of medical professionals. While the negative coefficient for the share of public healthcare expenditures is consistent with my expectation, the negative coefficient for total healthcare spending per capita is counterintuitive.

In contrast, the results from the pooled and random effects regressions seem relatively more intuitive for many regressors, including healthcare expenditures. The independent variable of focus is the public share of total healthcare spending. For the destination country, it is significant at least at the 10% level and has a negative coefficient, as expected. As destination countries' healthcare systems become more public, the immigration rate into the country becomes lower. The random effects estimates suggest that each percentage point increase in public spending on healthcare will decrease the immigration rate by 0.0125. I determine the economic significance of this rate change by using the elasticity estimates in Table 4 above. The public share of health expenditure-elasticity coefficient is $|-1.161|$. Thus, a percentage increase in public share of health expenditure results in a significantly larger percentage change in the immigration rate because of the elasticity greater than one.

The most useful interpretation is the change in the number of immigrants. Since the immigration rate is dependent upon the population (100,000's) of the origin country, the coefficient cannot produce a clean cut change in the number of immigrants into a destination country because the change differs for each country. The change in immigrant inflow into a country can be determined by multiplying the expected rate change and the origin country's population at time *t* as illustrated in equation 3 below, where β_n is the expected rate change as predicted by the coefficient estimate and $Immigration_{ijt}$ is the immigration rate into a destination country before the predicted rate change. I include two dyad examples of this in Table 5 below.

$$Population_{jt} * \beta_n = \Delta\, Immigration_{ijt} \quad (3)$$

Table 5: Example Change of Immigration of Medical Physicians

Destination Country	Origin Country	Year	Population of Origin Country (100,000's)	Predicted Change in Immigration Rate[1]	Original Immigration	New Immigration	Change in Immigration Inflow
United States	India	2000	10159	-0.0125	37608	37481	-127
United States	China	2000	12626	-0.0125	3394	3236	-158

Predicted rate change based on random effects output coefficient estimate for the share of total health expenditure that is public.

By applying equation 3 to the average population across the dataset, I find an on average decrease of 5 medical migrants for every one percentage point increase of public share of health expenditure.

I used overall health expenditure per capita to control for migrants' overall preferences towards increased healthcare levels. The random effects regression reflects this hypothesis for the destination country. For each increase of one US dollar of total health expenditure per capita, the immigration rate into the destination country will increase by 0.000169. This is significant at the 1% level. The total health expenditure per capita-elasticity coefficient is inelastic with an estimate of 0.520. On average, an increase of one hundred US dollars in health spending per capita will result in an increase of 7 medical migrants. It is important to note that neither public health spending share nor total health spending per capita of the origin country is significant in the random effects regression.

Following Gubert and Nordman's (2009) model, I use the log of GDP per capita. The log GDP per capita of the origin country is significant at least at the 5% level with a counterintuitive positive coefficient estimate. As the log of GDP per capita in the origin country increases by one unit, the immigration rate into the destination country increases by 0.00177. On average, a one hundred US dollars increase in the origin country's GDP per capita results in an increase of 70 medical migrants.

Population density and urban population growth of the destination country are both significant at least at the 5% level. They both have the expected negative coefficient estimates. Each unit increase in population density of the destination country decreases the immigration rate into the destination country by 0.00196. The $|-0.084|$ elasticity coefficient reveals that immigration rate and urban population growth in the destination country have an inelastic relationship. By applying the estimated coefficient estimate to the average population, I find that a ten-unit increase in population density in the destination country results in a decrease of 8 medical migrants.

Each percentage point increase in urban population growth decreases the immigration rate into the destination country by 0.0781. Urban population growth in the destination country and immigration rates are highly inelastic with an elasticity coefficient of $|-0.010|$. On average, a one unit increase of urban population growth in the destination country results in a decrease of 31 medical migrants. Following Gubert and Nordman (2009) I use the log of tertiary education levels which for the destination country is significant at the 1% level. A one unit increase in the log of tertiary education level results in a 0.00138 increase in the immigration rate into the destination country. The rate change equates to an on average increase of 10 medical migrants for ten units increase in the log of tertiary education.

Another benefit of the random effects model is that the time-invariant bilateral geographical relationships can be included in the regression. The distance, common language, colonial links, and island nation variables are all significant. The log of the distance, linguistic links, and island nations are significant at the 1% level. The further away the destination country is from the origin country, the immigration rate decreases by 0.0061. On average, if a country is 100 kilometers closer, 236 additional medical physicians will migrate to it. A common language increases the immigration rate by 1.062 or an average of 417 additional medical migrants. Island integers increase the immigration rate into the destination country by 1.250 if one is an island and 2.500 if both are an island. Those equate to 490 and 980 additional medical migrants respectively. The island coefficient estimate counters the expected estimate. Colonial links are significant at 95% confidence level with an increase of the immigration rate of 3.461 or an average of 1357 additional medical migrants if the destination and origin share a link. A summary of the average change in medical migrants for each variable is in Table 12 in Appendix II.

The random effects mode that I prefer has a low R^2 value of 6.94%. Though a higher R^2 is generally preferred, because of the broadness of this analysis a lower R^2 makes sense. The broadness of origin countries in the analysis results in wide variation of migrant preferences. Though migrants' idiosyncratic preferences differing from country to country were expected to cancel each other out, some of those may attribute to the low R^2. Additionally, since macroeconomic data is hard to measure in many developing countries, measurement error by the data sources in various socio-economic variables can also attribute to the low R^2. Nonetheless, meaningful relationships in this analysis still exist.

