UNIVERSITAT
ROVIRA I VIRGILI
DEPARTAMENT D'ECONOMIA

(creip)
CENTRE DE RECERCA EN ECONOMIA
INDUSTRIAL I ECONOMIA PÚBLICA

WORKING PAPERS

Col·lecció "DOCUMENTS DE TREBALL DEL DEPARTAMENT D'ECONOMIA - CREIP"

The Catalan health budget rationing problem

María José Solís Baltodano

Document de treball n.27- 2016

DEPARTAMENT D'ECONOMIA – CREIP
Facultat d'Economia i Empresa

UNIVERSITAT ROVIRA I VIRGILI

DEPARTAMENT D'ECONOMIA

Edita:

Departament d'Economia
www.fcee.urv.es/departaments/economia/public_html/index.html
Universitat Rovira i Virgili
Facultat d'Economia i Empresa
Av. de la Universitat, 1
43204 Reus
Tel.: +34 977 759 811
Fax: +34 977 758 907
Email: sde@urv.cat

CREIP
www.urv.cat/creip
Universitat Rovira i Virgili
Departament d'Economia
Av. de la Universitat, 1
43204 Reus
Tel.: +34 977 758 936
Email: creip@urv.cat

Adreçar comentaris al Departament d'Economia / CREIP

ISSN edició en paper: 1576 - 3382
ISSN edició electrònica: 1988 - 0820

DEPARTAMENT D'ECONOMIA – CREIP
Facultat d'Economia i Empresa

The Catalan health budget rationing problem

María-José Solís-Baltodano[a]

[a] *Universitat Rovira i Virgili, Dep. d'Economia, CREIP, Av.Universitat 1, 43204 Reus, Spain. (E-mail address: mariajose.solis@urv.cat)*

Abstract

The financial and economic crisis in Spain during recent years has induced public budget adjustments. The crisis has caused a great social impact due to the way the austerity measures have been implemented, affecting mainly key economic sectors such as the civil service, justice, education and health. Among all of these sector, the current paper focuses on the health budget distribution, since the changes in the provision of the health services induce faster and clearer impacts in the social welfare. Spain is divided into 17 regions, and each region manages its own health system. Specifically, we analyse the Catalan health budget assignment since Catalonia is one of the most populated regions and one where the restrictions have been more evident. We study the health budget distribution for the period 1998-2014, from the point of view of the conflicting claims problem (O'Neill, 1982). Accordingly, alternative allocations of the health budget are proposed by using some of the most used solutions in the body of literature. Finally, in order to choose the most appropriate solution, we require the fulfilment of (i) some commonly accepted social constraints, (ii) some criteria of fairness and stability, and (iii) low inequality indexes.

Keywords: Distribution problems; Health; Axiomatic analysis; Public budget

1. Introduction

The subprime mortgage crisis, which originated in the USA in 2007, was triggered by a large decline in home prices after the collapse of a housing bubble. This fact, jointly with the lower credit quality (lowered lending standards and higher-risk mortgage), induced a decline in the capacity and willingness of the private financial system to support lending, i.e., the monetary liquidity gave up the financial market (Calvo, 2008). Consequently, the investors lost confidence in the monetary market, and the most affected banks, such as Northern Rock, Bear Stearns and Lehman Brothers failed (Orlowski, 2008).[1]

Due to the crisis, the USA and Europe experienced several consequences, such as economies in deep recession, million of lost jobs, decreasing gross domestic product, and a fall in the stock market. The reaction of the countries

[1] Timeline: Credit crunch to downturn, BBC NEWS, 2009. Lehman Bros files for bankruptcy, BBC NEWS, 2008.

against the so-called "greatest financial crisis worldwide" was heterogeneous. In the USA and Japan, the Central Banks decided to apply expansionary policies that led to injecting trillions of dollars in order to rescue the bankrupt financial entities. In Europe, following the recommendation of the European Central Bank, countries such as Greece, Ireland, Portugal and Spain applied austerity measures (Hemerijck, 2012).

In particular, Spain has applied economic policies that are designed to reduce public expenditure. For instance, during 2013, the education sector suffered a budget reduction of 326.17 million euros more than the previous year, that is, a decrease of 14.4%; in the culture sector the budget assigned in 2013 was 175.81 million euros less than in 2012, representing a reduction of 19.6%. All these spending adjustments provoked, almost immediately, negative consequences in the provision of public services. Specifically, in the health sector, which suffered a reduction of 906.06 million euros in the period 2009-2013, and according to the reports of the Sociedad Española de Salud Pública y Administración Sanitaria, many primary attention centres closed, and the numbers of beds, operating rooms, and sanitary staff, among others, were drastically reduced, inducing an increase in numbers on the waiting lists (43% from 2009 to 2012).

Accordingly, the present paper focuses on the health sector, because (i) it is a sector that generates great social impact, (ii) health is essential for social welfare, and (iii) the way in which the budget readjustment has been applied, have induced a substantial decrease in the quality of the health services (according to the Spanish National Health System, SNS).

Health was defined by the World Health Organization (WHO, 1946) as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity".[2] From an economic point of view, it is important to ensure the protection and promotion of health, because the population's vitality increases the labour force and the productive capacity (Arrow, 1963).

In Spain, the Constitution (1978) establishes in its article 43, the right to the protection of health and health attention of all citizens. The SNS in Spain is known as one of the best in the world (Stuckler et al., 2011). Specifically,

[2]Preamble to the Constitution of the World Health Organization as adopted by the International Health Conference, New York, 19-22 June, 1946; signed on 22 July 1946 by the representatives of 61 States (Official Records of the World Health Organization, no. 2, p. 100) and entered into force on 7 April 1948.

