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The impact of decentralisation on the performance of health care systems: A non-linear relationship

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Abstract

The impact of decentralisation on the performance of health care systems: a non-linear relationship

This paper examines the relationship between the degree of administrative decentralisation across levels of government in health care decision-making and health care spending, life expectancy as well as hospital costs. This empirical analysis builds on previous analytical research carried out by the OECD (Lorenzoni, Murtin et al., 2018; Lorenzoni and Marino, 2017), both of which established new methodological tools to analyse health sector performance. The present analysis extends this framework to examine the impact of centralisation versus decentralisation of responsibilities across levels of government, making use of newly collected data on governance and expenditure assignment, as well as non-linear empirical specifications.

Keywords: Public economics, health care, hospitals, intergovernmental relations, governance, regional economics

JEL classification: H75, I18, O43

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Résumé

De nouvelles analyses apportent des éclairages quant à l'impact de la décentralisation sur les performances des systèmes de santé

Cette note présente les conclusions d'analyses empiriques visant à étudier la relation entre le degré de décentralisation des prises de décisions concernant la santé entre les différents échelons de l'administration d'une part et les dépenses de santé, l'espérance de vie et les coûts du système hospitalier d'autre part. Ces analyses empiriques s'appuient sur des analyses antérieures réalisées par l'OCDE (Lorenzoni, Murtin et al., 2018 ; Lorenzoni et Marino, 2017), qui ont toutes deux permis d'établir de nouveaux outils méthodologiques pour analyser les performances du secteur de la santé. La présente analyse permet d'élargir ce cadre à l'examen de l'impact de la centralisation, ou au contraire, de la décentralisation, entre les différents échelons de l'administration, à l'aide de données récemment collectées sur la gouvernance et les affectations de dépenses, et en s'appuyant sur l'utilisation empirique de spécifications non linéaires.

Mots-clés : Économie publique, santé, hôpitaux, relations inter-administrations, gouvernance, économie régionale.

Classement JEL : H75, I18, O43

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The impact of decentralisation on the performance of health care systems: A non-linear relationship

By Sean Dougherty, Luca Lorenzoni, Alberto Marino and Fabrice Murtin[1]

I. Introduction and main findings

1. This paper reports initial findings of empirical analysis aimed at exploring the relationship between the degree of administrative decentralisation across levels of government in health care decision-making and health care spending, life expectancy and hospital costs. This empirical analysis builds on previous analytical research carried out by the OECD Secretariat on "Which policies increase value for money in health care" (Lorenzoni et al., 2018) and on "Understanding variations in hospital length of stay and cost" (Lorenzoni and Marino, 2017), both of which established new methodological tools to analyse health sector performance. The present analysis expands on this earlier work by adding "decentralisation" as a core explanatory variable in the country-level and hospital-level models, at the request of the Fiscal Network and Joint Network of Senior Budget and Health Officials. The administrative decentralisation indicator as well as indicators for other institutional features of health care systems were used for a country-level regression analysis of the impact of policy changes on health spending and life expectancy, whereas the association between decentralisation and hospital costs was looked at by using a multilevel (or hierarchical) model.[2]

2. Several key findings emerge from these analyses:

- The results point to a statistically significant effect of "administrative decentralisation" on health expenditure and life expectancy. The sign and size of the coefficients show that a moderate degree of decentralisation reduces public health spending and increases life expectancy – saving public resources and improving outcomes – as compared to a situation with very low decentralisation.
- However, "excessive decentralisation" is associated with higher public spending on health and lower life expectancy – reversing cost-saving and outcome-enhancing effects – as compared to a situation with an intermediate degree of decentralisation.
- The sign and size of the coefficients estimated for the hospital-level analysis suggest that hospital costs are significantly lower in countries with a higher degree of administrative decentralisation, even after controlling for particular treatments.

3. The analysis is divided into three sections. Firstly, it describes how scores were assigned to the decentralisation indicator. It then presents results of the country-level analysis, and discusses the impact of a higher degree of decentralisation on health spending and life expectancy. Finally, it reports the results of the hospital-level analysis, and looks at the relationship between decentralisation and hospital output cost for selected services.

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1. This paper was prepared for the OECD Network on Fiscal Relations across Levels of Government, and presented at the 2018 Annual Meeting (19-20 November). The authors are grateful to Francesca Colombo, Peter Gal, Peter Hoeller and Chris James from the OECD Secretariat and Fiscal Network delegates for their useful comments. The paper builds upon collaborative work conducted with the OECD Joint Network of Senior Budget and Health Officials.

2. A simple two-level hierarchical model yields estimates of the "country effect" and of the "hospital effect" on cost in this study.

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II. Measuring the degree of decentralisation in decision-making in health care

4. Data on institutional and health systems characteristics obtained through OECD surveys carried out in 2008, 2012, 2016 and 2018 (see Box 1) were used to derive an indicator of "decentralisation" as well as 16 additional indicators to describe key institutional characteristics that shape health insurance and health care institutions (see Table 1).

