REVISITING HEALTH EXPENDITURE DETERMINANTS AND THE PUBLIC-PRIVATE MIX

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Introduction

This paper was motivated by an interest in economics of health care systems. More precisely, I was searching for ways to look at how institutional arrangements, economic forces and public decisions have come together to form current health care systems, and whether the differences between them are substantial. A comparative international approach to studying this subject seemed natural as it allows one to see whether different system designs and socio-economic conditions in fact produce health care systems with different economic characteristics.

There certainly exist problems related to cross-country data and health system comparability. For the purposes of the current study, health expenditures were chosen as the primary economic indicator. Information on health expenditures in different countries seems to be appropriate for comparing different health systems, at least in the sense that it reflects how each system design performs in terms of aggregate spending. The latter can be considered a kind of common measure which is quantitative and convertible using, for example, purchasing power parities.

As an object of economic research, health expenditures have been scrutinized for many years. Among the first papers are Kleiman (1974) and Newhouse (1977), for whom the importance of the topic was due to the high and rising share of health expenditures in GDP, a phenomenon which is still evident today: according to the OECD Health Data 2009, in 2007 (latest available year) 16% of GDP was spent on health in the US, as compared to 11% in France and 10.4% in Germany. In many cases the studies used cross-country comparisons in their attempt to explain health expenditure dynamics and determinants. In this way, knowing the characteristics of individual countries and having data on final spending allowed researchers to come up with the factors able to account for expenditure heterogeneity.

There have been a number of papers written on this subject and a wide range of factors explaining the variability in health expenditures have been proposed. These explanatory factors span many areas of the health economics field: the demand for health care, its microeconomic characteristics as a good (normal or luxury) and factors influencing the demand for health care, such as aging or health habits; supply effects, such as the induced demand hypothesis, rising costs due to technological developments, and disproportionately increasing medical labour wages; organizational structure; and financing methods. Some studies have suggested that there is a two-way causal relationship between health expenditures and GDP in terms of a human capital macroeconomic approach, as in Barro (1996).

Looking at the list of factors proposed by different authors as the determinants of health expenditures, one could assume there exists a rich theoretical ground for health expenditure analysis. As the factors mentioned represent different concepts of health economics, each has its own underlying theoretical literature. For example, such variables as the number of physicians is associated with both theoretical models of the demand for health and the induced demand hypothesis. But a closer look at these factors suggests that they are too different and too often unrelated to be able to form a coherent theory. Moreover, it is even an accepted fact that there is a lack of theoretical basis explaining the "causal mechanisms involved" in the determination of aggregate health expenditure (Gerdtham and Jönsson, 2000, p. 19). Thus there is no solid foundation to rely upon when choosing explanatory variables.

Nevertheless, some authors did try to apply a theoretical basis to the analysis of health expenditures. For example, Leu (1986) used a public choice approach and studied the effects of institutional factors such as the degree of government intervention in the health sector. In doing so he introduced new variables into health expenditure analysis using some results from public choice

theory. His assumptions will be discussed in more detail later. Despite many criticisms, his and some other similar papers influenced the research that followed at least to the effect that most began to include the variables summarizing their theories.

More specifically, many studies undertaken after Leu (1986) began to include institutional factors, such as measures of public financing and public supply (the latter refers to the situation where governments act directly as suppliers of health services, e.g., state-employed doctors at public hospitals). Often when researchers wanted to include a variable describing the overall organization of health systems they used the share of public expenditure in total health expenditure, as did Baltagi and Moscone (2009) and Lopez-Casasnovas and Saez (2007). Following these authors I will consider the share of publicly financed health care as a measure of overall health system organization and therefore pay special attention to this variable.

Apart from its possible explanatory power (according to Leu, higher public finance increases health care expenditures), the share of publicly financed health care is important in its own right for the following reasons. First, in all OECD countries more than half of the total health expenditures are publicly funded (OECD Health Data 2009) and hence constitute a substantial part of aggregate public spending. This is why health expenditures are often on the political agenda as the issue of public health spending worries politicians and taxpayers alike. Moreover, as Gerdtham and Jönsson (2000) suggest, high health expenditures may ultimately exert pressure on public budgets, in particular in a situation of public debt. Therefore, according to them, there is a tendency to decrease this pressure by reducing the share of public health provision.

Second, publicly provided health services usually differ from those provided privately. Accessibility, quality and effective prices may vary and thus the publicly provided health services may be considered quite distinct from the private services. The users of the two may constitute

different social groups, and therefore the health outcomes as well as the price and income elasticities of the two sectors may differ.

Finally, the public provision of health services is an important part of social services. The expenditure on them reflects the importance that a state attaches to social programs. They therefore indicate the degree to which the "Welfare state" notion characterizes a country. It follows that political forces must also be in play, since determining the public share of health services provided implies making political decisions about public funds.

Consequently, the separate analysis of privately and publicly provided health services seems to be reasonable. Assuming their distinct nature, as suggested above, it seems important to look into what determines each one and whether the interplay of those determinants makes any difference for total expenditure, which is the combination of the two.

Unlike most of the empirical models in the literature, which are not usually based on the economic theory of health expenditure, I wanted to use some theoretical foundation that could show power in predicting expenditure on health. Since it was decided to consider separately public and private health care, theories modeling public provision of goods and services seemed appealing. There exist some studies that have tried to apply elements of "public choice" theory to health sector. The model offered in one of these studies (Gouveia, 1996) was chosen as the theoretical framework to be used in my paper. The element of public choice theory implemented in Gouveia's paper is the so-called "majority rule" mechanism for determining the level of public provision of a good that the majority prefers. Gouveia's (1996) model also allows for private supplementation, which is considered to be a residual. Thus, looking into the determinants of public provision should explain the public-private mix, and, therefore, the total expenditures that result.

Of course, no study of health expenditures is possible without accounting for the forces that have been accepted by all researchers. Therefore a review of the findings of the literature, including the latest publications, will be a part of the present work.

The main research questions I intend to answer in this work are as follows:

- What is the role of health system organization (proxied by the share of public health spending) in determining total health expenditures?
- Is health care a luxury or a necessity?
- Does the health care sector have relatively low productivity; i.e., is there evidence of Baumol cost disease?
- Do the public and private health sectors have different income and price elasticities?
- Does the majority rule framework perform well when tested empirically using international health care expenditure data?

To answer these questions, I estimate several regressions. The first is a general model describing the relationship between total health expenditures and health system organization factors (i.e., public-private mix) as well as other factors found to be important in the literature. According to the results obtained, the organization of health systems has a non-negligible role in determining total health expenditures (the regression coefficient of the public-private mix variable was significant and equaled 0.004). Also, the regression estimates suggest that health care can be considered a necessity. The hypothesis that the health sector has relatively low productivity had to be rejected (the regression coefficient of price turned out to be negative). In addition two more equations are estimated: one each for public and private health expenditures. The aim of estimating these two equations is to see whether the coefficients of the common determinants of the public and private shares are considerably different. According to the regression results, there is evidence of different income and price elasticities of public and private health expenditures (the private sector has lower income and price elasticities). This is another indication of the importance of the public-private

composition of total health expenditure (or overall health system organization), which should always be considered when studying the determinants of total health spending.

The OECD Health Data 2009 is used as the principal source of expenditure and socio-economic data covering the period 1975 to 2007 and the following countries: Australia, Austria, Belgium, Canada, Denmark, Finland, Germany, Iceland, Ireland, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States The Czech Republic, France, Greece, Hungary, Italy, Korea, Luxembourg, Mexico, Poland, the Slovak Republic and Turkey were excluded due to severe data problems (missing observations for more than 10 years in a row). France was excluded due to underreporting of health spending during the period 1975 to 1990. OECD Health Data is a reliable source of internationally comparable information on health spending due to the use of common definitions and regular updates. More details on the data used are provided later in the paper, after a review of the literature on health expenditures and a more detailed discussion of the models and methods employed.

For estimation of the equations a panel data model is used. This modeling approach assumes that the regression coefficients are the same across countries, i.e., the same factors have an identical effect on the dependent variable in all countries. In other words it is assumed that the factors reflecting the organization of the health system as well as other determinants influence expenditures in the same way across all countries. However, when using a panel model one should be aware of its implications; i.e., the estimation problems common to panel data such as heteroskedasticity, correlation between panel units as well as autocorrelation (Beck and Katz, 1995). In the presence of these problems methods other than OLS should be employed. Therefore a number of tests will be performed before deciding which estimation technique is more appropriate. Apart from OLS, feasible GLS and panel corrected standard error methods (Beck and Katz, 1995) will be considered.

The analysis offered in this paper contributes to the body of empirical studies of health expenditure determinants by providing estimation results using the most recent OECD data. Also it offers updated empirical results for the model proposed by Gouveia (1996), more than a decade after the original results were first published. During this time extended data series became available and the OECD data has seen multiple refinements. Therefore the findings reported here should give an improved picture regarding the regression coefficients of the models.

Literature review and principal findings

Overview

As has been mentioned in the introduction, health expenditure analysis seems to be able to provide some insights into the economics of health systems. Looking at health care costs and spending trends in different countries with different health systems and using the available data describing the main characteristics of these systems should help determine the expenditure determinants. Identifying what makes expenditures differ in different countries should allow one to draw conclusions regarding the influence of those determinants.

The growth of health spending in all developed countries is one of the main reasons for the existence of the main body of the literature on health expenditure. But, as has also been mentioned, some researchers, while trying to define the main determinants of expenditure dynamics, had a particular interest in institutional factors. Thus they were trying to find out whether certain system designs or funding schemes had a significant influence on the level of health expenditure. The importance of knowing this is its straightforward application. Since institutional arrangements are the result of policies and as such can be changed or adapted, unlike other uncontrollable factors such as the demographic composition, finding an institutional mechanism able to control expenditure, could, for example, lead to a method of cost containment. This latter point is particularly interesting

and reviewing the results of the literature that considered institutional variables will be a part of the present paper. But since the importance of the classical health expenditure determinants, such as income, cannot be ignored, only after having accounted for them may the other forces be considered and their validity analyzed. Here I will try to review the main results of the existing literature and bring together all the factors found to play a role in determining health expenditures. In doing so, I will pay particular attention to the elements related to health system design that different authors analyzed and found significant.

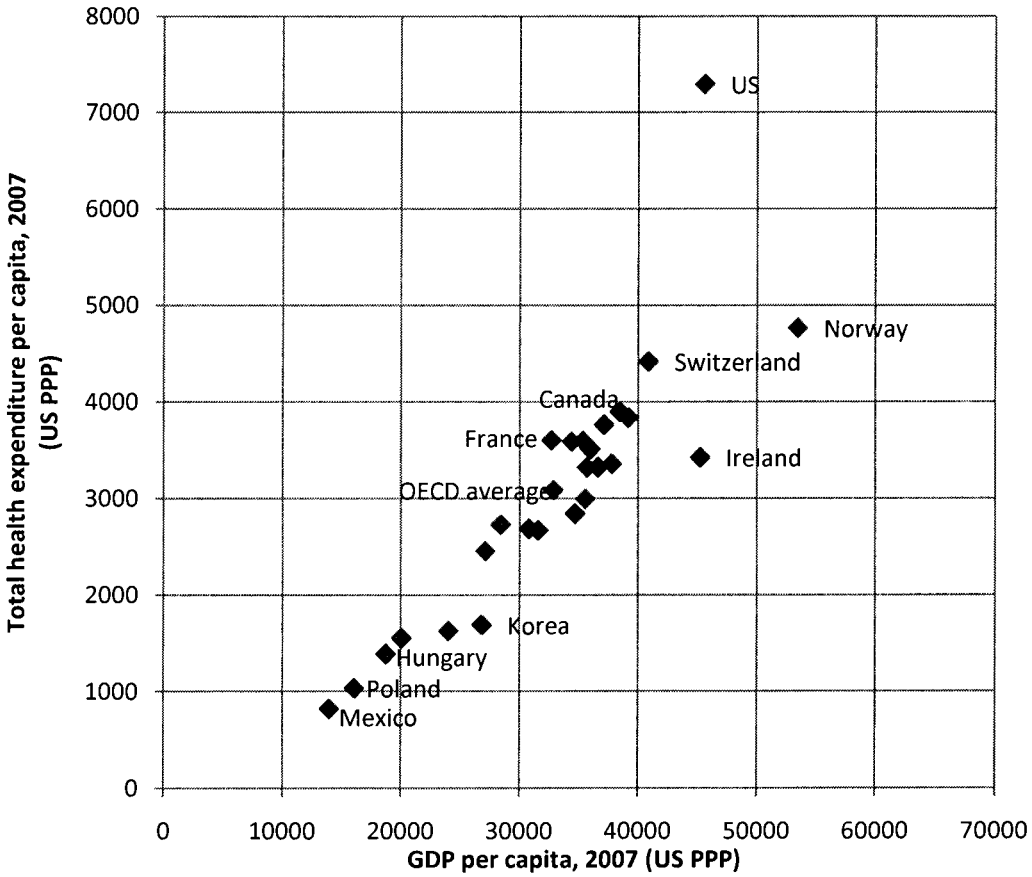
It should be noted, and many authors have pointed this out, that international comparisons of national health expenditures pose problems; usually they are related to differences in measurement, accounting practices, purchasing power conversion errors.[1] To mitigate these complications a homogeneous set of OECD member countries will be used as the basis for comparison. Also, the OECD countries are probably the most widely used sample in the literature on international comparisons of health care expenditures. Therefore it seems natural to keep to this custom. This also has the merit of making possible the replication and comparison of the results from different papers that used OECD data.