Figure 1: Spanish regions. Source: SNS, 2012.

the services provided by the SNS are: prevention, diagnosis, treatment and rehabilitation, pharmaceutical services, orthopaedic and prosthetic services, dietary products services, non-emergency health transport. Likewise, the SNS is independently managed by the 17 regions of Spain (see Figure 1).

Among all the regions, we analyse Catalonia because it is the second most populated region, that allocates more resources to the maintenance of the health system (in absolute terms), and it has been the region where more budget adjustments have been applied.[3] The health services in Catalonia are managed by the Health Department, which also coordinates the central organisms: the Servei Català de la Salut, and the Institut Català de la Salut.[4]

The health budget is not enough for satisfying Catalan health needs. In this regard, during the period 2009-2011, the number of patients in the waiting lists increased by 30,000 and the waiting time increased by up to 4.57 months.[5] Likewise, the numbers of public health employees was reduced by 37,000. Also, not all the primary care centres have access to 24 h emergency

[3]Cataluña y Castilla-La Mancha, a la cabeza de los recortes en sanidad. Expansion, 2013

[4]Catalan Health Service (SCS) and Catalan Institute of Health (ICS), respectively.

[5]Las listas de espera aumentan el 43% por los recortes de Mas en sanidad. EL PAIS, 2012.

attention.[6] Similarly, among other negative implications, several hospitals beds and operating theatres have been closed, and pharmacy spending decreased.[7] Therefore, clearly, the Catalan health budget distribution fits the conflicting claim problem approach (O'Neill, 1982), since the resources cannot satisfy the aggregate needs.

The conflicting claims problem approach models those situations where the available resources are not enough to totally honour the aggregate claim. Usually, this model has been used to explain how to distribute the money of a failed bank among its creditors, or an inheritance among heirs. Nonetheless, it can be applied to so many different situations, such as medical assistance, budget distribution in universities (for instance, Pulido et al., 2002, propose that the funds should be allocated proportionality to the number of teachers, students, etc., of each department), milk quota distribution among EU member states, and the distribution of seats in parliament in the USA or Spain (see Giménez-Gómez and Peris, 2014). This theory is also applied also in environmental issues such as the reduction of fishing quotas (Iñarra and Prellezo, 2008; Inarra and Skonhoft, 2008; Kampas, 2015), and in the case of global carbon budget where the allocation of CO2 emissions among countries is studied (Giménez-Gómez et al., 2016).

The body of literature on conflicting claims problems has proposed several ways of solving these types of situations, often by the application of rules. To the best of our knowledge, health sector has not been studied from this perspective, but this sector is suitable as a conflicting claim problem. In the present paper, we consider that dealing with the health budget problem in this way is potentially more effective than the current distribution. Therefore, we provide an implementation of the conflicting claims problems theory with respect to the Catalan health sector.

Firstly, we analyse, during the period 2011-2014, how the budget is distributed among the different economic areas of the public health expenditure (consolidated health budgets): salary, current expenditures of goods and services, current transfer, transfer of capital, real investment, and variation of financial assets. Secondly, we apply some of the solutions that have been proposed in the literature to mediate conflicts: the proportional, the constrained equal awards, the constrained equal losses, the Talmud, the adjusted propor-

[6] Cataluña cierra quirófanos y consultas. EL PAIS, 2011.

[7] Sanidad sacará 456 fármacos de uso común de la financiación pública. El PAIS, 2012.

tional and the $\alpha - min$ solutions. Thirdly, since, our aim is to find the most appealing and fairest solution, we introduce the Power Index, which is a criterion of stability and fairness that ensures a reasonable assignment of the budget. Fourthly, we apply inequality indexes such as the Atkinson index, the Gini coefficient and the Generalized Entropy. Finally, we introduce several commonly accepted social constraints in the health context; and we propose to choose the solution that satisfies the fair criterion, the equity indexes and the social constraints.

The remainder of the paper is organised as follows. Section 2 provides an overview of the health sector in Catalonia and the budget problem in this sector after the crisis. Section 3 describes the health budget as a conflicting claims problems. Section 4 presents some theoretical solution to the conflicting claims problem. Sections 5 and 6 introduce fairness and stability criteria, and some commonly accepted social constraints, respectively. Finally, Section 7 concludes.

2. Department of Health in Catalonia

The Spanish National Health System (SNS) is the organisation responsible for the coordination, cooperation and administration of health services, and it is organized in two levels: primary and specialist health care. The population can receives basic services in the primary health care centres, and if they need a specialized treatments, they can be attended to in the specialized centres and hospitals.

As aforementioned, Spain is divided into 17 regions, and each region administers its health system independently. Specifically, each region is responsible for the management of the centres and the health services within the region.

Among all of the regions, we focus on Catalonia, mainly for the availability of data, but also because it is (i) the second region with the greatest population density, (ii) the region that allocates more budget to the health sector; and, as aforementioned, it has been the Spanish region where where the most budget adjustments have been applied (see Figure 1).

