Is there a "Pig Cycle" in the labour supply of doctors?

How training and immigration policies respond to physician shortages

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Abstract

Many OECD countries currently face shortages of physicians in remote areas. Policy makers try to tackle this issue by increasing the number of individuals entering medical school training and by recruiting internationally. This paper investigates which strategies OECD governments adopt and when these policies are effective in addressing the medical shortages. Due to the length of time medical training requires, the impact of the expansion of medical school capacity should take longer to be effective than the recruitment of foreign physicians. We have built a dataset that comprises information about physician shortages, the number of medical school graduates, and the number of foreign-trained physicians by using the A. Bhargava et al. (2011) dataset for 17 OECD countries between 1991 and 2004. We find that OECD governments, after a period of medical shortages, produce a higher number of medical graduates in the long run but in the short run face an increasing emigration of their practicing physicians and recruit highly from abroad. In terms of policy time delay, medical education policy adjustments take at least five years to produce an effect whereas recruitment from abroad takes only one year to address the shortage issue.

Keywords: shortages of physicians, international migration of doctors, medical graduates, foreign-trained physicians

JEL Codes: F22, F35, O15, C23, I1, O11.

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Acknowledgements

We would like to warmly thank Mathias Czaika, Christopher Parsons, Sorana Toma and Angèle-Flora Mendy for their useful comments and advice. I would like to thank the participants of the “Drivers and Dynamics of High-Skilled Migration” Workshop at the University of Oxford in 2014; and the “Globalization, working conditions and health” international conference at the Université Montesquieu Bordeaux 4 in 2015.

The research leading to these results draws on DEMIG POLICY database from the DEMIG project, which has received funding from the European Research Council under the European Community’s Seventh Framework Programme (FP7/2007-2013) / ERC Grant Agreement 240940. For more information, see www.migrationdeterminants.eu .

Any errors are ours alone.

1. Introduction

The international shortage of physicians is a major concern in developed countries around the world. These shortages will probably increase over the coming decades. Indeed, population ageing and changing technologies are likely to contribute to an increase in the demand for health workers while, at the same time, the populous 'baby boom' generation of health workers reaches retirement age. According to predictions, the United States will face a deficit of 200,000 physicians by 2020–2025 (R.A. Cooper, 2004). In France, the supply of physicians should decrease by around 10 per cent in 2020 and then return to a level close to its current level in 2030 (DREES, 2004). In the United Kingdom, the supply of physicians will increase by 27 per cent whereas the demand will rise by 50 per cent for the period 2005-2020. Thus, shortage is likely to reach 20 per cent in 2020 (D. Wanless, 2002). The main aim of health workforce planning is to try to achieve a proper balance between the demand and supply of different categories of health workers in both the short- and longer-term. This is important because any shortage of certain categories of health workers may create access problems for certain population groups, if there are no adjustment measures put in place.

Government policies generally consider two options when they are facing a shortage of physicians: either training a sufficient number of medical graduates able to replace the waning health workforce, or recruiting internationally a sufficient number of physicians trained abroad, or both. However, the two strategies take different times to enact. Given the duration of training in medical schools, the impact of increasing the number of medical graduates will be visible only between 7 and 10 years after the decision is taken. Thus, a parallel could be drawn with the theoretical literature in agricultural economics called 'Cobweb or Pig/Hog Cycle' which observed, in the 1930s, a time delay between altering the price and the corresponding reaction of the production on pig market. Therefore, the equilibrium usually observed between the supply and the demand of pig did not match automatically and the producers found it necessary to introduce a time delay to adjust their supply to the price on pig market. In the case of medical doctors, if governments have a preference for increasing the number of medical graduates, it implies that they are able (1) to estimate the future needs of physicians, (2) to devote sufficient financial resources to their training system and (3) to wait a sufficient period of time before the medical graduates could really address the shortage issue. Due to the uncertainty of measuring expected shortages in advance, this strategy fails to address in a timely fashion the sudden appearance of shortages in the medical profession.

In some countries, one of the responses to shortages of certain categories of health professionals has been to rely on immigration. The recruitment of foreign-trained doctors and nurses has been used in some countries as an adjustment variable, when the production of domestic doctors and nurses was not sufficient to respond to the demand. Different tools have been implemented in OECD countries in this way: immigration points systems favourable to physicians, the renewal of visas for health professionals, and the appearance of health professionals on an occupational shortage list (OECD, 2007). Consequently, developed countries has become an attractive place for physicians, either coming from other developed or developing countries (A. Bhargava and F. Docquier, 2007). Currently, foreign physicians represent a significant proportion of physicians' workforce in OECD countries. Based on Circa 2000, on average 18 per cent of physicians employed in OECD countries were already foreign-born; about half being located in the US, almost 40 per cent in Europe and the remainder in Australia and Canada (OECD, 2007). In 2000, foreign-trained practicing physicians represented 21.4 per cent of the total workforce of physicians in Australia, 30.4 per cent in the United Kingdom and 34.5 per cent in New Zealand (Forcier M.B. et al., 2004). In 2002, 23 per cent of physicians in Canada were trained abroad, and 24 per cent in the US were trained overseas (M. Awases et al., 2004).

The need to recruit physicians from abroad is mainly explained by the inability of the educational system to ensure an equal distribution of healthcare workers within the country, by the rigidity of the adjustment itself, and by the time it takes to respond to the problem. Indeed, in OECD countries the number of places offered by medical schools each year is always regulated by government decisions. This regulation could take the form of a fixed number of places being created at medical schools, based on predicted needs (France, Belgium and Germany) and political considerations. Or it could also be explained by budget constraint which limit the number of training places offered by medical schools or hospitals (Australia, United Kingdom, United States) (OECD, 2008). Traditionally, the regulation of the number of graduates in the medical profession is explained by four reasons: First, physicians are usually educated through partly public subsidies, and they are sometimes directly employed by the welfare system (as in the UK) or closely linked to welfare health benefits (France). In a context of financial constraints, the regulation of entrances into the medical profession could be viewed as a strategy for limiting government expenditures. Second, the production of medical graduates each year is closely linked to forecasting in terms of health care needs and the requirements for replacing doctors in the near future. Thus, the number of places offered in medical schools is adjusted in order to fill this anticipated gap. Third, the highly selective process caused by the limited places in medical schools is associated with high quality of health care delivery to patients. However, the limited access into the medical profession for new members is a way to ensure privileges for people who are already physicians (insiders) in terms of, for example, wages and employment protection (S. Nicholson and C. Propper, 2011, B. Peterson et al., 2013). All these limitations on the expansion of the medical profession have failed to resolve the shortage and been unsuccessful in particular in ensuring an egalitarian supply of healthcare delivery across rural and urban areas. Therefore an increase into the shortage of physicians is supported in the short-run by physicians who are already registered to practise in the country. Therefore, the additional health delivery induced by shortage episodes leads to the deterioration of health working conditions and create incentives for emigrating out of the country (R. M. Scheffler et al., 2008). This situation will likely be exacerbated by an increasing aging of the overall population (which will in turn cause greater demands on the health service) and the future retirement of doctors (decreasing the supply of healthcare) in OECD countries particularly in remote areas (OECD, 2007, 2008).

The current context for health workforce planning is also characterised in many countries by conflicting pressures from 'cyclical' factors, which may be lowering the demand for certain categories of health workers in the short term, and more 'structural' factors which point toward growing and changing demand for healthcare in the longer term. The literature failed to address how OECD government policy decisions react to an episode of shortage in the health sector. The main reasons are an unclear definition of medical shortage and a lack of data either on medical graduates or on immigrant doctors. As K. Diallo (2004) explains in his paper : '... despite the fact that there are many sources for statistics on the migration of health personnel, most datasets are neither complete nor fully comparable, and they are often underused, limited and not timely'. We take advantage of the release of the OECD (2014) health dataset and the A. Bhargava, F. Docquier and Y. Moullan (2011) dataset to fill this gap. It allows us to create a new indicator of shortage in the medical profession and to compare the overall trend of medical graduates to that of foreign-trained physicians from a long-term perspective. This paper addresses these research questions: Do we observe any change in the number of medical graduates trained after the episode of shortage of physicians? And/or do we observe a higher recruitment of foreign-trained physicians to fill this shortage? Is there an emigration of physicians following the appearance of shortage? How long does the expansion of medical school capacity take compared to the policy of overseas recruitment? Do OECD governments react proportionately to the level of shortage? Do we observe an under-investment or over-investment in the supply of physicians several years after the appearance of a shortage?

This paper offers a quantitative analysis of the linkages between medical shortages, production of medical graduates, the recruitment of foreign-trained physicians and the emigration of practicing physicians in OECD countries. We used the theoretical foundation developed by agricultural economics called the 'Cobweb/Pig Cycle' theory (M. Ezekiel, 1938). It has explained the persistence of disequilibrium on the market between the supply and the demand by focusing on the pig market (R.H. Coase and R.F. Fowler, 1935, M. Ezekiel, 1938). This disconnection between the price and the production of pigs explains the persistence of cycle characterised by periods of rising price (underproduction) and falling price (overproduction). This theory emphasises that the production adjustment to the price variation is not immediate but occurs with a time delay. We propose adapting this theory to the case of medical doctors. This theoretical background concludes there is the existence of a time delay between the episode of shortages and the response of the production in terms of medical graduates due to the duration of medical training. Therefore, policy decisions consisting of increasing medical graduates in order to tackle shortage issues should be effective only in the longer term, whereas recruiting foreign-trained physicians from abroad should offer a quicker response to the problem. We build on a panel dataset about the dynamics of physician shortage, the number of medical graduates, the number of foreign-trained physicians and the number of doctors registered abroad. We restrict our working sample to 17 OECD countries between 1991 and 2004 for which foreign-trained physicians' data are available. Our estimate confirms that medical graduates respond to shortages only on average seven years after their appearance, whereas foreign-trained physicians arrive in considerable volume during the year when the shortage has occurred. Our results shown evidence of emigration of practicing doctors when the shortage episodes persist.

This paper begins in Section 2 by describing the theoretical background of the paper. Section 3 is devoted to the dataset used through descriptive statistics. The empirical model and strategy adopted is thoroughly documented in Section 4. Section 5 presents the results. The conclusion is reported in Section 6.

2. Theoretical background

We start with a simple aggregate model of the physician labor market. We use this model to explain our empirical strategies to infer the link between on the one-hand physician shortages and on the other hand the medical graduates and the foreign-trained doctors. The physician labor market may follow the traditional 'Cobweb/Pig Cycle' model (R.H. Coase and R.F. Fowler, 1935, M. Ezekiel, 1938, N. Kaldor, 1934). The main contribution of this model is to explain why market equilibriums are sometimes not reached or take time to reach. The Cobweb theory points out the adjustment in time of the production due to a price change. Initially, this model was developed to explain the fluctuations of prices in the agricultural markets (potatoes, pigs, bacon, etc.). The validity of this theory is based on several assumptions: (1) production is determined by the producers in a framework of pure competition, (2) the adjustment of production to a price change should take time, and (3) price should respond to the supply available. Under a similar theoretical framework including the role of expectation, B.P. Pashigian (1977) applies this model to the case of the legal market. Other interpretations of this model were also developed in the specific case of teachers (T. Falch et al., 2009, S.C. Farber, 1975)

In this paper, we adapt the Cobweb theory to explain the functioning of the medical market. The healthcare professional market is far from a competitive market. This market is characterised by several imperfections such as rigidity of prices, state decisions about the supply of physicians, the information asymmetry between healthcare providers and patients as well as between insurance and insured, or between states and the medical workforce (M. Grignon et al., 2012, S. Nicholson and C. Propper, 2011). These characteristics lead us to consider two assumptions in our theoretical model related to government intervention: (1) health services are provided at a fixed price which is largely regulated, (2) the supply of health services is perfectly inelastic to the health price, due to extensive entry regulation for the profession.