Box 1. OECD Health Systems Characteristics and follow-up surveys

The OECD survey on Health Systems Characteristics is based on a conceptual framework grounded in concrete structural or organisational characteristics of health care systems (OECD, 2008; Paris et al., 2010). This framework comprises three domains:

- Health financing and coverage arrangements;
- Health care delivery systems; and
- Governance and resource allocation.

Three surveys were completed by most OECD countries. The 2008 survey included 81 questions, often with sub-questions providing further details, including on the degree of decentralisation. The 2012 and 2016 surveys comprised 91 and 78 questions, respectively, with certain changes to questions across surveys.[3] As a result, the decentralisation information collected in 2008 was not collected in the 2012 and 2016 surveys. Consequently, in a joint survey of the Fiscal Network and Joint Network of Senior Budget and Health Officials, comparable information on administrative decentralisation was updated to 2018.

5. With regard to the "degree of decentralisation across levels of government", countries were asked to indicate the level of government that is responsible for the following thirteen policy or service areas:

- setting the level of taxes which will be earmarked for health care spending;
- setting the basis and the level of social contributions/premiums for health care;
- setting the total budget for public funds allocated to health care;
- deciding resource allocation between sectors of care;
- setting remuneration methods for physicians;
- defining payment methods for hospitals;
- financing new hospital buildings;
- financing new high-cost equipment;
- financing the maintenance of existing hospitals;
- financing primary care services;
- financing specialist out-patient care;
- financing current hospital spending; and
- setting public health objectives.

3. The United States did not respond to the questionnaire, reflecting the complexity and variety of the US system.

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6. For each decision in which the government is involved, a score was attributed according to the rules defined in Table 1.

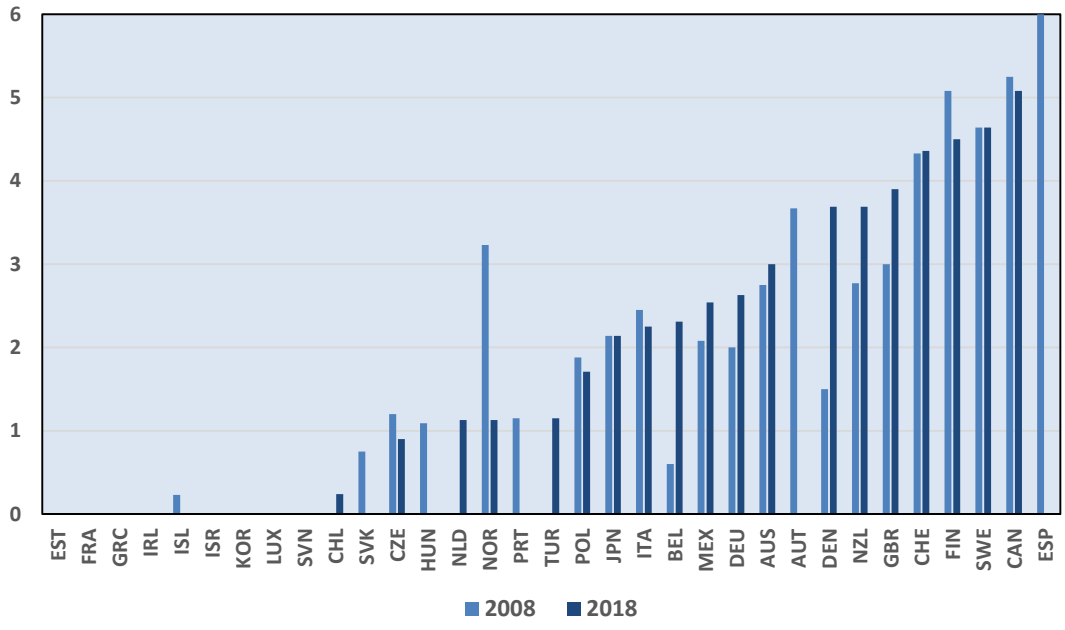
Table 1. Scoring system for the degree of decentralisation

Level (or multiple levels) of decision		
Central	Local	Score
X		0
X	X	3
	X	6

7. Then, an overall score was computed as the simple average of sub-scores related to each decision. The maximum score of six was assigned when all decisions are taken at the local level, and a zero score was assigned when all decisions are taken at the central level.

8. Figure 1 shows the "decentralisation" scores by country in 2008 and 2018. Out of the 22 countries for which responses were available both in 2008 and 2018,[4] seven countries reported a lower level of decentralisation in 2018 as compared to 2008, 10 countries a higher level, whereas for five countries there was no change in the level of decentralisation.

