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Count-data Analysis of physician Emigration from Developing Countries: A Note

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Abstract

This paper examines possible determinants of physicians' emigration from a wide set of developing countries, using count data analysis. We find that standard-of-living, health-infrastructure, and workload in source countries play important roles in such medical brain drain. Also the emigration culture, governance and colonial history of the sending country affect such expatriation. Better health-infrastructure, work environment as well as strict anti-emigration policies can help reduce such important brain-drain for developing countries.

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1. Introduction:

Medical-brain-drain is a source of significant angst in developing countries because much scarce resource is spent in producing such professionals. Despite a vast literature on brain-drain, studies addressing '*medical'* brain drain are somewhat limited, consisting of either case studies or analyses of narrow groups of countries (notably sub-Saharan Africa). The present study contributes to the existing, though sparse, literature on Physicians' emigration in two important ways — (1) investigating determinants of physicians' emigration for a much wider set of developing countries compared to the existing literature, and (2) performing a count-data regression of the number of physicians' emigrating; departing from existing econometric works which are limited to linear modeling of the *emigration rate*. Modeling the 'count' is important, because losing a sizeable *volume/number* of physicians can be costly even if the associated rate may not be as high.

Docquier et al (2007) compile detailed data on medical-brain-drain for a broad set of countries and note that low-income countries experience substantial emigration. Using data on sub-Saharan Africa (SSA), Bhargava et al (2008) find that low wage and poor health conditions in developing countries are key factors behind medical-brain-drain. Using data on 50 developing countries, Moullan (2013) investigates the effect of foreign-health-aid but fails to find substantial impact in reducing physician emigration. Several case studies, such as, Hagopian et al (2004) for SSA, Chibango et al (2013) for Zimbabwe, Anarfi et al (2010) and Dovlo et al (2003) for Ghana, note that economic factors like low wages and poor living standards in developing countries are the most compelling factors affecting emigration. Dovlo et al (2003) also confirm the effects of bureaucracy in the source country as contributing to the outflow.

We use Docquier et al (2007) data set, which is one of the most comprehensive, to examine possible factors affecting physician emigration.[1] In our analysis the main influences behind such emigration turn out to be poor standard-of-living and meager health-infrastructure in the developing countries, although workload, migration culture, governance and colonial history in the sending country are also crucial. Our results therefore suggest that on the policy side, strict anti-emigration rules (by the sending countries) should be combined with assurance of a more favorable working environment as short-run panacea.

2. Methodology

Data on physician emigration (number of doctors emigrating) are essentially integer in nature, which suggests that a linear modeling of the link function for analyzing determinants of emigration would be inadequate. Poisson regression is a natural starting point for modeling such count dependent variable. However, quite often, data show 'over-dispersion' and hence the

[1] We consider only low and middle income economies according to the World Bank classification. After dropping some countries due to many missing values, our sample size becomes 128. Since India and South-Africa stand as outliers for emigration, we present the result without them. Inclusion of these does not change the results, except that past_migration loses its significance. The list of countries and the results including the outliers can be provided upon request.

mean-variance equality restriction (as imposed in Poisson) gets rejected. The same happens to our data and we therefore resort to negative-binomial modeling of the response variable.

Following Greene (2008) and Cameroon and Trivedi (2005), the standard probability function of the response variable Y_i, conditional on regressors x_i (for *i-th* observation) for negative-binomial model can be stated as:

$p(Y_i = y_i \mid x_i) = \frac{\Gamma(y_i + \alpha^{-1})}{\Gamma(y_i + 1)\Gamma(\alpha^{-1})}\left(\frac{\mu_i}{\alpha^{-1} + \mu_i}\right)^{y_i}\left(\frac{\alpha^{-1}}{\alpha^{-1} + \mu_i}\right)^{\alpha^{-1}}$; with conditional mean function, $\ln \mu_i = x_i \beta$, and dispersion parameter α. The conditional variance of the dependent variable is given as: $V(y_i \mid x_i) = \mu_i + \alpha\mu_i^2$. One may test the null hypothesis of no-overdispersion, $H_0 : \alpha = 0$ against the alternative: $H_1 : \alpha > 0$ (Cameroon and Trivedi, 2005). We reject the aforementioned null strongly for our data (dispersion parameters being positive and significant at 1% level), as shown in Table 2. Therefore, negative-binomial, as opposed to Poisson is a more appropriate modeling strategy for us.[2] However, one might argue about using a zero-inflated model instead since many observations are zeros. For that we use Vuong (1989) test. Since zero-inflated models add more parameters than single equation models, Vuong (1989) suggests using corrections while making a comparison of any zero-inflated model with a typical single equation model such as Poisson or negative binomial. We use Akaike and Bayesian information corrected Vuong test following Desmarais and Harden (2013). In Table 2 we report the test statistics and their associated p-values. In all cases we fail to reject negative binomial (as opposed to zero-inflated negative binomial).

One may also be interested in examining the determinants of emigration *'rate'* as opposed to the *'number'*.[3] However, in this paper our main interest is in the *number/volume* of expatriation, simply because even if the rate might be fairly low, each emigration may entail significant loss (or cost) for any developing economy, most of which are already swamped with grave challenges in the health sectors. Also in case of a nationally funded medical training program (as is the case in many developing countries), such brain-drain can be economically very expensive. Thus our *interest* is in modeling the *number/volume* of emigration itself. However, we also consider the rate as a dependent variable for comparison (associated results are discussed in detail in Section 4, but are not reported due to space constraint). Note that the *rate* of emigration shows relatively much less variation across countries, compared to the *number* of emigration, which is not surprising, and thus the latter serves as a substantial dependent variable to model, in a regression setting (where we try to explain the *variations* of the response due to variations in the covariates).

3. Data and Variables

Based on some lead from the existing literature we choose our regressors. The most important determinant of emigration considered in the literature is per-capita-GDP (standard-of-living) of the sending country (Bhargava, 2011 and Moullan, 2013). We use GDP-per-capita and health-expenditure per capita of the source country (the latter serving as a proxy for health-

[2] The overdispersion test also favors negative binomial as opposed to Poisson when we use zero-inflated frameworks.

[3] We are thankful to an anonymous referee for bringing our attention to this point.

infrastructure), and both are expected to affect emigration negatively. We also add square terms for these variables to check for any possible diminishing returns. Both GDP and health-expenditure variables are measured in 2005 constant US dollars (PPP adjusted). One can argue about adding physicians' wage; however, we do not find comparable cross-country wage-data for developing countries. Vujicic et al (2004) make an important point; generally the wage difference between the source and the host countries are so large that any marginal change in wages (in the sending countries) will not make any substantial impact. Since number of physicians emigrating crucially depends on the availability of physicians in the source country (phy_supply), following Bhargava (2011) we add this variable.[4] One might argue about adding population as a regressor because highly populated countries will have more doctors to emigrate. However, in this context more relevant is the number of doctors available in the sending country, which we include as a regressor instead of just the total population. The other important determinant we consider is workload in the sending country by using physician to population (in thousands) ratio (calling it inverse-workload) with a one-period lag, and inverse-workload is expected to affect emigration negatively. There could be other important measures such as average waiting time on part of the patients or available medical facilities, which could indicate overall work environment and work load of the physicians as well, but data on such measures are not available at a detailed cross-country level. Data collection and compilation of such measures for a wide set of developing countries can be an important future research agenda. Note that our per capita health-expenditure variable also provides important information on health infrastructure/environment of the economy. Another critical determinant is past-migration which captures cultural aspects facilitating migration. Countries with well-established culture of emigration make it easier to emigrate; also, new emigrants may get support from their past peers. We use number of physicians emigrated (past_migr) from the sending country in the last five years. Moullan (2013) analyses a growth equation for the medical emigration rate for SSAs and use past migration as a covariate in his equation. Additionally we use governance variables such as control-of-corruption index, and rule-of-law index in the sending country (both expected to have negative effects on the outflow). We add colonial information following the trade literature, adding dummies: (a) whether a former British colony, (b) or a French colony (c) or a Spanish colony, simply because literacy in one of these languages helps immigrants from developing countries find jobs in the developed ones. Variables such as supply of physicians, the number of physicians emigrating and workload are obtained/constructed from Docquier et al (2007) data set, while the governance variables are from the World Governance Indicators, 2011, and the other control variables are from the World Development Indicator, 2011. The dependent variable is the number of physician emigrated between 2002-2003[5]. GDP-per-capita, health-expenditure and governance variables are the average values from 1998-2002 in order to avoid business-cycle or sudden instability problems. Although business cycle could be a useful variable in modeling dynamics of migration, ours is a cross-sectional analysis. Emigration is a reasonably long term decision and therefore, such five-year past averages (of per capita GDP or per capita health expenditure) will provide a good picture of the general living standards and the health infrastructure of the countries. Such lags will also subdue any possible endogeneity. Workload

