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A multilevel analysis on the determinants of regional health care expenditure: a note

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Abstract Health care in most countries is a rather ''local good'' for which the fiscal decentralization theory applies and heterogeneity is the result. In order to address the issue of multijurisdictional health care in estimating income elasticity, we constructed a unique sample using data for 110 regions in eight Organisation for Economic Co-operation and Development (OECD) countries in 1997. We estimated this sample data with a multilevel hierarchical model. In doing this, we tried to identify two sources of random variation: within- and between-country variation. The basic purpose was to find out whether the different relationships between health care spending and the explanatory variables are country specific. We concluded that to take into account the degree of fiscal decentralization within countries in estimating income elasticity of health expenditure proves to be important. Two plausible reasons lie behind this: (a) where there is decentralization to the regions, policies aimed at emulating diversity tend to increase national health care expenditure and (b) without fiscal decentralization, central monitoring of finance tends to reduce regional diversity and therefore decrease national health expenditure. The results of our estimation do seem to validate both these points.

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Introduction

It is now more than 25 years since the publication of the pioneering paper of Newhouse [12] on international comparisons of health expenditure. Since then, interest in understanding the factors involved in health care spending growth has created a third-generation industry for exploring the theory, data, and econometric methods to approach the main issues involved (see [5]). However a missing element from research has been that of taking into account the regional composition of national health expenditure figures. This is particularly important in decentralized countries in which health care is a local public good. For instance, regional authorities may have rather different per capita incomes. Moreover, they may oversee the externality problems related to health care provision and so the need of coordination. Finally, the concern for a geographical redistribution of care may be weak under multijurisdictional health care. These factors undoubtedly affect the size of the health care sector in a country. Therefore, by ignoring them, an aggregation fallacy in estimating the national income elasticity of health expenditure may result, and a simple dummy variable for country-specific effects may not correctly capture the problem.

Indeed, in most Organisation for Economic Co-operation and Development (OECD) countries, fiscal federalism allows some key decisions on health spending and finance to be made by regional or local authorities. Australia, Canada, Italy, Spain, Sweden, UK, Germany, etc. in one way or another are decentralized countries, with regions enjoying total or partial autonomy for regional health care expenditure. As a result, if we ignore the regional factor in international comparisons, we run the risk of incurring a kind of aggregation fallacy. It may be, then, not just the national average income but also regional distribution that influences health care expenditure. This has to do with the way the variance in health needs reflects into health care utilization and expenditure assessment for revenue allocation methods and on the sources of regional finance. Whereas in a private system income differences and health status usually imply differences in the equilibrium between insurance coverage and health care premiums on an individual basis, this is not usually the case in public health care systems, whether of the national health service type or of the social-insurance-based type. This may be particularly the case when a central assessment of the financial allocation substitutes a local assessment of health expenditure needs. Even if this is not so, it may be that the group with the highest regional need or highest demand (influenced by income) crucially affects the average national level of health care provided. For instance, in Spain, with regions running the health services, policies to emulate others may exist, extending the larger benefit levels of some regions to the rest on behalf of social cohesion. If these differences in benefits have to do with income or health status or any of the other explanatory factors usually considered in the estimation of health expenditure growth, we could predict higher-than-expected health care expenditure, other things being equal, in decentralized countries such as these.

The way in which regional differences are taken into account by health authorities may depend on one of the following questions:

1. Is finance still under state control? Here, the relevant factor will be the way revenues are geographically allocated. The Resource Allocation Working Party (RAWP) formula for England is a perfect example of this. Under this scheme, however, a relative higher regional income is not accounted for positively as a factor stimulating demand but, rather, in a negative sense, as evidence of a need for redistribution. Italy also provides some examples for this.
2. Is health care finance fully decentralized? How large are margins to move away from standard national health care levels? The Canadian ''fiscal room'' (a rebate applied to the state personal and corporation income tax in favor of the provinces) is here the example. Large local autonomy in the financial side appears in the Swedish case, also.
3. What is the nature of the powers for the devolution of health care on a regional basis? For example, these are very important constitutional powers in Spain, Canada, or Australia but without political weight in England or France.