Figure 1. Degree of "decentralisation" scores by country, 2008 and 2018



4. Four countries – Estonia, Israel, Slovenia and Chile – did not fill in the questionnaire, as they were not members of the OECD in 2008. Seven countries – France, Korea, Slovakia, Hungary, Portugal, Austria and Spain – did not respond to the questionnaire in 2018. For those 11 countries, an assumption of no change in the decentralisation score is made in the regression analysis.

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9. Scores for the other indicators used to characterise the institutional context (as described in Table 2 below) were assigned applying the methodology described in Lorenzoni et al. (2018) to the Health System Characteristics survey responses gathered in 2008, 2012 and 2016.[5]

10. For the ten countries covered by the hospital-level analysis, on the basis of changes in the decentralisation score over time, Canada and Norway were qualified as having "high and decreasing" levels of decentralisation, Switzerland and Turkey as showing "high and increasing" levels and Estonia, France, England, Ireland, Israel and Luxembourg as reporting "low" decentralisation.

III. The relationship between "decentralisation" and health expenditure and life expectancy

11. To explore the relationship between the degree of decentralisation and health expenditure and life expectancy, a simultaneous equation non-linear regression analysis was used (see Lorenzoni et al., 2018 and de la Maisonneuve et al. 2017, for a description of the model and its use in previous work at the OECD). A micro-founded model of utility maximisation by a social planner subject to a budget constraint and a health production function underlie the empirical work. This model suggests that health spending per capita depends on income and on the share of the elderly (age of 65+ years) in the population. Similarly, a model based on utility maximisation by a social planner subject to a budget constraint and a life expectancy production function was assumed. This model suggests that life expectancy depends on health spending, GDP per capita (net of total health expenditure), the stock of people with upper secondary and higher education, the prevalence of daily smoking and alcohol consumption in litres per capita.[6] Lags of five years were used to account for lagged effects of explanatory variables on health status and health spending.

12. Non-institutional data used in the analysis cover 26 OECD countries over the period 2000-2015 as well as comparable life expectancy at birth data extracted from OECD.Stat and expenditure data from the OECD's System of Health Accounts[7] (OECD, Eurostat and WHO, 2011) database.

13. The economic intuition underlying the non-linear specification of the model is straightforward. There are fundamental factors driving the core amount of health spending which can be magnified by some health policies and institutions, or on the contrary, be reduced by efficient regulations and practices. For that reason, policies and institutions intervene in a multiplicative way in the model and affect all determinants in a similar way.

5. See https://qdd.oecd.org/subject.aspx?Subject=hsc

6. This model follows James et al. (2017). Environmental factors, the unemployment rate and healthy diet were excluded from the model, as the association between life expectancy and those variables was not significant in their analysis.

7. The SHA database provides a systematic account of overall financial flows through national health systems, including information on where the money comes from, who manages it, and how it is used. The 2016 release of the SHA used in this study includes national expenditure estimates through 2015.

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14. The econometric model of health spending per capita (H) for country *i* in year *t* can be written as:

$$\log H_{i,t}^{Public} = e^{\sum_m \phi_m \cdot Z_i^m} \times \left[\beta \log GDP_{i,t-5} + \gamma \log D_{i,t-5} + e_i + f_t\right] + \eta_{i,t}$$

where *GDP* is the GDP per capita at constant USD PPP net of total health expenditure, *D* is the share of the elderly (age of 65+ years) in the population, Z^m is a normalized index of institutional and health systems features (m) with zero-mean and unity standard deviation, ϕ_m a coefficient capturing the effect of institutional and health systems variables on health spending, *e* are unobserved country effects and *f* unobserved time effects.

The econometric model of life expectancy (LE) for country *i* in year *t* can be written as:

$$\log LE_{i,t} = e^{\sum_m \pi_m \cdot Z_i^m} \times \left[\alpha \log H_{i,t-5} + \sum_k \lambda_k \log X_{i,t-5}^k + c_i\right] + \varepsilon_{i,t}$$

where *H* is the total health spending expressed in per capita constant USD PPP[8], π_m a coefficient capturing the effect of institutional and health systems variables on life expectancy, *c* are unobserved country effects and X^k is a set of other observed factors, which includes income as measured by GDP per capita at constant USD PPP net of total health expenditure, the stock of upper secondary and higher education, prevalence of daily smoking and alcohol consumption in litres per capita.

8. Purchasing Power Parities (PPPs) are conversion factors that show the ratio of the prices in national currencies of the same basket of goods and services in different countries. Thus they can be used as both currency converter and price deflators. When PPPs are used to convert expenditure to a common unit, the results are valued at a uniform price level and should reflect only differences in volumes of goods and services consumed in countries (Eurostat and OECD, 2012).