[4] We consider the number of doctors available in the sending country with 1-year lag, because the availability of doctors in the current year will be affected by the number of doctors emigrating currently and therefore, won't serve as an appropriate determinant.

[5] The net difference in the stock of physician abroad from the source country during the period is used as proxy.

and physician supply variables are measured with one-year lag, to avoid any possible two-way-causality in the measurement.[6]

4. Results

The results for the negative binomial models for various covariate sets are presented in Table 1. If we include health-expenditure and GDP in the same regression, the significance levels drop substantially for both, and this is attributable to the fact they are highly correlated with a sign of multicollinearity (simple correlation coefficient being 0.93). We therefore, include them alternatively; thereby both GDP and health expenditure variables turn out to be statistically significant at 5% level with the expected signs (negative), with the associated square terms being positive and significant. This means that countries lose fewer physicians with economic progress (and betterment of health-infrastructure) but the marginal effects of these variables are diminishing, as expected. Our finding that emigration depends significantly (and negatively) on GDP (or living standards of the sending country) is consistent with the existing literature though it focuses only on a particular country or region. See, Hagopian et al (2004) for SSA, Chibango et al (2013) for Zimbabwe, Anarfi et al (2010) and Dovlo et al (2003) for Ghana. For the Sub-Saharan African (SSA) countries, Bhargava et al (2008) find that medical conditions in the sending country significantly (and negatively) affect the medical emigration which is also consistent with our finding for a large number of developing countries. Note that they used HIV and AIDs prevalence measures to assess the health condition in the context of SSA, a region heavily affected by such disease. We use a broader set of developing countries, many of which are mostly affected by several other diseases; therefore, we choose a more general measure like health expenditure per capita of the sending country which will also provide a more comprehensive information regarding the health infrastructure of the country, especially from an emigration-decision point of view.[7] Additionally, we check for and attest that the marginal impacts of living standards and health infrastructure are diminishing. Physician supply has expected signs and is significant (at 1% level) which is consistent with findings of Bhargava (2013) for the SSAs. The governance variables always have the right signs; the rule-of-law variable is significant at 5% level while control-of-corruption is not.[8] The literature has used different governance variables and they are often significant (for example, Dovlo et al (2003) has used a measure of bureaucracy), although it depends on the particular index that is being used. Thus, for the aforementioned covariates our findings are highly consistent with the literature. However, note that the literature is mostly focused on specific country or region (SSA, for example), while we examine the determinants of medical brain-drain for a large set of developing countries. In addition, to the best of our knowledge, our inspections of the 'workload'

[6] Health-expenditure variable is available from 1995 (for many countries from 2000); the governance variables are available from 1996 (some cases from 1998). However, data on physician information essentially end around 2003 in the dataset used. (Information on physicians' supply for 2004 and 2003 are same in the dataset). Given such data constraints, a detailed longitudinal analysis of the problem will be difficult though can serve as a future research agenda. We simply focus on cross-sectional analysis as a starting point.

[7] We also consider infant mortality rate, male adult mortality rate and female adult mortality rate (averages over 1998-2002), one at a time as covariates. However, none of these turn out to be significant.