		Millions of Euros	GDP %	GDP per capita	Inhabitants
Health expenditure 2011	Andalucia	9,442	6.6%	1,121	8,8422,837
	Aragón	2,051	6.1%	1,523	1,346,684
	Asturias	1,721	7.6%	1,591	1,081,710
	Baleares	1,273	4.8%	1,144	1,112,762
	Canarias	2,731	6.5%	1,284	2,126,947
	Cantabria	767	5.8%	1,293	593,194
	Castilla y León	3,332	6.0%	1,302	2,559,140
	Castilla-La Mancha	3,067	8.3%	1,450	2,115,172
	Cataluña	10,120	5.1%	1,342	7,540,984
	Com. Valenciana	6,717	6.6%	1,313	5,115,765
	Extremadura	1,693	9.9%	1,526	1,109,346
	Galicia	3,556	6.3%	1,272	2,795,597
	Madrid	8,418	4.4%	1,297	6,490,362
	Murcia	2,266	8.1%	1,541	1,470,474
	Navarra	988	5.3%	1,538	642,393
	País Vasco	3,566	5.4%	1,632	2,185,049
	Rioja	461	5.7%	1,428	322,829
	Maximum for Spain	**10,120**	**9.9%**	**1,632**	**8,422,837**
	Average for Spain	62,169	5.9%	1,322	47,031,336
	Minimum for Spain	461	4.4%	1,121	322,829
Health expenditure 2012	Andalucia	9,223	6.6%	1,091	8,453,712
	Aragón	2,043	6.3%	1,514	1,349,406
	Asturias	1,655	7.6%	1,536	1,077,474
	Baleares	1,293	5.0%	1,155	1,119,481
	Canarias	2,519	6.3%	1,189	2,118,587
	Cantabria	1,046	8.3%	1,762	593,644
	Castilla y León	3,455	6.4%	1,357	2,546,057
	Castilla-La Mancha	2,613	7.2%	1,231	2,122,665
	Cataluña	9,480	4.9%	1,252	7,571,885
	Com. Valenciana	6,116	6.3%	1,192	5,130,872
	Extremadura	1,556	9.5%	1,404	1,108,262
	Galicia	3,530	6.4%	1,269	2,781,718
	Madrid	7,666	4.1%	1,180	6,496,610
	Murcia	2,111	7.9%	1,431	1,475,192
	Navarra	918	5.2%	1,425	644,211
	País Vasco	3,449	5.4%	1,573	2,192,626
	Rioja	419	5.3%	1,296	323,302
	Maximum for Spain	**9,480**	**9.5%**	**1,762**	**8,453,712**
	Average for Spain	59,092	5.8%	1,255	47,105,703
	Minimum for Spain	419	4.1%	1,091	323,302
Health expenditure 2013	Andalucia	8,812	6.2%	1,044	8,440,613
	Aragón	1,656	5.0%	1,229	1,347,437
	Asturias	1,520	7.1%	1,423	1,068,166
	Baleares	1,278	4.9%	1,150	1,111,304
	Canarias	2,553	6.3%	1,205	2,118,672
	Cantabria	801	6.6%	1,354	591,581
	Castilla y León	3,391	6.3%	1,346	2,519,316
	Castilla-La Mancha	2,506	6.6%	1,193	2,100,587
	Cataluña	9,265	4.7%	1,227	7,550,937
	Com. Valenciana	5,671	5.8%	1,109	5,113,616
	Extremadura	1,543	9.1%	1,397	1,104,510
	Galicia	3,559	6.5%	1,287	2,765,346
	Madrid	7,403	3.8%	1,140	6,493,860
	Murcia	2,086	7.8%	1,417	1,472,124
	Navarra	892	8.0 %	1,384	644,509
	País Vasco	3,394	5.3%	1,549	2,191,091
	Rioja	415	5.4%	1,288	322,205
	Maximum for Spain	**9,265**	**9.1%**	**1,549**	**8,440,613**
	Average for Spain	56,745	5.4%	1,208	46,955,873
	Minimum for Spain	415	3.8%	1,044	322,205

Table 1: Regional health public investment 2011-2013. Source: Estadística de Gasto Sanitario Público, Centro de Estudios del Sindicato Médico CESM-Granada.

The Health Department in Catalonia is the highest authority and manages its regional health politics. The Servei Català de la Salut **(CatSalut)** is the responsible for the funding and purchase of health services, and for supplying these services to health centres and hospitals. Regarding the provision of these health services, there exists a set of entities that supply them to the population.[8] These entities can be either public, concerted (50% public, 50% private) or fee-paying private. Figure 2 shows the organisation chart of the Catalan Health System.

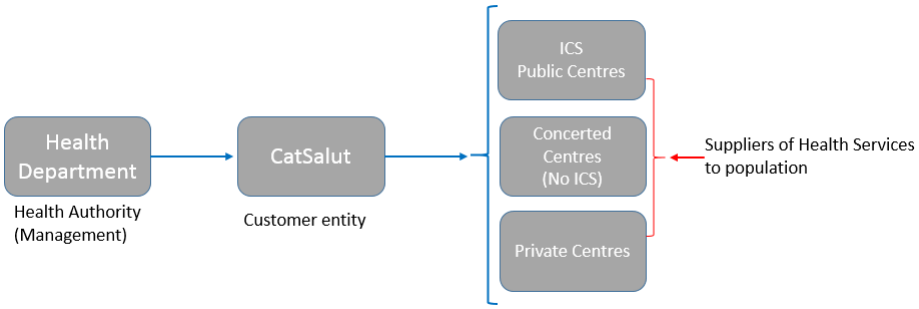

Figure 2: Organisation chart of the Catalan Health System.

