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# 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

Shortage of physicians is a big challenge in many OECD countries. Policy makers try to tackle this issue by increasing the number of students entering medical school 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-trained 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. 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 term face an increasing emigration of their practicing physicians and recruit highly from abroad. IV estimations confirm the effect through the immigration strategy. Simulation results show the limits of only recruiting abroad in the long term but also point out its appropriateness, in the short term, where there is a recurrent cycle of shortage/surplus in the labour supply of physicians.

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

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

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# 1 Introduction

The international shortage of physicians is a major concern in developed countries around the world (Siyam and Dal Poz 2014). These shortages will probably increase over the coming decades due to the increase in population ageing which affects demand for but also the supply of health workers through retirement. The European Commission forecasts a shortage of one million health professionals in the EU around 2020 (WHO 2013). According to predictions, the US may face a deficit of 124,000 physicians by 2025 (AAMC 2008). In France, the density of physicians should decrease by around 10 per cent between 2006 and 2030 (Attal-Toubert and Vanderschelden 2009). In the UK, the shortage is likely to reach 20 per cent in 2020 (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.

In order to respond to shortages, governments generally consider three policy options. The first is to train a sufficient number of medical graduates able to replace the waning health workforce. The second is to recruit internationally a sufficient number of physicians trained abroad. The third is to increase the retention of the health workforce. Additional considerations have emerged regarding willingness to increase the productivity of the health workforce (through technology or additional staff) and to resolve the maldistribution between rural and urban areas (OECD 2016) but remain difficult to solve. However, these training, immigration and retention strategies take different times to enact. Given the duration of training in medical schools, the impact of increasing the number of medical students on the reduction of any shortage will be visible only between seven and 10 years after the decision is taken. This long-term policy cannot address immediately the shortage, and does not guarantee to address this issue in the long term either due to the uncertainty of predicting shortages.

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 as an adjustment policy, when the production of domestic doctors and nurses was not sufficient to respond to the current demand. Different tools have been implemented in OECD countries in this way: immigration points systems which act in ways favourable to physicians, the renewal of visas for health professionals, the appearance of health professionals on an occupational shortage list, bilateral agreements, and recognition of diplomas (OECD 2007, WHO 2013). Consequently, developed countries attract physicians, either coming from other developed or developing countries (Bhargava and Docquier 2007, Siyam and Dal Poz 2014). Currently, foreign-trained physicians represent on average 17.1 per cent of the physician workforce in OECD countries (OECD 2016). Around the year 2010, 37 per cent of the UK's registered doctors were trained abroad, as were 26 per cent of registered doctors in both Australia and the US, and in Canada, 22–24 per cent (Siyam and Dal Poz 2014).

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 shortage. Indeed, in all OECD countries, the number of places offered by medical schools each year is regulated by government (OECD 2008). This regulation could take the form of a fixed number of places being created at medical schools, based on predicted needs and political considerations (as in France, Belgium and Germany). Or it could also be explained by budget constraints which limit the number of training places offered by medical schools or hospitals (as in Australia, the UK and the US).

Traditionally, the motivations to regulate the number of graduates in the medical profession are several. First, in a context of financial constraints, the regulation of entrances into the medical profession could be viewed as a strategy for limiting government expenditure. This is explained by the fact that 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). 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 and to avoid any oversupply of physicians in the future. 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 to 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 (Nicholson and Propper 2011, Peterson et al. 2013)[6].

Even if these regulations are effective in controlling the quantity of physicians trained, they have had limited success in addressing the maldistribution of doctors between rural and urban areas and they do not allow adjustment in case of unpredicted shortage in the short term. Therefore, before any recruitment of physicians from abroad, an increase in the shortage of physicians is first supported in the short term by physicians who are already registered to practice in the country. Therefore, this additional health care delivery necessitated by episodes of shortage leads to additional work burden and potentially to the deterioration of working conditions for the physician workforce, and creates incentives for moving out of the health workforce either through periods of inactivity or emigration (Scheffler et al. 2008). This situation will likely be exacerbated by an increasing ageing of the overall population, which will in turn cause greater demands on the health service and cause more retirement of doctors in OECD countries (OECD 2007, 2008).

In the context of the regulation of physicians' supply and health workforce planning, it is important to understand how OECD governments react to an episode of shortage in the health sector. This paper fills this gap in the literature by addressing the following research questions: Do we observe any change in the number of medical graduates trained after an episode of shortage of physicians? And/or do we observe an increased recruitment of foreign-trained physicians to fill this shortage? Is there an emigration of physicians following the appearance of a shortage? How long does the expansion of medical school capacity take compared to the policy of overseas recruitment to address a shortage? 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?

So far, the literature has not investigated this issue because of an unclear definition of medical shortage and a lack of data either on medical graduates or on the migration of medical doctors (Diallo 2004). We take advantage of the shortage definition adopted by Scheffler et al. (2008), the release of the OECD (2014) health dataset and the Bhargava et al. (2011) dataset to fill this gap. 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 use the theoretical foundation developed by 'cobweb/pig cycle' theory (Ezekiel 1938) to explain the time delay adjustment between the demand and the supply of physicians.

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 data on foreign-

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[6] See table A1 in appendix for a description of the regulatory environment of medical education and immigration.

trained physicians are available. Our estimate confirms that the increase in the number of medical graduates responds to a shortage only on average seven years after its occurrence, whereas foreign-trained physicians arrive during the year in which the shortage has occurred. Our results show evidence of the emigration of practicing doctors when an episode of shortage persists. IV estimations conclude on a preference for recruiting migrant physicians and emigrating physicians instead of training and producing more medical graduates. Simulation results show the limitation of reducing the shortage only through immigration but point out its appropriateness during the cycle observed between shortage and surplus in the supply of physicians.

This paper begins in Section 2 by describing the theoretical background. Section 3 is devoted to the dataset used. Section 4 thoroughly documents the empirical model and strategy adopted. Section 5 presents the empirical results and Section 6 the simulation results. Section 7 reports the main conclusion.

# 2 Theoretical background

We start with a model of the physician labour market where the mismatch between the demand and labour supply implies linkages with the medical graduates and the foreign-trained doctors. We make a parallel between the physician labour market and the 'cobweb/pig cycle' model which explains the persistence of disequilibrium between the supply and the demand on the pig market (Coase and Fowler 1935, Ezekiel 1938, Kaldor 1934). Initially, this model was developed to explain the fluctuations in prices and quantity in agricultural markets (potatoes, pigs, bacon, etc.) and shows the persistence of cycles characterised by periods of underproduction (rise of price) and overproduction (drop in price). In applying this mechanism to the market of physicians, we make the assumption that the production of new medical graduates in response to a period of shortage, will occur with a time delay due to the duration of the medical training. We adapt this model to the case of physicians as Farber 1975 and Falch et al. 2009 have done for teachers, and as Pashigian (1977) has done for lawyers.

Our theoretical foundation is derived from Pashigian (1977) and adapted to the specificity of the 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 $E_t$.

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

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

New physicians in *t*, $N_t$, equal some proportion of students registered in medical school $\gamma$ 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 students and foreign-trained doctors who are recognised as physicians in the local labour market in *t*. $\varepsilon_t$ is a random variable and represents the stock of persons who have the skills to practice medicine, but who fail the examination procedure. $\varepsilon_t$ includes unrecognised foreign-trained physicians and students who have not graduated in time.

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

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 $L_t$:

$$LS_t = \alpha_1 + \alpha_2 P_t + \alpha_3 L_t + v_t \tag{2.3}$$

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

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 age) and a living standard index (the income elasticity of health is higher than one). $\varphi_t$ is a disturbance term.

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

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

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

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

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

Figure 1: The physician labour market

| 1a. Competitive labour market | 1b. Noncompetitive labour market |
|---|---|

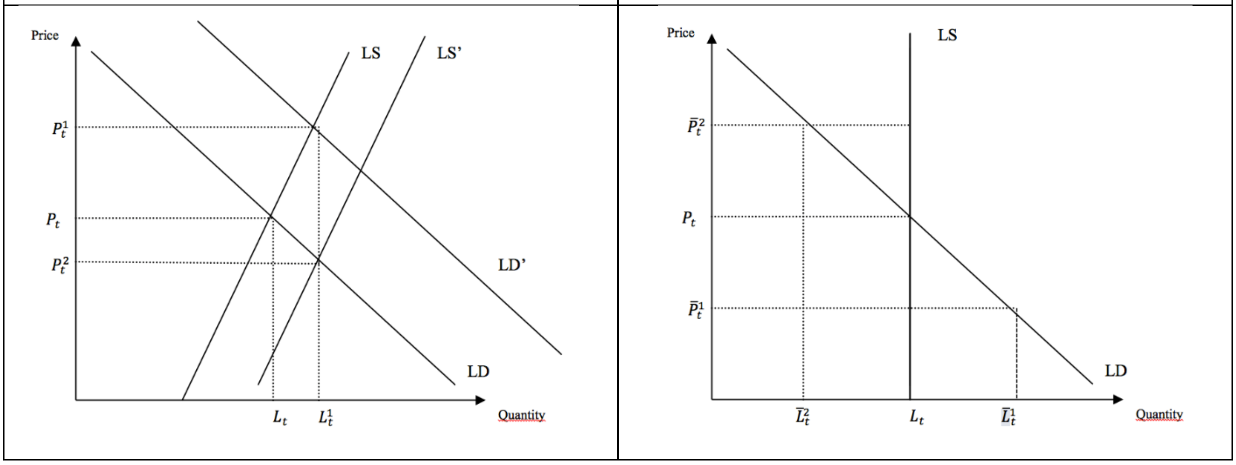



Figure 1a gives the basic intuition related to the functioning of the physician labour market. The *LS* curve represents the quantity of medical services supplied (equation 2.3) and the *LD* curve represents the demand for health services (equation 2.4). In the case of a competitive market, the price of medical services, $P_t$, is adjusted so as to ensure balance in the market. 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 ($P_t^2$). Any change in the degree of public support of health is reflected by a rightward shift of the demand curve ($LD'$)[7]. For a given price, this increase 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 ($P_t^1$).

The healthcare professional market is far from competitive. This market is characterised by several imperfections such as rigidity of prices, state regulation of the supply of physicians, information asymmetry between healthcare providers and patients as well as between insurance and insured, or between states and the medical workforce (Grignon et al. 2012, Nicholson and Propper 2011). These characteristics lead us to consider two assumptions in our theoretical model related to government intervention: (i) health services are provided at a fixed price, which is largely regulated. The rigidity of the price is essentially due to a decision taken by regulators in order to correct the imperfection and ensure access to health care for everyone; (ii) the supply of health services is perfectly inelastic to the health price (thus, the *LS* curve is vertical), due to extensive entry regulation for the profession (Figure 1b). Therefore the number of physicians allowed to practice each year is related to a political decision and not to the will of individuals.