[8] The results for the governance variables depend largely on how these indices have been constructed and how broad their scopes are.

as well as the cultural (past emigration) angles in the context of medical brain-drain analysis at a cross-country level are new contributions to the literature. Both variables produce expected signs and are always highly statistically significant at 1% or 5% levels. Our examination of the colonial angle is also new to the literature. Interestingly, being a former British colony raises the chance of physician emigration, which is also expected since the developed host countries are mostly English speaking, but being a former French or a Spanish colony does not necessarily increase the chance of such expatriation. In fact for the former Spanish colony dummy we obtain negative and statistically significant coefficients for Cases II and IV (See, Table1).

There might also be another interesting "institutional" angle to the colony-effect. The quality of the overall institutions in a country largely depends on its colonial history, and the quality of institutions is extremely important in many aspects. It has been noted in Acemoglu et al. (2001) that for the colonies, the Europeans undertook contrasting policies; building up solid institutions where they settled down (such as Australia, USA) but focusing mostly on extractive activities (and weakening the institutions) where they did not want to inhabit (presently many developing countries). Our study focuses mostly on developing countries, therefore, a thorough analysis of expatriation in the lights of colonial history and varying quality of institutions is beyond the scope of the paper. However, we make some interesting observations.[9] Although the rule of law or the control of corruption variables present only partial pictures of the quality of institutions, we try to compare the ranges of these variables for countries with different colonial history. For example, we find that the rule of law variable ranges from (a) -1.95 to +0.006 for the former French colonies, (b) -2.027 to +0.99 for the former British colonies and (c) -1.38 to +1.22 for the former Spanish colonies in our sample. Thus former Spanish colonies in our sample (that includes Argentina, Chile, Costa Rica, Uruguay, for example, with about 90% white population, supposedly the European settlers) have relatively better institutions compared to the former British or French colonies. These former Spanish colonies produce lot more physicians (the mean physician to population ratio being 3.7 times higher) but have much less expatriation (almost half) compared to the former British colonies (which are mostly the developing countries in our sample, where the Europeans did not like to settle down).[10] This can justify our findings that the former British colony dummy produces positive (and significant) effect, whereas the former Spanish colony dummy entails negative (and for some cases significant) effect on the expatriation. Thus the colonial history and the quality of institutions can produce interesting impacts on emigration.

5. Additional Analysis:

We run several additional analyses in order to provide a more comprehensive perspective to the issue.

Zero-inflated model: Although AIC and BIC corrected Vuong tests do not support in favor of zero-inflated models, given that about 30% of our observations are zeros, we run zero-inflated negative binomial regressions (results can be made available upon request) and obtain

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[9] We are thankful to an anonymous referee for bringing our attention to such issues.

[10] The former French colonies (again mostly the developing countries) in our sample seem to produce relatively low number of physicians, probably due to poor institutions and other reasons. They also seem to have relatively low expatriation (probably due to lack of enough supply as well as language barriers for the English speaking countries). So although they have less expatriation, but that is partly due to a wrong reason - that they do not produce as many physicians.

same conclusion as far as GDP, past migration, governance and colonial dummy variables are concerned. However, the work-load variable loses its significance (though maintains the expected sign) while used with GDP variable in the regressions (in specifications like Case I and Case II). Alternatively, health-expenditure variable loses its significance (though maintains the correct sign), but workload variable still remains significant in specifications such as Case III and Case IV. All other regressors carry expected signs and significance. However, given strong evidences (based on overdispersion and Vuong test) in favor of negative binomial regressions, we only present the detailed results from this specification.

Modeling Emigration rate versus number: We find that for the emigration rate (as a percentage of total doctors produced), all the covariates have correct signs, though only the workload variable always turns out to be statistically significant at 5% level. For the rate of emigration as a percentage of total population, there is not enough relative variation across countries, which is not surprising and we do not get any statistically significant result. Interestingly, for the "emigration rate as a percentage of physicians" variable, former Spanish colony dummy becomes negative and statistically significant at 5% for all cases, substantiating our previous argument regarding colony and institution. Our analysis regarding 'rate versus number' shows that we can excerpt substantial information regarding the determinants of emigration if we use the number of emigration (a direct measure of the volume of expatriation) as opposed to the rate of emigration, and that is why count data analysis is crucial in certain situations.