In this paper, we study the **CatSalut**, because it is the supplier of health services to all centres and hospitals, and the **ICS**, and because it is the most important public entity that provides these health services to all users. The main objective of the **CatSalut** and the **ICS** is to ensure the equity, quality and efficiency of the health system in order to improve the population's quality of life.

In order to analyse the health budget distribution as a conflicting claims problem, we formally introduce this approach in the following section.

3. The health budget as a conflicting claims problem

As aforementioned, it is noteworthy that the conflicting claims problem approach, which originates formally with O'Neill (1982), has been used by many authors to solve conflicts of interests in actual situations. For instance, it has been implemented for allocating budget among the departments of a

[8] Catalan Health Services (CatSalut) and Catalan Institute of Health, respectively.

university, where the available resources are distributed proportionally to the number of professors, students, subjects, etc. (Pulido et al., 2002). Furthermore, in environmental contexts, Iñarra and Prellezo (2008), Inarra and Skonhoft (2008), and Kampas (2015) analyse the fishery sector and based on conflicting claims solutions, propose an alternative way to reduce the fishing quotas among agents; or, recently, Giménez-Gómez et al. (2016) study how to allocate the global carbon budget among world regions.

Formally, consider a set of agents $N = \{1, 2, ..., n\}$, such that each agent has a claim $c_i \in \mathbb{R}_+$ on an infinitely divisible resource, the endowment $\mathbf{E} \in \mathbb{R}_+$. Let $c \equiv (c_i)_{i \in N}$ be the claims vector. Then, a **conflicting claims problem** is a pair (E, c) with $C = \sum_{i=1}^{n} c_i > E$, that is, the endowment is not enough to honour all the claims. Without loss of generality, we order the agents increasingly according to their claims, $c_1 \leqslant c_2 \leqslant \ldots \leqslant c_n$. We denote by $\mathcal{B}$ the set of all claims problems.

In the present paper, we consider that the endowment is the health budget assigned to the health sector in each one of the evaluated years (from 2011 to 2014). Besides this, we use an inflation rate by using the consumer price index **(CPI)** in order to compare the real and the nominal values of the changes in the yearly budget.

Furthermore, since we focus our analysis on the financial adjustment that the health sector suffered since the crisis to the present day, we use the economic classification of the public health expenditure for defining who the claimants are. Specifically, there are six claimants: salaries **(S)**, current expenditures of goods and services **(EGS)**, current transfers **(CT)**, transfers of capital **(TC)**, real investment **(RI)**, and variation of financial assets **(VFA)**.

Finally, in order to define the amount of resources that the six economic areas will claim from the year 2010 on, it is noteworthy that the number of inhabitants has remained stable. Additionally, as Table 2 shows, the health budget has been diminishing in all economic areas from the year 2011 on. Therefore, it seems natural that each economic area would claim at least, the same resources it has before the crisis. Likewise, we define the claims with the health budget assigned to each claimant (economic area) for the year 2010.

	2009	2010	2011	2012	2013	2014
S	2,035,379	2,237,960	2,006,766	1,942,218	1,748,645	1,778,335
EGS	5,221,535	5,638,145	5,476,274	5,397,504	5,195,782	5,191,950
CT	1,880,247	1,659,558	1,455,598	1,173,754	1,140,209	1,112,639
TC	27,035	48,829	85,175	69,712	42,621	48,152
RI	195,904	218,610	149,183	135,156	124,071	117,536
VFA	66,424	85,175	69,712	71,786	42,621	48,152

Table 2: Initial health expenditure budget for the period 2009-2014. Total and disaggregated by chapters (in euros).

Since, we are proposing an alternative way of allocating the Catalan health budget, the next section introduces some different proposals (rules) considered in the in the literature about conflicting claim problems.

4. How to distribute the health budget

The conflicting claims literature provides a vast number of solutions, called rules, to distribute the endowment among the agents. Specifically, a **rule** is a solution function $\varphi : \mathcal{B} \to \mathbb{R}^n_+$ such that $\varphi_i(E, c) \geqslant 0$, for all $i \in N$ (**non-negativity**), $\varphi_i(E, c) \leqslant c_i$, for all $i \in N$ (**claim-boundedness**), and $\sum_{i=1}^{n} \varphi_i(E, c) = E$ (**efficiency**).

In this paper, as aforementioned, among all the rules that have been proposed in the literature to mediate conflicts of interests, we consider those rules that are widely used in actual situations: the proportional, the constrained equal awards, the constrained equal losses, the Talmud, the adjusted proportional and the $\alpha - min$ rules. Furthermore, since we are looking for a fair allocation of the health budget, we propose the rules satisfying some commonly accepted social constraints (see Section 6 for further discussion). Formally,

The **proportional (P)** rule divides the health budget proportionally with respect to each economic area's claim.
For each $(E, c) \in \mathcal{B}$ and each $i \in N$, $P_i(E, c) \equiv \lambda c_i$, where $\lambda = E/\sum_{i \in N} c_i$.

The **constrained equal awards (CEA)** rule (Maimoindes, 1135,1204), proposes an equal distribution of the health budget. However, CEA does not consider the differences between economic areas in terms of losses.

For each $(E,c) \in \mathcal{B}$ and each $i \in N$, $CEA_i(E,c) \equiv \min\{c_i, \mu\}$, where μ is such that $\sum_{i \in N} \min\{c_i, \mu\} = E$.