Let us modify our purely competitive model in order to incorporate these specificities of the labour market of physicians. Contrary to the perfect competition situation, 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. Thus, the required number of physicians to ensure market equilibrium is derived from equation 2.5:

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

But the number of practitioners $L_t$ cannot adjust instantaneously, particularly due to the time required for training new doctors. Therefore, for all situations where the regulated price $\overline{P}_t$ is different from the market price $P_t$, adjustments take place on the quantities side. When $\overline{P}_t < P_t$, the health market is thus in a shortage position so that $L_t < \overline{L}_t$. In Figure 1, for a regulated price $\overline{P}_t^1$ lower than the equilibrium market price, $P_t$, the medical supply is too low so that the actual number of physicians, $L_t$ is not sufficient compared to that required to balance the market, $\overline{L}_t^1$. 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 so as to achieve $\overline{L}_t^1$. The whole question is then to know how long this adjustment will take. The preference for internal training of doctors or immigration will

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

have implications in terms of reaching (or not reaching) the equilibrium, in terms of the rapidity to converge to the equilibrium and in terms of creating fluctuations around the 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:

$$\overline{L_t} - L_t = \sigma(\overline{P_t} - P_t) \qquad \text{with } \sigma < 0 \tag{2.7}$$

Combining equation (2.6) and (2.7) and the condition on evolution of the physician population (equation (2.1) and (2.2)), we can then express the number of (national and foreign) doctors ( $ND_t = S_{t-\gamma} + M_t$) required in order to achieve a market equilibrium:

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

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 has a positive impact 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 in 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) in the market of physicians in OECD countries.

# 3 Data

In the literature, the definition of shortage is multiple and requires multiple pieces of information to measure it appropriately. Four different approaches have been identified to assess medical shortages (Bärnighausen and Bloom 2011):

(i) 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. However, this definition of shortage requires a great amount of information on the health status of the population to infer health service requirements and ignores the actual health care provision of the country (Bärnighausen and Bloom 2009). More critically, in developed countries, this definition is likely to predict a number of health workers lower than the current number observed, meaning that no shortage exists in developed countries (Cooper et al. 2003, Cooper 2004).

(ii) The demand approach is based on the estimated evolution of the population, their characteristics and income. This definition has the advantage of requiring less information than the previous methodology. Since Seale (1959), the literature emphasises the role of income and gross national income (GNI) as the main determinant of demand for healthcare (Cooper et al. 2003, Newhouse 1977, Scheffler et al. 2008). This approach presents the benefits of providing a baseline scenario about health worker requirements, on which governments can adjust their policy.

(iii) The service targets approach consists of dividing the need in the health sector into objectives that should be attained for different health services. Based on these objectives, the number of health professionals is estimated by taking into account the constraints that the country is facing. This approach is appropriate in a context of limited budget where a government needs to maximise the impact of each intervention (Bärnighausen and Bloom 2009). However, it is rare that the health worker requirement matches perfectly the demand for services predicted.

(iv) The population ratio approach (the most popular) is based on the ratio of health professionals to population (WHO 2006). The objective of this approach is to reach a certain threshold of density in the near future in order to deliver a certain health outcome. To give two such examples, the World Bank calculations have shown that 0.1 physicians per 1,000 people is required to deliver essential clinical interventions (World Bank 1993). The World Health Organization has advocated the threshold of 2.5 health workers to ensure a coverage rate of 80 per cent for deliveries by skilled birth attendants and measles immunisation (WHO, 2006). The popularity of this approach is based on the fact that this ratio is easily measurable across countries and allows cross-country comparison even if it neglects geographical disparities (Bärnighausen and Bloom 2009).

In this paper, we assume that healthcare expenditures are a function of real per capita gross domestic product. For that purpose, we follow the methodology of Scheffler et al. (2008) which uses the demand approach to predict the density of physicians per 1,000 people. Then, by comparing this prediction to the actual density of physicians, we are able to determine whether the prediction is filled by the current density or not. Among the determinants of the demand for health care, many papers highlight that the gross domestic product (GDP) or the gross national income (GNI) are the best predictors of the demand for healthcare (Cooper et al. 2003, Newhouse 1977, Scheffler et al. 2008). Indeed, two main reasons are given in the literature as to why a bilateral relationship between healthcare expenditures and real per capita income could exist. First, by definition, health expenditures are a function of resources available (i.e. GDP). Second, a reverse causation – income as a function of health expenditures – also has a theoretical background due to the fact that health expenditure is a determinant of human capital (Grossman, 1972), labour supply (Erdil and Yetkiner, 2009) and thus economic growth (Lucas, 1988). We, thus, follow the literature by defining the demand as the following:

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

Where $\text{Predicted Physicians per 1000}_{j,t}$ expresses the prediction of the density of doctors derived from the projection of the $\text{GDP per capita}_{j,t}$, $\varphi_j$ is country-fixed effects, $\varepsilon_{j,t}$ is the disturbance term, $\alpha_0$ and $\alpha_1$ are parameters to be estimated. In order to control for the fact that GDP per capita over time could be volatile, we use the Hoddrick-Prescott filter in order to exclude the 'cyclical' from the 'structural' part of the GDP growth (Hoddrick and Prescott 1997). Because we are using annual data, we use the HP smoothing parameter equal to 6.25 as recommended by Ravn and Uhlig (2002).[8]

Table 1 and Figure 2 report the estimation of equation (3.1) where density of physicians is explained by the GDP per capita (in USD in purchasing power parity (PPP)) with country fixed effects.

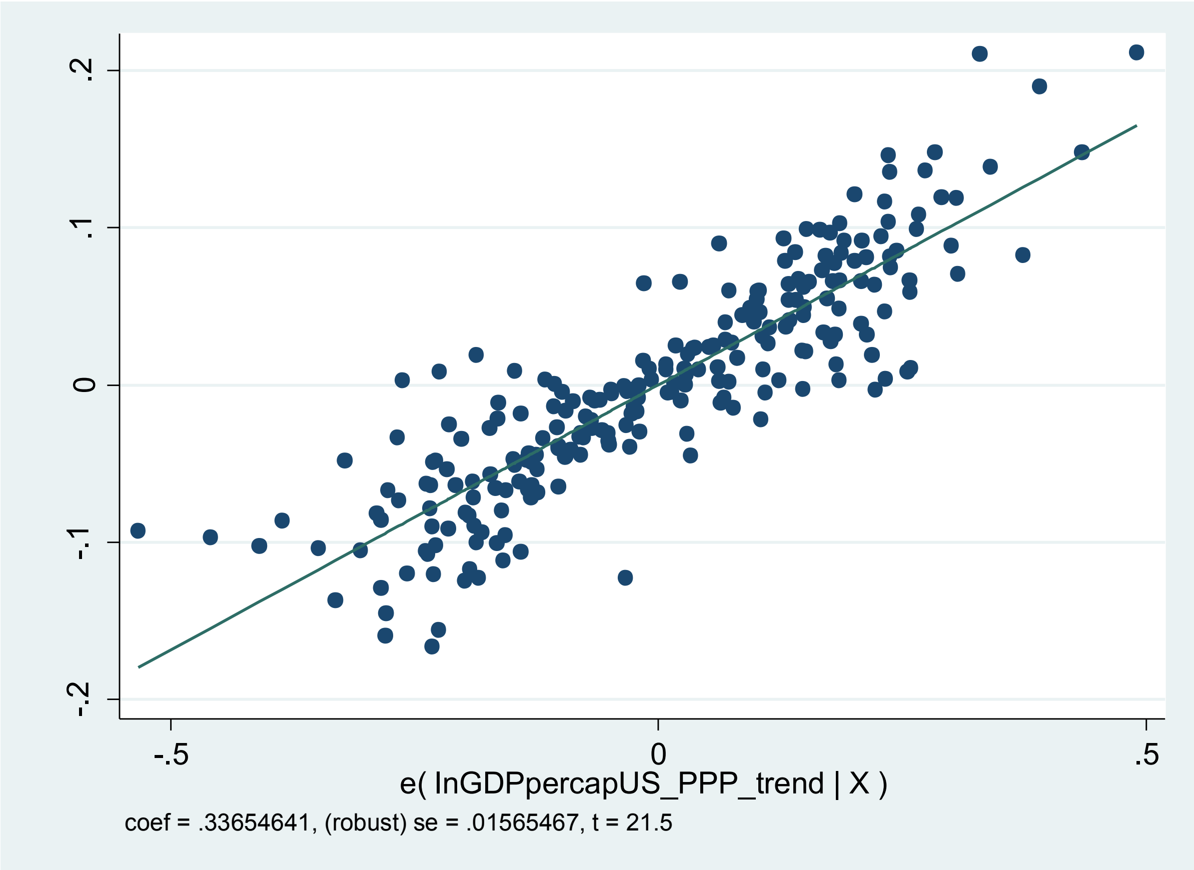
Table 1: OLS estimation of density of physicians by GDP per capita

| | (1) |
|---|---|
| | OLS |
| VARIABLES | Ln(physician density 1000) |
| | |
| Ln(GDP per cap) | 0.337*** |
| | (0.0157) |
| Constant | -2.152*** |
| | (0.151) |
| | |
| Observations | 238 |
| R-squared | 0.985 |
| j | YES |
| t | NO |

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

[8] Our results are robust to different values of the smoothing parameter. Robustness checks are available from the authors on request.

Figure 2: Correlation between GDP per capita and density of physicians per 1,000 people




These results are close to what Scheffler et al. (2008) find in their paper, where the coefficient associated with the GDP per capita is equal to 0.237 and the R-squared is 0.974.[9] Then, we compare this predicted demand (predicted density ratio) with the actual supply (observed density ratio) which reveals the situation of the medical labour market. For that purpose, we define the shortage/surplus in a country *j* at time *t* in the following way:

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

where $\text{Predicted Physicians per } 1000_{j,t}$ expresses the prediction of the density of doctors derived from the previous equation. If $\text{Shortage}_{j,t} > 0$, the demand for physicians is higher than the observed medical density. It reveals a situation of shortage in the countries. On the other hand, if $\text{Shortage}_{j,t} < 0$, it reveals a physician surplus in the healthcare market[10].

[9] As robustness checks, we added additional variables as determinants of demand for health: age dependency ratio has been added in order to capture population ageing and the number of GP consultations as a proxy for health consumption. The inclusion of these two variables does not change the R-squared and are significant only at 10 per cent. We also constructed our shortage variables by using the GDP lagged by five years. This estimation provides the same results except that the adjustment through medical graduates is visible since the year t (which corresponds to the five-year delay found in our results). Results are available upon request.

[10] This approach is based on a country level analysis and neglects potential asymmetries of shortage at a finer level. Therefore, computation of shortage at the regional level and specialisation level is difficult because of the lack of data in OECD countries.

Turning now 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 tools used by OECD governments to potentially reduce shortages is to attract from abroad physicians who are 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 reregister. Second, focusing on country of training avoids considering physicians born outside but educated within the destination countries. Third, the definition of education allows us to control 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 (Bhargava et al. 2011).

Our data on the international migration of physicians comes from Bhargava et al. (2011). 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 one non-OECD country (South Africa). For the purpose of our paper, we focus 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 its specific role as an important regional medical training centre in Southern Africa.

This dataset reports the stock of foreign-trained physicians annually. Ideally, flows data would be more suitable for our analysis as they capture the entry of foreign physicians from abroad. 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. Indeed, entry could be due to becoming active following a break, and exit may be related to deaths or a period of inactivity. 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 (Beine et al. 2011). For this reason, we prefer to define immigration and emigration in rates instead of flows:

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

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.

The emigration rate is defined as follows:

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

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.

In the appendix of this paper, we report correlation between shortages and respectively medical graduates, immigration rate and emigration rate for each country in our sample.