6. **Conclusion**

To the best of our knowledge, this is the first systematic analysis examining possible determinants of physician emigration from a wide set of developing countries using count-data modeling of the outflow. To the extent of our knowledge, this is also the first study that uses several new covariates (such as workload, migration-culture, health-infrastructure, colonial history) in a cross-country setting while examining physician emigration in particular. We find that standard-of-living, health-expenditure and workload in the sending country play crucial roles. We also find importance of past-emigration (network or culture channel), governance and colonial history. On the policy side developing countries must improve their health outlays to provide better work environment and incentives for physicians. Bhattacharyya et al (2011), in a case study for India suggest that if any host country undertakes strict immigration policies, physicians still emigrate to other developed countries where immigration policies are favorable. To reduce the outflow, restrictions are needed in the source countries. One plausible restriction that can be imposed by the sending countries is that the doctors must serve the country that he/she has received training from, for at least few years before emigrating, especially if he/she has used nationally funded medical training. Also arranging for better social security and fringe benefits for the physicians, as well as creating better work environments (providing physician assistants, better medical equipments) can help reduce the emigration. More comprehensive future research should be oriented towards exploring long term policy options for developing countries to reduce the outflow of physicians as well as other health professionals.

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Table 1: Negative binomial regression results for physicians' emigration

	Case I	**Case II**	**Case III**	**Case IV**
Past_migration	**0.005 (0.046)****	**0.006 (0.029)****	**0.005 (0.034)****	**0.006 (0.018)****
GDP	**-4.873 (0.010)*****		**-4.806 (0.010)*****	
GDP-square	**0.357 (0.004)*****		**.357 (0.004)*****	

Health-expense		**-1.832 (0.021)****		**-1.727 (0.032)****
Health-exp-square		**0.280 (0.001)*****		**0.278 (0.001)*****
Inverse-Workload	**-0.442 (0.013)****	**-0.630 (0.001)*****	**-0.391 (0.024)****	**-0.597 (0.002)*****
Phy_suppy	**0.678 (0.000)*****	**0.718 (0.000)*****	**0.649 (0.000)*****	**0.697 (0.000)*****
Control-of-corruption	**-0.307 (0.269)**	**-0.471 (0.098)***		
Rule-of-Law			**-0.494 (0.052)****	**-0.637 (0.015)****
British_colony	**1.274 (0.005)*****	**1.328 (0.002)*****	**1.382 (0.002)*****	**1.435 (0.001)*****
French_colony	**-0.685 (0.106)**	**-0.606 (0.151)**	**-0.755 (0.065)***	**-0.692 (0.078)***
Spanish_colony	**-0.536 (0.175)**	**-0.745 (0.072)***	**-0.547 (0.148)**	**-0.800 (0.047)****
Constant	**12.626 (0.088)***	**-1.461 (0.497)**	**12.099 (0.105)**	**-1.943 (0.374)**
Log-Likelihood	**-403.593**	**-402.098**	**-402.246**	**-400.278**

*Note: p-values are in the parentheses. *, ** and *** indicate significance at 10%, 5% and 1% levels respectively.*

Table 2: Statistical Tests on the model

	Case I	Case II	Case III	Case IV
Dispersion parameter (Poisson versus NB)	1.375 (0.000)***	1.344 (0.000)***	1.336 (0.000)***	1.300 (0.000)***
Dispersion Parameter (ZIP versus ZINB)	0.784 (0.000)***	0.813 (0.000)***	0.808 (0.000)***	0.831 (0.000)***
AIC-corrected Vuong Z-stat (NB versus ZINB)	0.81 (0.210)	1.11 (0.133)	0.79 (0.214)	0.98 (0.163)
BIC-corrected Vuong Z-stat (NB versus ZINB)	-1.30 (0.903)	-1.07 (0.857)	-1.43 (0.924)	-1.28 (0.900)

*(p-values are in the parentheses). *** implies statistical significance at 1% level. AIC or Akaike-corrected and BIC or Schwarz-corrected normal z statistics have been reported for the Vuong tests.*