In conjunction with the above factors, the causes of heterogeneity become more complex: (a) dispersion in the central finance of regional health care expenditure may be greater whenever the political powers of the regions are weak and no ''fiscal room'' for revenue raising exists amongst the regions (this seems to be the case in France and the UK (see descriptive data in Table 1); (b) dispersion in central finance of regional health care expenditure is smaller when political power in the regions is strong, but no ''fiscal room'' exists for the regions (as has been the case in Spain, Australia, and Italy). This is due to the fact that any difference in regional finance is viewed politically as a gap in social cohesion to be centrally guaranteed; and finally, (c) when fiscal autonomy for the regions and strong political power go together, dispersion in health care expenditure is again large, influencing total health expenditure (as in Germany, Canada, and Sweden).

As a result, what is usually accepted with regard to international comparisons—i.e., that income, education, and social development exert pressure for higher health care expenditure (the positive income elasticity factor)—may not be the case if decentralization ''filters'' revenue and spending decisions of the local units (that is, a way of ''implicit'' centralization); for instance, fully centralized revenue allocation of health care financing and/or an important redistributive finance policy in favor of less-wealthy regions. However, under a fiscal federalism regime and/or a regional decentralization framework of health services provision, it may prove to be very difficult to eliminate those pressures for higher regional expenditure in some wealthy regions, and the opposite of the previously commented effect may result. If this is the case, states with regional decentralization should show both larger variance and higher levels of health care expenditure than in more centralized systems. In addition, if regional emulation exists, higher levels of national health

Table 1 State coefficients of variation (CV), weighted by population, for regional variables (1997)

States	CV for regional public health care expenditure, per capita	CV for regional income, per capita
Australia	0.05625	0.07717
Germany[a]	0.14308	0.23390
Canada	0.08083	0.12629
France	0.12551	0.27703
Italy	0.08981	0.26862
Sweden	0.08784	0.10906
Spain	0.02111	0.16371
UK	0.15182	0.09226

Source: own elaboration

[a] Based on input utilization

care spending should exist in decentralized countries because regions, independently of their particular development status, can take the standard of the highest benefit region in pushing expenditure up.[1]

Therefore, our hypotheses, to be tested in the next section, are first, that income elasticity of health care expenditure increases with the relative variation in health care expenditure, and second, that its relative variation depends not only on the relative variation of income but on the degree and nature of the regional decentralization process.

Sample and methods

In order to get an understanding of the above process, we applied a multilevel hierarchical model to an unbalanced panel for 110 regions of eight OECD countries in 1997: Australia (eight states), Canada (12 provinces), France (22 provinces or quasiregions), Germany (16 länders), Italy (19 regions), Spain (eight nationalities), Sweden (8 health counties), and the UK (17 regional health authorities).

Multilevel models are extensions of the random effects panel data models to the case where there are any number of levels in the data hierarchy and the residual variance function is complex and includes random coefficients at any level of the data hierarchy [16]. In particular, we tried to identify two sources of random variation: within- and between-country variations; that is, we allowed for the possibility that the different relationships between health care spending and the explanatory variables may be country specific. Furthermore, we allowed for the possibility of the existence of unobserved heterogeneity and to permit unobservables to affect the different groups in different ways.

We estimated the relationship between health care expenditure (per capita) and income (per capita), controlling by demographic structure and institutional variables. Both health care expenditure and income were converted from national currencies into purchasing power parities (PPP). The percentage of population 65 years of age and over was considered the proxy for demographic structure, and public health expenditure as a percentage of total health expenditure approached the nature of the health system.

The above-mentioned relationship was assessed by means of a multilevel hierarchical model. In particular, one level (the country), or alternatively, two sources of random variation (within country and between country) were considered. As commented earlier, the basic idea was that the different relationships between health care expenditure and its explanatory variables might be country specific. In our basic model (1), only the intercept was assumed to be a random effect.

$$\log(\mathrm{HE}_{ij}) = \beta_{0i} + \beta_1 \log(Y_{ij}) + \beta_2 \mathrm{POP65}_{ij} + \beta_3 \mathrm{PUB}_{ij} + u_{ij} \quad (1)$$

where HE denotes per capita total health care expenditure (in \$PPP); Y is per capita gross domestic product (GDP), (in \$PPP); POP65 is the percentage of population 65 years and over; and PUB is the public health expenditure as a percentage of total health expenditure. The subscript i denotes the country (i = Australia, Canada, France, Germany, Italy, Spain, Sweden, and UK) and the subscript j (j = 1,2,...,Ni) the region within the country.