# 4 The econometric model and framework

Our research question focuses on the linkage between the dynamics of the shortage and the policy 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 a set of equations to estimate:

$$Ln\left[\left(\frac{\text{Medical graduates}}{\text{Physicians}} * 1{,}000\right)_{j,t+\gamma}\right] = \alpha_0 + \alpha_1 \text{ Shortages}_{j,t} + \alpha_2 \; Ln(\text{X}_{j,t}) + \text{FE}_j + \text{FE}_t + \nu_{j,t} \qquad (4.1)$$

$$Ln \; (1 + \text{Immigration rate}_{j,t}) = \beta_0 + \beta_1 \text{ Shortages}_{j,t} + \beta_2 \; Ln \; (\text{X}_{j,t}) + \text{FE}_j + \text{FE}_t + \eta_{j,t} \qquad (4.2)$$

$$Ln \; (1 + \text{Emigration rate}_{i,t}) = \chi_0 + \chi_1 \text{ Shortages}_{i,t} + \chi_2 \; Ln \; (\text{X}_{i,t}) + \text{FE}_i + \text{FE}_t + \mu_{i,t} \qquad (4.3)$$

with $i$ referring to origin country, $j$ to the receiving country and $t$ to time dimension.

In these equations, we estimate respectively the graduates (equation 4.1), the immigration (equation 4.2) and the emigration rate (equation 4.3) by the shortages of physicians. 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 $\gamma$, the immigration rate and the emigration rate, all expressed in logarithmic terms. We include *1+variable* in the case of immigration and emigration in order to keep the zero in the dataset. The medical graduates' data have been collected from the OECD Health statistics (2014). The variable in which we are interested is the shortage of physicians which is, as previously mentioned, 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 of at least 65 years and the number of persons between 15 and 65 years old (World Population Prospect, UNDP 2012), the GDP per capita in USD in PPP (World Development Indicators), and the social expenditure per capita in the public sector in USD in PPP which refers to the generosity of the welfare system (OECD Health statistics). In the graduate model, the school enrolment in secondary and tertiary education expressed as gross (World Development Indicators) are introduced as controls because it captures the adjustment of places in medical training due to the arrival of a young cohort in the educational system. In the immigration and emigration equations, two controls capture the changes in immigration policy, one capturing the magnitude and another capturing the restrictiveness of immigration policy for high-skilled individuals (DEMIG 2015). $\nu_{j,t}$, $\eta_{j,t}$ or $\mu_{i,t}$ are the error terms. Due to the panel structure, several dummy variables are included in 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 geography and some shocks inherent to a particular year. All explanatory and dependent variables are expressed in logarithmic form, which induces a log-log specification. In terms of interpretation of results, coefficients should be read as elasticity. All standard errors are clustered over the destination time dimension.

In the previous methodology, each model is separately estimated which assumes that no potential correlation exists between the decision to produce more medical graduates and the immigration and emigration patterns during a period of shortage. However, the appearance of a shortage can simultaneously affect the number of graduates, the recruitment of immigrants and the retention of doctors in the medical workforce at 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. As a second stage, we consider these equations as simultaneously related through the methodology developed by Arnold Zellner (1962) named Seemingly Unrelated Regression Equations (SURE), in which correlations of error terms are assumed across equations.

Another 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 increased following a long time delay (at least five years). Or it could be driven by omitted variables, which is the most likely source of the endogeneity issue. Any variables potentially correlated with our dependent variables and with shortage variables could be elected as omitted variables. In order to mitigate this bias, we use the Two Stage Least Square (2SLS) approach, as a final stage. This methodology requires valid instruments, which are variables that explain the shortage variable without any direct link with our dependent variables. In our case, two sets of instruments are considered: the ageing of the physician workforce and the regional density, in remote areas particularly.

The first instrument used is the age dependency ratio for the physicians' profession. By using the OECD Health statistics, we collect data about the proportion of physicians by age group. By using some extrapolations based on the same trend observed after 1997, we are able 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 also affected the physicians' profession. Therefore, an ageing physician population would probably lead to an increase of the retirement of physicians in the future and will affect probably the level of physician shortage.

The second set of instruments is the local density of physicians within a country. Two variables are computed for that purpose. First, the rural density ratio of physicians, which is the average number of physicians over the last three years over the population living in rural areas. Second, the lowest density of physicians in each country which proxies the most severe shortage observed in a region of this country. This indicator has been collected from the OECD's 'Region at a Glance' reports over the period and extrapolated for the missing years. These two instrumental variables capture the density of physicians within each country at a regional level. Therefore, a low national density of physicians means that the access to physician services is probably caused by local shortages of physicians in some specific (rural) areas.

# 5 Empirical results

In this section, we run econometric regressions to analyse 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+3 and t+4 (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 statistically significant only at 10 per cent in T+3 and T+4 but it becomes more significant and positive after at least five years (from T+5 until T+9).

As explained by the pig cycle/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. The magnitude of the coefficient when the average medical graduates is between t+5 and t+7 is 0.71 which means an increase of 10 per cent of the shortage indicator in time *T* corresponds to a rise of 7.1 per cent in the average proportion of medical graduates (in the population of physicians) five to seven years later. This coefficient increases to 7.3 per cent for graduates who reached qualification after eight and nine 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 expresses the selection that occurs when entering medical schools whereas secondary enrolment shows that the number of places in medical schools tends to adjust to the size of the forthcoming new cohort of students.

Age dependency ratio is negatively correlated with no significance with the proportion of medical students graduating between five and seven years later but significantly positive with those graduating at least eight 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 8.6 per cent in the average medical graduates produced between eight and nine 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 entire period.

Table 3 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) and 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 took seven years, whereas the recruitment of foreign-trained physicians' response is effective immediately (Column 1), or at least one year (Column 2) after the shortage.

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

| | (1) | (2) | (3) |
|---|---|---|---|
| | OLS | OLS | OLS |
| | Average over t+3 and t+4 | Average over t+5, t+6 and t+7 | Average over t+8 and t+9 |
| VARIABLES | Ln(Graduates) | Ln(Graduates) | Ln(Graduates) |
| | | | |
| (Shortage)t | 0.584* | 0.714*** | 0.731*** |
| | (0.333) | (0.265) | (0.269) |
| Ln(Tertiary school enrolment)t | -0.188* | -0.241*** | -0.148* |
| | (0.0996) | (0.0780) | (0.0835) |
| Ln(Secondary school enrolment)t | 0.255* | 0.245** | 0.137 |
| | (0.140) | (0.110) | (0.114) |
| Ln(Population)t | -2.220** | -2.399*** | -1.664** |
| | (1.052) | (0.743) | (0.710) |
| Ln(Age dependency)t | -1.542*** | -0.434 | 0.857*** |
| | (0.389) | (0.324) | (0.325) |
| Ln(GDP per cap)t | -0.537 | 0.298 | 1.137*** |
| | (0.340) | (0.247) | (0.278) |
| Ln(Social expenditure per cap)t | 0.998*** | 0.680*** | 0.269** |
| | (0.192) | (0.142) | (0.130) |
| Constant | 40.77** | 40.24*** | 22.85* |
| | (20.24) | (14.35) | (13.50) |
| | | | |
| Observations | 222 | 228 | 224 |
| R-squared | 0.792 | 0.850 | 0.857 |
| j | YES | YES | YES |
| t | YES | YES | YES |
| Cluster | jt | jt | jt |

Table 3: OLS estimation of foreign-trained inflows of physicians by different lags of shortages

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| | OLS | OLS | OLS | OLS | OLS | OLS | OLS | OLS |
| VARIABLES | Ln(IMR) | Ln(IMR) | Ln(IMR) | Ln(IMR) | Ln(EMR) | Ln(EMR) | Ln(EMR) | Ln(EMR) |
| | | | | | | | | |
| (Shortage)t | 0.126*** | | | | 0.163*** | | | |
| | (0.0442) | | | | (0.0318) | | | |
| (Shortage)t-1 | | 0.0453 | | | | 0.137*** | | |
| | | (0.0441) | | | | (0.0380) | | |
| (Shortage)t-2 | | | -0.0159 | | | | 0.130*** | |
| | | | (0.0423) | | | | (0.0449) | |
| (Shortage)t-3 | | | | -0.0859* | | | | 0.107** |
| | | | | (0.0479) | | | | (0.0519) |
| Ln(Population)t | -0.0259 | 0.0906 | 0.232** | 0.346*** | -0.880*** | -0.892*** | -0.908*** | -0.847*** |
| | (0.0911) | (0.102) | (0.108) | (0.121) | (0.0947) | (0.114) | (0.139) | (0.166) |
| Ln(Age) dependency)t | 0.0154 | 0.0599 | 0.105*** | 0.118*** | -0.0810*** | -0.0708** | -0.0593* | -0.0424 |
| | (0.0370) | (0.0382) | (0.0367) | (0.0370) | (0.0284) | (0.0306) | (0.0333) | (0.0353) |
| Ln(GDP per cap)t | 0.0408 | 0.0514 | 0.0706** | 0.0821** | -0.0428* | -0.0348 | -0.0221 | -0.0115 |
| | (0.0327) | (0.0350) | (0.0343) | (0.0348) | (0.0222) | (0.0236) | (0.0269) | (0.0296) |
| Ln(Social expenditure per cap)t | -0.0185 | -0.0400** | -0.0643*** | -0.0771*** | -0.0243** | -0.0279** | -0.0340** | -0.0374** |
| | (0.0179) | (0.0188) | (0.0184) | (0.0215) | (0.0114) | (0.0131) | (0.0152) | (0.0173) |
| (Immig change level)t | 0.00335*** | 0.00448*** | 0.00527*** | 0.00432*** | -0.00237 | -0.00224 | -0.00156 | 1.89e-05 |
| | (0.00119) | (0.00125) | (0.00128) | (0.00123) | (0.00151) | (0.00168) | (0.00167) | (0.00198) |
| (Immig restrictivness)t | 0.0107*** | 0.0124*** | 0.0119*** | 0.00875** | -0.00393 | -0.00326 | -0.00281 | 0.00194 |
| | (0.00332) | (0.00364) | (0.00367) | (0.00339) | (0.00373) | (0.00417) | (0.00409) | (0.00528) |
| Constant | 0.354 | -1.570 | -4.254** | -5.297*** | 14.61*** | 17.79*** | 18.12*** | 13.58*** |
| | (1.278) | (1.839) | (2.026) | (1.879) | (1.424) | (2.108) | (2.591) | (2.431) |
| | | | | | | | | |
| Observations | 237 | 220 | 203 | 186 | 237 | 220 | 203 | 186 |
| R-squared | 0.993 | 0.994 | 0.995 | 0.996 | 0.989 | 0.988 | 0.988 | 0.988 |
| 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 4: SURE estimations