Our theoretical foundation is derived from B.P. Pashigian (1977) and adapted to the specificity of medical sector. Let the number of physicians in year t, L_t, equal a fraction of the number of physicians previously in activity, L_{t-1}, plus a fraction of new arrival N_t and deducting the number of doctors who emigrated E_t.

$$L_t = (1-d)[L_{t-1} + N_t - E_t] \quad (2.1)$$

where d denotes the depreciation rate related to death or inactivity of physicians (voluntary resignations and retirements).

New physicians in t, N_t, equal some proportion of students registered in medical school γ years before ($S_{t-\gamma}$) and some number of foreign immigrant doctors (M_t) trained abroad. Both categories are subject to registration requirements for entry into the medical association, with r_t the proportion of first year student and foreign-trained doctors who are recognised as physicians on local labour market in t. ε_t is a random variable and represents the stock of persons who have the skills to practise medicine, but who fail the examination procedure. ε_t includes unrecognised foreign-trained physicians and students who have not graduated in time.

$$N_t = r_t(S_{t-\gamma} + M_t) + \varepsilon_t \quad (2.2)$$

The quantity of medical services supplied, LS_t, is assumed to increase with the price of health services, P_t, and the number of practicing physicians L_t:

$$LS_t = \alpha_1 + \alpha_2 P_t + \alpha_3 L_t + \nu_t \quad (2.3)$$

$$\alpha_1 > 0,\ \alpha_2 > 0 \text{ and } \alpha_3 > 0$$

where v_t is a disturbance term.

The demand for health services, LD_t, is (i) negatively related to what the patient actually pays for each medical service ('out of pocket' spending), i.e. the difference between the price of health services, P_t, and what is covered by the public health system (WF_t) and (ii) positively related to a vector of exogenous variables, X_t, that includes the size of the population, the age structure of the population (demand for health services is assumed to increase with the age of the population) and a living standard index (the income elasticity of health is higher than one). φ_t is a disturbance term.

$$LD_t = \beta_1 + \beta_2(P_t - WF_t) + \beta_3 X_t + \varphi_t \qquad (2.4)$$

$$\beta_1 > 0,\ \beta_2 < 0 \text{ and } \beta_3 > 0$$

If this market is perfectly competitive, given the stock of physicians, L_t, $LS_t = LD_t$ when

$$P_t = \frac{(\beta_1 - \alpha_1) - \beta_2 WF_t + \beta_3 X_t - \alpha_3 L_t + \varphi_t - v_t}{(\alpha_2 - \beta_2)} \qquad (2.5)$$

Since $(\alpha_2 - \beta_2) > 0$, P_t increases with WF_t and X_t and decreases with L_t.

Figure 1: The physician labor market

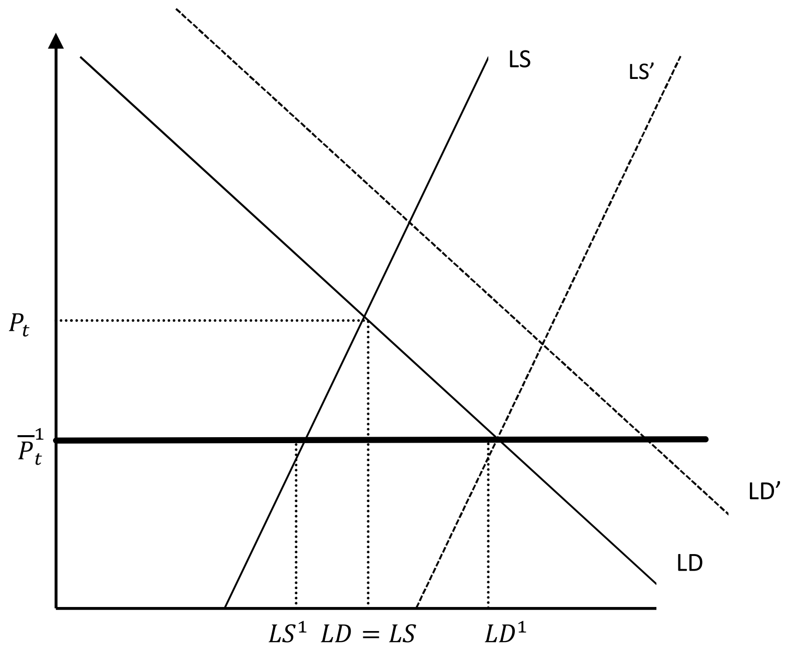


Figure 1 gives the basis intuition related to the functioning of the physician labor market. The LS curve represents the quantity of medical services supplied (equation 2.3) and the LD curve represents the demand for health service (equation 2.4). In the case of a competitive market, the price of medical services, P_t, is adjusted so as to ensure balance on the market.

One specificity of the health service market functioning is the price rigidity due to political decision taken by regulators. Whatever the demand for health services, the adjustment of price is not related to an equilibrium between demand and supply because we are in presence of imperfection on the health services market. Moreover, a part of medical expenses is not supported directly by patients but is socialized through public support (WF_t). Finally, the number of physicians allowed to practice each year is related to a political decision and not to the will of individuals.

Lets modify our purely competitive model in order to incorporate these specificities of the labor market of the doctors. Any change in the number of practicing physicians (through graduated students or migration) consists in a rightward shift of the supply curve (LS'): for a given price, the supply of medical services increases. In the case of a competitive market, this extra supply tends to decrease the equilibrium price. Any change in the degree of public support of health is reflected by a rightward shift of the demand curve (LD')[5]. For a given price, this increased in public support reduces the actual cost supported by the patient and thus increases the demand. In the case of a competitive market, this extra demand tends to increase the equilibrium price. But as we noted earlier, the price of a medical procedure is generally regulated by the public authorities and therefore does not instantly adjust to market conditions. Let $\overline{P}_t$ be the regulated price of health services, fixed at the State level. Therefore, for all situations where the regulated price is different from the market price, adjustments take place on the quantities side. Thus, the required number of physicians to ensure the market equilibrium is given by:

$$L_t = \frac{1}{\alpha_3}((\beta_1 - \alpha_1) + (\beta_2 - \alpha_2)\overline{P}_t - \beta_2 WF_t + \beta_3 X_t + \varphi_t - v_t) \quad (2.6)$$

But the number of practitioners cannot adjust instantaneously, particularly due to the time required for training new doctors, to difficulty to precisely regulate the migratory flows required or to anticipate supply and demand conditions. When $\overline{P}_t < P_t$, the health market is thus in a shortage position so that the actual number of physicians, L_t, is not sufficient compared to the one required to equilibrate the market, $\overline{L}_t$. On figure 1, for a regulated price $\overline{P}_t^1$ lower than the equilibrium market price, P_t, the medical supply is not sufficient. Because the price is set by the regulator, a way to regain balance may be to increase the number of doctors, which translates into a rightward shift of the medical supply curve (LS'). The whole question is then to know how long will take this adjustment, if it is preferable to foster internal training of doctors or immigration and whether it will actually balancing or it will cause fluctuations around equilibrium.

On the contrary, when $\overline{P}_t > P_t$, the market is in surplus so that $L_t > \overline{L}_t$. We could thus express a shortage/surplus indicator, $\overline{L}_t - L_t$, as a function of the gap between the regulated and the equilibrium price:

$$\overline{L}_t - L_t = \sigma(\overline{P}_t - P_t) \qquad \text{with } \sigma < 0 \quad (2.7)$$

[5] It should be mentioned here that any change in the vector of exogenous variables, X_t, for example coming from the aging of population, produced the same type of shift in demand.

Combining equation (2.6) and (2.7) and the condition on evolution of the physicians' population (equation (2.1) and (2.2)), we can then easily express the number of (national and foreign) doctors ($ND_t = S_{t-\gamma} + M_t$) required in order to achieve a market equilibrium:

$$ND_t = \frac{(\beta_1 - \alpha_1) + (\beta_2 - \alpha_2)(\frac{\overline{L}}{\sigma} + P_t) - \beta_2 WF_t + \beta_3 X_t + \varphi_t - v_t}{(\alpha_3 + \frac{\beta_2 - \alpha_2}{\sigma})(1-d)r_t} - \left[\frac{L_{t-1} + \varepsilon_t - E_t}{r_t}\right] \quad (2.8)$$

Expression (2.8) allows us to identify the main determinants of the number of domestic and foreign physicians that enter each year into the labour market. Logically, the number of trained and foreign doctors negatively depends on the number of doctors working in previous periods (L_{t-1}) and positively on the number of doctors who have emigrated to another country (E_t).

Given that $(\alpha_3 + \frac{\beta_2 - \alpha_2}{\sigma})(1-d)r_t > 0$, the number of new domestic and foreign physicians is positively impacted by:

(i) the shortage indicators represented by the required number of physicians, $\overline{L_t}$ (since $\beta_2 < 0$, $\alpha_2 > 0$ and $\sigma < 0$). For a given number of installed practitioners, any increase in the required number of practitioners necessary to balance the healthcare market is naturally reflected by an increased number of new physicians.

(ii) the generosity of the public health system WF_t(since $\beta_2 < 0$): ceteris paribus, any increase in public support of health spending plays positively on the health demand which encourages the entry of new doctors.

(iii) the demographic and living standard variables X_t (since $\beta_3 > 0$): as in the previous case, any increase in one of the vector variables is a growing demand.

On the contrary, the number of new domestic and foreign physicians is negatively impacted by the actual price of health P_t (since $\beta_2 < 0$ and $\alpha_2 > 0$): for a given regulated price, $\overline{P}_t$, new entries of doctors are discouraged when the real price of health, P_t, increases. Indeed, this produces a degradation of working conditions on the health market since the real cost of a medical procedure increases while the cost charged (which will determine the income of doctors) remains constant.

This equation will serve as a basis to evaluate how the number of new physicians reacts to possible situations of imbalance (shortage / surplus) on the market of doctors in OECD countries.

3. Data and descriptive statistics

In the literature, the definition of shortage is vague and difficult to measure. This is for several reasons: first, the scale of shortage can differ according to the level of geographical analysis used in the study. Indeed the calculation could be based either on cross-country comparison or within-country comparisons, i.e. those between rural and urban areas. Second, the scale of the shortages can differ because of the timeframe of analysis adopted. Several countries assess shortages according to the estimated supply and demand factors that could influence the need for healthcare workers in the years ahead. Therefore, the timeframe of the analysis plays a key role in assessing the shortage and it in turn, as with the geographical analysis, is often different from country to country. These predictions are limited in terms of the unreliability of their estimates of future needs for healthcare workers, and they are always subject to mistakes and adjustments across time. Third, and more fundamentally, shortages could be defined with the aid of different approaches referring either to the needs of countries in medical sector, or to the estimated demand in this sector, or to the objective in term of health services that a country would like to address, or according to the population size (T. Bärnighausen and D.E. Bloom, 2011). Because this definition is not sufficiently precise, the fear of there being a shortage of physicians is often linked to the perception that countries have of their future (M. Grignon, Y. Owusu and A. Sweetman, 2012). It leads policy makers to take decisions that could be disproportionate compared to the reality of the situation.