The **constrained equal losses (CEL)** rule (Maimoindes, 1135,1204; Aumann and Maschler, 1985) focuses on distributing losses, that is, all the economic areas must lose equally, but none of them must receive a negative amount.
For each $(E,c) \in \mathcal{B}$ and each $i \in N$, $CEL_i(E,c) \equiv \max\{0, c_i - \mu\}$, where μ is such that $\sum_{i \in N} \max\{0, c_i - \mu\} = E$.

The **Talmud (T)** rule (Aumann and Maschler, 1985) contains the CEA and the CEL. It takes the middle of the claims as a reference point. If the half of the aggregate claim is lower than the health budget, then the CEA is applied over the half-claims. Otherwise, each economic area receives the half of its claim and the CEL is applied in order to distribute the remaining budget.
For each $(E,c) \in \mathcal{B}$, and each $i \in N$, $T_i(E,c) \equiv CEA_i(E, c/2)$ if $E \leqslant C/2$; or $T_i(E,c) \equiv c_i/2 + CEL_i(E - C/2, c/2)$, otherwise.

The **Adjusted Proportional (AP) rule** (Curiel et al., 1987) ensures that each economic area receives its minimal right (O'Neill, 1982), m.[9] Then, it divides the remaining health budget in proportion to the revised claims, taking into the account that if a claim is greater than the available budget, it is truncated accordingly.
For each $(E,c) \in \mathcal{B}$ and each $i \in N$, $AP_i(E,c) = m_i(E,c) + P_i((\min\{c_i - m_i(E,c), E - \sum m_j(E,c)\})_{i \in N}, E - \sum m_j(E,c)\})$.

The **α-min rule** (Giménez-Gómez and Peris, 2014) ensures, for each $(c,E) \in \mathcal{B}$, an equal division of the health budget among the economic areas as far as the smallest claim is totally honoured; then, the remaining budget is distributed proportionally.
For each $(E,c) \in \mathcal{B}$ and each $i \in N$, if $c_1 > E/n$ then, $\alpha - min_i(E,c) = E/n$, or, $\alpha - min_i(E,c) = c_1 + P(E - nc_1, c - c_1)$, otherwise.

[9] For each $(E,c) \in \mathcal{B}$ and each $i \in N$, the minimal right m guarantees to each agent the not unclaimed part of the endowment, i.e., $m_i(E,c) = \max\{E - \sum_{j \neq i \in N} c_j, 0\}$.

Table 3 summarises the comparison among the proposed rules and the four considered health budgets. As aforementioned, we consider six economic areas (claimants) and the consolidated health budget for the years 2011-2014 (budget allocations).

Claims: TC=41.1; VFA=82.1; RI=207.8; CT=1,497.7; S=2,080.6; EGS=5.391.1							
		P	CEA	CEL	T	AP	$\alpha-$min
Health Budget 2011: 8,952.8	TC	42.4	44.1	0.0	22.1	32.9	44.1
	VFA	79.0	82.1	20.8	41.1	61.3	80.6
	RI	200.0	207.8	146.5	135.9	155,2	201.5
	CT	1441.3	1497.7	1436.4	1425.8	1409.0	1441.3
	S	2002.2	2080.6	2019.3	2008.7	1991.9	2001.6
	EGS	5187.9	5040.5	5329.8	5319.2	5302.4	5183.7
Health Budget 2012: 8,403.8	TC	39.8	44.1	00.0	22.1	31.0	44.1
	VFA	74.2	82.1	00.0	41.1	57.8	78.3
	RI	187.7	207.8	14.45	103.9	146.16	191.51
	CT	1352.9	1497.7	1304.4	1253.5	1230.9	1353.0
	S	1879.41	2080.6	1887.3	1836.4	1813.8	1877.9
	EGS	4869.8	4491.5	5197.75	5146.9	5124.3	4858.9
Health Budget 2012: 7,840.6	TC	37.2	44.1	00.0	22.1	30.4	44.1
	VFA	69.2	82.1	00.0	41.1	56.7	76.0
	RI	175.1	207.8	00.0	103.9	143.4	181.3
	CT	1262.2	1497.7	1121.4	1065.8	1044.6	1262.5
	S	1753.5	2080.6	1704.3	1648.7	1627.5	1751.0
	EGS	4345.4	3928.3	5014.8	4959.2	4938.0	4525.8
Health Budget 2012: 7,841.8	TC	37.2	44.1	00.0	22.1	30.4	44.1
	VFA	69.2	82.1	00.0	41.1	56.7	76.0
	RI	175.2	207.8	00.0	103.9	143.4	181.3
	CT	1261.4	1497.7	1121.8	1066.2	1045.0	1262.6
	S	1753.7	2080.6	1704.7	1649.1	1627.9	1751.3
	EGS	4544.1	3929.5	5015.2	4959.6	4938.4	4526.5

Table 3: Allocation of each health budget according to each considered rule between the period 2011-2014. Rows provide the allocations recommended by each of the six considered economic areas: Transfer of Capital (TC), Variation of Financial Assets (VFA), Real Investment (RI), Current Transfers (CF), Salaries (S), and current Expenditure of Goods and Services (EGS). Columns show the allocations recommended by each rule for each economic area.

5. Fairness and stability criteria

In aiming at finding the rule rule that distributes in a fairer way the health budget, we introduce some criteria of justice, that is, following Robert (1974), "the complete principle of distributive justice would say simply that a distribution is just if everyone is entitled to the holdings they possess under the distribution."