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | SURE | SURE | SURE | SURE | SURE | SURE |
| VARIABLES | Ln(Graduates) | Ln(IMR) | Ln(EMR) | Ln(Graduates) | Ln(IMR) | Ln(EMR) |
| | Average | | | Average | | |
| | over t+5, t+6 and | | | over t+8, t+9 and t+7 | | |
| | | | | | | |
| (Shortage)t | 0.673** | 0.0937*** | 0.170*** | 0.612** | 0.0878*** | 0.177*** |
| | (0.269) | (0.0297) | (0.0287) | (0.264) | (0.0280) | (0.0277) |
| Ln(Tertiary enrolment)t | -0.334*** | | | -0.275*** | | |
| | (0.0791) | | | (0.0800) | | |
| Ln(Secondary Enrolment)t | 0.206* | | | 0.182* | | |
| | (0.106) | | | (0.105) | | |
| Ln(Population)t | -2.766*** | 0.0132 | -0.871*** | -2.001*** | 0.0483 | -0.941*** |
| | (0.721) | (0.0748) | (0.0725) | (0.655) | (0.0690) | (0.0682) |
| Ln(Age dependency)t | -0.479* | 0.0227 | -0.0755*** | 0.817*** | 0.0509* | -0.0936*** |
| | (0.259) | (0.0285) | (0.0277) | (0.264) | (0.0292) | (0.0289) |
| Ln(GDP per cap)t | 0.340 | -0.0579** | -0.0123 | 1.161*** | -0.0355 | -0.0187 |
| | (0.228) | (0.0252) | (0.0244) | (0.227) | (0.0246) | (0.0243) |
| Ln(Social exp cap)t | 0.735*** | -0.0233* | -0.0337*** | 0.335*** | -0.0204* | -0.0271** |
| | (0.122) | (0.0130) | (0.0126) | (0.114) | (0.0120) | (0.0119) |
| (Immig change level)t | | 0.00275*** | -0.00245** | | 0.00285*** | -0.00241** |
| | | (0.00104) | (0.00101) | | (0.000980) | (0.000991) |
| (Immig restrict)t | | 0.00915*** | -0.00385 | | 0.00971*** | -0.00406* |
| | | (0.00255) | (0.00246) | | (0.00244) | (0.00247) |
| | | | | | | |
| Constant | 46.98*** | 0.882 | 17.26*** | 28.87** | -0.0226 | 18.61*** |
| | (13.84) | (1.446) | (1.401) | (12.45) | (1.318) | (1.304) |
| | | | | | | |
| Observations | 227 | 227 | 227 | 223 | 223 | 223 |
| R-squared | 0.846 | 0.995 | 0.979 | 0.853 | 0.995 | 0.984 |
| i | YES | YES | YES | YES | YES | YES |
| t | YES | YES | YES | YES | YES | YES |
| Cluster | it | it | it | it | it | it |

The coefficient of shortage is positive and statistically significant at 1 per cent level in t and at 10 per cent level in t-1 (Column 2). The magnitude is 0.126 for t and 0.045 for t-1. In other words, a 10 per cent increase of the shortage in t is associated with a rise of 1.26 per cent of the immigration rate of physicians in T. This effect decreases to 0.45 per cent a year later and then nothing is significant after one year delay except that in t-3, the shortage becomes negative. This suggest that the immigration response to a shortage is positive in the short term and pursuing this approach in turn avoids the need to recruit from abroad in the coming years. The results for the emigration rate of physicians (Columns 5–8) shows that emigration is always linked to the shortages even after the episode. The coefficient of shortage t (Column 5) is significantly positive at about 0.163. In other words, increasing the shortage by 10 per cent in t will push up the emigration rate of physicians by 1.63 per cent. 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 response of the immigration approach stops when the shortage is lagged after t-1, the response of the emigration approach continues throughout 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 in turn incentivises them to move abroad continuously.

Table 4 reports the SURE estimations when we consider that new graduates, immigration and retention policies are simultaneously connected. Columns 1–3 report the results for the simultaneous model when the graduates are average over t+5 and t+7 whereas Columns 4–7 report the same results but when graduates are average over t+8 and t+9. Even in the presence of correlation between error terms, our results confirm our previous findings.

Table 5 describes the IV results when the 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 positive for each model, however for the graduate models, the magnitude of the coefficient becomes insignificant. In other words, the IV estimations show a clear preference for government towards migration policy instead of training more physicians through medical schools. The magnitude of the coefficients associated with immigration and emigration are now higher for the immigration (0.132) than for emigration (0.101). In other words, in a period of shortage, policy makers prefer to recruit more physicians from abroad compared to training more people in medical schools and of a sufficient magnitude in order to compensate for those who emigrate. Shortage is negatively correlated with density of coverage in rural areas but positively correlated with the ageing of physicians. A high regional density of doctors means that healthcare access is easy for everyone whatever their location (rural versus urban areas) and so less shortage is observed particularly in remote areas, whereas an ageing population of physicians increases the need for healthcare and drives up the shortage.

Table 5: IV estimations with shortage considered as endogenous

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| | 2SLS | 2SLS | 2SLS | 2SLS | 2SLS | 2SLS | 2SLS | 2SLS |
| | Sec Stage | First Stage | Sec Stage | First Stage | Sec Stage | First Stage | Second Stage | First Stage |
| VARIABLES | Ln(Grad t+5) | Shortage | Ln(Grad t+8) | Shortage | Ln(IMR) | Shortage | Ln(EMR) | Shortage |
| | | | | | | | | |
| (Shortage)t | 0.111 | | 0.272 | | 0.132** | | 0.101** | |
| | (0.528) | | (0.519) | | (0.0585) | | (0.0418) | |
| Ln(Tertiary enrolment)t | -0.252*** | -0.0415** | -0.274*** | -0.0659*** | | | | |
| | (0.0692) | (0.0196) | (0.0786) | (0.0215) | | | | |
| Ln(Secondary enrolment)t | 0.239** | 0.0563*** | 0.273*** | 0.0701*** | | | | |
| | (0.0931) | (0.0206) | (0.0994) | (0.0214) | | | | |
| Ln(Population)t | -1.103 | 1.732*** | -0.298 | 1.480*** | 0.171* | 1.727*** | -0.810*** | 1.810*** |
| | (0.964) | (0.181) | (0.800) | (0.181) | (0.0930) | (0.110) | (0.120) | (0.125) |
| Ln(Age dependency)t | -0.567 | 0.556*** | 0.0283 | 0.516*** | -0.0428 | 0.625*** | -0.0867*** | 0.613*** |
| | (0.398) | (0.0600) | (0.303) | (0.0684) | (0.0341) | (0.0597) | (0.0304) | (0.0596) |
| Ln (GDP per cap)t | 0.446 | 0.234*** | 0.520* | 0.164** | -0.180*** | 0.217*** | -0.0206 | 0.253*** |
| | (0.371) | (0.0600) | (0.315) | (0.0660) | (0.0370) | (0.0639) | (0.0304) | (0.0672) |
| Ln (Social exp cap)t | 0.163 | -0.162*** | 0.322** | -0.127*** | 0.0437* | -0.206*** | -0.0580*** | -0.146*** |
| | (0.197) | (0.0360) | (0.146) | (0.0390) | (0.0257) | (0.0384) | (0.0191) | (0.0403) |
| (Immig change level)t | | | | | 0.00245** | 0.00305 | -0.00243 | 0.00284 |
| | | | | | (0.00111) | (0.00264) | (0.00162) | (0.00259) |
| (Immig restrict)t | | | | | 0.00720** | 0.00799 | -0.00524 | 0.00755 |
| | | | | | (0.00290) | (0.00647) | (0.00403) | (0.00654) |
| Ln(Physician dependency)t | | 0.0788*** | | 0.0903*** | | 0.0857*** | | 0.0821*** |
| | | (0.0133) | | (0.0149) | | (0.0153) | | (0.0142) |
| Ln(Physician 3last years/rural)t | | -0.149*** | | -0.122*** | | | | -0.149*** |
| | | (0.0369) | | (0.0365) | | | | (0.0346) |
| Ln(lowest local density)t | | | | | | -0.0197*** | | |
| | | | | | | (0.00642) | | |
| Constant | 17.79 | -34.57*** | 0.878 | -29.12*** | -1.589 | -33.08*** | 16.35*** | -36.25*** |
| | (19.86) | (3.653) | (16.36) | (3.593) | (1.889) | (2.062) | (2.312) | (2.487) |
| | | | | | | | | |
| Observations | 194 | 194 | 188 | 188 | 181 | 181 | 195 | 195 |
| R-squared | 0.834 | | 0.855 | | 0.997 | | 0.962 | |
| i | 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 | | 0.553 | | 2.232 | | 0.649 | | 0.616 |
| P-Value (Hansen Test) | | 0.457 | | 0.135 | | 0.421 | | 0.432 |
| Kleibergen-Paap Test | | 26.31 | | 26.28 | | 22.88 | | 22.92 |

# 6 Simulation

In this part, we run some simulations on our estimated coefficients. Our main objective is to provide evidence on the reaction of our three main variables of interest (e.g. number of trained doctors, immigrant doctors and emigrant doctors) to the observed or simulated evolution of the surplus/shortage in the labour market. In order to do this, we use the elasticities for the medical graduates, immigration and emigration variables previously estimated in Tables 2 and 3. These elasticities indicate the reaction of the medical graduates, the immigration and emigration rates relative to the shortage-surplus situation of a country. Our previous econometric estimations highlight: (i) an instantaneous positive effect of shortage on the immigration rate, (ii) a negative time-persistent effect of the emigration rate, and (iii) a time delay response through the recruitment of medical graduates response. Therefore, our shortage-surplus indicator produces short run effect via the immigration rate whereas persistent adjustment over time appears through the emigration rates and medical graduates.

What would have been the situation of numbers of physicians if none of these components (trained, immigrant and emigrants) had reacted to the situation of surplus-shortage in the physician labour market? Do changes in graduated, immigrant and emigrant rates mitigate or accentuate the observed imbalance in the physician labour market? Should one of the three instruments be privileged in the management of the short-term and long-term physician labour market? To deal with these questions, we build a simple dynamic model giving the endogenous evolution of the number of doctors ( $L_{j,t}$ ) in each country of our sample based on an adapted version of equation 1 of our theoretical framework:

$$L_{j,t} = (1 - d_{j,t})\left[L_{j,t-1} + S_{j,t-\gamma} + M_{j,t} - E_{j,t}\right] \tag{6.1}$$

where $S_{j,t-\gamma}$ designates the number of students registered in medical school $\gamma$ years before, $M_{j,t}$ the number of immigrant doctors, $E_{j,t}$ the number of emigrant doctors and $d_{j,t}$ is the depreciation rate related to the death or inactivity of physicians.

Indeed, if the elasticities presented in Tables 2 and 3 provide several features of the average instantaneous impact of the observed situation on the physician labour market, it should be understood here that the effects are dynamic and cumulative. Dynamic refers to the fact that changes in the number of immigrants, graduates and emigrants, induced by a surplus-shortage situation in a given year, will change our surplus-shortage indicator for each following year. Therefore, the effects are cumulative in the sense that the adjustment in the number of immigrants, for example, will influence the number of trained doctors or emigrants. Moreover, when the stock of immigrants and emigrants reacts in an immediate way to changes in the shortage-surplus indicator, the number of trained doctors reacts with some delay according to the estimated elasticities used.