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Table 2. List of indicators selected for the analysis by domain

Domain	*Indicator*	*Short definition and interpretation*
Health financing and coverage arrangements	Depth of basic coverage	Coverage of eight health care functions by basic primary health insurance. The higher the score the more depth of coverage is reported.
	Level of financial protection for health care users	Share of health care spending financed by the public sector, social insurance and private insurance in total health spending. The higher the score the lower the share of out-of-pocket expenditure in total health spending.
	Out-of-pocket (OOP) payments for curative care	Share of OOP expenditure for in-patient and out-patient curative care in total health spending. The higher the score the higher the share of curative care paid OOP by households.
	Degree of user choice for basic coverage	Sources of basic health coverage, ability/freedom to choose an insurer and market share covered by top insurers. A high score indicates multiple insurers and a situation where individuals can choose among more than five insurers.
	Levers for the insurance market[9]	Scope for insurers to modulate the content of coverage (benefits, level of the coverage, premiums), the degree of available information on the benefits and premiums to users and information on the existence of risk equalisation schemes. A higher score reflects the availability of more levers for insurance competition.
	"Over the basic" coverage	Role played by private health insurance offering complementary, supplementary or duplicative coverage on a voluntary basis. The higher the score the larger the role for a highly competitive insurance market for "over the basic" coverage.
	Patient choice among providers	Whether individuals are free to choose any doctor or hospital to seek care, face incentives to choose a specific doctor or hospital, or have limited choice. A higher score reflects a system with greater choice among providers.
	Role of primary care in the health system (gate-keeping)	Financial incentives or obligation that individuals face when registering with primary care physicians, and incentives or obligation to access secondary care. A higher score reflects a higher level of constraints for individuals.
Health care delivery systems	Incentives for volume increase in physicians' payment methods	Predominant mode of payment of primary care physicians and specialists. The higher the score the stronger the incentive to generate volumes.
	Incentives for volume increase in hospitals' payment methods	Predominant mode of payment of hospitals. The higher the score the stronger the incentive to generate volumes.
	Degree of private provision – physicians	The highest score is assigned when the predominant provision of primary care and out-patient specialist services is private only.
	Incentives for health care quality	A higher score reflects a system with stronger incentives for primary care physicians, specialists and hospitals to increase quality.
Governance and resource allocation	Definition of the health benefit basket	Describes how the benefits covered by basic primary health insurance are defined for medical procedures and pharmaceuticals. A higher score reflects the definition of a benefit basket at central level by a positive list.
	Use of Health Technology Assessment (HTA)	Existence and use of health technology structure and capacity to determine benefit coverage, reimbursement level/prices and clinical guidelines. A higher score implies a greater use of HTA.
	Regulation of prices/fees for primary care physicians' services paid by third-party payers	The higher the degree of regulation by institutions providing financing of basic primary coverage the higher the score assigned.
	Regulation of prices/fees for hospitals' services paid by third-party payers	The higher the degree of regulation by institutions providing financing of basic primary coverage the higher the score assigned.
	Decentralisation	**The higher the degree of decentralisation across levels of government, the higher the score assigned.**

9. This indicator is not used in the regression analyses as only a few OECD countries with contributory entitlement to basic health coverage rely on choice and competition across multiple insurers.

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15. Table 3 reports regression results.[10,11] The core determinants of public[12] spending on health care are examined first. The share of the old-age population is not statistically significant in the regression and has a negative sign. This is contrary to previous results (see Lorenzoni et al., 2018) and to expectations as the effects of the interaction between population ageing and health status, functional impairment and disability, use of technology and proximity to death increase public health spending.[13] The results also show that a one per cent increase in GDP per capita is associated with a 0.47% increase in health spending. This partial income elasticity is lower than results reported in previous studies and meta-analyses.[14]

16. Focusing on the core determinants of longevity, a 1% increase in health spending per capita is associated with a gain of 0.31 months of life expectancy,[15] and a 1% increase in GDP per capita is associated with a gain of 0.32 months of life expectancy. A 1% increase in smoking is associated with a loss of 0.13 months of life expectancy, and a 1% increase in alcohol consumption is associated with a loss of 0.11 months of life expectancy.

17. The effect of decentralisation on health expenditure and life expectancy is statistically significant. The sign of linear coefficients show that a higher degree of decentralisation tends to reduce public health spending and increase life expectancy. This is in line with the limited literature on this topic (Arendts, 2017; Channa and Faguet, 2016; Jimenez and Smith, 2005) that also reflects the fact that "the ability of decentralisation to achieve its objectives is complex and ambiguous" (Saltman et al., 2012).

18. Moreover, the results also point to an intuitively appealing significant quadratic inversion for both health spending and life expectancy, suggesting that "excessive" decentralisation reverses both effects. Result are consistent with the recent pattern observed among Nordic countries – whose health care systems are built on decentralised models – of changing the balance of decision-making capacity in favour of intermediate levels of government (Magnussen et al., 2009; Saltman et al., 2012). This re-centralisation (or consolidation) in responsibility for organising and purchasing of health services can

10. For the regression analysis presented in this paper, scores for institutional and health system characteristics were averaged over the period in study. Using the change in policy over time to assess the magnitude of a policy effect would imply assuming that a policy reform has an instantaneous influence on the health system features that are likely to influence longevity or health expenditures, which is too strong an assumption. There is an additional econometric argument that changes in policy are statistically noisy and using them introduces significant measurement errors that drive policy coefficients to zero.