But despite the "homogeneity" of the OECD sample, the first observation that one makes looking at the health expenditure data is its high variability. According to the OECD Health Data 2009, the average spending on health in the OECD in 2007 (latest available year) was 9% of GDP. In the US it was equal to 16%, the highest share among all OECD countries, followed by 11% in France, 10.8% in Switzerland, and 10.4% in Germany. At the opposite end of the distribution scale are Korea, Poland and Mexico with 6.8%, 6.4% and 5.9% of GDP respectively.

[1] Gerdtham and Jönsson (1991a, b) and Hitiris and Posnett (1992) considered measurement issues and compared results based on different specifications. They found that the estimates differ depending on the method of conversion: the estimated income elasticity was lower when exchange rates were used than when GDP PPPs were used.

Figure 1 demonstrates the variability of total health expenditures among OECD countries. It is evident from the graph that total health expenditures do not constitute the same proportion of GDP in all countries. Therefore, given the strong variation in the importance of health expenditure in this relatively homogeneous sample of developed countries it should be possible to establish the most important factors that determine this variation. Furthermore, information on different health system designs in the countries under consideration should give some insight into whether the relationship between the institutional characteristics of health systems and total health expenditure is present.

Figure 1. Total health expenditure per capita and GDP per capita

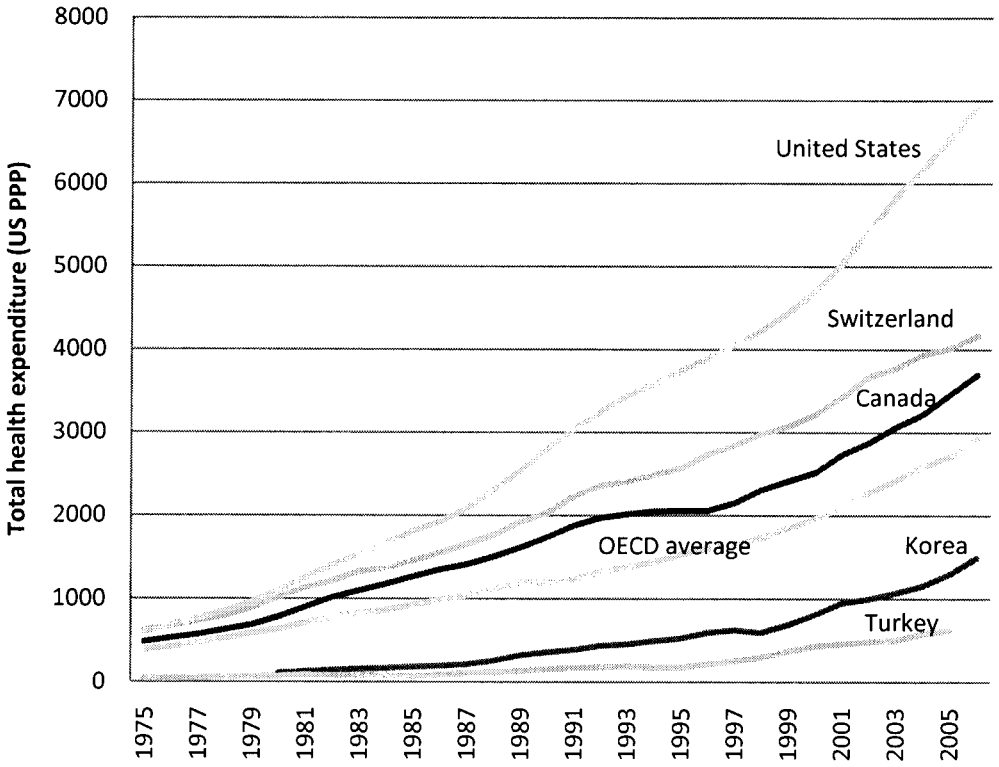


Source: OECD Health Data 2009

At the same time an important aspect of the health expenditure topic is its dynamics. As has been noted above, the constantly rising share of health expenditures in GDP in all the OECD countries has been a big concern and the subject of numerous studies. Some of the studies tried to make projections based on the observable rates of growth of total health expenditures and the results are often astonishingly high. For example, in the US, according to Borger et al. (2008, 69) "since the end of the Second World War per capita medical care expenditures have grown on average two-and-a-half percentage points faster per year than did per capita GDP." Note that it is customary in this kind of projection to treat the growth rate of health expenditures as a fixed percentage above that of GDP growth. Thus, if the growth rate of health expenditures were one percentage point above the GDP growth rate, by 2050 US national health expenditure would be about 33% of GDP, according to Borger et al. (2008).[2] In case of two and a half percentage points, expenditure on health would be 50% of GDP. Here I mention these figures just to illustrate the true dimension of the health spending issue, though the health spending projections will not be discussed in this paper. The recent trends in health expenditures for selected countries are demonstrated in figure 2.

[2] The source that they cite, which is not publicly available, is the Federal spending projections: Testimony of Douglas Holtz-Eakin, Director, Congressional Budget Office, before the Senate Committee on the Budget, "The Economic Costs of Long-Term Federal Obligations," February 16, 2005.

Figure 2. Health expenditure over time for selected countries, 1975-2007



Source: OECD Health Data 2009

However, OECD Health Data 2009 shows that there has been a trend towards slower growth of health expenditures as a share of GDP in many OECD countries recently, including zero or even negative growth in some cases. The health expenditure share of GDP on average across OECD countries began to stabilize in 2003 and rose by only 0.3 percent, from 8.7 percent in 2003 to 9 percent in 2007.[3] In many countries the percentage of GDP devoted to health fell slightly between 2005 and 2006, while in other countries it stabilized. In 2007 this tendency remained with the majority of changes being within the range of 0.05 per cent. Overall, according to the *OECD Factbook 2009*, the recent dynamics of health expenditure as a share of GDP "marked a pause in a

[3] The figures here and below are taken from the OECD Health Data 2009.

long-term rising trend that has seen health spending rise from 6.6% of GDP on average in OECD countries in 1980" (OECD Factbook 2009, p. 220). It is likely that at least in some countries policies aimed at cost containment played a role. If so, these recent expenditure movements should also be reflected in changing financing decisions, such as a lower share of public provision, or other related variables yet to be discovered.

Income and its interpretation

Moving the discussion to the principal determinants of health expenditures, it should be noted that all the available literature on the topic irrespective of its particular focus assigns the biggest explanatory power to aggregate income. But the way different authors, for example Newhouse (1977) and Blomqvist and Carter (1997), find it influences the dynamics of health spending varies. Therefore it seems important to evaluate the role of income in determining health expenditures using the latest data and to compare the results with those reported by previous studies.

Newhouse's (1977) paper is considered a classic in this area. Admitting that in principle the organization of health care (degree of centralization, financing, prices of medical services) should influence the level of total health spending, Newhouse decided to examine the relationship between medical spending and income. His sample included 13 developed countries (based on the availability of data for the years 1970-1972). He regressed per capita medical spending on per capita GDP and found that 90 percent of the variance in the dependent variable was explained by this sole regressor. This result was in line with the previously published findings of Kleiman (1974), where the latter reported that net national product explained 96 percent of per capita health expenditure variance in a sample of 16 countries (though not all of them were developed). Similarly, Leu (1986), who set out to empirically investigate the conclusions made by Newhouse using a 1974 OECD cross section, found GDP per capita to account for 89 percent of the variance in medical care expenditures. After

that empirical research usually took for granted the dominant role of income in explaining health expenditures, including Hitiris and Posnett (1992) and Gerdtham (1992).

Having found such an important relationship it was important to give it a proper interpretation. Newhouse tried to interpret the effect of income, i.e., whether health is a normal or a luxury good. He considered income elasticities at different levels of income, and found that they substantially exceeded one, whether derived from a regression where the dependent variable was health expenditure per capita or health expenditure as a share of GDP. These results led Newhouse to conclude that health expenditure is a luxury good. This conclusion, which followed from a small cross-section regression, required some further investigation, using a wider cross section and longer time series. At the time of writing, Newhouse stated that time-series data supported his finding, since in all developed countries medical spending was increasing. An elasticity of income greater than one was previously reported by Kleiman (1974) and later supported by Leu's results as well. Leu also showed that the high elasticity was robust to the choice of the countries as it remained greater than one when the poorer countries were excluded from the regression sample. This result seemed to speak in favour of the hypothesis of health care being a luxury good.

Nevertheless the magnitude of the income elasticity was later questioned by some researchers. Using cross-section analysis Gerdtham et al. (1992a, 1992b) reported income elasticities of 1.33 and 1.27, while Gerdtham (1992) reported an elasticity of 0.74 using a pooled cross section approach. Hitiris and Posnett (1992) obtained an elasticity of 1.16 using panel data for 20 OECD countries over the period 1960-1987. Gerdtham et al. (1998), using data for 22 OECD countries for the years 1970-1991, obtained an income elasticity lower than unity, testing a number of model specifications that included different institutional variables. For all specifications the income elasticity was not higher than 0.82.

Therefore, depending on the method (cross-section or panel data) and variables (the variables used by different authors in addition to GDP will be discussed later), the income elasticity estimates and as a result the interpretation of the role of income differed.

Considering the high income elasticity obtained in the cross-country regressions, there seemed to be a contradiction with what the numerous studies at the micro level (e.g. household surveys) reported. These studies, such as the Health Insurance Experiment by the RAND corporation (Manning et al., 1987), consistently found the income elasticities to be low and attributed this to the presence of insurance. It was believed that insurance makes households feel less constrained in spending on health and therefore not as sensitive to higher health care prices. Addressing this fact, Newhouse suggested that unlike the insured households, the country as a whole faces the full price of medical care, and thus the income elasticity at the macro level should be higher than at the micro level. Following this line of reasoning, he suggested that income should play a greater role across countries and in time-series data than across households at one point in time. This conclusion was widely accepted in the literature that followed and is taken as given, for example in Leu's (1986) and Gerdtham et al.'s (1992a) paper.

Newhouse also made an interesting inference about what the marginal spending on health buys if the latter is a luxury good. An important assumption he made was that the higher health expenditure of richer countries is not simply due to higher relative prices. This is a strong assumption that should be used carefully, and it seems reasonable to include a price index as a control variable in the regression (the price index as a variable will be discussed in more detail later); Newhouse and Leu couldn't do this due to a lack of data. Newhouse justified this assumption by his belief that there is no reason for price of capital in the health sector to be higher in wealthier countries. Neither did he expect medical salaries to grow faster than GDP, despite higher capital-

labour ratios in richer countries. He supported his idea with the data he could obtain showing that the ratio of the average earnings of physicians to average wages was similar across five countries. He concluded that "richer countries do not have higher relative factor prices for medical care resources, but are indeed devoting more real resources to medical care" (Newhouse 1977, p. 121). Therefore, in the absence of evidence of better physiological health in richer countries, Newhouse concluded, the marginal unit of health spending buys caring (further alleviation of symptoms, anxiety, additional information etc), rather than curing, which can probably be thought of as buying higher quality of health care.

Leu (1986) tried to empirically test this assumption that additional resources in wealthier countries are actually devoted to the consumption of health services and do not simply cover higher health care prices. Due to the lack of data on relative health care prices Leu used the number of physicians and beds relative to population in the regression of health expenditures as proxies for the level of supply of medical care. He obtained a significant coefficient for the ratio of beds to population. This led him to conclude that higher expenditure corresponds to a more extensive provision of health care, and therefore, that the assumption made by Newhouse must be correct.

But again, the conclusion that richer countries spend more on care (the subjective part of health care services which may be referred to as higher quality) is based on the income elasticity being greater than one. And this result seems to be arguable, as has been noted above. The disputability of Newhouse's (1977) results was due to the limitations that the small sample static regression that he used imposes. In this paper I verify his results by obtaining an estimate of income elasticity based on a bigger sample of countries and a wider time span; i.e., using panel data.