In a first step, our data allow us to assign a value, for each country and each year, to the depreciation coefficient $d_{j,t}$ . Then, for the OLS estimated values of the elasticities $\alpha_t$ , $\beta_t$ and $\chi_t$ (Tables 2 and 3) [11], we compute the hypothetical evolution of the number of doctors in the absence of reaction of the number of trained, immigrant and emigrant doctors normally induced by the surplus-shortage indicator. We then relax this assumption by neutralising each of the three variables independently so as to decompose the overall effect. In other words, we first look at the evolution of doctors without any adjustment and then we isolate the absence of the reaction of graduates, immigrants and

[11] We only retain values of $\alpha_1$ , $\beta_1$ and $\chi_1$ when these estimated coefficients are highly significant.

emigrants successively. The number of trained, immigrant and emigrant doctors are endogenously calculated for each country assuming our shortage-surplus indicator would not affect these stocks:

$$S_{j,t}^{cf} = \frac{Med\_rate_{t,j}^{cf}}{(1+\alpha_{1,t}\cdot Shortages_{j,t}^{cf}+\alpha_{1,t-1}\cdot Shortages_{j,t-1}^{cf}+...+\alpha_{1,t-\gamma}\cdot Shortages_{j,t-\gamma}^{cf})}L_{t,j}^{cf} \quad (6.2)$$

$$M_{j,t}^{cf} = \frac{immig\_rate_{t,j}^{cf}}{(1+\beta_{1,t}\cdot Shortages_{j,t}^{cf}+\beta_{1,t-1}\cdot Shortages_{j,t-1}^{cf}+...+\beta_{1,t-\gamma}\cdot Shortages_{j,t-\gamma}^{cf})}L_{t,j}^{cf} \quad (6.3)$$

$$E_{j,t}^{cf} = \frac{emig\_rate_{t,j}^{cf}}{(1+\chi_{1,t}\cdot Shortages_{j,t}^{cf}+\chi_{1,t-1}\cdot Shortages_{j,t-1}^{cf}+...+\chi_{1,t-\gamma}\cdot Shortages_{j,t-\gamma}^{cf})}L_{t,j}^{cf} \quad (6.4)$$

with $S_{j,t}^{cf}$, $M_{j,t}^{cf}$ and $E_{j,t}^{cf}$ designating respectively the counterfactual ($cf$) stocks of trained, immigrant and emigrant physicians in the case of a total lack of effect of the shortage-surplus indicator ($Shortages_{j,t}^{cf}$) on the labour market. Since our estimated elasticities include the effects of observed imbalances on the physician labour market on medical graduate rates ($Med\_rate_{t,j}^{cf}$), immigration rates ($immig\_rate_{t,j}^{cf}$) and emigration rates ($emig\_rate_{t,j}^{cf}$), so here we calculate what would have been virtually these rates in the absence of adjustment. The counterfactual evolution of these three factors

($S_{j,t}^{cf}$, $M_{j,t}^{cf}$ and $E_{j,t}^{cf}$) allows us to determine how the physician stock would have virtually evolved in each country in the absence of adjustment to the situation of shortage-surplus on the physician labour market:

$$L_{j,t}^{cf} = (1-d_{j,t})\left[L_{j,t-1}^{cf}+S_{j,t}^{cf}+M_{j,t}^{cf}-E_{j,t}^{cf}\right] \quad (6.5)$$

as well as the counterfactual surplus-shortage indicator:

$$\text{Shortage}_{j,t}^{cf} = Ln(\frac{L_{j,t}^{predic}}{1000}) - Ln(\frac{L_{j,t}^{cf}}{1000}) \quad (6.6)$$

Figure 3 gives the results of this counterfactual dynamic experiment for all countries. The black bold line of each figure corresponds to the current evolution of each of our variables of interest between 1991 and 2004. Thus, we observe (Figure 3a) that over the period considered, our countries successively alternate between periods of shortage (between 1991 and 1993 and between 1999 and 2002) and surplus (between 1994 and 1998 and between 2003 and 2004). The total number of physicians (Figure 3b) continuously increases on the period (+30%). The number of trained doctors tends to decrease significantly between 1991 and 2001, from about 56,000 to 51,100 (-9%) and increase slightly (+4%) in the following years (Figure 3e). The number of immigrant doctors (Figure 3c) grows continuously over the period from 284,000 to 407,000 (+43%). Finally, the number of emigrant physicians experienced a significant growth between 1991 and 1996 (+10%) and then stabilised around 71,000 people (Figure 3d).

Then, the red bold line represents the counterfactual evolution of these variables in the case where none of the three determinants reacted to changes in the surplus-shortage indicator. In other words, these variables follow a trend that is not driven by the shortage-surplus evolution across time. We observe that there is no strong adjustment in the total number of doctors (Figure 3b) following the shortage/surplus indicator evolution. Indeed, these counterfactual dynamics of the physician stock derive from the combination of changes in the number of trained doctors (who would have been 16 per cent higher in 2004 – Figure 3e), of the changes in immigrant doctors (who would have been 5 per cent lower in 2004 – Figure 3c) and of the change in emigrant doctors (also lower by about 5 per cent in 2004 – Figure 3d) in the absence of adjustments. Changes in these three variables tend to offset each other. These developments are far from trivial, since the same evolution of surplus-shortage in the labour market of doctors produced relatively dissimilar developments in the number of trained or immigrant doctors, given that the recruitment of trained doctors has a delayed effect. Finally, without the combined adjustment of these three variables, we find that the evolution of our dynamic imbalance indicator on the physician labour market would have been amplified (Figure 3a).

Finally, we disaggregate the counterfactual variations by successively neutralising the effect of each of the three components of the evolution of the stock of doctors and assuming that the two other components respond to the evolution of shortage-surplus variable (and thus follow their observed evolution). This allows us to better understand the relative influence of each of the three components in the change of the physicians' number due to the imbalance in the labour market for physicians. For example, the black dotted lines show the evolution of the imbalance indicator in the absence of adjustment in the number of immigrant doctors but retains the reaction of graduates and emigrant doctors. The dotted curves in dark grey and light grey offers the same exercise by neutralising respectively changes in the number of emigrant doctors and the number of trained doctors.

As clearly shown in Figure 3a, the situation without adjusting by immigration leads to a higher shortage of physicians after 1999 compared to the case where the adjustments through graduation or emigration is made. In other words, in the short run, immigration tends to decrease the shortage much more than the recruitment of graduates does. This is due to the fact that the training of additional doctors provides a solution only in the long run, with a time delay, whereas in the short term, the lack of reactivity of this policy increases the imbalance. The decrease of the dotted light grey line after 1999 (Figure 3a) suggests that graduation policy is effective probably around that date. Indeed, without adjustment, the number of graduated physicians would have significantly increased from 1998 (Figure 3e). The policy through retaining people (emigration) is too small to expect any significant decrease of the imbalance.

Figure 3a: Shortage (+) and surplus (-) in the labour market (in level)