V. Model Implications

This paper uses public share of health spending as a proxy to measure the level of government control over the healthcare sector in a country. The public share of healthcare spending in the destination country has the expected negative and significant coefficient estimate. The random effects mode, which I prefer, supports the original hypothesis that private healthcare systems attract skilled medical personnel. While brain drain is a problem for any country, many countries hope to attract skilled personnel to their country in hopes of gaining a comparative advantage and reducing labor shortages. The results show that destination countries can attract medical personnel with more privatized healthcare systems.

Though this paper aimed to provide a path to reduce brain drain for origin countries, the majority of significant results are only pull factors that origin countries have no control over. Thus, the significant results in fact provide destination countries with the tools to better attract skilled medical labor. Countries where migrants primarily originate from can take advantage of known pull factors to, in turn, attract medical migrants from other countries. In other words, the origin countries can take advantage of known pull factors in hopes of instead making themselves a destination country, counteracting the human capital loss of MBD.

GDP per capita produced a counterintuitive coefficient estimate. GDP is a measure of economic opportunity in a country and used as a proxy for income levels. I expected lower GDP per capita levels in origin countries to increase immigration flows. However, the contrary is true.

I hypothesize this is because increased GDP per capita gives migrants more ability to easily emigrate. They have more means to move to another country and have enough resources to job search. Lower origin GDP per capita levels could eliminate many migrants because they simply will not have the economic means to migrate. The implication of higher origin country GDP per capita levels resulting in more brain drain may have an unobserved maximum point where higher levels of GDP per capita would consequently result in less outmigration from the origin country.

The island nation integer also produced a counterintuitive coefficient estimate. I expected the coefficient to be negative, but it was positive. Contrary to my hypothesis of islands making it more difficult to travel, perhaps islands instead make it easier for migrants to travel. Landlocked countries may not allow for easy travel whereas island countries have direct access to waterways, easing travel.

The other bilateral geographic variables all support the hypothesis that country relationships help to make migration easier. Colonial and linguistic links make it easier to adapt to new cultures because of similarities in culture or language. As expected, the further away countries are, the harder it is to migrate.

It is important to note that all but one of the significant socio-economic independent variables in the random effects output are pull factors of the destination country. Migrants are a subset of the population who choose to leave their country in order to maximize their utility. Perhaps, once migrants have entered into that subset, it is impossible for an origin country to retain them. Instead, the only decision a migrant must make is where to emigrate. This analysis provides direction for countries to attract migrants who have decided to emigrate.

VI. Future Research

This analysis expected to provide insight for origin countries on how to reduce medical brain drain. However, the results showed pull characteristics from the destination countries as significant, while the origin countries had only one significant socio-economic variable. These imply origin countries have little control over migrants once they enter that subset of the population. In the future, this model could be applied to different destination countries, perhaps lower developed countries. Likewise, updating the model with more recent data would provide insight into more current economic conditions.

Many countries have policies to encourage immigration. Other countries have policies to inhibit outmigration. Finding a way to account for these policies and their level of acceptance or lack thereof would provide an interesting and important independent variable for migration patterns. Also, discovering a way to better measure country specific cultural characteristics could provide useful to better analyzing the significant determinants of brain drain.

I also mention in the results section of this paper that the coefficient estimate for GDP per capita of the origin country is counterintuitive. My allusion to the GDP per capita relationship possibly not being a linear relationship can lead to future research. Analyzing the level of GDP per capita that would result in decreasing medical outmigration could be beneficial to the literature chain.

VII. Conclusion

This analysis estimates the effects of healthcare spending on the migration patterns of medical professionals by estimating a gravity model for a longitudinal panel of 18 receiving countries and 143 origin countries for the 1995-2004 period. I use public health expenditure share as a proxy for the level of government control of the healthcare sector. I also control for total health expenditure per capita. I find that a higher share of public spending on healthcare in destination countries discourages immigration of medical professionals. My analysis also reveals that mostly pull factors from destination countries are significant determinants of medical immigration flows.

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Appendix I: Tests for Statistical Anomalies

Ho: Constant variance
Variables: fitted values of imrate
Chi2(1) =104185.42
Prob > Chi2 = 0.0000

Table 6: Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Table 7: Wooldridge test for autocorrelation in panel data

H0: no first-order autocorrelation
F(1, 2395) = 21.494
Prob > F = 0.0000

Table 8: Modified Wald test for groupwise heteroskedasticity in fixed effects regression model

H0: $sigma(i)^2 = sigma^2$ for all i
Chi2 (2537) = 5.8e+09
Prob>Chi2 = 0.0000

Table 9: Random Effects Tests

Arellano (1993) and Wooldridge (2002) Robust Random Effects Test
Ho: regressors are uncorrelated with the error term
Sargan-Hansen statistic = 50.98
P-value = 0.0000

Hausman Random Effects Test
Ho: difference in coefficients not systematic
Chi2(11) = 110.91
P-value = 0.0000

Table 10: Arellano-Bond autocorrelation test

	GMM Model 4		GMM Model 5	
Order	Z-stat	P-value	Z-stat	P-value
1	-2.5847	0.0097	-2.6838	0.0073
2	-.21727	0.8280	-.50758	0.6118

Ho: no autocorrelation

Table 11: Sargan test for GMM instruments

GMM Model 4	GMM Model 5
P-value	P-value
0.0000	0.0000

Ho: over-identifying restrictions are valid

Appendix II: Summary Statistics

Table 12: Summary of Average Changes in Number of Immigrants

Independent Variable	Unit Increase	Resulting Change in Medical Migrants
Public health spending share (i)	1 % point	-5
Health spending/capita (i)	100 US $	7
GDP/capita (j)	100 US $	70
Population density (i)	10 people/km	-8
Urban population growth (i)	1 % point	-31
Tertiary education (i)	10 % point	10
Distance	100 km	236
Common language	Yes	417
Colony	Yes	1357
Island nation	One	490
	Both	980

Based on the average population across the dataset.