To summarise, the measurement and the scale of shortage differs according to the level of analysis adopted because it could be defined (1) between developed and developing countries, or (2) between OECD countries, or (3) within countries. The cross-country comparison (1) between developed and developing countries reveals that the developing countries suffer much more than OECD countries from medical shortages according to the density thresholds of 0.1 physicians per 1,000 people (World Bank, 1993) and 2.5 health professionals per 1,000 inhabitants (WHO, 2006). Globally, the shortage of health professionals is four million, with the majority of this deficit in Sub-Saharan African countries (WHO, 2006). Developed countries, according to these estimates, do not suffer from any shortages in their economy and have an average of 3 physicians and 8.9 nurses per 1,000 population (OECD, 2008). Within the OECD countries (2), the situation is far from homogenous. The US, UK, and France already suffer or will suffer from medical shortages, whereas Norway does not report any shortage of physicians, and Italy even currently appears to have a surplus of physicians (WHO, 2014). These two previous measures of shortage are assessed at the country level (3), which corresponds to an average of the density of physicians regardless of their distribution across territory. However, when analysis assesses the level inside the country by distinguishing between its rural and urban areas, OECD and developing countries both suffer from an unequal distribution of physicians, which is biased towards cities (G. Dussault and M. C. Franceschini, 2006, R. Skeldon, 2009). In the US, there are 2.5 physicians per 1,000 inhabitants on average whereas Washington D.C reports a density close to 9. In Belgium, the city of Brussels reports a density of 6 physicians per 1,000 inhabitants whereas the average density is 2.9. In France, the density in rural areas is 2.5 whereas it is 4.1 in urban areas. In Portugal, the rural density is 2.2 whereas the urban density is 5.1, with a density of 5.6 for Lisbon, its capital (OECD, 2013).

Second, definitions of shortage can differ because of the different time lengths considered. Considering shortage as the number of places unfilled in the health sector over a specific period is an obvious definition. However, because of the difficulty of properly assessing the real observed deficit of health professionals, many countries consider their situation according to their own perception, based on forecasting analysis. This means that the perception of the future may be completely different to the real situation observed several years after, and it may be very different across countries and according to the time length and perspective adopted to calculate the shortage.

Third, the definition of shortage is further complicated by the different meanings it has. Four different approaches have been identified to assess medical shortages (T. Bärnighausen and D.E. Bloom, 2011). (1) The need approach, derived from epidemiological and medical disciplines, bases its calculation of the degree of health workforce requirements on a prediction of the level of disease amongst its population. (2) The demand approach bases its analysis on the estimated evolution of the population and their characteristics in terms of income, age, location, and education. Even if this exercise is highly uncertain, these estimations provide a useful assessment of healthcare demand that could drive future health workforce requirement. (3) The service targets approach consists of dividing the health sector into objectives that should be attained for different health service. The number of health professionals is, thus, predicted on these 'normative' bases. (4) The population ratio approach (the most popular) is based on the ratio of health professionals to population. The objective of this approach is to maintain or to reach a certain threshold of density in the near future. The popularity of this approach is based on the fact that this ratio is easily measurable across countries and does not require a great deal of information in order to calculate it. Even if this ratio suffers from limitations in terms of geographical disparities, we adopt this methodology in our paper because of the ease of results interpretation and thus the ability to provide clear policy recommendations for policy makers.

In this paper, we use the density of physicians per 1,000 inhabitants to approximate the supply of physicians in the country. By comparing the observed density ratio with the minimum density needed to fill healthcare needs (WHO, 2006, World Bank, 1993), no OECD country reveals any physician shortage. Therefore, the need approach is not adequate for OECD countries, and so a labour-demand approach seems more relevant. The labour demand approach uses the characteristics of countries to predict the potential demand of physicians per 1,000 inhabitants. Several papers have found that the Gross Domestic Product (GDP) or the Gross National Income (GNI) are the best predictor of the demand for healthcare and are therefore also used for demand of physicians forecast (R. A. Cooper et al., 2003, J. P. Newhouse, 1977, R. M. Scheffler, J. X. Liu, Y. Kinfu and M. R. Dal Poz, 2008). We follow this methodology by defining the demand as the following:

$$Ln(\text{Actual Physicians per } 1000_{j,t}) = \alpha_0 + \alpha_1 Ln(\text{GDP per capita}_{j,t}) + \varphi_j + \varepsilon_{j,t} \tag{3.1}$$

Where φ_j is country-fixed effects, $\varepsilon_{j,t}$ is the disturbance term, α_0 and α_1 are parameters to be estimated. Once this model is estimated and parameter known, we predicted the demand of physicians according to the GDP per capita of the country. Then, comparing this predicted demand (predicted density ratio) with the actual supply (observed density ratio) reveals the situation of the medical labour market. If the prediction (demand) exceeds the actual density (supply) of physicians, we are in shortage, otherwise it is a surplus. For this reason, we define the shortage in a country *j* at time *t* in the following way:

$$\text{Shortage}_{j,t} = Ln(\text{Predicted Physicians per } 1000_{j,t}) - Ln(\text{Actual Physicians per } 1000_{j,t}) \tag{3.2}$$

Where $\text{Predicted Physicians per } 1000_{j,t}$ expresses the prediction of the density of doctors derived from the previous equation. 3 situations could be identified. If $\text{Shortage}_{j,t}$ >0, the demand of physicians is higher than the observed medical density. It reveals a situation of shortage in the countries. On the opposite side, if $\text{Shortage}_{j,t}$ <0, the prediction is lower to the observed medical density and reveals a physician surplus in the healthcare market. It means that the number of practitioners is higher than expected. Finally, if $\text{Shortage}_{j,t}$ =0, we are in a situation where there is an exact match between demand and supply. We are thus at equilibrium and the planning of physician workforce matches perfectly the actual demand for physicians.

Table 1 provides an overview of the evolution of the actual density of doctors and the shortage associated across time. Between 1991 and 2004, the average density of physicians has overall increased from 2.55 in 1991 to 3.02 in 2004 (+18 per cent). By comparing the observed with the predicted density of physicians, 7 over 14 years report a shortage of physicians (i.e. the predicted shortage is negative). In other words, even in the presence of an increasing density of physicians per 1,000 inhabitants, OECD countries are sometimes facing shortages across time depending on the dynamics of their GDP per capita.

This time series shows that OECD countries swing between periods of shortage and periods of surplus. Between 1991 and 1992, a shortage of physicians is observed even if it then decreases across time to become a surplus between 1993 and 1996. 1997–1998 are characterised by shortage episodes that coincide with the economic boom observed in this period. 1999–2001 is then a period of an increase of the surplus of doctors, and between 2002 and 2004 shortages re-appear with an increasing magnitude (refer to Figure 1 for a visual representation).

In order to tackle shortage issues, OECD countries can adopt three different approaches: (1) increase in the number of graduates, (2) increase the recruitment of foreign-trained physicians, (3) retaining their practicing physicians by discouraging or preventing their emigration.

Table 1: Evolution of average density and shortages of physicians across time period 1991–2004

	Average density of physicians per 1,000 people	Average of Ln (density)	Average predicted density of physicians per 1,000 people	Average of Ln(predicted density)	Predicted shortage= average(ln prediction)-average(ln density)	Shortage in level= predicted density-observed density
1991	2,554	0,937	2,610	0,959	0,022	0,057
1992	2,620	0,963	2,636	0,969	0,006	0,016
1993	2,668	0,981	2,655	0,977	-0,005	-0,013
1994	2,717	1,000	2,700	0,993	-0,007	-0,018
1995	2,749	1,011	2,742	1,009	-0,003	-0,007
1996	2,810	1,033	2,778	1,022	-0,012	-0,032
1997	2,789	1,026	2,824	1,038	0,012	0,035
1998	2,844	1,045	2,861	1,051	0,006	0,017
1999	2,966	1,087	2,906	1,067	-0,020	-0,060
2000	3,041	1,112	2,972	1,089	-0,023	-0,069
2001	3,085	1,127	3,006	1,101	-0,026	-0,079
2002	3,021	1,106	3,040	1,112	0,006	0,018
2003	3,021	1,106	3,062	1,119	0,013	0,040
2004	3,021	1,106	3,111	1,135	0,029	0,090

Source: Authors' calculation.

Figure 1: Average density of medical graduates and shortage from 1991 to 2012

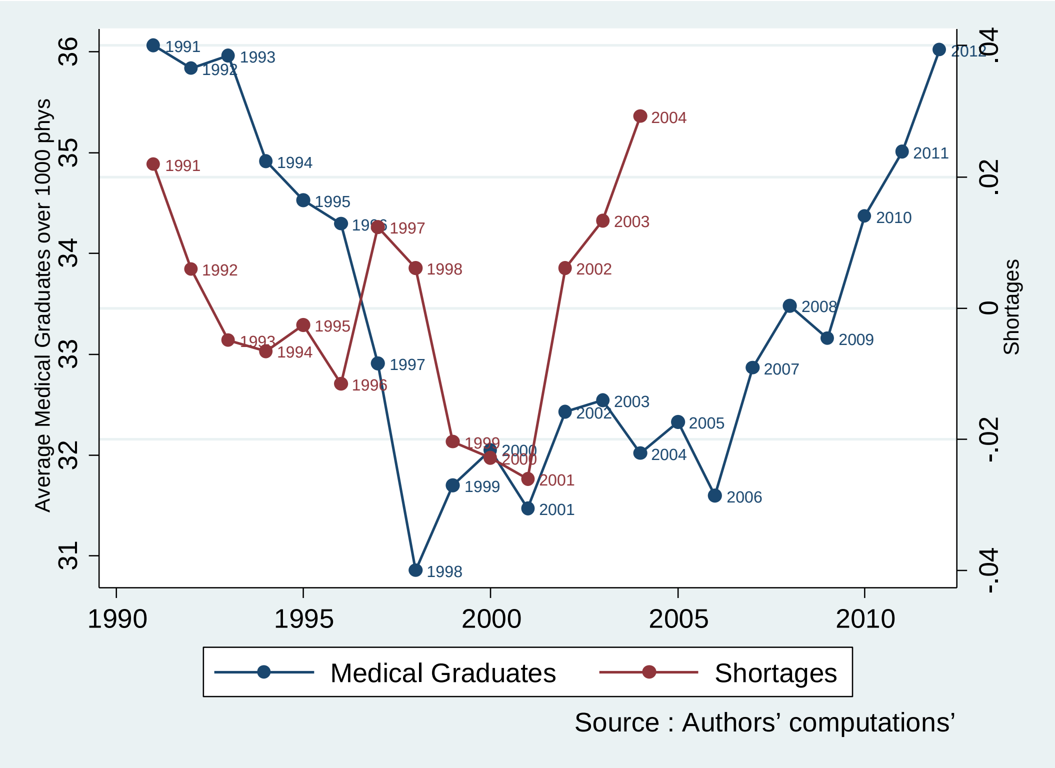


Figure 1 describes the first option by comparing the evolution of the density of medical graduates per 1,000 inhabitants and the evolution of the shortages from 1991 to 2012. Y-right axis describes the level of shortage (expressed as difference in logarithmic term) and the Y-left axis the average of medical density of graduates over 1,000 inhabitants. X-axis reports the year. A positive correlation appears between these two series with a time delay between the appearance of shortages and the responses of medical graduates. From 1991 to 1996, the decrease of the level of shortage is associated with a surplus since 1993 and a continuous decrease of medical graduates until 2001. In 1997–1998, a sudden appearance of shortage is related to a modest increase in the number of medical graduates in 2002 and 2003. After 2002, the shortage increases exponentially until the period 2004; however the medical graduate density adopts the same pattern only since 2007.