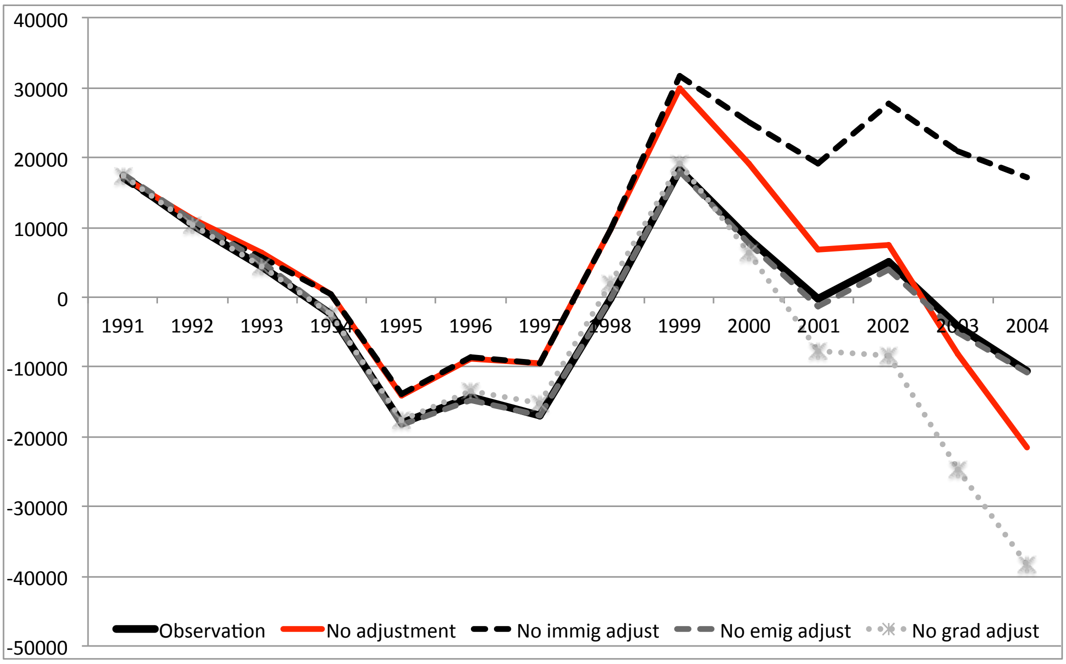



Figure 3b: Total physicians in level

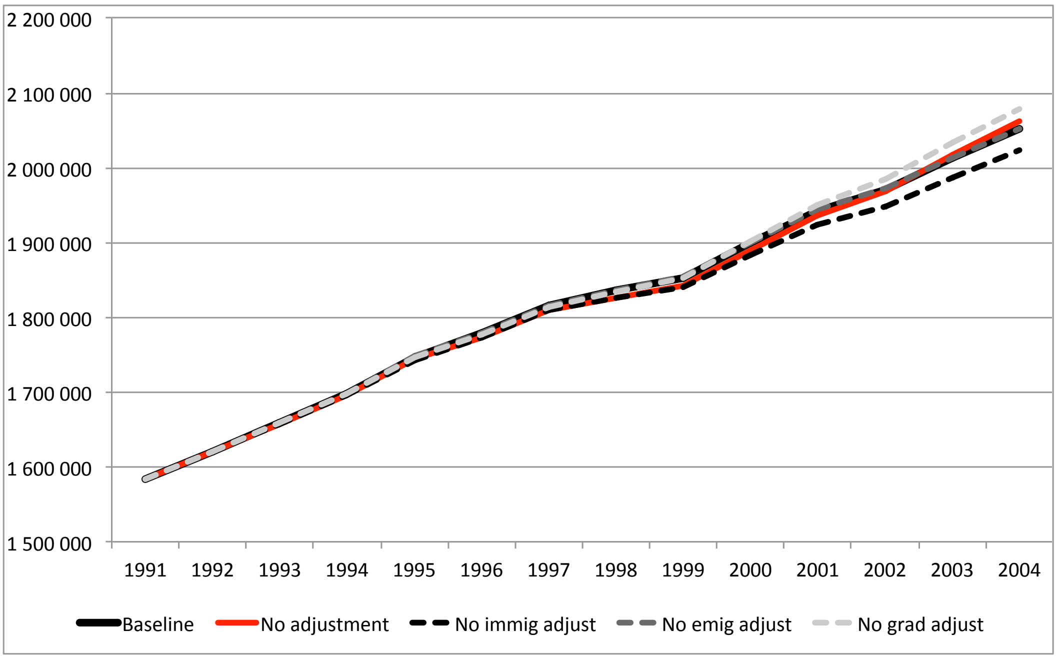


Figure 3c: Immigrant physicians in level

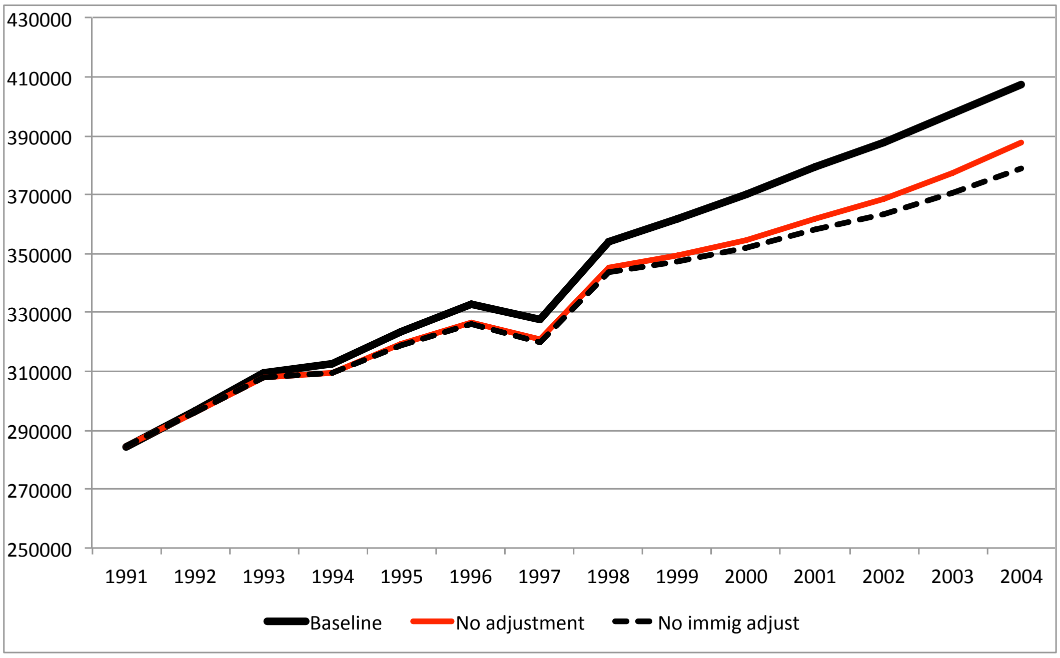



Figure 3d: Emigrant physicians in level

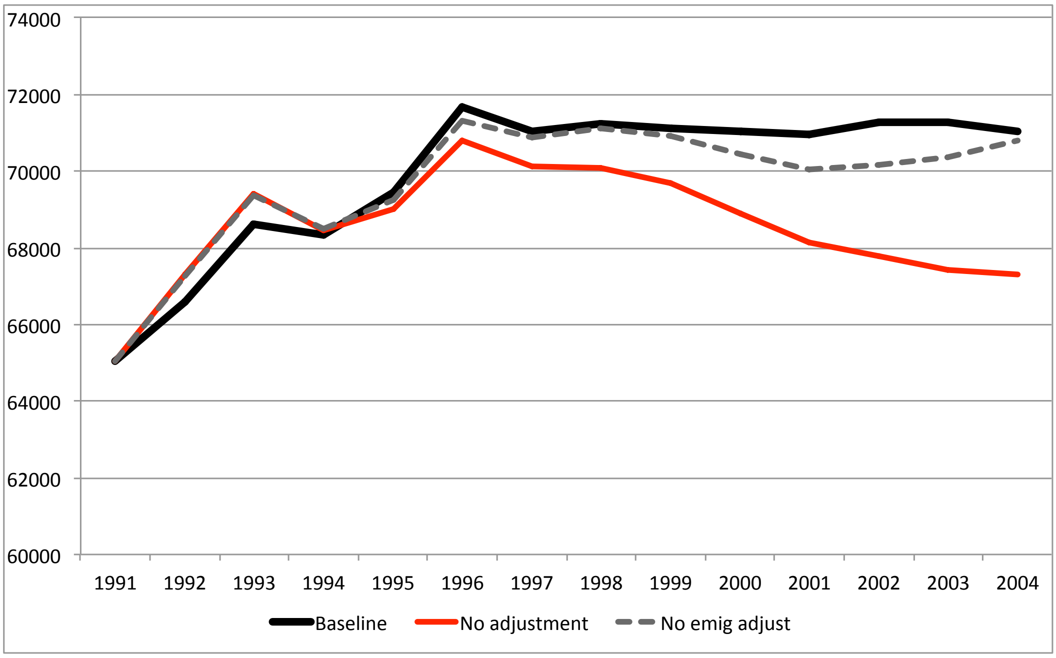
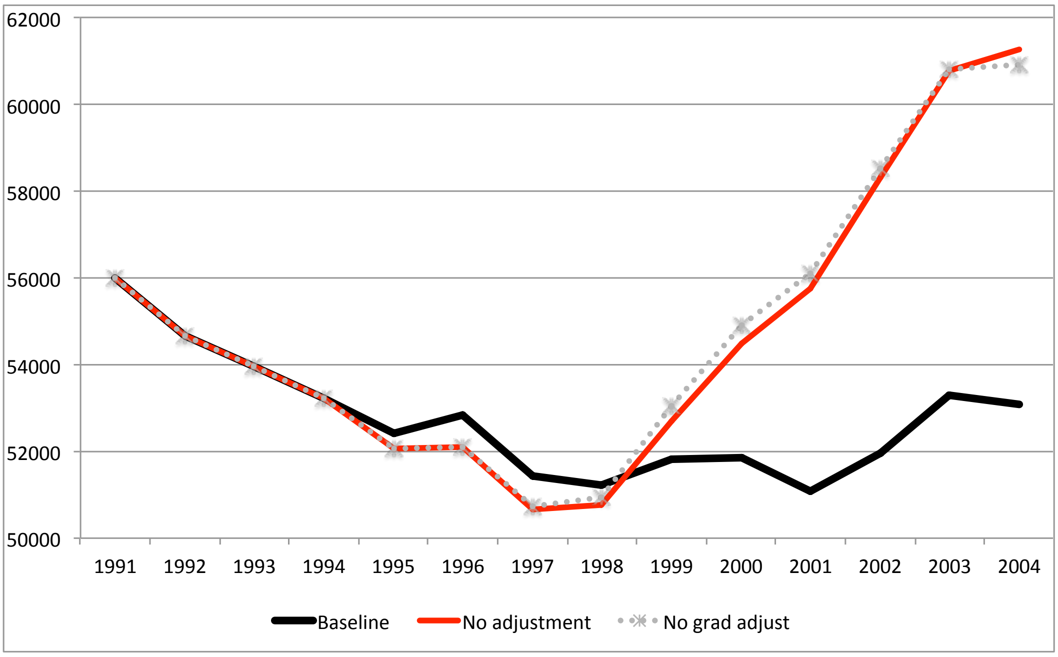


Figure 3e: Graduated physicians in level




In a second step, rather than starting from the observed imbalance in the labour market of each country, we implement simple hypothetical evolutions of the shortage across time, which allows each component to react to this shock. We complete four simulation exercises. The first scenario assumes a virtual gradual increase in the shortage from 1991 that reaches 5 per cent of the number of doctors in 2004 in each of the countries concerned (Figure 4a). The second scenario assumes a permanent shortage to 5 per cent of the labour force in each country (Figure 4b). The third scenario simulates a gradual increase in the shortage that reaches 5 per cent of the number of physicians in 1997 and then gradually returns to an equilibrium (Figure 4c). Finally, the last scenario proposes the opposite of Scenario 3 with a shortage which decreases between 1991 and 1997 and increases again to 5 per cent of the labour force.

More importantly, contrary to the previous simulations, we simulate here not the absence of reaction but the reaction itself due to a shock that happens to the labour market equilibrium. We successively simulate the reaction of one of the determinants and then end up with a situation in which all policies reacted. The bold black lines show the evolution of the shortage in the absence of adjustment to the number of trained, immigrant or emigrant doctors. This corresponds to the shock that we implemented on our model. Dotted lines show the evolution of shortage following the adjustment in the number of migrant doctors (black line), emigrant doctors (dark grey) or trained doctors (light grey). The red lines show the adjustment of the shortage in the case of a simultaneous adjustment of the three determinants of physician stock.

The results of these four scenarios clearly tend to confirm what appeared in our first set of simulations. The immigration of foreign doctors is a better short-term instrument in the mitigation of a shortage (permanent or temporary) in the labour market. However, in the absence of a more ambitious policy, the adjustment through migratory flows can only partly limit the extent of the imbalance. Even if it produces more consistent long-term effects, a physician training policy will be helpful only in the case of a permanent imbalance (Scenarios 1 and 2) and tends to strengthen this latter where the imbalance is itself unstable (Scenarios 3 and 4). Indeed, given the delay in the training of doctors, the effects of such a policy comes too late and even tends to increase the degree of disequilibrium (as in the 'cobweb/pig cycle' theory). The adjustment in the number of emigrant doctors again appears weak and so we can expect only small effects resulting in the management of imbalances by a policy of retention of physicians.