11. It should be noted that all variables are not simultaneously estimated.

12. Because policies and institutions considered in this analysis pertain to the public sector – which accounts for a large part of spending on health care across OECD countries, we concentrate here on public spending on health care. Estimates for total spending on health care are qualitatively similar for several important policies (Lorenzoni et al., 2018).

13. Mortality rates are higher for old-age cohorts, so a higher proportion of old-age people will lead to much higher health expenditure associated with the final months of life (Seshamani and Gray, 2004).

14. For example, Acemoglu et al. (2013) derive a central estimate for the income elasticity of health spending of around 0.72. For a literature review of the income elasticity of health spending, see de la Maisonneuve and Oliveira Martins (2013).

15. This is computed as follows: 80 (average LE) * 0.033 (regression coefficient for the covariate) / 100 * 12 (months per year).

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provide incentives to reduce geographical variations in access to and quality of care, keep higher control over fiscal and policy issues as well as improve care co-ordination (Couffinhal et al., 2016).

Table 3. Results for the effects of institutional arrangements on health spending and life expectancy

	Dependent variable:	LOG HEALTH SPENDING	LOG LIFE EXPECTANCY
		(1)	(2)
	CORE DETERMINANTS		
	Log of share of old-age population	-0.137	
		(0.17)	
	Log of health spending per capita		0.033***
			(0.03)
	Log of GDP per capita	0.478***	0.034***
		(0.11)	(0.04)
	Log higher education		-0.004
			(0.04)
	Log smoking		-0.014***
			(0.02)
	Log alcohol consumption		-0.012***
			(0.02)
	INSTITUTIONAL AND HEALTH SYSTEM CHARACTERISTICS		
Health financing and	Depth of basic coverage	-0.221***	0.106***
coverage arrangements		(0.04)	(0.02)
	Level of financial protection	-1.008***	0.369***
	for health care users	(0.09)	(0.06)
	Out-of-pocket payments for curative care	-1.051***	0.338***
		(0.12)	(0.06)
	Degree of user choice for basic coverage	0.196***	0.056**
		(0.04)	(0.03)
	"Over the basic" coverage	-0.487***	0.114***
		(0.05)	(0.03)
	Patient choice among providers	0.363***	-0.111***
		(0.06)	(0.03)
	Role of primary care (gate-keeping)	0.508***	-0.223
		(0.07)	(0.04)
Health care delivery	Incentives for volume increase	0.055	-0.022
systems	in physicians' payment methods	(0.06)	(0.04)
	Incentives for volume	0.376***	-0.007
	increase in hospitals' payment methods	(0.05)	(0.03)
	Degree of private provision	0.288***	-0.014
	of physicians services	(0.06)	(0.03)
	Regulation of medical staff in hospitals	-0.143***	0.251***
		(0.07)	(0.03)
	Incentives for health care quality	-0.04	0.059**
		(0.04)	(0.02)