Therefore, we use the next inequality indexes (the lower the index the more equality the allocation) to measure the distributive justice of each of the considered rules: the Atkinson Index (At), the Gini coefficient (Gi), and the Generalized Entropy (Ge). Formally,
The **Atkinson Index (At)** (Atkinson, 1970) is given by,

$$At = 1 - \left(\frac{1}{N} \sum_i \left(\frac{r_i}{\mu} \right)^{1-\epsilon} \right)^{1/1-\epsilon} \quad \epsilon \neq 1,$$

where, r_i is the the ith claimant's allocation of the health budget induced by a particular rule, and μ is the average health budget. This index, through the choice of parameter ϵ (where ϵ ranges from 0 to ∞), can be interpreted as an index of potential gains from redistribution, which takes values from [0,1].

The **Gini Index (Gi)** (Gini, 1921) is the commonly known inequality index, and it is considered in the literature as the best single measure of inequality,

$$Gi = \frac{1}{2N^2\mu} \sum_i \sum_{j<i} |r_i - r_{j<i}|.$$

It takes values in the interval $[0, 1]$, where $Gi = 0$ means perfect equality, and $Gi = 1$ means complete inequality.

The **Generalized entropy (Ge)** (Theil, 1967) is given by:

$$Ge = \frac{1}{\gamma^2 - 1} [\frac{1}{N} \sum_i \left(\frac{r_i}{\mu} \right)^{\gamma} - 1].$$

The values of Ge vary between 0 and ∞, $Ge = 0$ represents an equal distribution and higher value represents a higher degree of inequality.

Table 4 shows the computation of the aforementioned inequality indexes for each studied year and for each proposed rule. Comparing these results, note that the rules that have a lower index in comparison to the baseline (that is the real way of apply the distribution in the year 2010) are P, CEA and α-min rules for each inequality index.

		P*	CEA*	CEL	T	AP	$\alpha-$min*	Baseline
Atkinson Index	2011	0.368	0.360	0.446	0.408	0.390	0.366	0.368
	2012	0.368	0.347	0.521	0.418	0.396	0.363	
	2013	0.368	0.333	0.549	0.421	0.400	0.360	
	2014	0.368	0.333	0.549	0.421	0.400	0.360	
Gini Index	2011	0.609	0.601	0.632	0.627	0.622	0.609	0.609
	2012	0.609	0.585	0.653	0.638	0.631	0.608	
	2013	0.609	0.568	0.666	0.648	0.641	0.606	
	2014	0.609	0.570	0.670	0.650	0.641	0.604	
Generalized Entropy Index	2011	0.820	0.800	1.023	0.923	0.876	0.816	0.820
	2012	0.820	0.768	1.231	0.949	0.891	0.809	
	2013	0.820	0.734	1.315	0.958	0.903	0.801	
	2014	0.820	0.734	1.315	0.957	0.903	0.801	

Table 4: Computation of inequality indexes to each rule for each year. Asterisk indicates that the particular rule represents an equal distribution.

Now, we introduce a priority criterion, because we consider that each economic area should be treated differently, depending on its weight in the historical distribution of the health budget. In doing so, we use, as a measure of stability, the coefficient of variation. Formally,

the **coeficient of variation (CV)**,

$$CV = \frac{\delta}{PI},$$

where δ is the standard deviation of set and PI is the mean of the Power Index (PI), which has been applied as a measure for selecting stable solutions for cooperative problems (Dinar and Howitt, 1997; Read et al., 2014). Specifically, $PI_i = \dfrac{W_i(r_i^{max} - r_{ik})}{\sum_j W_j(r_j^{max} - r_{jk})}$, where W_i is the long-run average health budget share of the i area and r_i^{max} is the ideal solutions for area i across all the scenarios, and r_{ik} is the actual amount received in area i. Note that the higher the value of CV, the greater the instability.

Next, Table 5 presents the CV index and each of the rules for each year. Note that the rules that have a lower index in comparison to the baseline (that is, the real-life way of applying the distribution in the year 2010) are P, CEL, T, AP and α-min rules.

		P^*	CEA	CEL^*	T^*	AP^*	$\alpha-$min*	Baseline
CV	2011	1.819	2.449	1.228	1.235	1.254	1.828	1.917
	2012	1.819	2.449	1.237	1.260	1.268	1.828	
	2013	1.528	2.449	1.325	1.351	1.224	1.546	
	2014	1.528	2.449	1.504	1.271	1.224	1.546	

Table 5: Asterisk indicates that the particular allocation rule satisfies the stability criterion.

As the intersection of Tables 4 and 5 show, there are only two rules that have lower inequality indexes and satisfy the stability criterion (with respect to the baseline): the **P** and the α**-min** rules.

Next, we apply an election method to select only one of those rules. In particular, we consider the Borda count. Formally,
The **Borda count (B*)** (Black, 1976) is given by,

$$B^* = \max_m(B_m).$$

Note that in this election method each economic area votes using the rule it prefers. Each economic area assigns 1 point to the preferred rule, and zero, otherwise. Consequently, the rule that gets more votes will be chosen. Table 6 shows our results,

	P	$\alpha-$min
Transfer current	0	1
Variation of financial assets	0	1
Real investment	0	1
Current transfer	0	1
Salaries	1	0
Current expenditures of goods and services	1	0
Total	2	4

Table 6: Borda count for the P and $\alpha-$min rules.

Finally, we can observe that the rule with more votes is the α-min. Therefore, we may conclude that the economic areas prefer the allocation of the health budget as proposed by the α-min rule for each of the analysed years.