Turning to consider the recruitment of foreign physicians to address shortages, we must first determine how we define foreign physicians. In the literature, three different definitions are adopted based either on the country of birth, the country of education or the country of citizenship. In our analysis, we adopt the definition based on the country of training, for several reasons. First, one of the potential tools used by OECD governments to reduce shortages is to attract from abroad physicians who have already qualified. This strategy could be effective in the short-term only if these foreign-trained physicians are permitted to practice without considerable delays caused by requirements from the destination country for them to relicense/retrain. Second, focusing on country of training avoids considering physicians born outside but educated in the destination countries as a foreign physicians. In terms of 'brain drain', it is difficult to consider these people as a loss to their origin country because the destination countries have supported the financial costs of their education. Moreover, these people are following the same educational selection process into medical school and thus respond to a shortage episode as do native trained doctors. Finally, the definition of education allows controlling for the existence of medical schools in the origin countries, which is not possible for data based on a census. Although we prefer and thus adopt this definition in our paper, it is not exempt from limitations. In the particular case of regional medical schools, the definition based on country of training certainly overestimates the level of physicians' emigration because some of these doctors are foreign-born but trained in this country. However, this phenomenon remains locally concentrated in some countries, such as South Africa and Fiji (A. Bhargava, F. Docquier and Y. Moullan, 2011).

The data of international migration of physicians used in this paper comes from A. Bhargava, F. Docquier and Y. Moullan (2011). This dataset provides the number of foreign physicians by country of training and over a long time period. These data have been collected from registers of medical associations, which provide the number of foreign-trained physicians who are recognised and based in their countries. These data refer only to the number of licensed medical doctors ready to practice, which suits our analysis. This dataset reports the bilateral stock of foreign-trained physicians from 192 source countries to 18 destination countries over the period 1991 to 2004. Host countries include 17 OECD countries: Australia, Austria, Belgium, Canada, Denmark, France, Finland, Germany, Ireland, Italy, New Zealand, Norway, Portugal, Sweden, Switzerland, the UK, the US and 1 non-OECD country (South Africa). For the purpose of our paper, we focus our attention on the destination side, and we recalculate the number of physicians recruited by summing the bilateral data from different origin countries. We drop South Africa as a destination country because of the unavailability of data on medical graduates and because of their specific role as a big regional medical training center in Southern Africa.

This dataset reports the stock of foreign-trained physicians annually. Ideally, flows data will be more suitable for our analysis as it captures the entry of foreign physicians from abroad; however such data is not available. We therefore prefer to define our variables of immigration and emigration as migration rates for many reasons: (1) This definition combined with our panel-data methodology allows the capture of an entry into the receiving country, and we are interested in changing immigration rates. Therefore, an increase in the immigration rate is associated with a higher proportion of immigrants in the total number of physicians. (2) In Beine et al. (2011), inflows are imputed by the difference of the stock between *t* and *t-1*. However, this variation in stocks captures only partially the inflow of physicians because the stock of foreign-trained physicians for the following year is equal to the previous stock augmented by the number of new entries in receiving countries and reduced by the number of physicians who disappear from the register. However, for physicians, entry could be due to becoming inactive following a break, and exit may be related to deaths, inactivity or return migration, for example. Adopting this definition assumes the possibility of negative variation meaning that exits are higher than entries. However, the presence of a negative value in log-log model remains problematic and implies these flows are ignored, by replacing them as zero (M. Beine et al., 2011). Moreover, the interpretation of migration variable expressed in variation of stocks is usually suitable for cross-country study but in panel data analysis, as the interpretation is based on change, the interpretation is less obvious. Thus we prefer to use rate and we adopt the following definitions:

$$\text{Immigration rate}_{j,t} = \frac{\text{Stock immigrants}_{j,t}}{\text{Physicians}_{j,t}} \quad (3.3)$$

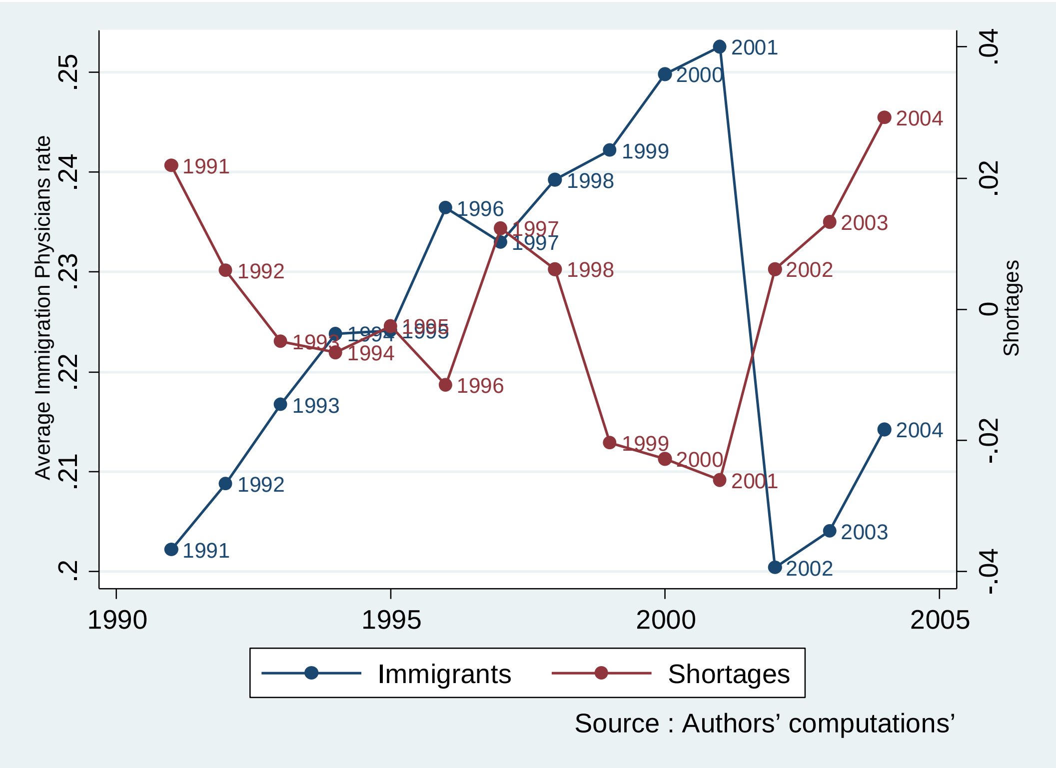
Where j is the receiving country and t the year. The numerator stock of immigrants refers to the number of foreign-trained physicians registered in the receiving country and the denominator physicians refers to the total stock of physicians in the country. In general this stock includes physicians who have previously been registered as well as those who are newly registered, such as immigrants.

$$\text{Emigration rate}_{i,t} = \frac{\sum_{j=1}^{16} \text{Stock emigrants abroad}_{i,t}}{\left(\text{Physicians}_{i,t} + \text{Stock emigrants abroad}_{i,t}\right)} \quad (3.4)$$

Where i is the country of origin and t the year. The numerator is the number of emigrant doctors registered in the other 16 destination countries and the denominator is the total number of trained physicians in the source country, which includes the stayers (physicians) and the movers (emigrants). This equation defines the emigration rates of physicians in our country.

Figure 2 reports the average immigration rate of physicians (Y-left axis) compared to the level of shortage (Y right axis). X-axis reports the year.

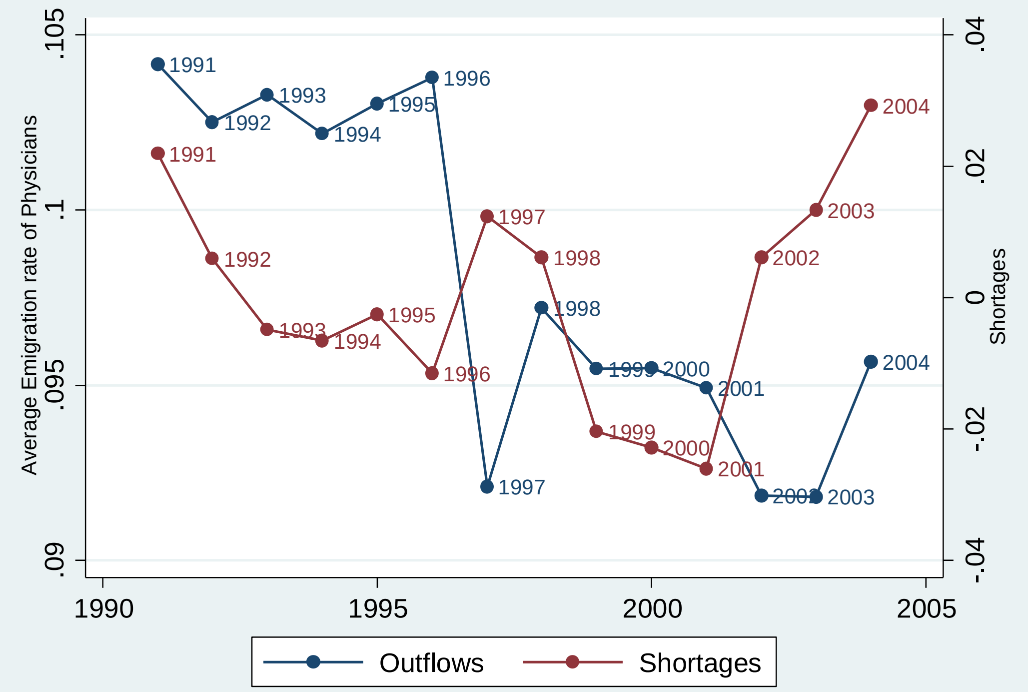
Figure 2: Average physician immigration rate and shortage from 1991 to 2004



We observed on average a constant increase in the immigration rate of physicians over the period examined, except in the case of 2002. This reduction correlates with a sharp decrease of the shortage around the year 2000. However, the increase of the shortage in 2002 is followed by a rise in the proportion of foreign-trained physicians since 2003. Compared to Figure 1, showing the changing proportion of medical graduates, the increase of physician shortage in 2002 is followed one year later by a higher entry of foreign-trained physicians, whereas in the case of medical graduates, the increase occurs only in 2007, i.e. at the earliest five years following the appearance of the shortage. It seems that the outcome of policies consisting of recruiting physicians from abroad are quicker in tackling shortages compared to policies which consist of expanding medical school capacity, because of the length of time necessary to complete medical training.

Figure 3 shows the evolution of physician emigration rate (Y-left axis) and the shortage (Y-right axis). X-axis reports the year. A positive correlation is observed between the emigration of physicians (medical brain drain) and the rate of shortage. Between 1991 and 1996, a decrease of the shortage is associated with a stagnation of the emigration rate with a drop particularly visible in 1997. In 1997-1998 a shortage of physicians is associated with an increase of the medical brain drain in 1998. Similar trend is observed after 1998 which suggests that the emigration rates of physicians seems to be important when the shortage of physicians is quite high. The burden of shortage seems to worsen the working conditions of practicing doctors, who find additional motivations for emigrating.