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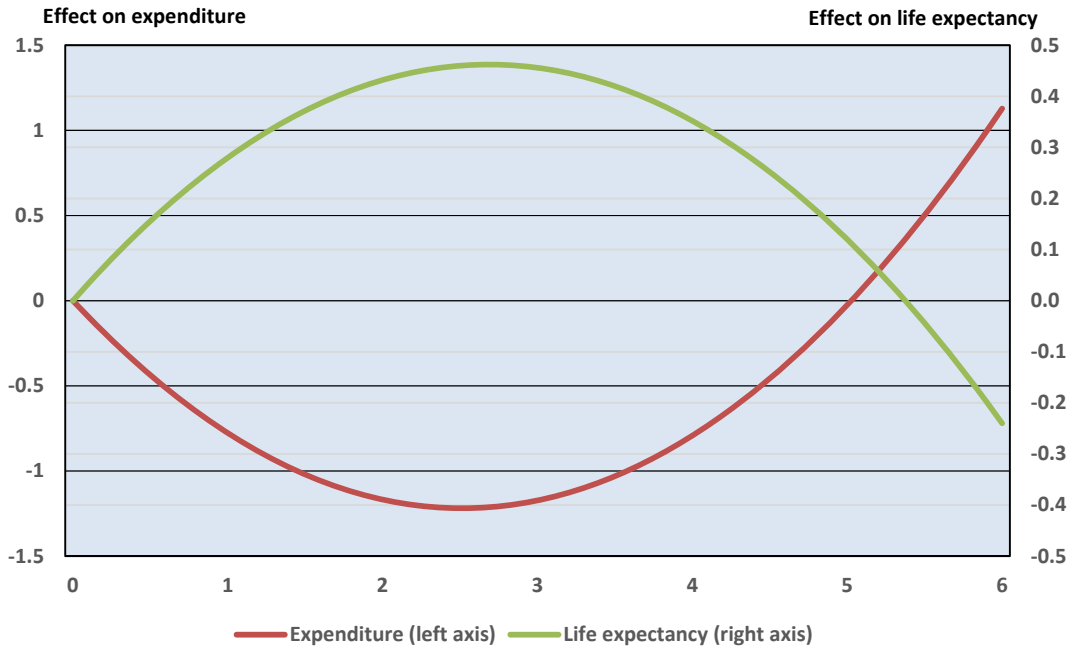
	Dependent variable:	LOG HEALTH SPENDING	LOG LIFE EXPECTANCY
Governance and resource allocation	Definition of health benefits basket	-0.053	0.042*
		(0.04)	(0.02)
	Use of HTA	0.184***	0.044*
		(0.04)	(0.02)
	Regulation of prices/fees for primary care	-0.310***	-0.086***
	physicians' services paid by third-party payers	(0.06)	(0.03)
	Regulation of prices/fees for hospitals'	0.211***	-0.179***
	service paid by third-party payers	(0.06)	(0.03)
	Decentralisation	**-0.970*** **	**0.344*** **
		(0.11)	**(0.05)**
	Decentralisation – squared term	**0.193** **	**-0.064*** **
		(0.02)	**(0.01)**
	N = 410		
	Country dummies	Yes	Yes
	Time dummies	Yes	No
	Adjusted R^2	0.999	0.999

Note: Robust standard errors in parentheses. Statistical significance: * 10% level; ** 5% level; *** 1% level. Note the non-linear estimator generates an unusually high R-squared value, which is partially by construction.

Figure 2. Marginal effect of decentralisation on public spending and life expectancy



Note: To generate the effective marginal coefficient values, the decentralisation coefficients from Table 3 are applied to simulated values along the 0-6 scale of the decentralisation index as well as the square of the index.

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19. Overall, the empirical analysis presented here with regard to the institutional context variables provides plausible results that are in line with previous work (Lorenzoni et al., 2018). Policies aimed at increasing the depth of basic coverage and the level of financial protection for health care users may help achieving higher value for money by raising life expectancy and reducing health spending at the same time, while policies associated to increasing capacity and use of health technology assessments and fostering a higher degree of user choice of basic insurance improve life expectancy and raise health spending at the same time. A stricter price regulation tends to be associated with lower public spending on health care, although the evidence on gate-keeping arrangements is more mixed.

20. In a few cases, the estimated effects on life expectancy and health spending of institutional and health systems characteristics indicators have differed from expectations. As an example, the sign of the coefficients on the log share of the old-age population becomes insignificant and negative once the quadratic decentralisation term is included. This may suggest a correlation of some demographic characteristics across specific local regions. More broadly, it is important to recognise that institutional and health system features may remain endogenous and could be affected by reverse (two-way) causality, which is not accounted for in this paper. For instance, low value for money could prompt changes in health policies. It must also be acknowledged that there is a risk of overfitting in our model stemming from a quite large number of explanatory variables in the regressions and that time series used in this work are too short for a robust panel analysis.

IV. The relationship between decentralisation and hospital costs

21. The relationship between decentralisation and hospital costs was investigated using a multilevel model to analyse data collected for selected hospital services in ten OECD countries.

22. By focusing on the following groups of tracing conditions/treatments likely to be similarly defined across countries, the analysis is less likely to violate the underlying assumption of a common production function across providers:

In-patient:

- Treatment of acute myocardial infarction: Acute myocardial infarction with percutaneous transluminal coronary angioplasty (AMI with PTCA) (IN01); Coronary artery bypass graft (IN02).
- Little discretion in use: Hip replacement: total and partial - unilateral; bilateral (IN03); hysterectomy with diagnosis of cancer (IN04).
- High-volume: Caesarean section (IN05); Normal delivery (IN06).

Day surgery:

- Lens and cataract procedures (DS01); Arthroscopic excision of meniscus of knee (DS02).

23. Hospital level data were provided by data custodians for Canada (for the provinces of Manitoba and Saskatchewan for the years 2012-2015), Estonia (2012-2015), France (2012-2015), Ireland (2012-2014), Israel (2012-2015), Luxembourg (2012-2015), Norway

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(2016[16]) and Turkey (2012-2015). Publicly available data were used for England, whereas hospital data were available at the OECD for Switzerland. Test regressions were run between panel data and pooling of hospitals across years (merging the years across the unique identifiers). Regressions with panel data, even if unbalanced, were higher in explanatory power and significance. Omitting a year variable also significantly affects the coefficient of the random hospital effect, rendering it almost zero.