By using a likelihood ratio test, we test for statistical significance of the variance of each of the remaining βs, i.e., for the possibility of other random effects other than intercept. In the final model, however, apart from autonomous health care expenditure, only income elasticity appears to be country specific. Summarizing, the following model is finally estimated:

[1] Within the state, differences in prices do not appear relevant enough for further adjustment (other than those considered in their own allocation of revenue formulas), unlike interstate comparisons where levels of technology and purchasing-power-parity (PPP)-adjusted salaries may differ also.

$$\log(\mathrm{HE}_{ij}) = \beta_{0i} + \beta_{1i}\log(Y_{ij}) + \beta_2\mathrm{POP65}_{ij} + \beta_3\mathrm{PUB}_{ij} + u_{ij}. \quad (2)$$

The intercept (the autonomous health care expenditure), β_0, and the income elasticity, β_1, are considered random effects:

$$\begin{aligned}\beta_{0i} &= b_0 + v_{0i}\\ \beta_{1i} &= b_1 + v^*_{1i} \quad \text{where } v^*_{1i} = v_{1i}\log(Y_{ij}).\end{aligned} \quad (3)$$

Hence, the "effect" of being the country i, is to shift the mean income elasticity, for instance, from β_1 to $\beta_1 + b_1$. Then, finally, model (4) becomes:

$$\log(\mathrm{HE}_{ij}) = b_0 + b_1\log(Y_{ij}) + \beta_2\mathrm{POP65}_{ij} + \beta_3\mathrm{PUB}_{ij} + \left(u_{ij} + v_{0i} + v_{1i}\right). \quad (4)$$

The random variables $v = (v_{0i}\ v_{1i})'$ were assumed to be normally distributed with mean zero and an unstructured covariance matrix, i.e.,

$$\mathrm{Var}(v) = \begin{pmatrix} \sigma_0^2 & \sigma_{12} \\ \sigma_{12} & \sigma_1^2 \end{pmatrix}. \quad (5)$$

Two sources of variability are assumed, the between-country and the within-country variability, measured by σ_v^2 and by σ_u^2, respectively. Part of the between-country variability is attributed to the autonomous health care expenditure (σ_{v0}^2) and part to the income elasticity (σ_{v1}^2).

The idiosyncratic disturbance term u_{ij} was assumed to be also normally distributed with zero mean and independent of v. Although we initially assumed a constant variance, σ_u^2, there were afterwards symptoms of within-country heteroscedasticity. For this reason, and because of its flexibility, we allowed the variance to follow a constant plus power of fitted values structure [15]:

$$\mathrm{Var}(u_{ij}) = \sigma^2\left(\delta_1 + |H\hat{E}_{ij}|^{\delta_2}\right)^2 \quad (6)$$

where, σ, δ_1 and δ_2 were unknown parameters to be estimated, and $H\hat{E}_{ij}$denoted fitted values (exponent) of a previous model where the variance was assumed to be constant.

Models were estimated by restricted maximum likelihood (REML) [7, 14, 17]. A problem is that, for small group sizes, although REML estimation is efficient, it is inconsistent when the random effects are correlated with one or more fixed predictors [3]. For this reason, we tested the null hypothesis that the random effects specification was correct by means of the Hausman test [8]. This is based on a straightforward comparison between the estimated parameters from a fixed-effects regression and those obtained through generalized least squares in a random-effects specification. If the exogeneity of the regressors with respect to the random effects was rejected, we tried the Mundlak's formulation [11]. As is known, the idea is that by conditioning on the group mean (of the variable correlated with random effects), the possible correlation will be broken [9]. In particular, if exogeneity of regressors was rejected, we introduced in the equation the within-group mean of the (correlated) variable.