Figure 3: Average physician emigration rate and shortage from 1991 to 2004



Source : Authors' computations'

In the appendix of this paper, we report similar figures by distinguishing the pattern of shortage, medical graduates, immigration and emigration rate by focusing on 6 countries: the US, the UK, France, Germany, Switzerland and Canada on the same period.

4. The econometric model and framework

Our research question focuses on the linkage between the dynamics of the shortage and the response for tackling this issue, either by the capacity of medical schools or by migration policies facilitating immigration, or by policies aimed at retaining medical doctors. Therefore we have two sets of equations to estimate in our paper:

$$\begin{cases} Ln\left[\left(\dfrac{\text{Medical graduates}}{\text{Physicians}}*1{,}000\right)_{j,t+\gamma}\right] = \beta_0 + \beta_1 \text{ Shortages}_{j,t} + \beta_2 \; Ln(\text{X}_{j,t}) + \text{FE}_j + \text{FE}_t + \nu_{j,t} \\ \text{Net migration rate}_{j,t} = \beta_0 + \beta_1 \text{ Shortages}_{j,t} + \beta_2 \; Ln\;(\text{X}_{j,t}) + \text{FE}_j + \text{FE}_t + \eta_{j,t} \end{cases} \qquad (4.1)$$

$$\begin{cases} Ln\left[\left(\dfrac{\text{Medical graduates}}{\text{Physicians}}*1{,}000\right)_{j,t+\gamma}\right] = \beta_0 + \beta_1 \text{ Shortages}_{j,t} + \beta_2 \; Ln(\text{X}_{j,t}) + \text{FE}_j + \text{FE}_t + \nu_{j,t} \\ Ln\;(\text{Immigration rate}_{j,t}) = \beta_0 + \beta_1 \text{ Shortages}_{j,t} + \beta_2 \; Ln\;(\text{X}_{j,t}) + \text{FE}_j + \text{FE}_t + \eta_{j,t} \\ Ln\;(\text{Emigration rate}_{i,t}) = \beta_0 + \beta_1 \text{ Shortages}_{i,t} + \beta_2 \; Ln\;(\text{X}_{i,t}) + \text{FE}_i + \text{FE}_t + \mu_{i,t} \end{cases} \qquad (4.2)$$

with *j* referring to the receiving country and *t* referring to time dimension. In the first set of equation (4.1), we estimate the graduates and the net migration rate, which is defined as the difference between immigration and emigration. Therefore a positive value of net migration rate means that the immigration rate is higher than the emigration rate of doctors, so the stock of physicians is increasing. In order to keep these negative values in our analysis, the equation of net migration rate is estimated in absolute terms without transformation with logarithmic terms. The other equations are expressed in logarithmic term because of the non-presence of negative value in the emigration and immigration rate. In (4.2), we split the migration rate into the immigration rate and the emigration rate. In the later equation, indices i refers to source country where all our countries are now senders of physicians abroad and no longer receiving countries. Our dependent variables are, respectively, the number of students who have graduated each year from medical schools over 1,000 physicians with a time delay γ , the net migration rate, the immigration rate and the emigration rate. The medical graduates' data have been collected from the Health OECD Database, whereas the migration variables are taken from the dataset of A. Bhargava, F. Docquier and Y. Moullan (2011).

The variable in which we are interested in the model is the shortage of physicians, described, as previously mentioned, as the difference between the predicted and the actual density of medical doctors, both expressed in logarithmic terms.

Control variables are implemented through the vector, $X_{j,t}$ or $X_{i,t}$ that includes the population size, the old age dependency ratio (measured as the ratio between the number of persons aged at least 65 years old and the number of persons between 15 and 65 years old (World Population Prospect, UNDP 2012)), the GDP per capita in $ in purchasing power parity (PPP) (World Development Indicators), and the social expenditure per capita in the public sector in $ in PPP which refers to the generosity of the welfare system (Health OECD Data). $\nu_{j,t}$, $\eta_{j,t}$ or $\mu_{i,t}$ is the error term and all explanatory and dependent variables are expressed in logarithmic form to interpret results as elasticity. Due to the panel structure, several dummy variables are included into the analysis: destination fixed effects FE_j or FE_i origin fixed effect in the emigration equation and time-fixed effects FE_t. The inclusion of these dummies mitigated partially the problem of potential omitted variables such as immigration policy specific and some shocks inherent to a particular year. All of our equation used a log-log specification (except for the equation of net migration rate) which induces interpretation into elasticities.

These empirical models are, first, estimated through Ordinary Least Square (OLS) regressions by clustering over the destination time dimension. However, one potential bias is the endogeneity issue. This could be due to either a potential reverse causality which is mitigated in the case of medical graduates because the number of graduates arrived with a long time delay (at least 5 years). Or omitted variables could be the most likely cause of our endogeneity issue. Any variables potentially correlated with our dependent variables and with shortage variable could be elected as omitted variables. In order to mitigate this bias, we used the Two Stage Least Square (2SLS) approach. This methodology requires valid instruments which are variables that explain the shortage variable without any direct link with our dependent variables (graduates, or immigration or emigration). In our case, two variables are considered as instruments: first, the geographical density of physician across the territory. This variable has been computed by dividing the total number of physicians in the country by the land area (measured as square meters). This density expresses an average of the geographical density of physicians which should be equally distributed across territory to ensure the same healthcare access whatever the population is located. Therefore, a low geographical density of physician means that the access to physician services is far probably caused by local shortages of physicians in some specific areas. The second instrument used in our paper is the age dependency ratio for the physician's profession. By using the Health OECD data, we collect data about the proportion of physicians by age group. By using some extrapolation based on the same trend observed after 1997, we are able to reconstruct the series and to calculate the age dependency ratio for physicians as the number of physicians over 55 years old over the number of doctors aged between 35 and 55 years old. This variable is a proxy of the ageing which affected also the physician's profession.

In the previous methodology, each model is separately estimated which assumes that no potential correlation exists between the medical graduates decision and the immigration and emigration patterns during a period of shortage. However, the appearance of shortage can simultaneously affect the number of graduates, the recruitment of immigrants and the retention of doctors in the medical workforce in the same time. Therefore, our three models are not totally disconnected and we should estimate these equations by assuming a potential correlation with their error terms. In a final stage, we considered these equations as simultaneously related through the methodology developed by Arnold Zellner (1962) named Seemingly Unrelated Regression Equations (SURE), in which correlations of error term are assumed across equations. Then, we use the Three Stage Least Square (3SLS) model which assume correlations between equations but also control for endogeneity issue. In order to correct for this later bias, each equation should report exclusion variables which identify one equation but not the other. In the graduate model, the school enrolment in secondary and tertiary education expressed as gross (World Development Indicators) are introduced because it captures the adjustment of places in medical training due to the arrival of young cohort in the educational system. In the immigration and emigration equations, two exclusion variables capture the changes in immigration policy , one capturing the magnitude and another capturing the restrictiveness of immigration policy for high skilled individuals (DEMIG, 2014). These variables and the inclusion of the shortage equation explained by instrument variables allows us to pass the identification rules and are reported at the end of our empirical analysis.

5. Empirical results

Table 2: OLS estimation of the average medical graduates from different time period with shortages

VARIABLES	(1) OLS Average over t+1 and t+2 Ln(Graduates)	(2) OLS Average over t+5, t+6 and t+7 Ln(Graduates)	(3) OLS Average over t+8 and t+9 Ln(Graduates)
(Shortage)t	0.191	0.449***	0.363***
	(0.141)	(0.140)	(0.136)
Ln(Tertiary school enrolment)t	-0.0647	-0.310***	-0.215***
	(0.112)	(0.0819)	(0.0735)
Ln(Secondary school enrolment)t	0.305**	0.240**	0.177
	(0.140)	(0.115)	(0.110)
Ln(Population)t	-0.645	-2.332***	-1.406**
	(0.865)	(0.693)	(0.701)
Ln(Age dependency)t	-1.748***	-0.839**	0.779**
	(0.432)	(0.361)	(0.342)
Ln(GDP per cap)t	-0.903**	0.225	1.203***
	(0.395)	(0.277)	(0.275)
Ln(Social expenditure per cap)t	0.943***	0.813***	0.295**
	(0.229)	(0.164)	(0.137)
Constant	13.23	29.12***	16.87
	(16.42)	(10.32)	(13.44)
Observations	213	226	224
R-squared	0.803	0.833	0.857
j	YES	YES	YES
t	YES	YES	YES
Cluster	jt	jt	jt

Table 3: OLS estimation of net migration rate with shortages

VARIABLES	(1) OLS Net Migration	(2) OLS Net Migration	(3) OLS Net Migration	(4) OLS Net Migration
(Shortage)t	0.214*			
	(0.109)			
(Shortage)t-1		0.142		
		(0.107)		
(Shortage)t-2			0.0104	
			(0.0883)	
(Shortage)t-3				-0.0830
				(0.0913)
Ln(Population)t	-0.121	-0.0366	0.0890	0.125
	(0.551)	(0.627)	(0.688)	(0.817)
Ln(Age dependency)t	0.0562	0.197	0.328**	0.380**
	(0.125)	(0.140)	(0.153)	(0.186)
Ln(GDP per cap)t	0.446	0.379	0.274	0.166
	(0.321)	(0.333)	(0.349)	(0.353)
Ln(Social expenditure per cap)t	-0.180	-0.245*	-0.311**	-0.412**
	(0.118)	(0.131)	(0.140)	(0.161)
(Immig change level)t	0.00378	0.00566	0.00585	-0.00176
	(0.0138)	(0.0150)	(0.0155)	(0.0170)
(Immig restrictivness)t	-0.0170	-0.0185	-0.0205	-0.0449
	(0.0369)	(0.0400)	(0.0404)	(0.0452)
Constant	-0.726	-0.554	-1.141	0.586
	(9.400)	(12.94)	(14.72)	(14.26)
Observations	237	220	203	186
R-squared	0.729	0.745	0.762	0.780
j	YES	YES	YES	YES
t	YES	YES	YES	YES
Cluster	jt	jt	jt	jt

In this section, we run econometric regressions to analyze how OECD countries react to potential medical shortages. Table 2 reports results of the OLS estimation of medical graduates as dependent variable (equation 4.1). The dependent graduates variable is respectively the average of medical graduates over t+1 and t+2 (Column 1), the average over t+5, t+6 and t+7 (Column 2), and the average over t+8 and t+9 (Column 3). As we can see, the coefficient of shortage is not statistically significant in T+1 and T+2 but it is significantly positive with at least five years later (from T+5 until T+9).

As explained by the Cobweb model, there is a time delay between the training of medical graduates and episodes of shortage, mainly due to the duration of medical training. When a country experiences a shortage, the decision to train further physicians is taken; however, because the duration of medical training can vary between 5 and 10 years, the increase in graduates appears only after a five- to ten-year delay. The magnitude of the coefficient when the average medical graduates is between t+5 and t+7 is 0.45 which means an increase of 10 per cent of the shortage indicator in time *T* corresponds to a rise of 4.5 per cent into the average proportion of medical graduates (in the population of physicians) between 5 and 7 years.