Figure 4a: Scenario 1 – Gradual increase in shortage

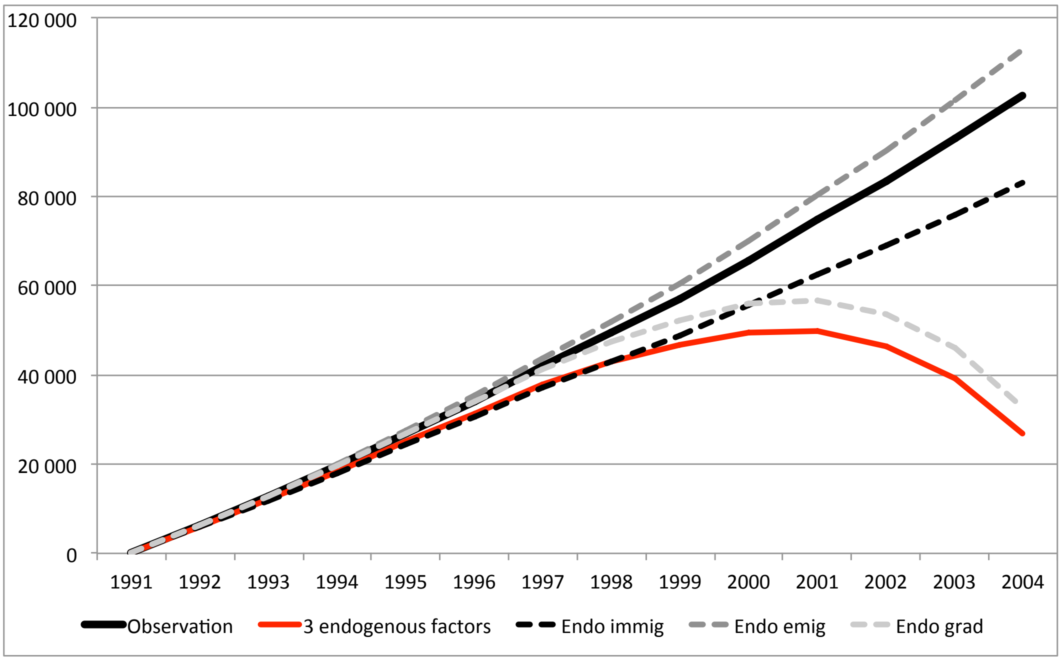



Figure 4b: Scenario 2 – Constant shortage

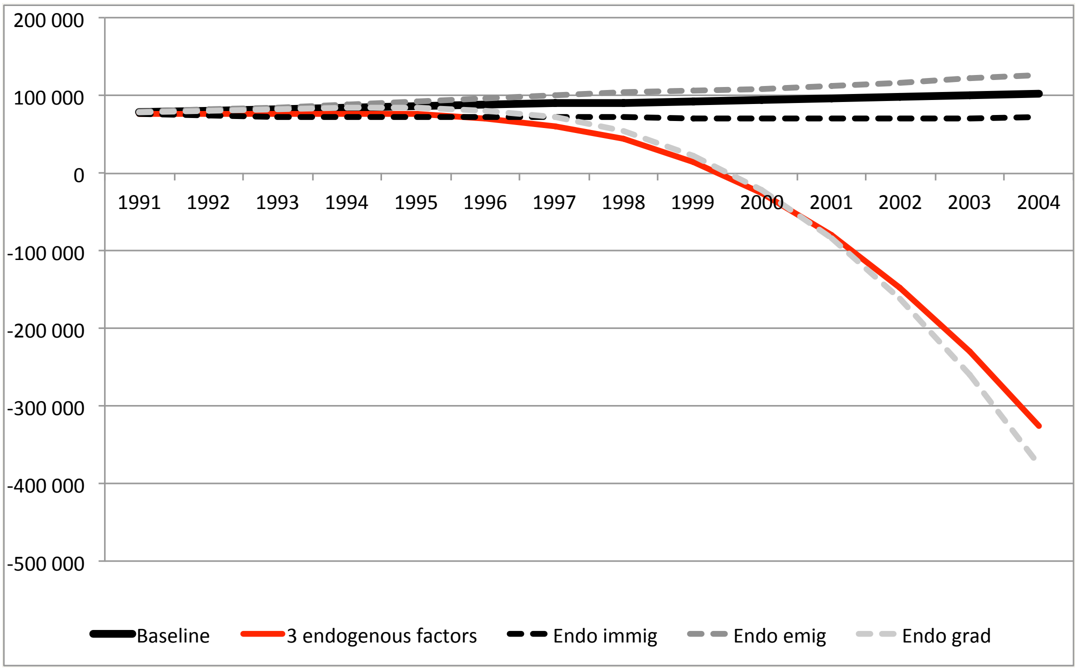


Figure 4c: Scenario 3 – gradual increase in shortage and return to equilibrium

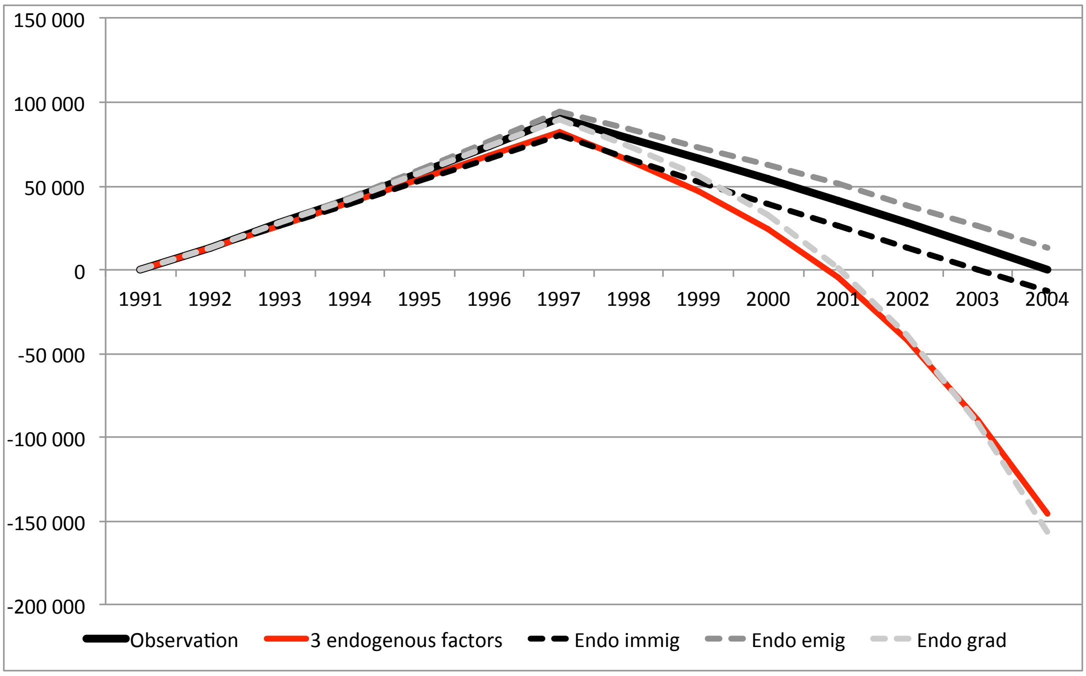
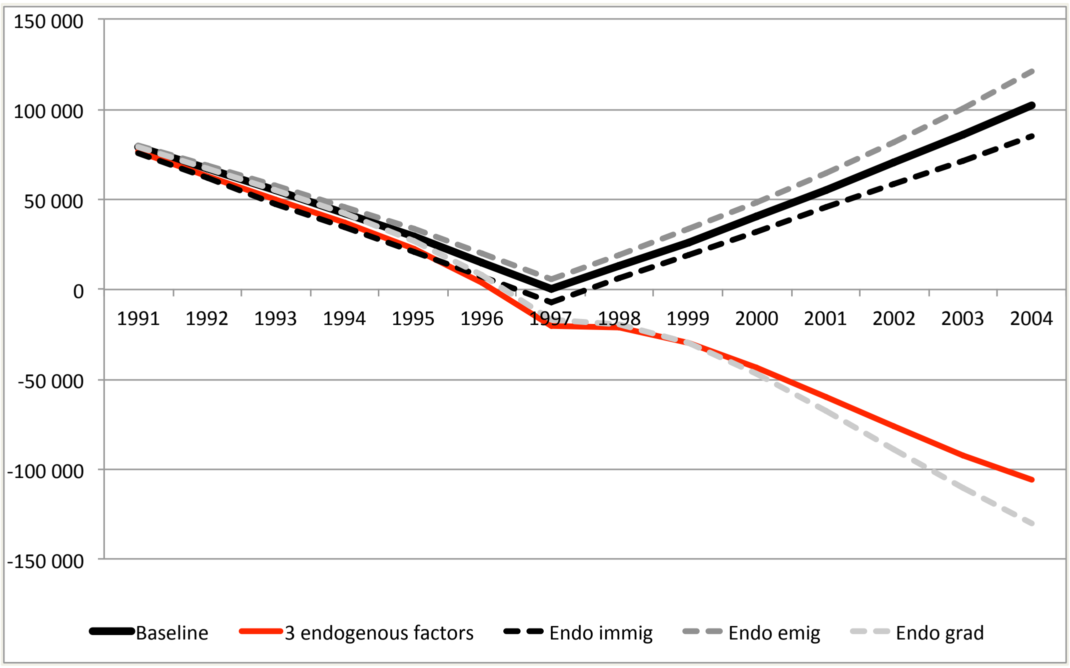



Figure 4d: Scenario 4 – Temporary reduction in shortage



# 7 Conclusion

This paper deals with the question of medical shortages in developed countries. In order to tackle this issue, governments could adopt three strategies: either producing a sufficient number of medical graduates and/or recruiting foreign-trained physicians and/or retaining their own medical workforce. However, the preference of governments to increase the number of domestic physicians by producing new graduates is a strategy that, in theory, is effective only in the long term because the medical training period is relatively long.

Following an episode of medical shortage, governments increase the capacity of medical schools to train more doctors. This materialises in an increase in medical graduates on average between eight and nine years after the appearance of the shortage due to the duration of medical study. Our results also find that governments fail to retain their practicing physicians during a period of shortage because a significant proportion emigrates, probably due to the burden placed on them by the shortage, including a deterioration of working conditions. Because the training approach requires a long time to become effective, shortages drive policies towards the recruitment of foreign-trained physicians in the short term. Immigration offers a quicker response to the shortage issue (involving a delay of at last one year) and explains the popularity of recruiting foreign-trained physicians. Our IV estimation clearly shows a preference for immigration over the two other policies. Hiring foreign-trained health workers on the international market could be used to save on the training of medical doctors, which is quite costly due to the length of study (Connell et al. 2007, 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 (Dussault and Franceschini 2006).

International recruitment of physicians is not without 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 (Bhargava and 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 (Bhargava and Docquier 2008).

Even if recruiting physicians from abroad seems to be the solution in the short term to tackle shortages in developed countries, it should be coherent with the aims of overseas development policy to foster better economic, social and well-being conditions in developing countries. Moreover immigration is limited in its ability to reduce shortages in OECD countries in the long term. Our simulation results show a limited effect of immigration itself to reduce the shortage of physicians even if it is appropriate for short-term adjustments. Therefore, the policy consisting of increasing the number of medical graduates seems to be the more efficient policy to reduce shortage in a sustainable way when the cycle of shortage is not recurrent.