Other determinants of health expenditure

Despite the widely accepted view regarding the dominant explanatory power of income, it is interesting to see what effects institutional variables have. As has been mentioned, it was common for researchers to obtain a regression result where over 90 per cent of the variance in health spending was attributable to income alone, as in Newhouse (1977). This seemed to suggest that any other explanatory factors are of secondary importance. Newhouse (1977) explains why this is so, considering in particular such factors as medical prices and funding schemes. He argues that spending on health is itself the result of rationing and public decisions which depend on the available resources and ultimately on the wealth of the country. So, following this line of reasoning, it is not the particular health system design, such as, for example, the centralized National Health System in the UK, that allows spending to remain low, but rather lower income that keeps expenditures on health low and motivates a centralized system. Therefore, Newhouse concludes, the health system organization may be treated as endogenous, while a country finds methods "by which to ration services consistent with its income" (Newhouse, 1977, p. 123).

The subsequent research nevertheless tried to introduce new variables into the regression of health expenditures. One of the reasons was that, according to Gerdtham et al. (1992a, p. 64), "some countries spend either more or less than expected on health care, even after correcting for the different income levels." So there was always this residual variance that required explanation since it suggested a possibility of a bias in the income coefficient due to omitted variables. This led to the emergence of the literature devoted to testing new variables for inclusion into health expenditure models.

As the non-income determinants of health expenditures, almost all authors used some socioeconomic variables. These usually included population age structure variables, such as the proportion of the population under the age of 15 and over the age of 65. These are the groups that

demand more healthcare and thus drive expenditures upward. For example, in Canada in 2006 people over 65 years old accounted for 13.2 per cent of the population, but their per capita health expenditures were more than three times higher than the average. According to the *OECD Health Data 2009*, 2973 Canadian dollars are spent on average on health per capita in Canada, and 9967 dollars per capita for those aged 65 and over. Thus the problem of an ageing population manifests itself in health expenditures and the age structure can be considered a relevant factor influencing health spending. The age structure variable was used in the models of Leu (1986), Hitiris and Posnett (1992), Gerdtham (1992) and Gerdtham et al. (1992a, 1992b). These authors expected to find a positive relationship between health expenditures and a higher share of the elderly. However it turned out to be insignificant in Leu (1986) and Gerdtham et al. (1998).

Lifestyle variables, such as tobacco or alcohol consumption, are also often used in the regressions, for example in Leu (1986) and Gerdtham et al. (1998), but are rarely found to have a significant effect on health expenditures.

Another socioeconomic factor that some considered relevant was the degree of urbanization measured as a percentage of the population living in towns. But there seems to be no universally accepted interpretation of the impact that urbanization might have on health expenditure. On the one hand, urbanization contributes to the spread of contagious diseases and pollution and thus has a negative effect on the standard of health (Kleiman, 1974). So it would seem that urbanization increases the demand for health services. But on the other hand, urbanization allows for easier access to care due to the availability of transportation and a greater number of health care facilities, i.e., it reduces time and travel costs (Gerdtham et al., 1992a) and thus should keep health expenditures down. However, the data for the level of urbanization that was found on the WHO website is only available for certain years (usually once every ten years). Since the analysis using panel data requires

time series, the available urbanization data cannot be used, which is probably the reason why this variable only appears in the studies that use cross-section econometric models (such as Gerdtham et al, 1992a) and not in those that use time series (such as Gerdtham 1992).

Another interesting factor that attracted the attention of researchers was the so called "supplier-induced demand hypothesis." Depending on institutional arrangements, supplier inducement may take different forms. For example, under the fee-for-service remuneration scheme physicians may set a target income which they try to achieve by adjusting workload. That is, when the number of physicians is too high or demand for their services decreases, physicians may induce patients to use more services (Gerdtham, 1992). Although some studies showed the existence of a relationship between the number of physicians and total out-patient health expenditure (Reinhardt, 1985), their results are not considered as evidence supporting the supplier induced demand hypothesis. The positive relationship may be attributable to real demand factors, such as increased real demand due to higher availability of physicians and as a result lower wait times (Gerdtham et al., 1992). So, perhaps a better way to look at the role of the supply of doctors would be simply to ask whether it increases health expenditure at all. The supply factors are likely to play a role in determining the amount of total spending on health, but restricting the supply of physicians to the income target hypothesis seems to be too stringent. Since the induced demand hypothesis is valid only under certain institutional arrangements, i.e., the fee-for-service remuneration scheme, the analysis would have to be limited to the few countries where these arrangements are present. Therefore, it seems more prudent to consider the number of physicians as a generic supply factor rather than to look at it in terms of the induced demand hypothesis.

As was noted during the discussion of the elasticity of income and its interpretation by Newhouse (1977), it seems important to include the health sector price index in the health

expenditure regression. Controlling for prices is crucial if the health price index differs from the GDP price index. Accounting for health price difference will ensure cross-country comparability of health expenditures measured in the economy-wide purchasing power parities. According to Hitiris and Posnett (1992, p. 176), if the relative health price influences health expenditures at all, they expect that "countries with higher (or lower) than expected real expenditure should be those countries with a high (or low) relative price." But they note that the empirical results are not supportive of this hypothesis: Gerdtham and Jönnson (1991b) and Milne and Molana (1992) reported a negative price elasticity. Consequently, Hitiris and Posnett (1992) concluded that higher health prices influence the quantity but not the expenditure on health, i.e., a lower quantity of health services is purchased in the countries with higher health prices, and the real expenditure is not higher than in the countries with lower health prices.

There is also another interesting theoretical concept linking real health prices with health spending called the Baumol (1967) cost disease. According to this argument, a lower productivity sector would see increases in prices compared to higher productivity sectors, since the wages of lower productivity sector workers will have to keep up with the rest of the economy. Despite many technological improvements in the health care, it remains a labour intensive activity and its lower relative productivity would have been confirmed if health care prices were found to rise over time with the demand for heath care remaining inelastic. In other words, finding a positive relationship between health spending and the health specific price index would confirm this theory.

Also, it is important to include some proxy of technological progress in the health expenditure regression. It is widely known that with the development of new technologies, more difficult cases became curable and many diseases have been eradicated or now cost virtually nothing to prevent by immunization. But at the same time there emerged new and very costly procedures.

Thus technological progress definitely has repercussions on health spending. The only problem, as Baltagi and Moscone (2009) note, is with finding the right proxy for technological progress. While a wide range of different variables has been considered for this role, including the number of certain types of surgical procedures or medical equipment as well as life expectancy, the time index seems to be a more general and customary way to account for technological progress. Therefore in my empirical analysis dummy variables for each year will be included in the regression to account for the effects of technological progress.

Other factors that I would like to consider may be referred to as institutional. Leu (1986) was the first to perform a detailed analysis of a range of these factors and determine the most significant ones. His work lead to wider acceptance of institutional variables for cross-country studies on health expenditure. He primarily considered the effects of public financing and public provision.

Leu argued that the nature of the public financing, i.e., financing via taxes and compulsory insurance, may influence the demand for and supply of health care. The demand may be subject to moral hazard which leads to overconsumption. Also, Leu pointed out that public financing may contribute to the development of new technologies since financing by taxes doesn't create incentives to keep costs down. Using the same argument, i.e., that prepaid financing by taxation creates no incentives for cost reduction, he concluded that public financing leads to higher input prices as a result of a lower price elasticity of demand. These features of public financing suggest that it is positively related to health expenditures. In his regression, Leu obtained a positive and significant result for the coefficient of public financing.

As for public provision, Leu hypothesized that public supply is more expensive than private due to lower efficiency of the public sector. He used the economic theory of bureaucracy as the conceptual framework, which attributes higher expenses to the budget-maximizing behaviour of the

bureaucracy. As a proxy for public provision, Leu used the percentage of state and non-profit hospitals. The regression coefficient that he obtained was significant and had the expected sign. Therefore empirical proof of Leu's hypothesis about the importance of public provision and its role in determining health expenditures was confirmed.

However, Hitiris and Posnett (1992) and Gerdtham et al. (1992), who replicated Leu's model using more recent data, couldn't obtain the same results. So either things have changed since the time of Leu's analysis with respect to the inputs used to practice medicine, or the validity of the theoretical basis proposed by Leu had to be questioned. Indeed, as Culyer (1989) suggested, the assumption that public provision is more expensive due to the bureaucracy's higher spending as compared to the competitive private sector is unjustified. Since to remain competitive the private sector, unlike the public sector, needs to spend additionally on marketing and advertising, the bureaucracy theory doesn't seem to work well in this case.

As an alternative to the public provision, another variable reflecting health system financing was proposed by Culyer (1989). It is the so-called "open-endedness" of funding, i.e., the absence of budgets in financing health spending. The idea was the same: in the case of no budget restriction there is no incentive to keep costs low and therefore spending on health tends to be higher. This variable was used by Gerdtham et al. (1992a, 1992b, 1998) who use dummy variables for the fee-for-service and global budgeting caps (i.e., unity for countries where such arrangements dominate and zero otherwise) as measures of the "open-endedness" of public funding. The regression results supported the significance of the coefficient of the new variable. Interestingly, the public financing variable included in the same model was also found to have a significant coefficient, but in contrast to Leu's results, had a negative sign. The regression coefficient of the fee-for-service dummy

variable (the adopted measure of "open-endedness" of funding) was positive, which is consistent with its suggested role as a force that increases health expenditures.

A number of other institutional variables also deserve consideration. A significant effort, and probably the biggest to date, has been made by Gerdtham and Jönnson (1995) and Gerdtham et al. (1998), who analyzed the effects of a wide range of institutional factors in one model. Eighteen institutional variables were considered along with seven non-institutional variables. The latter were the standard socioeconomic factors already discussed above, such as income and population structure. The institutional variables that they considered represented different organizational and financial parameters. For ease of presentation and interpretation, here they are organized into several groups.

The first group includes the following characteristics of health care financing:

- the share of health bills paid by the public insurer;
- the share of the population covered by public insurers.

Both of these parameters were interpreted as reducing the price to the consumer and thus increasing the demand for health care. Basically, in this interpretation they can be approximated by Leu's public financing variable.

The second group of factors characterizes the mechanisms of payment and consists of the dummy variables:

- the overall organization of health care: either public reimbursement, public contract or public integrated.

According to Gerdtham and Jönnson (1995), the differences in these systems reflect the relationship established between funders and providers. The overall organization usually predetermines the mode of payment to physicians and hospitals; these parameters were also included in the model as the

dummy variables (unity for countries where the arrangement specified dominates and zero otherwise):

- budget ceilings in the ambulatory sector and hospital sector;
- direct payment by patient before reimbursement;
- capitation payments;
- method of remuneration (unity if wages dominate, zero - if salaries);
- "overbilling", i.e., an arrangement where there is no agreed price set;
- fee-for-service or payment by bed days in in-patient care.

The third group includes the provision structure parameters:

- the share of in-patient expenditure in total expenditure;
- the share of public in-patient care beds in total in-patient care beds;
- a dummy for a gatekeeper role of the general practitioner.

Also, among the factors deemed to influence total expenditure, the rate of renal dialysis, the number of physicians and the interaction of the number of physicians with the fee-for-service payment method were included. The rate of renal dialysis was assumed to reflect the technological level of health care in a country and was expected to push health expenditures up.

It is clear that many of the "institutional" variables considered by Gerdtham and Jönnson (1995) and Gerdtham et al. (1998) are correlated. As Gerdtham et al. (1998) themselves note, certain variables are closely related and some may have insignificant coefficients, even if they make a significant contribution through the related variables. Therefore the authors admit that it is difficult to single out separate effects. This is one of the reasons why the results of the regressions were not robust. Nevertheless, Gerdtham et al. (1998) were able to draw several definitive conclusions regarding the roles of the institutional parameters. Among them, they established a positive

relationship between the proportion of inpatient care and total health expenditure, and the absence of such a relationship between higher government involvement (through public provision and financing) and total expenditure, contrary to the conclusions of Leu (1986). However the latter result was reported not to be robust. Also, the regressions did not confirm that budget ceilings help contain costs, while the presence of a gatekeeper proved to lower expenditure as expected.