24. For the purpose of the pilot data collection and analysis in this paper, the following hospital characteristics were collected:

- Teaching status (dummy): based on the designation of hospitals as academic medical centre/tertiary referral centre;
- Ownership type: publicly-owned; private for-profit; private not-for-profit;
- Number of beds, the average daily number of in-patient open and available beds;
- Bed occupancy rates.

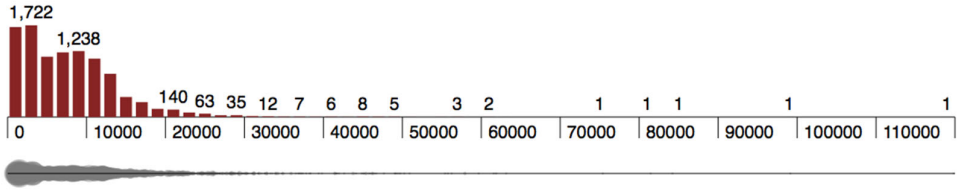
25. Hospital level data provided to the OECD also included:

- Number of cases by condition/treatment by hospital;
- Average cost and its coefficient of variation by condition/treatment by hospital.

26. Average costs provided by countries in local currencies were converted to PPP-adjusted currencies using Purchasing Power Parities statistics for GDP[17] (Figure 3, Panel A). Outliers were then identified based on the distribution of average cost by hospital. For average cost, a cut-off threshold of USD 70 000 (at PPP) was used.

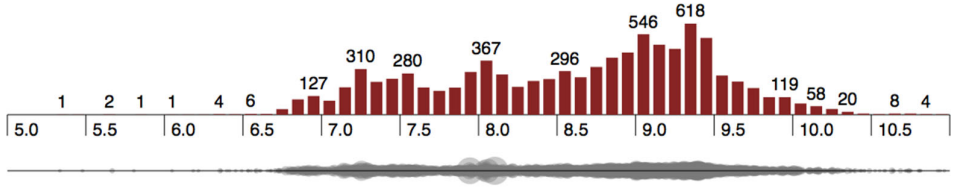
Figure 3. Distribution of average cost by hospital

Panel A – GDP-PPPs adjusted



Estimated mean = 7956.237 ± 128.389

Panel B – log-converted GDP-PPPs adjusted



Estimated mean = 8.603 ± 0.018

16. During the 2012-2015 period the system for cost calculation in Norwegian hospitals changed from a top down model to a patient cost model (bottom up). Due to this change in cost calculation, only data for 2016 are available for Norway.

17. Available at OECD.Stat.

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27. This measure was then converted in its natural logarithm, as is common practice for cost variables to normalise data (Figure 3, Panel B). The log-converted distribution allows working with a better-behaved distribution, and exploiting a log-log regression model for ease of interpretation of the results.

28. The multi-level structure of data to explore factors driving variations in cost across hospitals (Gaughan et al., 2012; Schreyogg et al., 2011; Or et al., 2005) was exploited. Since this is a benchmarking exercise, it does not require the specification of a production possibility frontier, an approach that can be criticised for its distributional assumptions and sensitivity to modelling choices (Worthington, 2004; Hollingsworth, 2008).

29. Preliminary t-test and ordinary least squares (OLS) regressions were performed to test hypotheses regarding differences in costs among condition sub-groups, and the restricted set of covariates to be used in the further regressions (multilevel modelling, ML).

30. All the regressions in this pilot study take the log-log form, for which the interpretation of any estimated non-dummy coefficient β is that a one percentage point increase in $X(\beta)$ will produce an expected increase in Y of β%.

31. Regressors were split into a fixed effects component and a random effects one, with a two-level nesting for hospitals (lower) within countries (upper) for the random part of the model. Two sets of regressions were used to evaluate the decentralisation effect. One would expect decentralisation to act partly on the random effect allocation of variation to the country level. Therefore, this hypothesis was tested by looking at the random effects of regressions with and without the decentralisation covariate.

32. The regressions on hospital cost (untrimmed data) were performed with both country random effects and year fixed effects, with the random effects component using the standard deviation as estimator to calculate the hierarchical intercepts for the two nests of the empirical exercise. Explanatory variables[18] such as occupied beds,[19] ownership and year were modelled as traditional fixed effects, and then nested under random intercepts for countries, hospitals and the residuals.

33. Regressions that include the "decentralisation" covariate were estimated to see whether there are significant differences in both fixed and random coefficients. Table 4 below reports the regression results across all conditions/treatments.

18. Teaching status is dropped from those regressions as it is not statistically significant for the conditions/treatments in this study. Its inclusion as covariate also reduces the number of observations considerably.

19. Occupied beds are calculated by multiplying the overall number of beds by the occupancy rate for any given hospital, country and year.