We assumed that all regressors were exogenous with respect to the idiosyncratic disturbance term, u_{ij}. In the presence of endogeneity of this nature, however, estimators will be, again, biased and inconsistent. For testing such exogeneity, we regressed the residuals of the final model (after the Mundlak's correction if it was the case) on all the regressors. If any regressor was found to be statistically significant (with a P value equal to or less than 0.1, i.e. 90% of confidence) we reestimated the model using the instrumental variables techniques. In particular, we preferred the method proposed by Rice et al. [16] because, although it is based in the estimators proposed by Ameniya and MacCurdy [1], Breusch et al. [4], and Arellano and Bover [2], it is the most efficient of all of them [16]. All the computations were carried out in S-Plus 6 Release 2.

Results and discussion

The pooled relationship between income (in \$PPP per capita) and health care expenditure (in \$PPP per capita) is shown in Fig. 1. Although there was a positive relationship, there was also a considerable dispersion both between and within countries (see Fig. 1).

The goodness-of-fit of our final specification, i.e., model 4, is reasonably high ($R^2 = 0.859$), and the model passed diagnostic tests such as absence of heteroscedasticity once it was corrected according to Eq. 6 (Breusch–Pagan test, see [6]). Despite a correct random-effects specification (P value of the Hausman's test equal to 0.6768), we can neither accept the exogeneity assumption for POP65 nor for PUB with respect to the idiosyncratic error term (see Table 2). In this sense, and following Rice et al. [16], we reestimate model 4 with the following set of instruments:

$$\mathrm{IV} = (Q_u Y, Q_u X_2, Y) \quad (7)$$

where Y denotes the $\mathrm{N} \times 1$ stacked vector of GDP; X_2 denoted a $\mathrm{N} \times 2$ matrix containing the stacked vectors

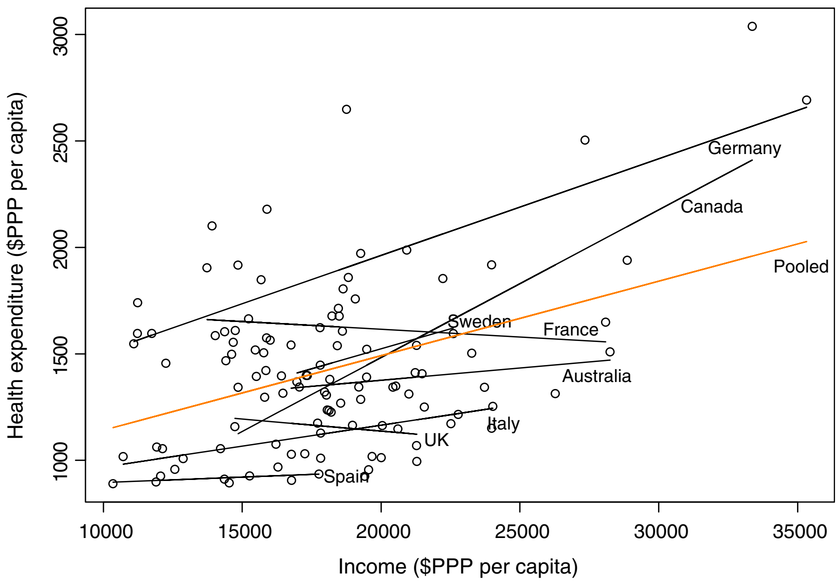

Fig. 1 Relationship between income [in $ purchasing power parity (PPP) per capita] and health expenditure (in $PPP per capita). Pooled and country specific

of POP65 and PUB; and Q_u converts a vector of group means into a vector of deviations from groups means.

Results of the instrumental variable (IV) estimation are shown in Table 3. The model now passes all the diagnostics tests. All the (fixed) coefficients are statistically significant and have the expected sign. Nevertheless, two particularities of our results with respect to the previous findings are worth mentioning. First, not only increases in income but also increases in the POP65 and PUB raise health care expenditure. Second, although it is known that in contrast with time-series studies cross-sectional analyses commonly produce estimates of income elasticity less than one (see [10]), we obtained rather low values for income elasticity (0.2559).

With respect to the random effects estimation, between-country variability (SD = 0.1123) is lower than within-country variability, leading to an intraclass correlation coefficient equal to 0.1092. Nearly 52% of between-country variability could be attributed to the autonomous health care expenditure, whereas 48% was attributed to income.