6. Commonly accepted social constraints

In this section, we analyse the distribution of the Catalan health budget from an axiomatic point of view, that is, we look for commonly accepted

social constraints that determines the way of distributing the health budget. Note that in our context, this approach is totally suitable since there is a regulatory entity (the Health Department) that manages the assignments of the budget among the different economic areas, in accordance with some principles or constraints.

Next, Table 7 summarises the axiomatic comparative among the considered rules, and we formally introduce the proposed social constraints.

	P	CEA	CEL	T	AP	α-min
Equal treatment of equal	Yes	Yes	Yes	Yes	Yes	Yes
Anonymity	Yes	Yes	Yes	Yes	Yes	Yes
Order preservation	Yes	Yes	Yes	Yes	Yes	Yes
Resource monotonicity	Yes	Yes	Yes	Yes	Yes	Yes
Super-modularity	Yes	Yes	Yes	Yes	Yes	Yes
Order preservation under claims variations	Yes	Yes	Yes	Yes	Yes	Yes
Reasonable lower bounds on awards	No	Yes	No	Yes	No	Yes

Table 7: The considered rules and the commonly accepted social constraints.

Equal treatment of equals says that the economic areas with similar claim should be rewarded with the same health budget allocation: for each $(E, c) \in \mathcal{B}$, and each $\{i, j\} \subseteq N$, if $c_i = c_j$, then $\varphi_i(E, c) = \varphi_j(E, c)$.

Anonymity implies that the health budget received by an economic area should depend only on its claim, and not on its identity: for each $(E, c) \in \mathcal{B}$, each $\pi \in \Pi^N$, and each $i \in N$, $\varphi_{\pi(i)}(E, (c_{\pi(i)})_{i \in N}) = \varphi_i(E, c)$, where Π^N is the class of all permutations of N.

Order preservation (Aumann and Maschler, 1985) requires respecting the ordering of the economic areas: if $i's$ claim is at least as large as $j's$ claim, it should receive and lose at least as much as j does, respectively: for each $(E, c) \in \mathcal{B}$, and each $i, j \in N$, such that $c_i \geqslant c_j$, then $\varphi_i(E, c) \geqslant \varphi_j(E, c)$, and $c_i - \varphi_i(E, c) \geqslant c_j - \varphi_j(E, c)$.

Resource monotonicity (Curiel et al., 1987), Young (1987) says that if the health budget increases, then all of the economic areas should get at least what they received initially: for each $(E, c) \in \mathcal{B}$ and each $E' \in \mathbb{R}_+$ such that $C > E' > E$, then $\varphi_i(E', c) \geqslant \varphi_i(E, c)$, for each $i \in N$.

Super-modularity (Dagan et al., 1997) requires that if the health budget increases, the economic areas with the greater claim experience a larger gain

than the others: for each $(E, c) \in \mathcal{B}$, all $E' \in \mathbb{R}_+$ and each $i, j \in N$ such that $C > E' > E$ and $c_i \geqslant c_j$, then $\varphi_i(E', c) - \varphi_i(E, c) \geqslant \varphi_j(E', c) - \varphi_j(E, c)$.

Order preservation under claims variations (Thomson, 2006) establishes that if any economic area's claim decreases, those economic areas with the greater claim experience a larger gain than the others: for each $k \in N$, each pair (E, c) and $(E, c') \in \mathcal{B}$, with $c' = (c'_k, c_{-k})$ and $c'_k < c_k$ and each pair i and $j \in N \backslash k$ with $c_i \leqslant c_j$, $\varphi_i(E, c') - \varphi_i(E, c) \leqslant \varphi_j(E, c') - \varphi_j(E, c)$.[10]

Reasonable lower bounds on awards (Moreno-Ternero and Villar, 2004; Dominguez and Thomson, 2006) ensures that each economic area receives at least the minimum of (i) its claim divided by the number of areas, and (ii) the health budget divided by the number of areas: for each $(E, c) \in \mathcal{B}$ and each $i \in N$, $\varphi_i(E, c) \geqslant \frac{\min\{c_i, E\}}{n}$.

Note that, with respect to the $\alpha-$min rule, not only it is the only rule satisfying the inequality indexes and the election method, as aforementioned, but also it fulfils all of the commonly accepted social constraints that may be considered as the basic criteria for guaranteeing a fair allocation of the heath budget.

7. Final Remarks

Spain applied the political economics of austerity in order to address the crisis. Consequently, some areas were affected significantly such as the health, the education and the culture sectors, which affect the social welfare. This paper has a particular focus on the Catalan health system. Specifically, by implementing the classical conflicting claims problem model (O'Neill, 1982), we propose an alternative way of allocating the health budget, among the different economic areas.

In doing so, we consider some rules together with some fairness and stability criteria in order to evaluate the different allocations. Accordingly, by using some inequality indexes (Gini, Atkinson and Generalized Entropy) and the Coefficient of Variation, we look for the most appropriate way to distribute the available health budget. Furthermore, we analyse this problem from an axiomatic point of view, that is, we study the fulfilment of some

[10] We write (c'_k, c_{-k}) for the claims vector obtained from c by replacing c_k by c'_k.

commonly accepted social constraints by the rules. Among all of the considered rules, we find that the α-min rule is the only rule satisfying all of the aforementioned criteria (see Table 8 to compare the allocations proposed by this rule with the actual distribution of the health budget).

Finally, it is noteworthy that a possible way of extending our results is by considering a more detailed distribution of the budget among more specific agents.