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Table 4. Multilevel regressions on cost, by condition

Panel A – fixed components estimates

	IN01	*IN02*	*IN03*	*IN04*	*IN05*	*IN06*
Constant	8.90***	9.20***	9.22***	8.33***	8.32***	8.05***
Beds (occupied)	.06**	.10***	.01	.08**	.02	.00
Decentralization						
High decreasing	**-.86*** **	**-1.83*** **	**-1.23*** **	**-.80***	**-.54***	**-.12**
High increasing	**-.41** **				**.27**	**-.01**
Ownership						
For-profit	-.06	.06	-.08**	.04	-.03	-.00
Not-for-profit	-.11	-.08	-.19***	-.55***	-.17**	-.03
Condition						
1	.03*		.62***			
2	.047***		1.47***			
3			.13***			

Note: Acute myocardial infarction with percutaneous transluminal coronary angioplasty (AMI with PTCA) (IN01); Coronary artery bypass graft (IN02); Hip replacement: total and partial - unilateral; bilateral (IN03); hysterectomy with diagnosis of cancer (IN04); Caesarean section (IN05); Normal delivery (IN06). For IN01, condition =1/2 refers to age groups (45-64 = baseline); for IN03, condition =1 refers to bilateral emergency, =2 bilateral planned, =3 unilateral emergency (unilateral planned = baseline). Statistical significance: * 10% level; ** 5% level; *** 1% level.

Panel B – random components estimates[20]

	IN01	*IN02*	*IN03*	*IN04*	*IN05*	*IN06*
Country	.128	.430	.122	.365	.233	.138
Hospital	.182	.210	.141	.187	.218	.197
Residual	.138	.321	.171	.289	.228	.228
Number of countries	6	6	6	5	7	7
Number of observations	402	232	1249	292	627	620

34. The decentralisation variable was initially tested as a random effect (under the country level nest) within the mixed model, but the small amount of degrees of freedom does not allow its use as a random parameter. Therefore, the regression specification above includes the decentralisation variable as a fixed effect that should capture the impact of a higher level of decentralisation on costs across countries. It is important to note that due to

20. Since it is a multilevel model, levels cannot be combined into one effect. Decentralisation is a fixed effect and therefore not shown here.

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the small number of countries in the analysis, the effect could partially capture country-specific differences in costs rather than the pure effect of decentralisation.

35. As can be seen from Table 4 above, the decentralisation dummy was highly significant across most conditions, and negative. Significantly lower hospital costs can be observed across most conditions for countries with high and decreasing decentralisation compared to those with no decentralisation. For the countries with high and increasing decentralisation, we also observe a significant negative coefficient, for one condition, but the variable drops for other conditions since the number of countries is excessively low. Coefficients for all other variables in the regression do not change significantly compared with regressions that exclude the decentralisation variable.

36. Nevertheless, it cannot be ruled out that the effect could be partially due to systematically lower costs in Canada and Norway (high and *decreasing* decentralisation) compared to the rest of the sample, although there are more countries in the first model. Note that in the random effects, the variation explained by the country level decreases significantly compared to regressions without decentralisation. This may be explained by the fact that a significant amount of country-specific variation was captured using the decentralisation variable within the fixed components of the regression.

37. Overall, the need for a more detailed variable emerged from the results of this regression, such as a hospital or regional-level interaction, or a larger country coverage. The sign and size of the variable suggests that costs were significantly lower across conditions in countries with greater decentralisation, but causality cannot be inferred due to the small number of countries within the sample. The index constructed for this analysis uses an average point in time to classify countries within three groups. A larger number of countries in the sample will allow for the construction of a continuous index that should limit the strong country-specific effect found in this analysis.

38. An important limitation of this analysis is that it does not consider differences in outcomes – that is, it assumes that the treatments/conditions result in the same outcomes across countries. More work is needed to understand how much of the variation is explained by differences in the quality of care, as opposed to technical efficiency in delivering care. Another limitation of this analysis is that it assumes consistency in the way cost by condition/treatment is estimated across countries, but countries do differ in this regard. Empirically, however, there is some evidence that different accounting approaches lead to similar results, especially at higher levels of aggregation (Chapko et al., 2009; Tan et al., 2009). Finally, unit cost metrics offer insights into the overall technical efficiency of a hospital (relative to other such entities), but give little operational guidance as to the reasons why such differences arise.

39. Notwithstanding hospitals being the data collection unit for this pilot analysis, we are effectively looking at the technical efficiency of provision (and performance) of particular types of hospital services (conditions or treatments). Future work will need to look more specifically at hospitals in the broader context of health care systems, including at the regional level (e.g., TL2 or TL3). While the payment system as a country-level covariate is used in the regressions, there is space for additional variables that take into account other factors, such as the organisation of primary care or health systems characteristics (Lorenzoni et al., 2018), which are not used in this study.

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