Both pooled and country-specific income elasticity as well as the within-country variability (unweighted in

Table 2 Diagnostics of the final estimated model

$\log\left(\hat{HE}_{ij}\right) = \hat{b}_0 + \hat{b}_1 \log(Y_{ij}) + \hat{\beta}_2 \mathrm{POP65}_{ij} + \hat{\beta}_3 \mathrm{PUB}_{ij} + \left(\hat{u}_{ij} + \hat{v}_{0i} + \hat{v}^*_{1i}\right)$	(4)
R-squared	0.859
Hausman's test (random effects residuals, $\hat{v}_{0i}$and $\hat{v}^*_{1i}$)	1.5237 (P = 0.6768)
Homoscedasticity test (Breusch–Pagan)	4.3340 (P = 0.2276)
Regression of the idiosyncratic residuals $\left(\hat{u}_{ij}\right)$ on the regressors	
F-statistic of overall significance	4.2360 (P = 0.0072)
t-statistics of individual significance	
$\hat{b}_1$	0.7621 (P = 0.4477)
$\hat{\beta}_2$	–1.9131 (P = 0.0584)
$\hat{\beta}_3$	–2.6867 (P = 0.0084)

Table 3 Estimation of model 4 [set of instruments (7)]

Fixed effects	$\hat{\beta}$ (s.e)	P value of the t-statistic
Income elasticity	0.2559 (0.0539)	<0.0001
Population over 65 years old	0.0091 (0.0049)	0.0655
Public health care expenditure	0.0180 (0.0049)	0.0004
Intercept	4.7018 (0.5199)	<0.0001
Random effects	$\begin{array}{cc} \hat{\sigma}_{v0} & \hat{\sigma}_{v0v1} \\ \end{array}$ $\begin{bmatrix} 0.02722 & -0.87665 \\ -0.87665 & 0.02525 \end{bmatrix} \begin{array}{c} \hat{\sigma}_{v0v1} \\ \hat{\sigma}_{v1} \end{array}$	
Idiosyncratic residual variance	$\mathrm{Var}\left[\hat{u}_{ij}\right] = 9.2869\mathrm{e}^{-010}\left(0.00033 + \lvert H\hat{E}_{ij}\rvert^{4.1678}\right)^2$	

Table 4 Country-specific income elasticity and (unweighted) within-country variation

Country	Income[a]	Rank	Income elasticity[b]	Rank	Within-country coefficient of variation		
					Observed		Residual
					Health care	Income	
Australia	1380.7	5	0.2571	4	0.0775	0.1707	0.0256
Canada	1588.0	3	0.2464	6	0.3530	0.2736	0.1118
France	1643.9	2	0.2307	7	0.1562	0.1459	0.1879
Germany	1903.3	1	0.2192	8	0.2792	0.3240	0.0343
Italy	1123.5	7	0.2764	2	0.0845	0.2363	0.0858
Spain	919.4	8	0.2935	1	0.0183	0.1207	0.0190
Sweden	1459.9	4	0.2483	5	0.1086	0.0879	0.0556
United Kingdom	1154.6	6	0.2758	3	0.1494	0.0843	0.0294
Pooled	1425.1	–	0.2559	–	0.2779	0.2471	0.2261

[a] Per capita gross domestic produce (GDP) [$ purchasing power parity (PPP)]