Both educational controls are statistically significant in Column 2. Tertiary enrolment is negatively correlated with the average medical graduates defined between t+5 and t+7, whereas the secondary enrolment is positive. Tertiary enrolment express the selection that occurs when entering medical schools whereas secondary enrolment shows that the number of places in medical schools tend to adjust to the size of the forthcoming new cohort of students.

Age dependency ratio is negatively correlated with the proportion of medical students graduated between 5 and 7 years later but positively correlated with those graduated at least 8 years later. It confirms that government decisions aim to match their healthcare demands with the supply of medical graduates, but that it occurs only in the long run. In terms of elasticity, a 10 per cent rise in the age dependency ratio today is associated with a rise of 7.8 per cent in the average medical graduates produced between 8 and 9 years later. The GDP per capita is correlated with an increase in the proportion of medical graduates only after t+7, whereas the social expenditures show a strong significant positive effect during the period from t+5 until t+7, which become less significant after that period.

Table 3 reports the estimation of net migration rates. The shortage variable appears statistically positive and significant at ten percent level only in Column 1 when the shortage variable expressed in time T. In other words, the appearance of shortage in t is associated with an increase the net migration rate, i.e higher immigration than emigration rate is observed in the physician labour market. However, when we lag the shortage variable in t-1 (Column 2), t-2 (Column 3) and t-3 (Column 4) nothing appears significant and the coefficient become negative in t-3 (Column 4) which suggests that higher emigration than immigration rate is observed with 3 years' delay.

Table 4 reports the estimation for the immigration rate of physicians (Columns 1–4) and the emigration rate (Columns 5–8). As in the previous table the shortage variable is lagged from t (Column 1 and 5) to T-1 (Column 2 and 6) to T-2 (Column 3 and 7) to t-3 (column 4 and 8). The results confirm that the time taken to respond to medical shortages is shorter via policies to recruit foreign-trained physicians compared with those to train new graduates. On average the medical graduates' response to a shortage took seven years, whereas the recruitment of foreign-trained physicians' response is effective immediately (Column 1), or at last one year (Column 2) after the shortage.

Table 4: OLS estimation of foreign-trained inflows of physicians by different lags of shortages

VARIABLES	(1) OLS Ln(IMR)	(2) OLS Ln(IMR)	(3) OLS Ln(IMR)	(4) OLS Ln(IMR)	(5) OLS Ln(EMR)	(6) OLS Ln(EMR)	(7) OLS Ln(EMR)	(8) OLS Ln(EMR)
(Shortage)t	0.165***				0.0588***			
	(0.0598)				(0.0133)			
(Shortage)t-1		0.0974*				0.0339**		
		(0.0571)				(0.0139)		
(Shortage)t-2			0.0312				0.0381***	
			(0.0476)				(0.0135)	
(Shortage)t-3				-0.0216				0.0277**
				(0.0489)				(0.0138)
Ln(Population)t	-0.496*	-0.436	-0.392	-0.351	-0.625***	-0.630***	-0.666***	-0.633***
	(0.290)	(0.330)	(0.360)	(0.427)	(0.101)	(0.113)	(0.126)	(0.147)
Ln(Age dependency)t	0.00642	0.106	0.179**	0.208**	-0.0473	-0.0326	-0.0345	-0.0293
	(0.0664)	(0.0743)	(0.0828)	(0.103)	(0.0300)	(0.0312)	(0.0308)	(0.0330)
Ln(GDP per cap)t	0.211	0.187	0.135	0.0759	0.0102	0.0334	0.0476*	0.0490*
	(0.170)	(0.175)	(0.177)	(0.176)	(0.0233)	(0.0244)	(0.0272)	(0.0295)
Ln(Social expenditure per cap)t	-0.136**	-0.175**	-0.215***	-0.270***	-0.0483***	-0.0485***	-0.0492***	-0.0472***
	(0.0611)	(0.0681)	(0.0735)	(0.0861)	(0.0170)	(0.0180)	(0.0169)	(0.0181)
(Immig change level)t	0.000253	0.000849	0.00120	-0.00196	-0.00230	-0.00322*	-0.00311	-0.00123
	(0.00708)	(0.00771)	(0.00799)	(0.00889)	(0.00182)	(0.00187)	(0.00191)	(0.00208)
(Immig restrictivness)t	-0.0122	-0.0131	-0.0141	-0.0244	-0.00560	-0.00660	-0.00630	-0.000896
	(0.0189)	(0.0205)	(0.0209)	(0.0237)	(0.00426)	(0.00450)	(0.00461)	(0.00514)
Constant	7.176	8.411	8.608	7.432	10.28***	12.24***	12.84***	9.732***
	(4.978)	(6.868)	(7.733)	(7.441)	(1.490)	(2.043)	(2.261)	(2.066)
Observations	237	220	203	186	237	220	203	186
R-squared	0.926	0.933	0.939	0.944	0.988	0.989	0.989	0.990
j	YES	YES	YES	YES	YES	YES	YES	YES
t	YES	YES	YES	YES	YES	YES	YES	YES
Cluster	jt	jt	jt	jt	jt	jt	jt	jt

Table 5: IV estimations with shortage considered as endogenous

VARIABLES	(1) 2SLS Second Stage Average t+5, t+6 and Ln(Graduates)	(2) 2SLS First Stage Shortage	(3) 2SLS Second Stage Average t+8 and t+9 Ln(Graduates)	(4) 2SLS First Stage Shortage	(5) 2SLS Second Stage Ln(IMR)	(6) 2SLS First Stage Shortage	(7) 2SLS Second Ln(EMR)	(8) 2SLS First Stage Shortage
(Shortage)t	0.299**		0.398***		0.114***		0.0539***	
	(0.130)		(0.106)		(0.0242)		(0.0151)	
Ln(Tertiary enrolment)t	-0.266***	-0.00357	-0.297***	-0.000186				
	(0.0727)	(0.00258)	(0.0656)	(0.00251)				
Ln(Secondary enrolment)t	0.188*	-0.00467	0.262***	-0.00532				
	(0.0988)	(0.00346)	(0.0939)	(0.00356)				
Ln(Population)t	-1.613**	1.041***	-0.408	1.071***	0.340***	1.063***	-0.661***	1.063***
	(0.664)	(0.0223)	(0.586)	(0.0199)	(0.0967)	(0.0205)	(0.0950)	(0.0205)
Ln(Age dependency)t	-0.920**	-0.0270**	-0.189	-0.0250**	-0.105**	-0.0235**	-0.0560	-0.0235**
	(0.371)	(0.0106)	(0.302)	(0.0113)	(0.0422)	(0.0108)	(0.0360)	(0.0108)
Ln (GDP per cap)t	0.377	0.258***	0.510**	0.258***	-0.281***	0.260***	0.0519	0.260***
	(0.276)	(0.0145)	(0.259)	(0.0143)	(0.0477)	(0.0142)	(0.0356)	(0.0142)
Ln (Social exp cap)t	0.255	0.0140**	0.413***	0.00732	0.0381	0.00855	-0.102***	0.00855
	(0.165)	(0.00642)	(0.139)	(0.00569)	(0.0278)	(0.00587)	(0.0270)	(0.00587)
(Immig change level)t					0.00105	-0.000398	-0.00256	-0.000398
					(0.00153)	(0.000347)	(0.00187)	(0.000347)
(Immig restrict)t					0.00241	0.000171	-0.00702	0.000171
					(0.00341)	(0.000786)	(0.00439)	(0.000786)
Ln(Physician/geo)t		-0.994***		-0.992***		-0.991***		-0.991***
		(0.00493)		(0.00539)		(0.00528)		(0.00528)
Ln(Physician dependency)t		0.00393**		0.00372**		0.00297*		0.00297*
		(0.00183)		(0.00181)		(0.00170)		(0.00170)
Constant	27.35**	-11.51***	2.128	-12.06***	-3.912**	-11.97***	13.12***	-11.97***
	(12.86)	(0.422)	(11.33)	(0.371)	(1.703)	(0.376)	(1.749)	(0.376)
Observations	193	193	188	188	195	195	195	195
R-squared	0.815		0.861		0.989		0.967	
j	YES	YES	YES	YES	YES	YES	YES	YES
t	YES	YES	YES	YES	YES	YES	YES	YES
Cluster	jt	jt	jt	jt	jt	jt	jt	jt
Hansen		1.379		1.790		1.620		1.376
P-Value (Hansen Test)		0.240		0.181		0.203		0.241
F-Test		47.28		30.32		959.7		138.3

Table 6: Simultaneous equation model with the average graduate over t+5, t+6 and t+7: SURE and 3SLS estimations

VARIABLES	(1) SURE Average over t+5, t+6 and t+7 Ln(Graduates)	(2) SURE Ln(IMR)	(3) SURE Ln(EMR)	(4) SURE Average over t+5, t+6 and t+7 Ln(Graduates)	(5) 3SLS Ln(IMR)	(6) 3SLS Ln(EMR)	(7) 3SLS Shortage
(Shortage)t	0.445***	0.133***	0.0487***	0.315**	0.118***	0.0337**	
	(0.136)	(0.0489)	(0.0144)	(0.135)	(0.0218)	(0.0151)	
Ln(Tertiary enrolment)t	-0.336***			-0.348***			
	(0.0835)			(0.0844)			
Ln(Secondary Enrolment)t	0.234**			0.152			
	(0.112)			(0.113)			
Ln(Population)t	-2.446***	-0.257	-0.518***	-1.970***	0.311***	-0.524***	
	(0.737)	(0.219)	(0.0643)	(0.722)	(0.0967)	(0.0671)	
Ln(Age dependency)t	-0.855***	0.00519	-0.0224	-1.005***	-0.116**	-0.0157	
	(0.283)	(0.0973)	(0.0286)	(0.320)	(0.0468)	(0.0325)	
Ln(GDP per cap)t	0.229	-0.209**	0.0478*	0.379	-0.293***	0.0870***	
	(0.240)	(0.0842)	(0.0248)	(0.292)	(0.0449)	(0.0311)	
Ln(Social exp cap)t	0.829***	-0.0904**	-0.0694***	0.324*	0.0511*	-0.145***	
	(0.132)	(0.0442)	(0.0130)	(0.185)	(0.0279)	(0.0194)	
(Immig change level)t		-0.00255	-0.00159		0.00124	-0.00204*	
		(0.00356)	(0.00106)		(0.00163)	(0.00112)	
(Immig restrict)t		-0.0151*	-0.00372		0.00270	-0.00510*	
		(0.00879)	(0.00261)		(0.00410)	(0.00280)	
Ln(physician/geo)t							-0.890***
							(0.0221)
Ln(physician dependency)t							0.0292***
							(0.00645)
Constant	40.35***	8.248**	10.14***	34.07**	-3.350*	10.51***	10.44***
	(14.00)	(4.155)	(1.223)	(13.81)	(1.821)	(1.263)	(0.257)
Observations	225	225	225	192	192	192	192
R-squared	0.830	0.943	0.981	0.809	0.988	0.969	0.915
j	YES	YES	YES	YES	YES	YES	YES
t	YES	YES	YES	YES	YES	YES	YES
Cluster	jt	jt	jt	jt	jt	jt	jt

Table 7: Simultaneous equation model with the average graduate over t+8 and t+9: SURE and 3SLS estimations