Replicating this analysis could be useful but one would have to deal with a number of problems. The first problem has already been mentioned and concerns the difficulty of obtaining significant regression results because of multicollinearity. Therefore interpreting the effects of different institutional parameters would be practically impossible due to multiple overlaps between these factors. Data are another problem. A large number of the institutional parameters are dummy variables which are not part of any national or international regular statistical data survey (such as OECD Health Data) and thus require collection and review. Reviewing the data used by Gerdtham et al. (1998) is necessary due to the fact that the institutional arrangements, as has been mentioned in the introduction, are parameters which can be adapted to the situation. Many countries have undertaken healthcare reforms and the provision arrangements (such as primary care organization, i.e., the changing role of the general practitioner) as well as payment methods might have changed at different times in different countries. To see if that was the case for the gatekeeper and the fee-for-service dummies, the data from Gerdtham et al. (1998) and a number of recent reports (Fujisawa and Lafortune, 2009, and Or et al., 2007) were compared. As it turned out, since 1991 (the last year included in the Gerdtham et al.'s sample) there had been some changes in health care arrangements. For example, the sets of countries where physicians are considered to have a gatekeeper role differ in Gerdtham et al. (1998) and Or et al. (2007). Therefore the data collected and used by Gerdtham et al. (1998) couldn't be used in the analysis of the more recent expenditure data as it didn't reflect the

most recent changes in health care systems. Hence replicating the analysis of Gerdtham et al. (1998) would require looking into the shifts in healthcare systems in all of these countries. Some reports, such as the OECD working papers (for example, WP no. 49 on the remuneration of physicians) or the "Health systems in transition" reports by the European Observatory on Health Systems and Policies publish data on certain institutional arrangements, such as the payment methods or the role of physicians in different countries. However, their data usually cover one point in time and a limited number of countries (as is the case for the European Observatory's reports). Thus there is no single data source containing information on institutional arrangement in all OECD countries and how they have changed over time. Although it seemed feasible to update Gerdtham et al.'s (1998) data using the country-specific reports, such as the ones published by the European Observatory or the OECD, an in-depth study of the individual health systems was beyond the scope of this paper.

It should be admitted that the necessity of obtaining time series data on institutional parameters arises only when one uses panel data methods, whereas a cross section regression would only require collecting the data for one point in time. So using panel data seems to create obstacles to adding more institutional variables to the model, but the many benefits that panel data methods provide, discussed later in this paper, outweigh this data problem. Moreover, some measures of institutional arrangements (such as the shares of inpatient care, public provision or copayment) are available from the OECD Health Data. Also, as the next paragraph will show, it seems more appropriate to substitute proxies for many of the Gerdtham (1995) and Gerdtham et al. (1998) variables.

As is evident from the interpretation of the institutional parameters, most of them relate to either the financing or provision arrangements. Generally, both financing and provision arrangements reflect the ultimate funding or provision agent. For example, the share of bills covered

reflects the role of government as the financing agent. The number of in-patient beds, on the other hand, is likely to reflect the share of public provision, as the inpatient health services are usually provided by the public sector. In this capacity the in-patient beds ratio is sometimes used as a proxy for public provision of health services, as in Gerdtham et al. (1992a). The distribution of funders and providers among public and private sectors is often used in the regressions that consider institutional factors, from Leu (1986) to Baltagi and Moscone (2009). This can probably be explained by the wide availability of this information (all health expenditure is reported as either private or public in the OECD Health Data). It also seems to be the most general way to characterize the organization of the health care system. Indeed, the share of publicly funded health care is often used as a proxy for the institutional arrangements of the system in general (Baltagi and Moscone, 2009, Lopez-Casasnovas and Saez, 2007). While not being a perfect proxy (it doesn't correlate perfectly with, for example, fee-for-service remuneration), the share of public financing is correlated with many of the payment and financing mechanisms highlighted by Gerdhtam (1998). The negative effect on total expenditure which Gerdhtam (1995) and Gerdtham et al. (1998) reported for the share of public financing probably should not be considered as a rejection of the opposite results obtained by Leu (1986), as there was high degree multicollinearity between the regressors, and the result, according to Gerdtham et al. (1998), was not robust.

Public and private health expenditure

As has been discussed in the introduction, the public and private shares of total expenditure on health may be regarded as different categories of goods and therefore have different characteristics, such as income elasticity. Public health expenditure, as also has been mentioned, is important across all OECD countries and its dynamics, according to Gouveia (1996), may reflect political processes. Political forces are often mentioned in the health expenditure studies, such as

Gerdtham et al. (1992a), but are rarely considered explicitly. But the political processes which determine public spending seem to be able to provide interesting theoretical grounds that could be empirically tested. An example of such approach is Gouveia's (1996) paper. In this paper he proposed a theoretical model explaining the split between public and private expenditures on health and estimated it empirically using panel data for OECD countries with two-way, i.e., country and time, fixed effects. He obtained price and income elasticities which allowed him to draw conclusions about the different nature of the public and private health expenditures. Here I would like to replicate this model using more recent data. Since this is the only theoretical model I use, the paper receives an extended discussion compared to the presentation of other studies all of which are empirical in nature.

Introducing this theoretical background implies extending the range of the determinants of health expenditures in addition to the ones discussed already. But as the public share of total expenditure was taken to be a proxy for the overall institutional organization of the health care system, introducing the theory explaining the determinants of the public share could be considered to some extent as explaining the determinants of the overall organization of the system. Following Gouveia (1996), I will look at public and private health expenditure separately.

Gouveia (1996) used the majority rule voting methodology following the theoretical work of Epple and Romano (1996) and Gouveia (1995) on the politics of the public provision of private goods. This approach assumes that collective decisions are taken based on welfare maximization for all voters. One of the interesting implications of the majority rule theory applied to the provision of a private good (which health care is), is that there may be a welfare loss if a public monopoly is adopted a priori where a market or mixed provision would be collectively preferred. This is because if the majority prefers that health care is provided both publicly and privately (i.e., their utility is

maximised under this type of provision) but instead all health care is provided publicly, the majority obtains a utility level lower than their maximal level. Therefore the sum of the utility levels in the case of solely publicly provided good would be lower than in the case of a mixed provision when the utility of the majority is maximised.

Public provision assumes equal consumption funded by income taxes. This implies that while consuming the same amount, different categories of consumers have different prices (depending on income). Private provision, on the other hand, assumes variable consumption (depending on needs) but equal prices for all consumers.

The voting mechanism assumes that a collective decision determines the level of provision of the good, that all voters participate and that the majority rules. Under these assumptions the median voter's preferred provision gets the majority support, hence to find the preferred level of public provision one needs to locate the median voter.

The problem with pure public provision of a private good is that while the price under public provision tends to increase the welfare of some (usually lower income) voters, other voters may be dissatisfied with the level of utility they get. Therefore there should exist a level of public provision which makes majority better off and this level is the majority voting outcome. Also, it is important to note that the tax price must exceed the market price for at least one voter to ensure fiscal solvency, while for the majority tax prices should be lower than the market price.

Gouveia (1996) builds his model of the public and private health spending assuming that private health care is a supplement. This set up was shown (Gouveia 1995, Epple and Romano 1996) to have a majority vote equilibrium and therefore can be characterized and empirically analysed. The model proposed by Gouveia defines the demand for health care as a function of market health care prices and a consumer's morbidity. The individual's demand has a positive income elasticity and a

negative price elasticity. Increasing morbidity is equivalent to increasing health care costs and higher demand for health care. Market demand is determined by aggregating individual demands across all consumers (who will also be voters in the model); i.e., it takes into account the income and morbidity distribution in a given country.

The model assumes that health care is financed through the income tax and provides a fixed amount of health care services free of charge. The latter is constrained by the government budget which depends on the aggregate morbidity rate (how much health care is demanded in a country) and the tax function (i.e., how much is being collected for financing this amount of health care and the way this financing burden is distributed among the population). Another important feature of the model is the individual's relative tax price of health care, which depends on how individual morbidity differs from the aggregate morbidity. Thus a taxpayer who is relatively healthy (has lower than average probability of getting sick) would have a higher relative tax price, which would make the use of public health for him more expensive compared to private health care. Therefore within the majority rule framework the ideal level of public provision for a voter will depend on the individual's relative price.

The process of voting over the amount of public provision is assumed to have two stages. First, the level of public provision is determined, and then each voter decides how much to supplement it with private health care. The demand for private health care is thus determined as the difference between each voter's total demand and the amount which is publicly provided.

Furthermore, it is important to note that since the level of public provision is bounded by the tax revenue, higher public provision would lead to higher taxes. But higher taxes imply lower disposable income which will have a negative income effect on the demand for private healthcare. This will also create a crowding out effect as the demand for the private supplement will decrease.

Combined together these effects imply that the marginal crowding out of private health care is greater (lower) than one if the relative tax price of public health care is greater (lower) than one.

According to Gouveia and under certain assumptions (continuous joint distribution of income and morbidity, and smooth consumer preferences over consumption and health care), the majority rule equilibrium exists and it is determined by the preferred provision of the median voter. To characterize the solution in more detail, Gouveia derived some comparative statics results which demonstrated that the effect of a change in unit price on the level of public expenditure demanded by a median voter is negative, and the price elasticity is less than one. The effect of a price change on the private health care demand is more complex since the private demand is a residual and depends on both total and public demands. It is composed of many offsetting individual effects, such as income and crowding out effects, and even knowing demand elasticities does not allow one to determine the sign of the price effect on private health demand.

The empirical implementation of this model is not straightforward as there is a problem with defining the median voter, who, according to Gouveia, is not characterised by a median income. To overcome this problem, Gouveia uses a number of shifting parameters which he believes are able to account for the changes in the location of the median voter. These parameters are the average income, morbidity (proxied by the share of the population aged over 65) and a measure of the progressivity of the tax system (which reflects the tax price).

The tax system information receives special attention in the empirical model. On the one hand, the progressivity of the tax system is a factor influencing the public health spending as it reflects the tax function – the distribution of the tax burden and tax prices to voters. Gouveia proposed to measure progressivity by the share of consumption and sales taxes in total tax revenues. This measure is based on the assumption that consumption and sales taxes tend to be regressive. On

the other hand, the tax system may have tax credits or deductions for health expenses and as such it affects the effective price of private health care. Therefore income taxes should be included in both the public and private expenditure equations.

Finally, Gouveia also included a time dummy to account for technological progress. In his view, introducing it was important to reflect the changing quality of health care as a good.

Health expenditure measurement issues

The issue of the cross-country comparability of data on health expenditure is not as big as it was at the time of Newhouse (1977). There has been a lot of work done by the OECD in terms of harmonizing international health statistics by introducing standards of reporting for health expenditure, such as the System of Health Accounts. Also data on price indexes and purchasing power parities for all OECD countries are now widely available, which makes international comparisons more reliable. Newhouse used market exchange rates to convert health expenditure data from national currencies into common units. But generally speaking this method is inaccurate and was motivated by the absence of a better means of conversion. As was already discussed, not accounting for health care prices may distort the measurement of real volumes of health services consumed in a country and hence distort the estimate of the income elasticity. The relative health price is now available, which allows testing the above mentioned assumption directly, without using proxies as in Leu (1987). The only complication is that not all countries compute health sector prices and there are gaps for certain years, which may complicate any analysis that uses time series. In fact, only 16 out of 30 OECD countries report the health care price index, according to the OECD Health Data 2009, and there are gaps in the time series of those countries that report, which complicates the use of panel data models. Some cross-section studies included the price index but found it to have an insignificant coefficient (Gerdtham et al., 1992). Other authors (Baltagi and Moscone 2009) suggest

it is better not to include it in the regressions at all due to the variability in price measurement, regulation and quality of health services in different countries.

Another way around the conversion issue is to use purchasing power parities (PPPs). One generally has a choice between the economy-wide PPPs, i.e., PPPs for GDP, or the specific PPPs for health care. The latter seem to be the best conversion factors as they capture variation in health sector prices which may differ from those in overall consumer prices (Gerdtham et al. 2000). The conversion issue has been discussed among others, by Parkin et al. (1987), Gerdtham and Jönsson (1991a,b) and Hitiris and Posnett (1992) . They showed that different conversion factors produce different results. As Gerdtham et al. (1991a) note, converting health expenditures using official exchange rates tends to exaggerate the true differences in health care expenditure, so it is definitely not a good practice to use exchange rates. But the development of the health sector specific PPPs is still underway by the OECD secretariat and they are not yet available in the OECD Health Data. Therefore it seems that the only possible way to proceed at present is to use general PPPs.

Modeling and estimation issues

Another important issue is that Newhouse (1977) as well as Kleiman (1974) and Leu (1986) used relatively small samples and "unsophisticated econometric modelling," according to Parkin et al. (1987, 116). Hitiris and Posnett (1992), following the observation of Parkin et al. (1987), stated that the results of Newhouse and others should at least be taken cautiously. Thus in replicating Newhouse's model, Hitiris and Posnett (1992), for example, tried to extend the data set by pooling cross sections and time series to overcome the limitations of the static cross-section models. Since then cross-country analysis of health expenditures has mostly used panel data as it offers the advantages of a larger sample size and possibilities of dynamic analysis, as well as the inclusion of the country-specific effects.