[b] Estimated income elasticity

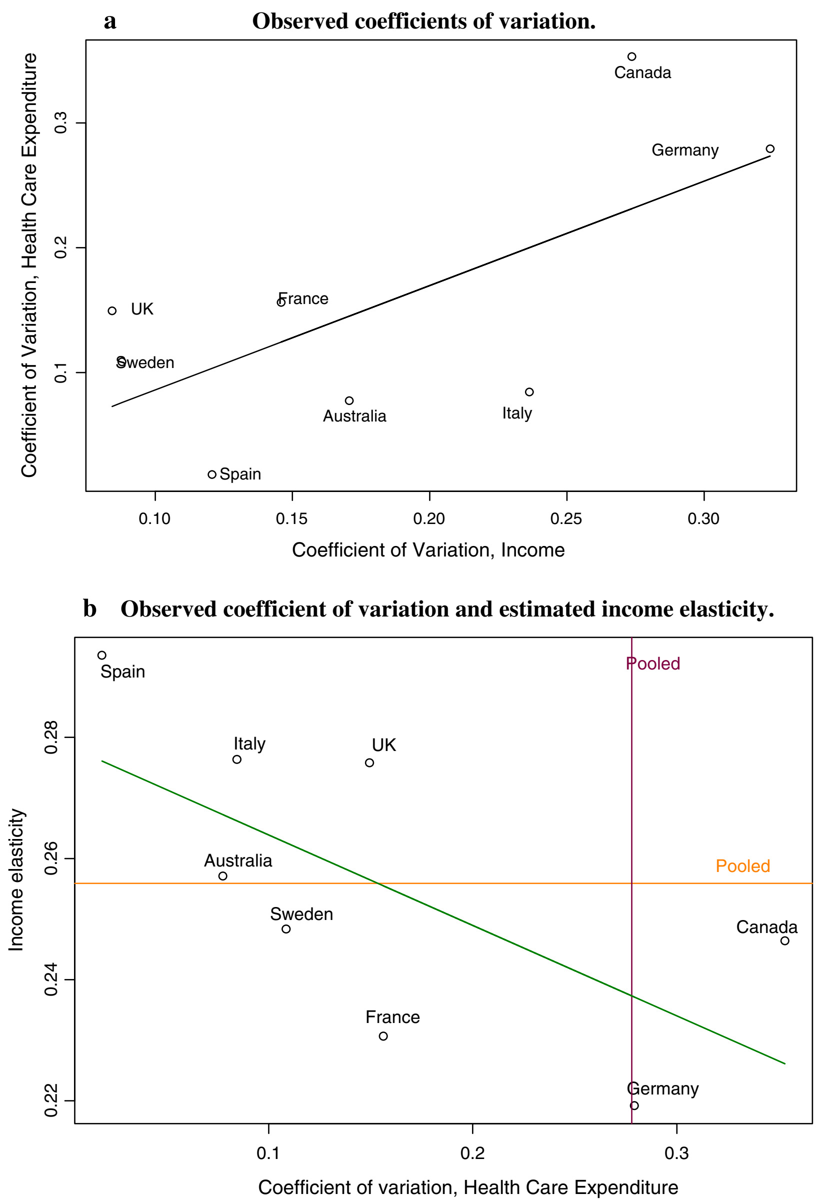

Fig. 2 Relationship between within-country variability and estimates of income elasticity. **a** Observed coefficients of variation. **b** Observed coefficient of variation and estimated income elasticity

all cases) are shown in Table 4. Spain (income elasticity = 0.2935), Italy (income elasticity = 0.2764), and UK (income elasticity = 0.2758) have individual income elasticities higher than the pooled value (i.e., the fixed-effect estimate 0.2559). For Germany (0.2192), France (0.2307) and, to a lesser extent, Canada (0.2464) and Sweden (0.2483), income elasticity was estimated below the pooled value.

Note that the ranking of estimated income elasticity was exactly the opposite of the ranking of income (Table 4). We believe that the explanation for this can be found in Fig. 2 (and Table 4): higher (relative) variation in income leads to a higher variation in health care expenditure (Fig. 2a, coefficient of correlation = 0.6674) and, consequently, to a higher estimated income elasticity (Fig. 2b, coefficient of correlation = 0.6647). This could be considered as the third feature of our paper that contributes to the existing literature.

To sum up, three particular aspects distinguish our paper from previous ones. First, we found that increases in the percentages of population over 65 and the percentage of public health expenditure in total raises health care expenditures. Second, we estimated income with very low elasticity values. Third, we found that higher (relative) variation in income leads to higher variation in health care expenditure and, consequently, to higher estimated income elasticity. Whereas the first two correspond to between-country variability, the last result clearly corresponds to within-country variability. Nevertheless, the three features are connected in some way to a source of variation of health care expenditure, usually neglected, which is the regional variation in the national data.

This particular source of variation cannot be captured without using an appropriate statistical model, such as the commonly used fixed-effects model with dummy country-specific variables. Note that in addition, this last type of model, with a fixed number of countries and regions, may lead to the classic incidental-parameters problem [13].

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