VARIABLES	(1) SURE Average over t+8 and t+9 Ln(Graduates)	(2) SURE Ln(IMR)	(3) SURE Ln(EMR)	(4) 3SLS Average over t+8 and t+9 Ln(Graduates)	(5) 3SLS Ln(IMR)	(6) 3SLS Ln(EMR)	(7) 3SLS Shortage
(Shortage)t	0.346***	0.117**	0.0616***	0.378***	0.111***	0.0555***	
	(0.126)	(0.0514)	(0.0154)	(0.116)	(0.0216)	(0.0166)	
Ln(Tertiary enrolment)t	-0.210***			-0.309***			
	(0.0764)			(0.0751)			
Ln(Secondary enrolment)t	0.174*			0.261**			
	(0.103)			(0.103)			
Ln(Population)t	-1.355**	-0.303	-0.662***	-0.499	0.389***	-0.689***	
	(0.624)	(0.225)	(0.0672)	(0.588)	(0.0962)	(0.0740)	
Ln(Age dependency)t	0.796***	0.106	-0.0518	-0.189	-0.0760	-0.0581	
	(0.270)	(0.109)	(0.0325)	(0.278)	(0.0488)	(0.0375)	
Ln(GDP per cap)t	1.200***	-0.256***	0.0396	0.486*	-0.283***	0.0559	
	(0.225)	(0.0894)	(0.0267)	(0.259)	(0.0455)	(0.0350)	
Ln(Social exp cap)t	0.294**	-0.142***	-0.0503***	0.423***	0.0465*	-0.110***	
	(0.115)	(0.0441)	(0.0132)	(0.150)	(0.0265)	(0.0204)	
(Immig change level)t		-0.00255	-0.00216**		0.00106	-0.00270**	
		(0.00360)	(0.00110)		(0.00161)	(0.00124)	
(Immig restrict)t		-0.0215**	-0.00536*		0.00304	-0.00770**	
		(0.00898)	(0.00275)		(0.00408)	(0.00314)	
Ln(physician/geo)t							-0.890***
							(0.0233)
Ln(physician dependency)t							0.0264***
							(0.00687)
Constant	15.93	10.23**	12.83***	4.118	-4.852***	13.68***	10.43***
	(11.72)	(4.225)	(1.263)	(11.24)	(1.806)	(1.390)	(0.270)
Observations	223	223	223	187	187	187	187
R-squared	0.855	0.949	0.984	0.857	0.989	0.968	0.911
j	YES	YES	YES	YES	YES	YES	YES
t	YES	YES	YES	YES	YES	YES	YES
Cluster	jt	jt	jt	jt	jt	jt	jt

The coefficient of shortage is positive and statistically significant at 1 per cent level in t and at ten per cent level in t-1 (Column 2). The magnitude is 0.165 for t and 0.098 for t-1. In other words, a 10 per cent increase of the shortage in T is associated with a rise of 1.65 per cent of the immigration rate of physicians in T. This effect decreases to 0.98 per cent a year later and then nothing is significant after one year delay. The results for the emigration rate of physicians (Columns 5–8) shows that emigration responds all the times to shortages. The coefficient of shortage t (Column 5) is significantly positive about 0.059. In other words, increasing the shortage by 10 per cent in T will push up the emigration rate of physicians by 0.59 per cent. Comparing this coefficient (0.059) with those detected for immigration rate (0.165) reveal that in t, shortage attracts many more physicians from abroad than it pushes out. This result is consistent with the positive effect found for the net migration rate in t (Table 3 column 1). More interesting is the coefficients of shortage in Columns 6, 7 and 8 which are still significantly positive with the emigration of physicians. Although the immigration's response stops when the shortage is lagged after T-1, the emigration's response continue over all the period (T, T-1, T-2, T-3). It suggests that the medical shortage increases the burden of health delivery on the existing physicians and incentives them to move abroad continuously. So when shortage is lagged by T-3, the emigration's response exceeds the immigration one which consistently leads to net migration rate which is negative (Table 3 Column 4).

Table 5 describes the IV results when endogeneity issue is taken into account. The equation of average graduates over t+5 and t+7 is, first, reported (Column 1 and 2), then the average over t+8 and t+9 (Column 3 and 4), then the immigration rate (Column 5 and 6) and then the emigration rate (Column 7 and 8). The IV estimations report the first stage when shortage is explained by instrument and the second stage for each model. The coefficient associated with shortage is always significant and positive for each model, however for the graduate models, the magnitude of the coefficient become more important when the average is calculated on T+8 and T+9 compared to those calculated on T+5, T+6 and T+7. In other words, the delay is longer to what the initial analysis with Ordinary Least Square (OLS) suggests (Table 2). An increase of the shortage by 10 percent is correlated with an increase of 3 percent (it was 4.5 percent in Table 2) of the average graduates between t+5 and t+7, whereas it is 4 percent (it was 3.6 percent in Table 2) for those who are graduated between t+8 and t+9. The effect is respectively 1.14 percent for immigration rate (it was 1.65 in Table 4) and 0.54 for emigration rate (it was 0.59 in Table 4). Shortage is negatively correlated with the geographic density but positively correlated with the ageing of physicians. A high geographic density of doctor means that healthcare access is easy for everyone whatever their location (remote versus urban area) and so less shortage is observed, whereas an ageing physician's population increases the need of healthcare and drives up the shortage.

Table 6 reports the estimations of the average medical graduates between t+5 and t+7 when we consider that new graduates and migration policies are simultaneously connected. Columns 1-3 report the results for the SURE model whereas Column 4-7 reports the 3SLS model. Even in the presence of correlation between error terms, our results confirm our previous findings. The shortage in t is associated with a higher proportion of medical graduates with a delay of 5 to 7 years whereas immigration and emigration respond positively in t.

Table 7 reports the SURE and 3SLS estimations when the average of medical graduates is between t+8 and t+9. Our previous findings are confirmed and in comparison with the effect on the average medical graduates between t+5 and t+7, the coefficient associated with shortage increases between the SURE and the 3SLS model. It confirms that the “Pig Cycle” effect should probably happened in the long run in t+8 and t+9 instead of between t+5 and t+7.

Conclusion

This paper deals with the issue of medical shortages in developed countries. In order to tackle this issue, governments adopt two strategies: either producing a sufficient number of medical graduates and/or recruiting foreign-trained physicians. However, the preference of governments to increase the number of domestic physicians by producing new graduates is a strategy that is effective only over the long term because the medical training period is relatively long. Hence, this time delay evidence could be linked to the ‘Cobweb or Pig/Hog cycle’ theory (R.H. Coase and R.F. Fowler, 1935, M. Ezekiel, 1938, N. Kaldor, 1934). In that theoretical framework, the response to a particular phenomenon is different to the moment in which production responds to it. This model applied in the 1930s, where the production of pig/hog responded to a variation of price with a delay of one period because of the duration of breeding. We propose in this paper adapting this theory to the case of medical doctors. In our case, the appearance of medical shortages leads to investment in medical school capacity, which leads to the production of new graduates with time delays. On average the duration of training in developed countries is about seven years, which leads to the addressing of the shortage with a delay of least seven years. Our results confirm these findings. Following an episode of medical shortage, governments increase the capacity of medical schools to train more doctors. This materializes in an increase in medical graduates on average between 8 and 9 years after the appearance of the shortage due to the duration of medical study. Our results find also that shortage leads to an emigration of practicing physicians out of the country due to the related deterioration of the working conditions. Because training policy requires a long timeline, shortage drives policies in favour of recruiting foreign-trained physicians in the short-run. Immigration offers a quicker response to the shortage issue (involving a delay of at last one year) and explains the success of recruiting foreign-trained physicians. However, hiring high-skilled workers on the international market could be used to save the training of medical doctors which is quite costly due to the length of study (J. Connell et al., 2007, E. J. Mills et al., 2011). Moreover, the recruitment of health workers from abroad is a tool that governments use for reducing the inherent issue of geographical imbalance of the density of doctors (G. Dussault and M. C. Franceschini, 2006). Immigrant doctors are now increasingly required to practice in remote areas where the shortage is severe, whereas new graduates tend much more to settle in cities.

Even if recruiting foreign-trained physicians seems to be popular in OECD countries, this strategy is not without its consequences for the source countries. This migration could be viewed as a ‘medical brain drain’ for the origin countries in the sense that they support the medical education of these individuals without benefiting from their skills once there are ready to practice. Moreover, the recruitment of foreign doctors calls into question the ethics of depriving origin countries of their human resources for health (WHO, 2006). Nowadays, high rates of emigration of physicians is observed in African countries, although this region already faces severe medical shortages (A. Bhargava and F. Docquier, 2007, WHO, 2006). This situation could have some detrimental effects on the health of these countries’ populations, in particular in the efforts to address epidemics (A. Bhargava and F. Docquier, 2008). Even if recruiting physicians from abroad seems to be the solution in the short term, to tackle shortages in developed countries, this policy should be coherent with the aims of overseas development policy to foster better economic, social and well-being conditions in developing countries, where education and health are two important components.

References

Awases, M.; A. Gbary; J. Nyoni and R. Chatora. 2004. "Migration of Health Professionals in Six Countries: A Synthesis Report," Brazzaville: World Health Organisation,

Bärnighausen, T. and D.E. Bloom. 2011. "The Global Health Workforce," S. G. a. P. C. Smith, *Oxford Handbook of Health Economics.* Oxford: Oxford University Press,

Beine, M.; F. Docquier and C. Özden. 2011. "Diasporas." *Journal of Development Economics*, 95(1), 30-41.

Bhargava, A. and F. Docquier. 2008. "Hiv Pandemic, Medical Brain Drain, and Economic Development in Sub-Saharan Africa." *World Bank Economic Review*, 22, 345-66.

____. 2007. "A New Panel Data Set on Physicians' Emigration Rates (1991-2004)," Université Catholique de Louvain:

Bhargava, A.; F. Docquier and Y. Moullan. 2011. "Modeling the Effects of Physician Emigration on Human Development." *Economics and Human Biology*, (9), 172-83.

Coase, R.H. and R.F. Fowler. 1935. "Bacon Production and the Pig-Cycle in Great Britain." *Economica*, 2(6), 142-67.

Connell, J.; P. Zurn; B. Stillwell; M. Awases and J.M. Braichet. 2007. "Sub-Saharan Africa: Beyond the Health Worker Migration Crisis?" *Social Science and Medicine*, 64(9), 1876-91.

Cooper, R. A.; T. E. Getzen and P. Laud. 2003. "Economic Expansion Is a Major Determinant of Physician Supply and Utilization." *Health Services Research*, 38(2), 675-96.

Cooper, R.A. 2004. "Weighing the Evidence for Expanding Physician Supply." *Annals of Internal Medicine*, 141(9).

DEMIG. 2014. "Demig Policy Database," IMI, International Migration Institute, University of Oxford:

Diallo, K. 2004. "Data on the Migration of Health-Care Workers: Sources, Uses, and Challenges." *Bulletin of the World Health Organisation*, (82), 601-07.

DREES. 2004. "La Démographie Médicale À L'horizon 2025: Une Actualisation Des Projections Au Niveau National," D. d. l. R. e. d. E. d. l. E. e. d. S. (DREES), *Etudes et Résultats.* Paris

Dussault, G. and M. C. Franceschini. 2006. "Not Enough There, Too Many Here: Understanding Geographical Imbalances in the Distribution of the Health Workforce." *Human Resources for Health*, 4(12), 12.

Ezekiel, M. 1938. "The Cobweb Theorem." *Quarterly Journal of Economics*, 52(2), 255-80.