However, in using time series, the issue of non-stationarity and spurious results arises. If the series are non-stationary, one could get significant regression results for a relationship that does not actually exist. To find out if the relationship exists, tests for cointegraion need to be performed and techniques other than OLS must be applied to the raw variables. This issue has been the subject of several studies, some of which found non-stationarity in health expenditure and GDP. Since the magnitude of the income elasticity is fundamental for understanding the nature of health expenditures, and the non-stationarity of health expenditures (HE) and income, according to Baltagi and Moscone (2009, 2), "cast doubt on prior inference on income elasticity obtained from spurious regressions," the issue of cointegration between health expenditure and income attracted a lot of attention.

Hansen and King (1996) were among the first to mention the possibility of non-stationarity in HE and GDP time series. They showed that one can rarely reject the unit root hypothesis when HE or GDP are considered separately for each OECD country. Similarly, for the country-by-country case they rarely could reject the hypothesis of no cointegration between the two variables. So they concluded that estimating relationship between HE and GDP using panel data models may give spurious results. This conclusion was revisited by other authors, such as McCoskey and Selden (1998), who used a panel data unit root test (the t-bar test by Im, Shin and Pesaran, 1996). Using this test they were able to reject the presence of a unit root in either variable, having as a null hypothesis that all the series contain unit roots. They noted that the single variable unit root tests used by Hansen and King (1996) are of lower power than the panel unit root tests which explains the different results obtained. Rejection of the hypothesis of unit roots in HE and GDP indicates that panel models are not misspecified as argued by Hansen and King (1996) and the OLS estimates of the coefficients are reliable. But they do mention that the test they employed doesn't take into

account heteroskedasticity, which is likely to exist. Also, for their panel unit root test McCoskey and Selden decided to exclude the time trend from the augmented Dickey-Fuller equation. They assumed the time trend would be accounted for by an intercept, while introducing the time as an additional variable would bring a large loss of power but little improvement of fit. Contrary to this approach, Gerdtham and Loethgren (2002) argued that since both HE and GDP series seem to be trended, it is important to include a time trend explicitly in the tests. Blomqvist and Carter (1997), as another example, did include a time trend, but were not able to reject the unit root hypothesis. They did further tests and found that cointegration was present by rejecting the null of no-cointegration using the Phillips and Perron (1988) test and not rejecting the null of cointegration using the Shin (1994) test. Gerdtham and Loethgren (2002), using a panel cointegration test, concluded that HE and GDP are cointegrated around linear trends. They also stressed the fact that the linear trend should be included in the cointegrating relationship since the GDP and HE data demonstrate growth, which is probably due to technological change.

So the conclusion one might draw from this strand of the literature is that it is important to perform a number of unit root tests to ensure that the high explanatory power of GDP and a certain level of income elasticity that the OLS regressions produce are reliable. However, if the unit root tests indicate non-stationarity, it is necessary to perform tests for cointegraion and use special techniques such as error-correction models to estimate the long-run relationships between the variables. In this paper I apply a number of unit root tests to the principal variables of the models. I find that depending on the test used, results differ significantly. Taking into account the low power of unit root tests, I decide to proceed with regressions aasuming stationarity of all data series.

The models

The model of total expenditures considered in this paper includes the determinants most often used in the cross-section time-series studies which were discussed in the literature review, while taking into account the availability of data. As the literature review revealed, most researchers agree that income should be included in the model of total health expenditures. Regarding the expected regression coefficient, there is no single view on whether one should expect that the income elasticity would be lower or greater than unity. However it is an established result that the relation between health expenditures and income is strong and positive.

The need to account for health price differences to provide for better cross-country comparability and prevent the income regression coefficient from distortion seemed convincing enough to include the health price index in the model. The hypothesis of Hitiris and Posnett (1992) that countries with higher prices should have higher health expenditures, as well as the Baumol cost disease hypothesis - two different ways of interpreting the price effect - both predict a positive regression coefficient for the health price index. However Hitiris and Posnett (1992) couldn't empirically support their hypothesis. Therefore obtaining a positive coefficient will be interpreted as a sign of Baumol cost disease while negative sign will signify that a lower quantity of health services is purchased in the countries with higher health prices.

The share of people over 65 years of age is also included as one of the most widely used socioeconomic factors in health expenditure models. Considering this variable would also help in answering the urgent question of the economic effects of population ageing; in this case, its effect on health expenditure. This variable could also be considered as a proxy of overall population morbidity. However, as the previous research has shown, the regression coefficient of this variable is

often found to be insignificant. So the general conclusion is that ageing and morbidity are not major forces driving health expenditures up.

The effects of supply are represented by physician density. As was already mentioned there exists an interesting hypothesis of induced demand, but it is only relevant under the fee-for-service payment scheme. Therefore the regression coefficient would not be interpreted in terms of this hypothesis.

As a variable of particular interest I also include the share of public expenditure on health. It is often used when researchers decide to account for differences in health systems across countries as was mentioned in the literature review. Here it will be especially interesting to see whether it has a significant coefficient. If public-private mix is found to have a significant coefficient then the fact that public and private health expenditures have different characteristics (if established using the other two equations) could be used in explaining the role of public-private composition of expenditures in determining total expenditures. According to the literature, there doesn't seem to exist an established view on the role of this variable. As was also discussed, the regression coefficients that different studies reported varied. Therefore there is no predetermined sign one would expect to obtain.

Finally, the effect of technological progress, which is often proxied by a time trend, will be accounted for by means of fixed time effects (i.e., a dummy variable for each year will be included in the regression equation).

Additionally the Gouveia (1996) model will be empirically tested. An important feature of this model is that it allows one to see whether public and private expenditures on health exhibit different responses to cost changes. Gouveia (1996) himself agrees that one of the driving force behind growing health expenditures is the growth in health care costs. Therefore if public and private

expenditure respond differently to cost changes, the resulting effect on total expenditure will depend on its composition, i.e., on the public-private mix. So, to better understand what determines total health expenditures, it is important to understand the differences between private and public health expenditures first.

The theoretical model, following Gouveia (1996), as was already discussed, includes two equations: one each for the public and private sectors. Since the focus of his theory is on the median voter's preferred choice, the dependent variable in the public sector equation is the median voter's demand for public provision as a share of his income. For the empirical estimation this would imply using public expenditure as a percentage of GDP. The private share as a residual (a difference between the total demand and public provision), is a function of the public share. It is also measured in the empirical model as a share of GDP. The empirical equations with the description of the variables used are shown below.

In their pioneering studies, Newhouse (1977) and Leu (1986) used log-linear functional forms for their models, which allowed them to interpret coefficients as constant elasticities. Almost all authors who have studied international comparisons of health expenditure after that used log-linear specification. Gerdtham et al. (1992a, 1992b) tested different functional forms using a Box-Cox transformation and concluded that the logarithmic transformation is superior to other specifications (linear or exponential). Therefore the double-log (also known as log-log) functional form will be used here as well. As usual, continuous variables are transformed into logs (income, price and total expenditure) while variables measured as shares are left unchanged in the equation. As for the econometric modeling method, the studies that used panel data usually found the two-way (country and time) fixed-effects panel model to be the most reliable (Gerdtham, 1992, Gouveia,

1996, Baltagi and Moscone, 2009). Therefore the two-way fixed-effects panel data approach was adopted as the econometric model.

The total health expenditure equation will have the form:

$$ln(HEtot)_{it} = \varphi_0 + \varphi_1\, ln(GDP)_{it} + \varphi_2\, ln(Price)_{it} + \varphi_3 Pop65_{it} + \varphi_4 Phys_{it} + \varphi_5 HEpub_{it} + \sum_j \gamma_j DC_{jit} + \sum_s \delta_s DT_{sit} + \varepsilon_{it}\ , \quad (1)$$

where *HEtot* is total health expenditure, *GDP* is aggregate income measured by GDP, *Price* is relative health prices, *Pop65* is the share of people aged 65 years and older, *Phys* is the density of physicians per 1000 population and *HEpub* is the share of public expenditures in total health expenditure. Finally, DC_j is the fixed effect for country j and DT_s is the fixed effect for year s. The reference country and year are Australia and 1975 respectively. One country and one year dummy must have been dropped to avoid the dummy variable trap.

Since in Gouveia (1996) the dependent variable is the median voter's demand for public provision as a share of his income, for empirical estimation Gouveia used public expenditure as a percentage of GDP. The private share is also measured in the empirical model as a share of GDP. The estimation equations for the public and private shares are as follows:

$$Xpub_{it} = \alpha_0 + \alpha_1\, ln(GDP)_{it} + \alpha_2\, ln(Price)_{it} + \alpha_3 Pop65_{it} + \alpha_4 inctax_{it} + \alpha_5 constax_{it} + \sum_j \theta_j DC_{jit} + \sum_s \vartheta_s DT_{sit} + \varepsilon_{it}\ , \quad (2)$$

$$Xpriv_{it} = \beta_0 + \beta_1\, ln(GDP)_{it} + \beta_2\, ln(Price)_{it} + \beta_3 Pop65_{it} + \beta_4 inctax_{it} + \beta_5 XPub_{it} + \sum_j \sigma_j DC_{jit} + \sum_s \omega_s DT_{sit} + \varepsilon_{it}\ . \quad (3)$$

The variable *inctax* is the sum of income and profits taxes and *constax* is the sum of consumption and sales taxes as shares of total tax revenue.

Since the models estimated are not double-log, to derive the income and price elasticities of public and private health expenditure shares one would have to do an additional calculation. Following Gouveia (1996), the income elasticity is computed as:

$$\mu_{GDP} = \frac{dX}{dln(GDP)}\frac{1}{X} + 1 ,$$

whereas the price elasticity is:

$$\mu_{price} = \frac{dX}{dln(Price)}\frac{1}{X} - 1 .$$

These elasticities will be evaluated at the sample means of the data.

However the estimation of a panel model, as was mentioned in the introduction, may be complicated by the presence of non-spherical error terms, i.e., by heteroskedasticity or autocorrelation. To deal with these problems, tests for heteroskedasticity and autocorrelation will be performed. Panel-level heteroskedasticity will be tested using the likelihood-ratio (LR) test based on the estimation results from two models (one assuming heteroskedasticity and the other assuming homoskedasticity). Also another test for heteroskedasticity will be used, which is based on the Modified Wald statistic for groupwise heteroskedasticity in fixed effects models, following Greene (2000, p. 598). The test for autocorrelation is the test for panel-data models following Wooldridge (2002, p. 282). It assumes an AR(1) process and that the coefficients of the AR(1) process are the same for all the cross-sectional units.

In the presence of non-spherical errors, instead of the OLS estimation technique feasible GLS and Panel Corrected Standard Errors (PCSE) can be used. FGLS is able to estimate a model in the presence of heteroskedasticity and autocorrelation as well as cross-section correlation. However, as Beck and Katz have shown (Beck and Katz, 1995), using FGLS for panel data in small samples produces inaccurate standard errors which leads to serious overconfidence. An alternative method

developed by them, the PCSE technique, assumes that the OLS coefficients are correct (since they are consistent) and just recalculates standard errors (since the OLS estimates are inefficient in the presence of non-spherical errors). It allows for errors that exhibit heteroskedasticity as well as cross-section correlation. Autocorrelation if present needs to be corrected before applying PCSE (by estimating coefficients using the FGLS correcting for autocorrelation only). Therefore using PCSE produces the same coefficients as does OLS in case of no autocorrelation, and the FGLS correcting for autocorrelation (also called Prais-Winsten regression) coefficients whenever autocorrelation is detected. However the PCSE standard errors would be different from either OLS or FGLS standard errors, producing more reliable estimates, according to Beck and Katz. Therefore if different, the estimates produced by PCSE should be preferred to the FGLS results.

Also, for panel data there may be a correlation between panel units, i.e., the error terms of different countries could be correlated. Here I will not test for this type of problem. However, it should be noted that PCSE corrects for it by default.

Therefore the following types of regression estimates will be compared:

- fixed effects (country and time) model with i.i.d. errors estimated using OLS;
- GLS estimation of fixed effects model with non-spherical errors (if the problems are revealed by the diagnostic tests); and
- fixed effects model estimated using OLS or GLS correcting for autocorrelation with panel-corrected standard errors.