		Actually	$\alpha-$min
Health Budget 2011: $8,952.8$	TC	43.0	44.1
	VFA	69.4	80.6
	RI	147.5	201.5
	CT	1353.7	1,441.3
	S	1,922.6	2,001.6
	EGS	5,416.7	5,183.7
Health Budget 2012: $8,403.8$	TC	39.6	44.1
	VFA	70.4	80.6
	RI	131.8	201.5
	CT	1,028.5	1,441.3
	S	1,861.5	2,001.6
	EGS	5,272.0	5,183.7
Health Budget 2013: $7,840.6$	TC	41.0	44.1
	VFA	41.3	80.6
	RI	132.1	201.5
	CT	1,929.,5	1,441.3
	S	1,710.2	2,001.6
	EGS	5,512.3	5,183.7
Health Budget 2014: $7,841.8$	TC	41.6	44.1
	VFA	46.8	80.6
	RI	123.4	201.5
	CT	1,912.8	1,441.3
	S	1,711.3	2,001.6
	EGS	5,534.2	5,183.7

Table 8: Comparison between the $\alpha-$min rule and the actual distribution of the health budget between the period 2011-2014.

Acknowledgements: The usual caveats apply. I am particularly grateful to Salvador Maluquer, Maria José Àlvarez, Misericòrdia Carles, Cori Vilella and José-Manuel Giménez-Gómez for their guidance. I also thank seminar participants at Universitat Rovira i Virgili and GRODE For their suggestions. Financial support from Generalitat de Catalunya (2014SGR325 and 2014SGR631) is acknowledged.

References

Arrow, K. J., 1963. Uncertainty and the welfare economics of medical care. The American economic review 53 (5), 941–973.

Atkinson, A. B., 1970. On the measurement of inequality. Journal of economic theory 2 (3), 244–263.

Aumann, R. J., Maschler, M., 1985. Game Theoretic Analysis of a bankruptcy from the Talmud. Journal of Economic Theory 36, 195–213.

Black, D., 1976. Partial justification of the borda count. Public Choice 28 (1), 1–15.

Calvo, G., 2008. La super-crisis subprime: claves para entenderla y navegarla. presentación en el taller de la Corporación Andina de Fomento sobre La crisis financiera global y su impacto en América Latina, Caracas, 1º de diciembre.

Curiel, J., Maschler, M., Tijs, S., 1987. Bankruptcy games. Zeitschrift für Operations Research 31, A143–A159.

Dagan, N., Serrano, R., Volij, O., 1997. A non-cooperative view of consistent bankruptcy rules. Games and Economic Behavior 18, 55 – 72.

Dinar, A., Howitt, R. E., 1997. Mechanisms for allocation of environmental control cost: empirical tests of acceptability and stability. Journal of Environmental Management 49 (2), 183–203.

Dominguez, D., Thomson, W., 2006. A new solution to the problem of adjudicating conflicting claims. Economic Theory 28 (2), 283–307.

Giménez-Gómez, J.-M., Peris, J. E., 2014. A proportional approach to claims problems with a guaranteed minimum. European Journal of Operational Research 232 (1), 109–116.

Giménez-Gómez, J.-M., Teixidó-Figueras, J., Vilella, C., 2016. The global carbon budget: a conflicting claims problem. Climatic Change, 1–11.

Gini, C., 1921. Measurement of inequality of incomes. The Economic Journal 31 (121), 124–126.

Hemerijck, A., 2012. Changing welfare states. OUP Oxford.

Iñarra, E., Prellezo, R., 2008. Bankruptcy of fishing resources: The northern european anglerfish fishery. Marine Resource Economics 17, 291–307.

Inarra, E., Skonhoft, A., 2008. Restoring a fish stock: a dynamic bankruptcy problem. Land Economics 84 (2), 327–339.

Kampas, A., 2015. Combining fairness and stability concerns for global commons: The case of east atlantic and mediterranean tuna. Ocean & Coastal Management 116, 414–422.

Maimoindes, M., 1135,1204. Book of Judgements, (translated by Rabbi Elihahu Touger, 2000). Moznaim Publishing Corporation, New York; Jerusalem.

Moreno-Ternero, J. D., Villar, A., 2004. The Talmud rule and the securement of agents' awards. Mathematical Social Sciences 47 (2), 245–257.

O'Neill, B., 1982. A problem of rights arbitration from the Talmud. Mathematical Social Sciences 2 (4), 345–371.

Orlowski, L. T., 2008. Stages of the 2007/2008 global financial crisis is there a wandering asset-price bubble? Economics Discussion Paper (2008-43).

Pulido, M., Sánchez-Soriano, J., Llorca, N., 2002. Game Theory Techniques for University Management. Annals of Operations Research, 129–142.

Read, L., Madani, K., Inanloo, B., 2014. Optimality versus stability in water resource allocation. Journal of environmental management 133, 343–354.

Robert, N., 1974. Anarchy, state and utopia. New York basic book.

Stuckler, D., Basu, S., Suhrcke, M., Coutts, A., McKee, M., 2011. Effects of the 2008 recession on health: a first look at european data. The Lancet 378 (9786), 124–125.

Theil, H., 1967. Economics and information theory. Tech. rep.

Thomson, W., 2006. How to divide when there is not enough; from the Talmud to game theory. Unpublished manuscript.

Young, P., 1987. On dividing an amount according to individual claims or liabilities. Mathematics of Operations Research 12, 198–414.