Falch, T.; K. Johansen and B. Strom. 2009. "Teacher Shortages and the Business Cycle." *Labour Economics*, (16), 648-58.

Farber, S.C. 1975. "A Labor Shorage Model Applied to the Migration of College Professors." *Journal of Human Resources*, 10(4), 482-99.

Grignon, M.; Y. Owusu and A. Sweetman. 2012. "The International Migration of Health Professionals." *IZA Discussion Paper*, (6517), 1-39.

Kaldor, N. 1934. "A Classificatory Note on the Determinants of Equilibrium." *The Review of Economic Studies*, 1(2), 122-36.

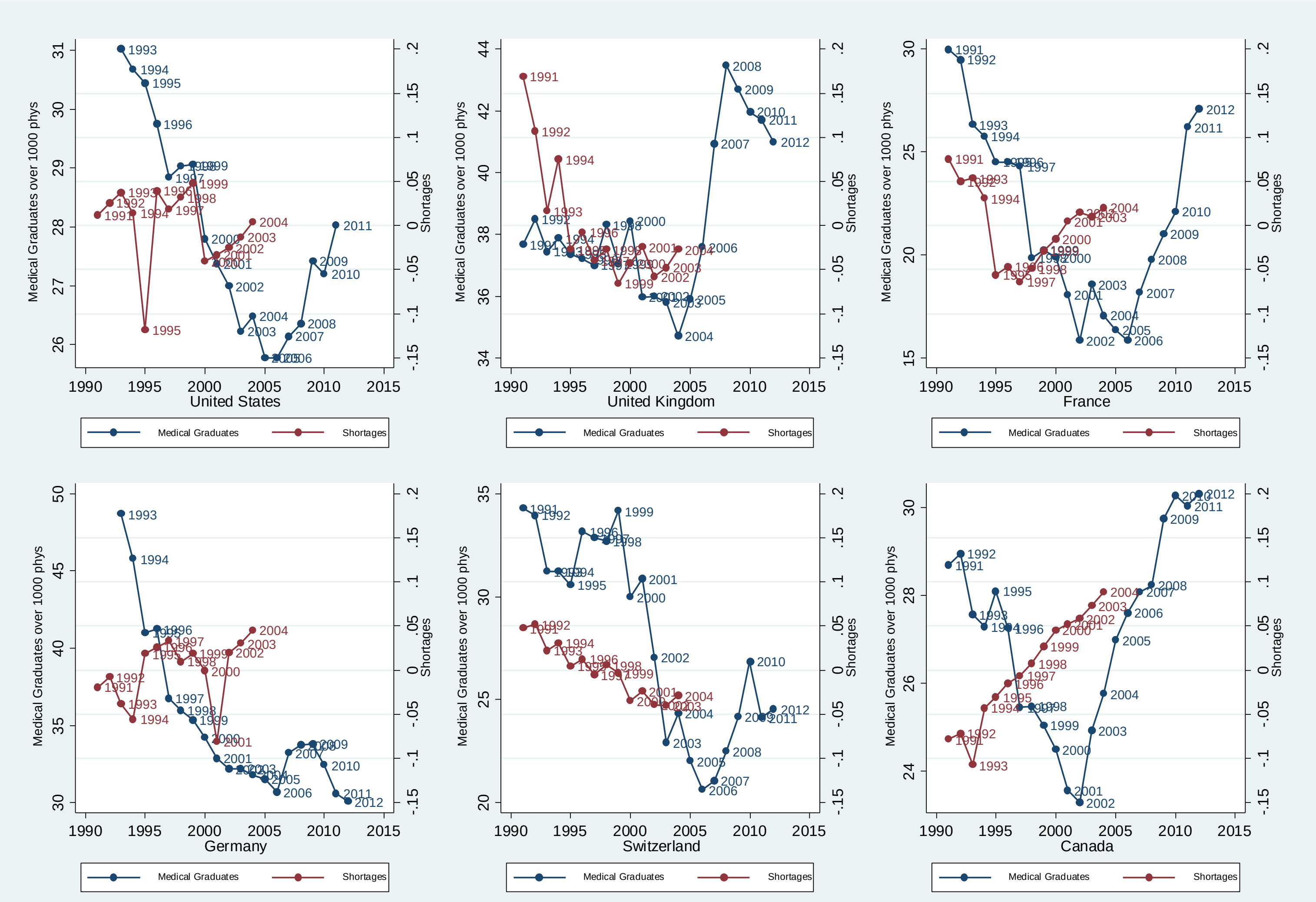
M.B., Forcier; Simoens S. and Giuffrida A. 2004. "Impact, Regulation and Health Policy Implications of Physician Migration in Oecd Countries." *Human Resources for Health*, 2(12), 1-11.

Mills, E. J.; S. Kanters; A. Hagopian; N. Bansback; J. Nachega; M. Alberton; C. G. Au-Yeung; A. Mtambo; I. L. Bourgeault; S. Luboga, et al. 2011. "The Financial Cost of Doctors Emigrating from Sub-Saharan Africa: Human Capital Analysis." *BMJ*, 343, d7031.

Newhouse, J. P. 1977. "Medical-Care Expenditure: A Cross-National Survey." *J Hum Resour*, 12(1), 115-25.

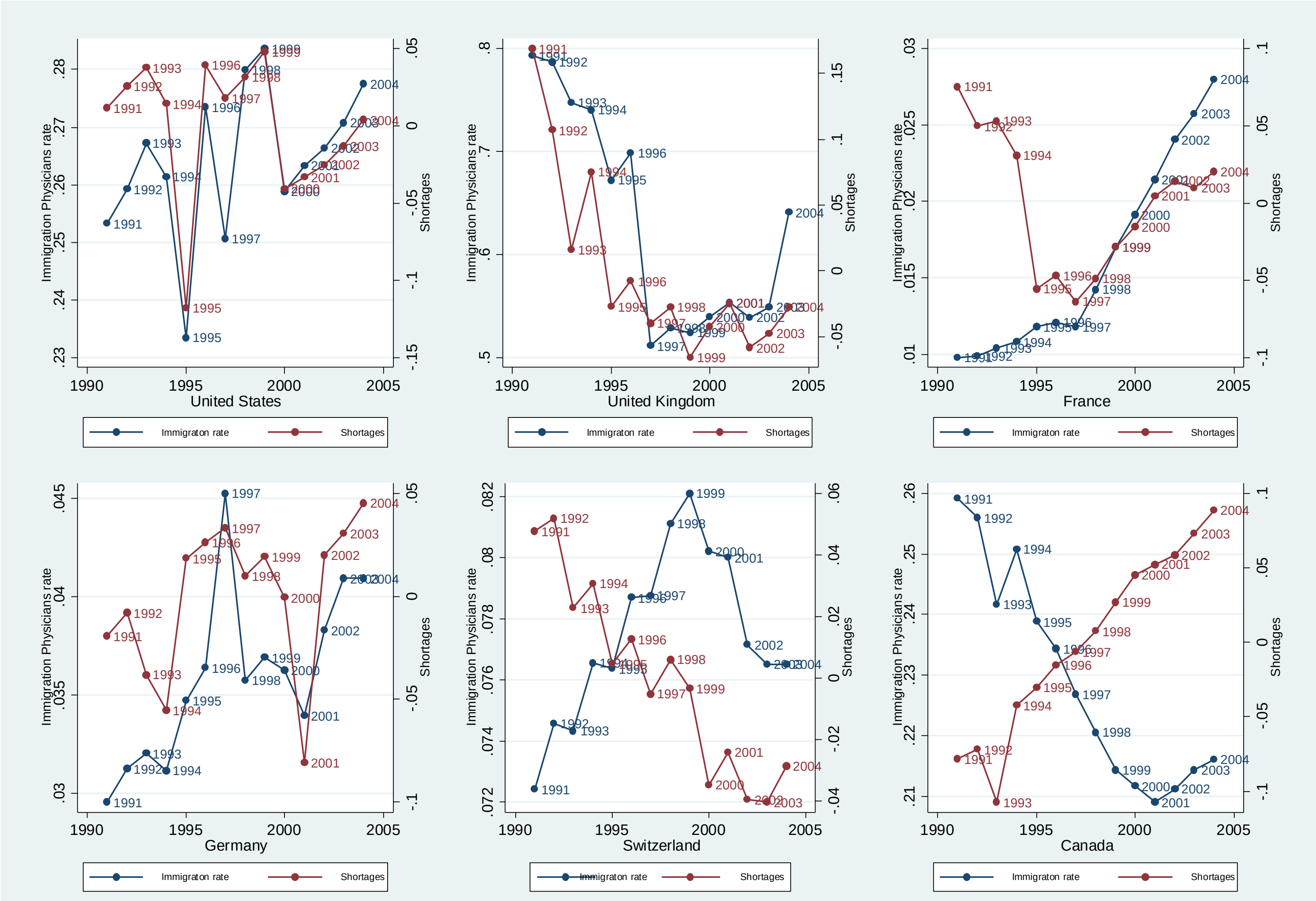
Nicholson, S. and C. Propper. 2011. "Medical Workforce," M. V. Pauly, T. G. McGuire and P. P. Barros, *Handbook of Health Economics.* North Holland,
OECD. 2013. "Health at a Glance 2013," *OECD Indicators.* Paris: OECD,
____. 2014. "Health Oecd Data," OECD,
____. 2007. "Immigrant Health Workers in Oecd Countries in the Broader Context of Highly Skilled Migration," OECD-SOPEMI, *International Migration Outlook 2007.* Paris: 161-228.
____. 2008. "The Looming Crisis in the Health Workforce, How Can Oecd Countries Respond?," *OECD HEALTH POLICY STUDIES.* OECD,
Pashigian, B.P. 1977. "The Market for Lawyers: The Determinants of the Demand for the Supply of Lawyers." *Journal of Law and Economics*, 20(1), 53-85.
Peterson, B.; S.S. Pandya and D. Leblang. 2013. "Doctors with Borders: Occupational Licensing as an Implicit Barrier to High Skilled Migration," U. o. Virginia,
Scheffler, R. M.; J. X. Liu; Y. Kinfu and M. R. Dal Poz. 2008. "Forecasting the Global Shortage of Physicians: An Economic- and Needs-Based Approach." *Bull World Health Organ*, 86(7), 516-23B.
Skeldon, R. 2009. "Of Skilled Migration, Brain Drains and Policy Responses." *International Migration*, 47(4).
Wanless, D. 2002. "Securing Our Future Health. Taking a Long Term View," London: H.M Treasury,
WHO. 2014. "Migration of Health Workers, Who Code of Practice and the Global Economic Crisis," S. A. and D. P. M.R., Geneva: World Health Organisation,
____. 2006. "Working Together for Health," W. H. Organization, *World Health Report.* Geneva: World Health Organization,
World Bank. 1993. "Investing in Health," O. U. Press, New York: World Bank,
Zellner, Arnold. 1962. "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias." *Journal of the American Statistical Association*, 57(298), 348-68.

Figure 4: Average density of medical graduates for the US, the UK, France, Germany, Switzerland and Canada between 1991 and 2012



Source : Authors' computations'

Figure 5: Average immigration rate of physicians for the US, the UK, France, Germany, Switzerland and Canada between 1991 and 2005



Source : Authors' computations'

Figure 6: Average emigration rate of physicians for the US, the UK, France, Germany, Switzerland and Canada between 1991 and 2005