In addition to estimating the equations using the three methods and performing heteroskedasticity and autocorrelation tests, tests for stationarity will be carried out. Since the panel of data (as will be shown below) turned out to be unbalanced, the Im, Shin and Pesaran (1996) test was not applicable. Instead, the Fisher panel data test developed by Maddala and Wu (1999) was used. This test assumes that all series are non-stationary under the null hypothesis, against the alternative that at least one series in the panel is stationary. Additionally, a t-test for unit roots in

heterogeneous panels with cross-section dependence (the CADF test), proposed by Pesaran (2003), was used. The null hypothesis assumes that all series are non-stationary and the alternative is that some of the series are stationary.

Data

The principal source of data is the OECD Health Data 2009. Additionally, the OECD Revenue Statistics of OECD Member Countries (Comparative tables Vol. 2008 release 01) was used for the income and consumption taxes. Initially 19 OECD countries and the period from 1975 to 2007 were chosen based on availability of health expenditure data series. However, some further data exploration analysis discussed below lead to the decision to exclude certain countries from the analysis, so that the final sample included only 10 countries. The variables' definitions and data sources are presented in table 1 of the Appendix.

After the first unit root test results were obtained, it became evident that there were still severe problems in the data sample. In particular, the output of the CADF unit root test indicated a problem of insufficient observations in the public and private health expenditure series, such that the test statistic could not be computed. To establish the source of the problem, a table showing missing observations by variable and year was constructed and is shown in the Appendix (table 2). As can be seen from this table, the series of public and private expenditure are virtually empty for Belgium. Therefore the decision was made to exclude Belgium from the sample. Another observation one can make is that the health care price series have numerous missing values. Limited availability of health care prices data was mentioned in the literature review and is not unexpected. However it needs to be stressed here that the estimated sample size is determined by the number of observations of a variable with the lowest number of observations, which is the health care price. Therefore, despite

the availability of observations for other variables over longer periods, only the years for which the price index is available are included in the estimation sample.[4] This is likely to have a distorting effect on the variability of the sample. To illustrate the degree to which the data change when observations are deleted from the sample, in addition to table 3 for the initial sample, three more tables of descriptive statistics for each equation are given in the Appendix (tables 4, 5 and 6). Nevertheless, there is no better way to estimate the models constructed than to employ what is currently available from the OECD Health Data. As was mentioned, it is the most reliable source of internationally comparable data and if the data are missing, it means that they either are not being collected at the national level or they don't comply with the OECD standards and thus are not deemed comparable across countries.

Results

Before proceeding with the regressions, the results of unit-roots tests will be discussed. As was mentioned in the literature review, regression results may be not quite reliable due to the possibility of unit roots in the variables. But since obtaining the correct measures of income and price elasticities is essential for understanding the nature of health expenditures, it is important to make sure the regression coefficient estimates are not spurious. For this reason unit root tests were performed. Tables 7 and 8 present the results of unit-root tests for all variables from the three equations, considering separately the case of an intercept only and an intercept and a trend in the test equation.

In table 7 the p-values of the Fisher panel unit root test are presented. Since this test doesn't allow for cross-country dependence, another test for unit roots (the CADF test) proposed by Pesaran

[4] Adding dummy variables for the missing price could not have resolved the issue as having zeros in place of the missing values would be equivalent to dropping these observations.

(2003) was used. Pesaran's CADF test allows for cross-section dependence and therefore will produce reliable results if such cross-section dependence is present, whereas the Fisher test will not be applicable. The results of Pesaran's CADF test are presented in table 8. The null hypothesis of both tests is that all series for all countries are non-stationary. The alternative is that at least one series in a panel is stationary.

The results of the two tests differ significantly considering the tests' p-values with the lowest AICs.[5] Using the Fisher test for the model of total expenditure (equation 1), the unit root hypothesis was rejected in the case of an intercept only by the log of income, *ln(GDP)*; the age structure variable, *Pop65*; public health expenditure as a share of total health expenditure, *HEpub*; the density of physicians, *phys*; and the price series, *ln(Price)*. In the case of an intercept and a trend the panel level unit root was rejected by the log of total health expenditure, *ln(HEtot)*; log of income, *ln(GDP)*; public expenditure as a share of total health expenditure, *HEpub*; and the log of price, *ln(Price)*, series. It should be noted that obtaining stationarity for total expenditure and income, as is the case here, when the ADF test equation includes intercept and trend, contradicts the finding of other authors, such as Hansen and King (1996) or Blomqvist and Carter (1997), who found these two series to exhibit non-stationarity.

As for equation (2) and (3), in addition to the results discussed above, the dependent variables, *Xpub* and *Xpriv*, show evidence of non-stationarity in both intercept only and intercept and time trend cases. Also, the income tax variable, *inctax*, is non-stationary according to the test.

However, the results of Pesaran's CADF test give the reverse results confirming the unit root hypothesis for almost all variables, with the exception of the log of total health expenditure. However the results of the test for total health expenditure were extremely sensitive to the number of

[5] The Akaike information criterion. It is used to determine the optimal number of lags. The number of lags is chosen so as to minimize the AIC.

lags included. Considering the lowest AICs, the p-value for the null hypothesis that total health expenditure is not stationary in all panels was 0.002 in the case of intercept only and 0.05 – in the case of an intercept and a trend. The latter result was complicated by the fact that p-values for higher AICs were above 0.05. Therefore the hypothesis of panel non-stationarity for total health expenditure could be rejected at the 5% level in case of an intercept only, and at the 10% significance level – in case of an intercept and a trend. The CADF test could not be performed for the physicians' density and the log of price due to multiple gaps in the series.

Since the main difference between the tests is that Pesaran's test accounts for the possibility of cross-section dependence, while the Fisher test doesn't, the difference between the tests' results should probably be attributed to this latter fact. Thus the conclusion can be drawn that cross-country correlation is present. This is in line with the findings of Baltagi and Moscone (2009), who performed a number of different unit-root tests as well as a test for cross-section correlation. Their results indicated the presence of cross-section dependence which led them to conclude that the unit root tests allowing for cross-section dependence should be given preference when choosing between the tests with differing results. Following this advice, the results of Pesaran's CADF test should be preferred to the results of the Fisher test. According to the results obtained, the hypothesis of a panel level unit root could not be rejected for the log of total health expenditure (when a trend was included in the ADF test equation) nor for any other variable. This is in line with what Baltagi and Moscone (2009) reported.[6] They obtained stationarity for the health expenditure and income series using the "first generation" unit root tests but non-stationarity using Pesaran's CADF test and the latter was taken as the correct result. Therefore no definitive conclusion could be drawn about the

[6] The results of the unit root tests not allowing for cross-section dependence ("first generation tests") which Baltagi used all rejected the unit root hypothesis. These tests included the Maddala and Wu (1999) Fisher test used in the present paper, as well as the Im, Pesaran and Shin (2003), the Levin Lin and Chu (2002) and Breitung (2000) tests.

stationarity of the total health expenditure series. Nevertheless, as was mentioned before and as the obtained results illustrate, the results of unit root tests are sensitive to the choice of test. They also tend to have low power (Baltagi and Moscone, 2009) especially with short series like the ones available for health expenditures. Also, as Baltagi and Moscone mention, there are possibilities of structural breaks. Once the structural breaks are accounted for, the series might as well turn out to be stationary. Therefore I will proceed assuming the series are stationary and the regression coefficients are meaningful.

According to the framework discussed in the "Models" section, three equations were estimated. First, total health expenditure was estimated using equation (1) and then the shares of public and private expenditures were estimated using equations (2) and (3).[7] Each equation was estimated using three different methods, i.e., OLS, FGLS and PCSE. But before moving to the regression results, the issue of non-spherical errors needs to be discussed. To establish whether the errors exhibit any of the non-spherical characteristics, tests for panel-level heteroskedasticity and autocorrelation were performed. The results are presented in table 9 of the Appendix.

The LR test for heteroskedasticity rejected the null hypothesis of homoskedasticity while the modified Wald test could not reject heteroskedasticity. Therefore both tests indicated that heteroskedasticity is likely to be present in all three equations. The presence of autocorrelation in residuals was also confirmed by the test in two (1 and 2) out of three models (the null of no autocorrelation could not be rejected for equation 3). Therefore, the presence of non-spherical errors was confirmed for all three equations and using FGLS and PCSE is justified.

At the next step, the three equations were estimated using OLS as well as feasible GLS and PCSE. According to the results of the diagnostic tests, the correction for heteroskedasticity was used

[7] For all estimations Stata/10.0 was used.

in estimating all three equations while the correction for autocorrelation (assuming identical AR1 processes for all cross-sectional units) was used for equations (1) and (2). As was mentioned during the discussion of the PCSE method, PCSE estimation adopts the OLS coefficients if there is no autocorrelation. Otherwise autocorrelation needs to be corrected before applying the PCSE. Since the autocorrelation was detected only for equations (1) and (2), the PCSE regression coefficients for equation (3) will be equal to the OLS coefficients, while the PCSE coefficients for equations (1) and (2) will be the same as the coefficients estimated using the FGLS correcting for autocorrelation only (not reported here).

The regression results are presented in tables 10, 11 and 12 for equations (1), (2) and (3) respectively. The income and price elasticities which needed additional calculation are shown in those tables (11 and 12) below the regression coefficients.[8] The models were first estimated assuming that the errors are homoskedastic and uncorrelated using pooled OLS. The results of these estimations are reported in column 1 of tables 10, 11 and 12. Column 2 shows the estimation results using FGLS while column 3 presents the results with PCSE.

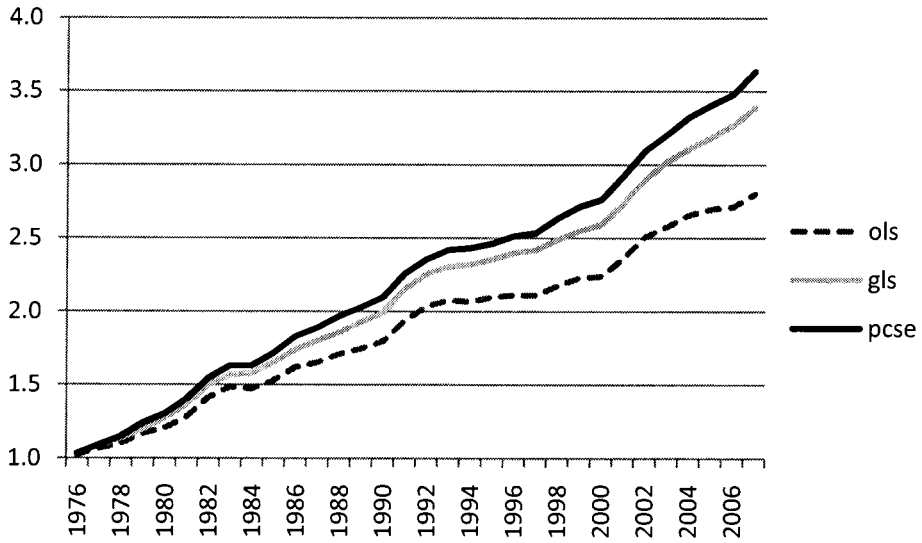
The models were also tested for the validity of the fixed effects approach for country and year effects separately. These results, as well as the statistics showing overall significance, are given in each table below the regression results.

As can be seen from table 10, the test of overall significance and the test of significance of the fixed effects in the model of total health expenditure both reject the hypothesis that all coefficients (or all coefficients of the corresponding dummy variable) are zero. Therefore the choice of the fixed effects method and the specification of the model may be assumed to be valid. The coefficients of the country dummies are shown in the regression results while the year dummy

[8] For equation (1), income and price elasticities equal the respective regression coefficients and therefore no amendment is made to the table of regression results (table 10).

coefficients are omitted. However, since the year dummies are meaningful as they represent the influence of technological change, it was decided to show them graphically. According to the results of the test for fixed effects significance, time fixed effects could be rejected at the 5% significance level for equations (2) and (3) in two out of three cases (the joint significance of the year dummy coefficients could not be rejected only when the PCSE was used). Therefore the year dummies' coefficients were graphed only for total health expenditures and are shown in figure 3. To make them more meaningful, the coefficients were transformed so that they describe the effects of years on the level of total health expenditure and not on its logs (i.e., by exponentiation). Thus, for example, if in the OLS regression of *ln(HEtot)* the coefficient of the year 1990 equals 0.59, the effect of year 1990 on *HEtot* will be 1.79 ($e^{0.59}$=1.79). As figure 3 shows, the effect of each consecutive year is strongly positive and increasing. It is also interesting to note that years seemed to have a consistently higher influence under PCSE estimation model than under FGLS or OLS models.