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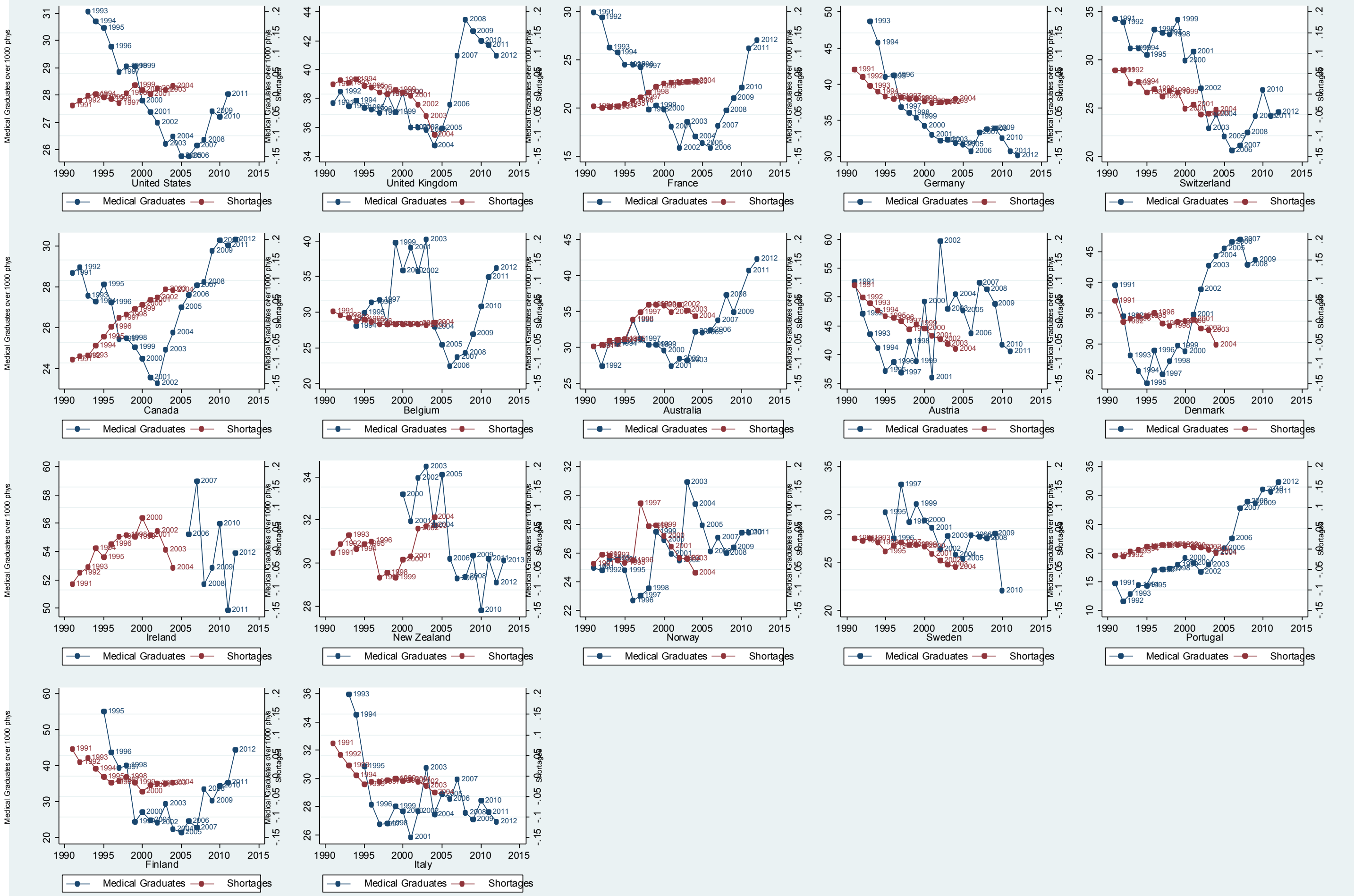
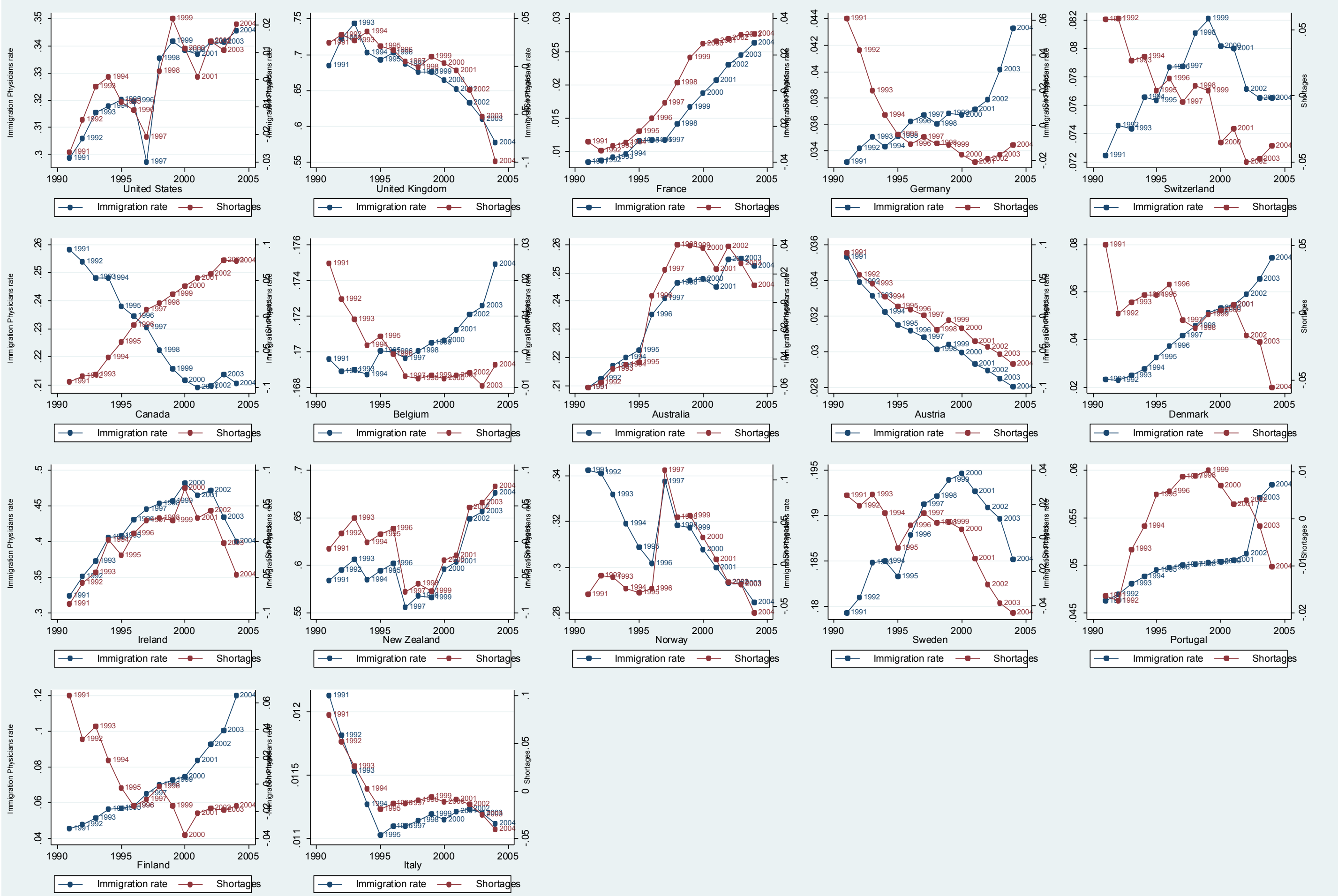
# 9 Appendix

Figure A.1: Average density of medical graduates in our 17 OECD countries between 1991 and 2012



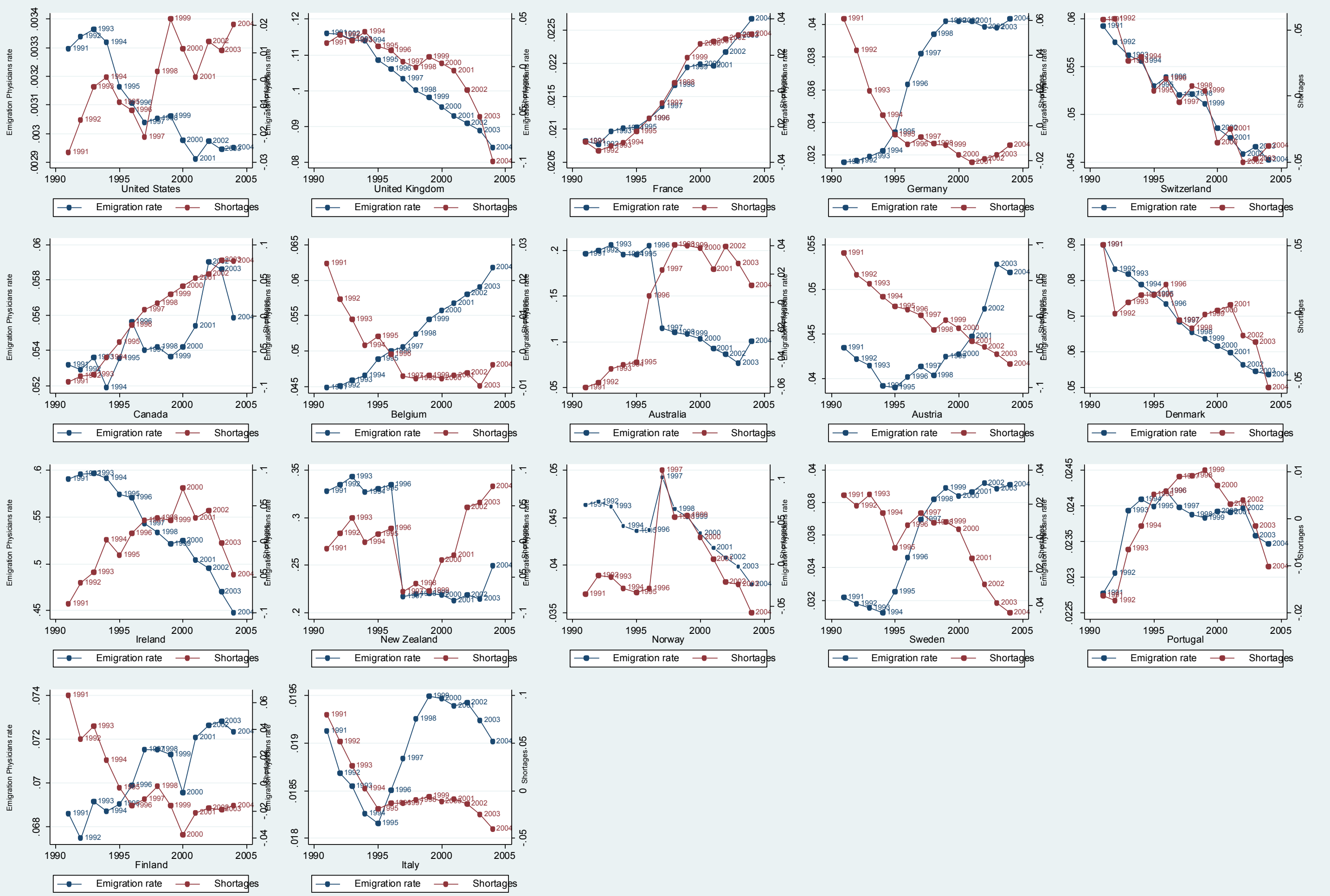

Source : Authors computations

Figure A.2: Average immigration rate of physicians in our 17 OECD countries between 1991 and 2005




Source : Authors computations

Figure A.3: Average emigration rate of physicians in our 17 OECD countries between 1991 and 2005




Source : Authors computations

TABLE A.1: Regulatory environment in medical education and immigration policies in 17 OECD countries

| | **Places in medical schools** | **Recognition of diploma** | **Language test** | **Citizenship required** | **Doctors on occupational shortage list** |
|---|---|---|---|---|---|
| US | Initial intake and training spots limited | Residency period in the US and examination tests | YES | NO | NO |
| UK | Initial intake limited | Medical degree should be approved except for UE and Swiss members | YES | NO | YES |
| France | Initial intake and training spots limited | Examination tests except for UE and Swiss members | YES | YES | NO |
| Germany | Initial intake limited | Examination test except for UE and Swiss members | YES | NO | NO |
| Switzerland | Initial intake limited | Federal state decisions | YES | NO | NO |
| Canada | Initial intake and training spots limited | Examination tests and medical degree approved | YES | NO | Regional lists |
| Belgium | Initial intake and training spots limited | Examination tests and medical degree approved | NO | NO | Regional lists |
| Australia | Initial intake limited | Examination tests and medical degree approved except for UK, US, Canada, Ireland and New Zealand | YES | NO | YES |
| Austria | Initial intake limited | Examination test except for UE and Swiss members | YES | NO | NO |
| Denmark | Initial intake and training spots limited | Examination tests except for UE and Swiss members | YES | NO | YES |
| Ireland | Initial intake limited | Licence delivered under restriction with exception according to origin | YES | NO | YES |
| New Zealand | Initial intake limited | Examination test with exception for specific origin | YES | NO | YES |
| Norway | Initial intake limited | Licence delivered under condition except for UE and Swiss members | YES | NO | NO |
| Sweden | Initial intake limited | Examination test and supervision except for UE and Swiss members | YES | NO | NO |
| Portugal | Initial intake and training spots limited | Approval for medical degree except for UE and Swiss members | YES | NO | NO |
| Finland | Initial intake limited | Examination and practical test except for UE and Swiss members | YES | YES | NO |
| Italy | | Medical degree should be approved by the Ministry of Health except for EU and Swiss members | YES | YES for specialists | NO |

Source: OECD International Migration Outlook 2007 and 2015.