Figure 3. Transformed year dummies' coefficients



The country effects can be observed from tables 10, 11 and 12. As the tables indicate, out of 19 countries in the initial data sample, 9 were dropped due to multicollinearity resulting from

multiple missing observations. Therefore only 10 countries were actually included in the sample. There is no dummy variable for one of these ten since it was chosen as a reference category against which the effects of the other country dummies were assessed. The included countries were: Canada, Denmark, Finland, Iceland, Ireland, Spain, Sweden, Switzerland and the United States; Australia was the reference country. Also, not all country effects were significant as the regression results indicate. Nevertheless the country fixed effects could not be rejected according to the Wald test for all but the private expenditure model (when estimated using OLS and FGLS only).

Turning to the other regression coefficients, in the case of total health expenditures (equation 1) all variables included turned out to have significant coefficients except the log of the price index in the FGLS estimation (table 10). Since the diagnostic tests revealed the presence of heteroskedasticity and autocorrelation, these two problems were dealt with through FGLS and PCSE estimations. The resulting coefficients are slightly different. Since, as was mentioned, FGLS may lead to overconfidence in small samples, the results of PCSE should be preferred. According to these results, the variable of interest – the share of publicly funded health expenditures – was found to have a significant positive coefficient. Its magnitude (0.004) suggests that an increase of 10 percentage points, for example, (i.e., from 70.2 to 80.2) in the share of public health expenditures in total health spending would result in an increase of 4 % in total health expenditures. Therefore the overall organization of the health system, as proxied by this latter variable, has an impact on the level of total health expenditures which cannot be ignored.

The regression coefficient of income, which measures income elasticity in this model, equals 0.72. This supports the view that health care is a necessity. Also, the price elasticity was equal to -0.23, suggesting that neither "Baumol cost disease" nor Hitiris and Posnett's (1992) hypothesis of positive correlation between prices and health expenditure could be validated. The effect of an

ageing population was found to have a negative coefficient, which can be considered as an odd result since it is believed that an ageing population is one of the main forces that drive health expenditures up while empirical literature has found no effect. Finally, the density of physicians was found to have a positive impact on health expenditures. Taking into account that the dependent variable is in logs, the magnitude of the *phys* regression coefficient (0.054) suggests that an increase in the density of medical doctors, from 2.5 to 3.5 per 1000 population, for example, (i.e., evaluating the changes at the sample mean which is 2.5), would lead to an increase in the level of total health expenditures per capita of approximately 5.4%.

Overall, the three estimation methods produced robust results for the income and price elasticities – at least in the sense that the income elasticity was below unity in all three cases and price elasticity was negative and small.

As table 11 shows, however, the coefficient estimates for equation (2) change substantially every time a different estimation method was applied. This is especially true for the income and price coefficients. Although the coefficient of income is significant at the 10% level when OLS is used (column 1), the other two methods (columns 2 and 3) give quite different estimates which are not statistically significant according to the t-tests. But the values of the coefficients shouldn't be taken as indicative of the elasticity magnitude, since the dependent variable is not a logarithm, and to obtain the elasticity additional computation is necessary. The only coefficient which remains significant in all three regressions is that of *pop65* (although it is still negative), whereas the coefficient of *inctax* is significant in the first two estimations (OLS and FGLS). Therefore the theoretical model of public health expenditure as proposed by Gouveia (1996) did not perform well based on the available data: only one coefficient according to the preferred estimation method (PCSE) was found to be significant.

The private expenditure estimation in table 12 yields more significant coefficients than the public expenditure model. The results are robust to the estimation method. However this is probably because autocorrelation was not detected and didn't have to be dealt with. As was mentioned, this is the reason why the coefficients estimated by OLS and PCSE are the same. Interestingly, the regression coefficient of the share of public expenditure equals -0.999. This indicates that the data don't support the proposition that the trade-off between the public and the private sector is not one-for-one. Also, according to the regression results obtained, the income and price elasticities in the private sector are lower than in the public sector. This is in accordance with what Gouveia expected and obtained in his 1996 paper. Together, this means that a higher price, for example, leads to lower public health expenditure and the private supplement substitutes for public health care in the proportion of one-to-one.

Again, as the regression coefficient of the share of public health expenditure in equation (1) indicated, the role of the health system organization in determining the level of total health expenditures cannot be ignored and therefore should be used in the models of international comparisons. But drawing definitive conclusions about the effects of financing and provision requires understanding the private and public health expenditure characteristics. The analysis of these characteristics using the chosen theoretical approach was complicated here by the data problems. Therefore unless the data gaps in the series of the health price index as well as public and private health expenditures get eliminated, it doesn't seem feasible to obtain better results.

Conclusion

In this paper a model of total health expenditure was constructed and empirically tested, as was a theoretical model proposed by Gouveia (1996). In the total health expenditure model the most widely accepted explanatory variables were included. However there are other potential explanatory

factors which have been proposed in the literature on health expenditures but were not considered in this paper. Assuming that political processes indeed play a role in determining public expenditure on health, more politically relevant factors could be included. For example, one could consider some measure of the national preference for public health, such as the party composition of the government. This latter parameter was used for example by Navarro et al. (2006), who reported that the proportion of public spending is positively related to left-parties' cumulative time in government. Another potential regressor is the degree of income inequality in a country. Its theoretical relevance is demonstrated by Epple and Romano (1996), who considered the dual public-private system of provision, and concluded that the rich and poor prefer lower public care while the middle class prefers higher public care. And since income distribution is likely to affect the middle-class base of support for public health expenditures, it also could play a role in determining the size of public health expenditure.

But a single model could not account for all the potential explanatory factors. Here, following the findings of the existing literature I tried to combine the most important factors into a single equation. This was supplemented by two equations describing public and private shares of health expenditure based on a coherent theoretical framework. The main theoretical assumption - that there is a distinction in income and price elasticities between public and private health care sectors - was confirmed, although this distinction was not as noticeable as Gouveia (1996) reported in his paper. The importance of accounting for the public-private mix was further confirmed by the total expenditure regression results where variable showing the share of public spending in total health expenditure was found to have a significant positive effect on total spending.

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Appendix

Table 1. Variable definitions and data sources

Variable	Description	Source
HEtot	Total health expenditure, per-capita, GDP PPP adjusted	OECD Health Data 2009
Xtot	Total health expenditure, % of GDP	OECD Health Data 2009
Xpub	Public health expenditure, % of GDP	OECD Health Data 2009
Xpriv	Private health expenditure, % of GDP	OECD Health Data 2009
GDP	Gross Domestic Product, per-capita, GDP PPP adjusted	OECD Health Data 2009
Price	Total health expenditure price index, (2000=100)	OECD Health Data 2009
Pop65	Population age structure (the share of people aged 65 years and over)	OECD Health Data 2009
Phys	Physicians' density, per 1000 population	OECD Health Data 2009
HEpub	Share of public expenditure in total health expenditure	OECD Health Data 2009
inctax	Share of income taxes in tax revenues (sum of income and profits taxes for all levels of government)	OECD Revenue Statistics 2008
constax	Share of consumption taxes in total tax revenue (Sum of consumption and sales taxes for all levels of government	OECD Revenue Statistics 2008

Table 2. Variables with missing observations by years and countries

	Lgdp	*Lprice*	*HEtot*	*HEpub*	*Xtot*	*Xpub*	*Xpriv*	*Pop65*	*Phys*	*Constax*	*Inctax*
Australia	---	2007	2007	2007	2007	2007	2007	---	2007	2007	2007
Austria	---	1975-2007	---	---	---	---	---	---	---	---	---
Belgium	---	1975-2007	---	1975-1994	---	1975-1994	1975-1994	---	---	2007	---
Canada	---	---	---	---	---	---	---	---	---	---	---
Denmark	---	2002-2007	---	---	---	---	---	---	1975-1991, 2007	---	---
Finland	---	2006-2007	---	---	---	---	---	---	1975-1999, 2007	---	---
Germany	---	1975-2007	---	1991	1991	1991	1991	---	1975-1990	---	---
Iceland	---	2004-2007	---	---	---	---	---	---	---	1976 - 1979, 2007	1976-1979
Ireland	---	---	---	---	---	---	---	---	1975-1991	2007	---
Japan	---	1975-2007	2007	2007	2007	2007	2007	---	1983, 87,89 91, 93,95, 97 99,01,03, 05,07	1975-1988	2007
Netherlands	---	1975-2007	---	2003-2007	---	2003-2007	2003-2007	---	1992-1997	---	---
New Zealand	---	1975-2007	---	2007	---	2007	2007	---	1975	---	---
Norway	---	1975-2007	---	---	---	---	---	---	1988-1990	---	---
Portugal	---	1975-2007	2007	2007	2007	2007	2007	1975-1979	---	---	1975-1988
Spain	---	1975-2007	---	---	---	---	---	---	1975-1994	1975-1985	---
Sweden	---	1975-1992	---	---	---	---	---	---	1991, 2007	---	---
Switzerland	---	2004-2007	---	1975-1984	---	1975-1984	1975-1984	---	---	---	---
United Kingdom	---	1975-2007	---	---	---	---	---	---	---	---	---
United States	---	---	---	---	---	---	---	---	1975-1992	---	---

Table 3. Descriptive statistics of the initial data sample

Variable	Obs	Mean	Std. Dev.	Min	Max
ln(HEtot)	591	7.2	0.71	5.0	8.9
ln(GDP)	594	9.7	0.55	8.0	10.9
ln(Price)	282	4.2	0.49	2.4	4.9
HEpub	574	74.1	11.93	39.0	98.0
Pop65	589	13.6	2.49	7.9	21.5
Xpriv	574	25.4	11.95	1.7	60.9
Xpub	574	74.6	11.95	39.1	98.3
Xtot	590	8.0	1.77	4.5	16
Phys	455	2.4	0.66	1.13	3.93
inctax	574	32.1	10.17	13.9	61.6
constax	561	4.6	6.21	0.3	40.1

Table 4. Descriptive statistics of the estimation sample: Total health expenditure (equation 1)

Variable	Obs	Mean	Std. Dev.	Min	Max
ln(HEtot)	178	7.5	0.60	5.9	8.9
lLn(GDP)	178	10.0	0.43	8.8	10.7
ln(Price)	178	4.4	0.33	3.3	4.9
HEpub	178	70.2	12.61	42.0	89.0
Pop65	178	12.5	2.40	8.5	17.8
Xpriv	178	29.3	12.60	10.4	57.0
Xpub	178	70.7	12.60	43.0	89.6
Xtot	178	8.5	2.14	5.3	16.0
Phys	178	2.5	0.49	1.5	3.7
inctax	174	35.8	7.66	18.9	53.8
constax	173	8.6	8.55	0.5	40.1

Table 5. Descriptive statistics of the estimation sample: Public health expenditure (equation 2)

Variable	Obs	Mean	Std. Dev.	Min	Max
ln(HEtot)	258	7.3	0.65	5.6	8.9
ln(GDP)	258	9.8	0.51	8.2	10.7
ln(Price)	258	4.2	0.48	2.4	4.9
HEpub	258	70.1	13.99	39.0	89.0
Pop65	258	12.6	2.15	8.5	17.8
Xpriv	258	29.4	14.01	10.5	60.9
Xpub	258	70.6	14.01	39.1	89.5
Xtot	258	8.4	1.98	5.3	16.0
Phys	173	2.5	0.49	1.5	3.7
inctax	258	36.1	8.19	17.3	55.8
constax	258	6.8	7.77	0.3	40.1

Table 6. Descriptive statistics of the estimation sample: Private health expenditure (equation 3)

Variable	Obs	Mean	Std. Dev.	Min	Max
ln(HEtot)	268	7.2	0.68	5.6	8.9
ln(GDP)	268	9.8	0.53	8.2	10.7
ln(Price)	268	4.2	0.50	2.4	4.9
HEpub	268	70.4	13.84	39.0	89.0
Pop65	268	12.6	2.13	8.5	17.8
Xpriv	268	29.1	13.87	10.5	60.9
Xpub	268	70.9	13.87	39.1	89.5
Xtot	268	8.3	2.01	5.2	16.0
Phys	174	2.5	0.49	1.5	3.7
inctax	268	35.5	8.64	16.2	55.8
constax	258	6.8	7.77	0.3	40.1

Table 7. Fisher Panel Unit Root Test: p-values

Number of lags	0	1	2	3
With an intercept only				
ln(HEtot)	0.000 (-168.163)	0.459 (-182.310)	0.659 (-180.697)	0.794 (-172.338)
ln(GDP)	0.000 (-169.173)	0.000 (-161.275)	0.010 (-153.098)	0.332 (-147.162)
Pop65	0.001 (-85.489)	0.443 (-84.911)	0.949 (-84.687)	0.999 (-81.807)
HEpub	0.006 (72.916)	0.845 (73.361)	0.125 (71.119)	0.038 (70.502)
Xpub	0.011 (69.371)	0.781 (63.068)	0.209 (63.201)	0.061 (63.143)
Xpriv	0.002 (69.371)	0.790 (63.068)	0.113 (63.201)	0.056 (63.143)
inctax	0.000 (109.384)	0.000 (95.450)	0.071 (93.701)	0.133 (93.317)
constax	0.002 (12.128)	0.000 (12.242)	0.000 (5.556)	0.290 (6.232)
Phys	0.032 (-57.835)	0.968 (-51.747)	1.000 (-45.615)	1.000 (-41.356)
ln(Price)	0.000 (-184.033)	0.028 (-202.321)	0.000 (-206.864)	0.000 (-198.422)
With an intercept and time trend				
ln(Hetot)	0.231 (-168.985)	0.000 (-183.425)	0.000 (-182.237)	0.000 (-177.061)
ln(GDP)	0.000 (-175.254)	0.000 (-168.539)	0.000 (-164.077)	0.000 (-155.824)
Pop65	1.000 (-85.540)	0.895 (-83.062)	0.619 (-83.142)	0.045 (-83.839)
Hepub	0.004 (69.824)	0.457 (69.460)	0.683 (68.909)	0.030 (65.344)
Xpub	0.009 (66.640)	0.642 (59.479)	0.568 (60.536)	0.030 (58.207)
Xpriv	0.006 (66.640)	0.649 (59.479)	0.587 (60.536)	0.028 (58.207)
inctax	0.000 (111.125)	0.000 (97.402)	0.001 (95.665)	0.285 (95.296)
constax	0.414 (12.439)	0.000 (10.172)	0.000 (0.935)	0.985 (3.915)
Phys	0.522 (-61.804)	0.036 (-58.618)	0.710 (-53.272)	0.981 (-48.031)
ln(Price)	0.000 (-182.052)	0.521 (-203.493)	0.000 (-207.733)	0.000 (-203.320)

Notes: The table shows the p-values from the Fisher's panel unit root test developed by Maddala and Wu (1999). The values of Akaike Information Criterion are in parentheses.

Table 8. CADF Panel Unit Root Test: p-values

Number of lags	0	1	2	3
With an intercept only				
ln(Hetot)	0.063 (-176.183)	0.002 (-183.022)	0.111 (-180.275)	0.982 (-170.789)
ln(GDP)	0.112 (-181.705)	0.004 (-177.974)	0.016 (-169.508)	0.069 (-164.232)
Pop65	1.000 (-85.713)	0.976 (-81.473)	0.779 (-82.158)	0.481 (-80.980)
Hepub	0.493 (76.740)	0.997 (78.905)	1.000 (77.579)	0.927 (79.486)
Xpub	0.566 (72.219)	0.840 (68.860)	0.990 (65.427)	0.983 (67.214)
Xpriv	0.409 (72.311)	0.864 (68.576)	0.995 (67.305)	0.992 (68.291)
inctax	0.000 (109.556)	0.000 (100.268)	0.095 (94.701)	0.418 (96.566)
constax	0.223 (15.915)	0.031 (14.597)	0.161 (7.597)	0.953 (9.778)
Phys	insufficient observation			
ln(Price)	insufficient observation			
With an intercept and time trend				
ln(Hetot)	0.662 (-176.224)	0.050 (-181.240)	0.758 (-178.335)	1.000 (-168.889)
ln(GDP)	0.684 (-181.116)	0.093 (-178.265)	0.783 (-171.086)	0.862 (-162.688)
Pop65	1.000 (-86.231)	1.000 (-80.736)	1.000 (-83.809)	1.000 (-82.398)
Hepub	0.250 (72.028)	0.997 (73.034)	1.000 (70.445)	0.959 (69.474)
Xpub	0.522 (70.159)	0.995 (61.308)	1.000 (60.927)	0.995 (62.472)
Xpriv	0.457 (70.421)	0.994 (61.388)	1.000 (62.668)	0.998 (62.933)
inctax	0.084 (111.097)	0.364 (101.629)	0.996 (92.230)	1.000 (94.264)
constax	0.947 (13.765)	0.380 (13.473)	0.954 (3.617)	1.000 (8.562)
Phys	insufficient observation			
ln(Price)	insufficient observation			

Notes: The table shows the p-values from the Pesaran's CADF panel unit root test developed by Pesaran (2003). The values of Akaike Information Criteria are in parentheses.

Table 9. Diagnostic tests' results

Test	Equation (1)	Equation (2)	Equation (3)
Likelihood-ratio test for heteroskedasticity[a]	44.27 (0.000)	100.44 (0.000)	634.45 (0.000)
Modified Wald test[b]	45.27 (0.000)	1135.54 (0.000)	860000 (0.000)
Wooldridge test for panel-level Autocorrelation[c]	46.27 (0.000)	62.159 (0.000)	0.62 (0.451)

Notes:

The table shows the values of test statistics as computed by Stata 10.0. The probabilities of obtaining such value or greater are given in parentheses.

[a] The assumption of the test is that the model with homoskedasticity as a restricted form of the one with heteroskedasticity, A hypothesis is tested that the model with homoskedasticity is nested in the model with heteroskedasticity., i.e., the null hypothesis is that there is homoskedasticity. The test statistic reported is LR chi2 (9).

[b] Modified Wald statistic for groupwise heteroskedasticity in the residuals of a fixed effect regression model, following Greene (2000, p. 598). The null hypothesis is that there is no heteroskedasticity. The test statistic reported is F (1, 9).

[c] A test for serial correlation in the idiosyncratic errors of a linear panel-data model following Wooldridge (2002, p.282). The null hypothesis is that there is no first order autocorrelation. The test statistic reported is chi2 (10).

Table 10. Equation (1) regression results: total health expenditure

VARIABLES	Ltotexp (1)	Ltotexp (2)	Ltotexp (3)
ln(GDP)	0.9394*	0.6408*	0.7196*
	(0.060)	(0.068)	(0.082)
pop65	-0.0204**	-0.0289*	-0.0265**
	(0.010)	(0.008)	(0.013)
phys	0.0738*	0.0460**	0.0540***
	(0.021)	(0.020)	(0.032)
HEpub	0.0039*	0.0035*	0.0039**
	(0.001)	(0.001)	(0.002)
ln(Price)	-0.3582*	-0.0744	-0.2294*
	(0.049)	(0.071)	(0.080)
Canada	0.1719*	0.1655*	0.1657*
	(0.014)	(0.020)	(0.023)
Denmark	0.0734***	0.1006**	0.0933
	(0.043)	(0.043)	(0.068)
Finland	-0.0252	-0.0201	-0.0129
	(0.034)	(0.041)	(0.055)
Iceland	0.0089	0.0130	0.0177
	(0.026)	(0.035)	(0.038)
Ireland	-0.2225*	-0.2335*	-0.2331*
	(0.020)	(0.025)	(0.034)
Spain	-0.0462	-0.0920**	-0.0813
	(0.049)	(0.045)	(0.076)
Sweden	0.0557	0.1202**	0.1004
	(0.067)	(0.061)	(0.099)
Switzerland	0.3037*	0.3884*	0.3730*
	(0.052)	(0.041)	(0.071)
US	0.6931*	0.7397*	0.7375*
	(0.034)	(0.038)	(0.048)
Constant	-1.2804*	0.5169	0.2901
	(0.482)	(0.529)	(0.744)
Observations	178	178	178
Wald chi2 for country fixed effects	1932.83 (0.000)	954.67 (0.000)	1184.42 (0.000)
Wald chi2 for year fixed effects	201.44 (0.000)	318.47 (0.000)	965.47 (0.000)
R-squared	-	-	0.999
Wald chi2[a]	52767.78 (0.000)	36006.52 (0.000)	108896.36 (0.000)

Standard errors are in parentheses. * indicates a p-value less than 0.01, ** indicates p-value greater than 0.01 but less than 0.05, and *** indicates a p-value between 0.05 and 0.1.

[a] Shows overall significance by testing the hypothesis that all coefficients are 0. The statistic for the estimated model is chi2 (46); the probability of obtaining this level of chi2 is shown in parentheses

Table 11. Equation (2) regression results: public health expenditure

VARIABLES	pubexp_gdp (1)	pubexp_gdp (2)	pubexp_gdp (3)
ln(GDP)	-4.0582***	-0.0908	2.6654
	(2.465)	(2.517)	(3.015)
ln(Price)	-3.0121	-0.2457	-3.1709
	(1.889)	(1.834)	(2.303)
pop65	-1.8854*	-1.6019*	-1.3566*
	(0.298)	(0.312)	(0.401)
inctax	-0.2661*	-0.0830***	-0.0769
	(0.065)	(0.048)	(0.049)
constax	0.0113	-0.0016	0.0093
	(0.038)	(0.027)	(0.031)
Canada	5.9629*	5.7611*	5.6996*
	(0.696)	(1.841)	(1.256)
Denmark	29.0408*	24.4386*	23.8255*
	(1.581)	(2.312)	(2.031)
Finland	11.9829*	12.4066*	11.9709*
	(1.061)	(2.115)	(1.957)
Iceland	15.0095*	16.2556*	16.7818*
	(1.108)	(2.056)	(1.441)
Ireland	4.5440*	8.1419*	8.0712*
	(1.274)	(2.297)	(1.726)
Spain	9.0796*	12.5138*	12.6294*
	(1.764)	(2.509)	(2.098)
Sweden	28.8853*	27.8252*	26.4747*
	(1.867)	(2.867)	(2.766)
Switzerland	-5.0787*	-6.7389*	-8.0256*
	(1.514)	(2.435)	(2.189)
US	-23.0805*	-23.8849*	-24.8735*
	(0.989)	(2.012)	(1.614)
Constant	141.8618*	88.3139*	71.9382*
	(19.815)	(21.845)	(25.427)
Income elasticity	0.945	0.998	1.0357
Price elasticity	-1.040	-1.003	-1.0425
Observations	258	258	258
Wald chi2 for country fixed effects	4806.48 (0.000)	1859.64 (0.000)	1182.92 (0.000)
Wald chi2 for year fixed effects	33.62 (0.389)	39.56 (0.168)	1351.92 (0.000)
R-squared	-	-	0.972
Wald chi2	9229.50 (0.000)	2729.49 (0.000)	3769.67 (0.000)

Standard errors are in parentheses. * indicates a p-value less than 0.01, ** indicates p-value greater than 0.01 but less than 0.05, and *** indicates a p-value between 0.05 and 0.1.

Table 12. Equation (3) regression results: private health expenditure

VARIABLES	(1) Xpriv	(2) Xpriv	(3) Xpriv
ln(GDP)	-0.0352*	-0.0043	-0.0352*
	(0.013)	(0.008)	(0.004)
ln(Price)	0.0092	0.0002	0.0092*
	(0.009)	(0.004)	(0.002)
HEpub	-0.9996*	-1.0000*	-0.9996*
	(0.000)	(0.000)	(0.000)
pop65	0.0001	0.0001	0.0001
	(0.001)	(0.001)	(0.000)
inctax	0.0002	0.0000	0.0002*
	(0.000)	(0.000)	(0.000)
Canada	0.0006	0.0002	0.0006
	(0.004)	(0.002)	(0.001)
Denmark	-0.0094	-0.0003	-0.0094*
	(0.011)	(0.004)	(0.002)
Finland	-0.0047	-0.0006	-0.0047*
	(0.006)	(0.003)	(0.001)
Iceland	-0.0002	0.0005	-0.0002
	(0.007)	(0.003)	(0.001)
Ireland	0.0023	0.0081	0.0023
	(0.006)	(0.006)	(0.002)
Spain	-0.0091	-0.0016	-0.0091*
	(0.008)	(0.005)	(0.002)
Sweden	-0.0054	-0.0004	-0.0054**
	(0.012)	(0.005)	(0.003)
Switzerland	0.0122	0.0007	0.0123*
	(0.008)	(0.003)	(0.002)
US	0.0183**	0.0010	0.0183*
	(0.009)	(0.004)	(0.002)
Constant	100.2386*	100.0360*	100.2392*
	(0.108)	(0.072)	(0.030)
Income elasticity	0.998	0.999	0.998
Price elasticity	-0.999	-0.999	-0.999
Observations	268	268	268
Wald chi2 for country fixed effects	15.30 (0.083)	2.81 (0.971)	411.63 (0.000)
Wald chi2 for year fixed effects	44.45 (0.070)	0.44 (1.000)	71222.45 (0.000)
R-squared	-	-	1.000
Wald chi2	3.49e+08 (0.000)	4.53e+09 (0.000)	104568.96 (0.000)

Standard errors are in parentheses. * indicates a p-value less than 0.01, ** indicates p-value greater than 0.01 but less than 0.05, and *** indicates a p-value between 0.05 and 0.1.