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US state health expenditure convergence: A revisited analysis☆

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ABSTRACT

This paper studies the evolution of US state health expenditure for a sample that covers 1966–2014. Our results provide evidence against the existence of a single pattern of behavior of personal health care expenditure across the US states. Rather, we can observe the existence of two statistically different convergence clubs. We cannot find evidence of convergence when we disaggregate health expenditure into its three main payers: Medicare, Medicaid and private health insurance expenditure, whilst we again find evidence of convergence clubs. However, the estimated clubs for Medicaid and private health insurance expenditure are statistically different that estimated for total health expenditure. Consequently, our results offer strong evidence of heterogeneity in the evolution of US health expenditure. The analysis of the forces that drive club creation shows that economic situation and some supply-side factors are important. We can also appreciate that some healthcare outcome variables are only related to private insurance health expenditure. The other health expenditures, thus, show a certain lack of efficiency which may be due to practices that have little benefit for patient health.

1. Introduction

Health care expenditure (HCE) has been rising sharply in most developed countries for at least the last three decades. This process has been facilitated by economists' efforts to identify the driving factors that can help us to understand the evolution of HCE. Since the seminal paper of Newhouse (1977) and, until the recent paper of Hartwig and Sturm (2014), who review the determinants of HCE suggested in the literature for 33 OECD countries in 1970–2010, national income or Gross Domestic Product has been considered as the most important determinant of HCE.

Given this central role of income, as it converges among territories, HCE could also be expected to converge, especially if we bear in mind that technological advancement, which is a major contributor to HCE, tends to be common among territories, as is stated in Newhouse (1992). Therefore, as countries grow over time, consumers may demand new medical services and procedures and contribute to the convergence of HCE, as Pekkurnaz (2015) points out.

However, following Villaverde et al. (2014), the interest of the researchers on investigating the issue of HCE convergence/divergence in health expenditures is relatively recent. In this regard, we should cite the works of Barros (1998), Alcalde-Unzu et al. (2009), Fallahi (2011), Panopoulou and Pantelidis (2011) and Pekkurnaz (2015) who focus on OECD countries, whilst Hitiris (1997), Nixon (2000), Hitiris and Nixon (2001), Hofmarcher et al. (2004), Kerem et al. (2008), Villaverde et al. (2014) and Lau et al. (2014) consider the European Union. The findings of these studies are mixed. Some papers, such as Hitiris and Nixon (2001) and Alcalde-Unzu et al. (2009), found convergence. By contrast, some others, such as Montanari and Nelson (2013) and Lau et al. (2014), are not so favorable to this hypothesis.

Giving the high degree of heterogeneity among countries with different health systems due to law, financing or management, this result is not unexpected, especially if we take into account the results of Clemente et al. (2004) and Costa-Font and Pons-Novell (2007). Consequently, convergence is more probable across regions within a country than across countries. We should note the existence of a growing literature related to the analysis of convergence in health expenditure, the case of the United States being particularly attractive. There are several reasons for this choice.

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First, US health spending is significantly higher than in other developed countries. The share of Gross Domestic Product (GDP hereafter) devoted to health care was around 11.9% in 1991, increasing to 16.4% in 2009. During the last fifty years, the total health expenditure as a share of GDP has more than tripled, as stated in Bose (2015). For the same dates, Canada spent 9.1% and 10.6% and, among the European countries, the United Kingdom spent 5.5% and 8.7% of its GDP on health. In sum, the United States spends twice as much per capita on health care as any other advanced nation in the world, as Rugy (2013) points out.

Second, following Wang (2009b), convergence is likely to have occurred more rapidly amongst American states than among the EU or OECD countries because American states are more homogeneous in medical technology, consumer preferences, health policies and the structure and general characteristics of the health care system.

Finally, the American health care system presents some peculiarities. Despite the high health spending, the USA does not have universal health insurance coverage. The two largest government health care programs, Medicare and Medicaid, which, in 2014, represented 23% and 17% of the total health expenditure, respectively, coexist with an extensive system of private insurance, 34% of the total health expenditure. The segmented character of this health system can introduce some kind of divergence among states. Important differences also exist with respect to public programs.

Given this heterogeneous starting point, it comes as no surprise that the results of the convergence of health expenditure in the American states are far from conclusive. Wang (2009a) makes a first analysis of convergence for per capita personal health expenditure and its nine components for 1980–2004. He finds moderate evidence of convergence with respect to total health expenditure and diverse results for its components, concluding that hospital costs are responsible for the observed convergence. Panopoulou and Pantelidis (2013), applying the methodology designed in Phillips and Sul (2007) to the same database used by Wang (2009a), conclude that there is no full convergence in health expenditure among the US states. Instead, states form two groups that converge to two different equilibria (clubs). At the same time, they find no convergence for the main components of HCEs. Even more recently, Apergis et al. (2017) studies the convergence of health expenditures in all US states for the 1966–2009. They employ the results of Freeman (2012) who builds the database for the 1966–1990 period. Furthermore, Apergis et al. (2017) use data by State of Residence instead of by the State of Providers used in preceding papers. According to these authors, their empirical analysis provides overwhelming evidence of convergence in per capita real health care expenditure. This convergence may be due to the convergence of personal disposable income among states.

We can then appreciate that there is no clear conclusion on the convergence of the US health expenditures. However, as Apergis et al. (2017) recognize, convergence should be continuously re-evaluated as new data becomes available. Against this background, the aim of this paper is to re-analyze the possible existence of convergence in US health expenditure from the perspective of the State of Residence. To that end, we use the data recently published by the Center for Medicare and Medicaid Services Health Expenditures that has extended the previous database up to 2014. This data has not been commonly employed in the previously mentioned literature, with the abovementioned exception of Apergis et al. (2017). Additionally, we disaggregate the total personal health care expenditure into its three main payers (Medicare, Medicaid and private health insurance expenditures) in order to offer a more complete analysis of the US health regional variations. We employ the methodology designed in Phillips and Sul (2007), previously used in Panopoulou and Pantelidis (2013) for a shorter sample, to test the null hypothesis of convergence. If we reject it, we can try to identify the existence of some convergence clubs and, subsequently, study the factors that may help us to understand the formation of these clubs. Further, we compare the evolution of some healthcare outcome variables across the different convergence clubs in order to analyze whether the variation in health expenditure implies a variation in health status, a question which has recently been analyzed in some very interesting papers, such as those of Finkelstein et al. (2016) and Cutler et al. (2018).

The structure of the paper is as follows. Section 2 introduces the methodology. Section 3 presents the data and the analysis of the results. Finally, Section 4 draws the most important conclusions and some policy implications.

2. Methodology

In this section, we briefly outline the methodology that we will employ to test for the presence of a convergence process in the health expenditures of the US states. We will follow the papers of Phillips and Sul (2007, 2009) where they develop a framework that allows us, first, to test the convergence hypothesis and, if this hypothesis is rejected, to estimate the convergence clubs that make up the US state health expenditure behavior. The methodology developed in Phillips and Sul (2007) is closely related to the standard sigma-convergence analysis, a concept introduced by Barro and Sala-i-Martin (1990) and Barro et al. (1991), in that it tests for the decline of the variable of interest over time in the cross-sectional dispersion. However, it clearly outperforms the classical convergence analysis, namely, the abovementioned sigma-convergence concept and the beta-convergence concept, which was first introduced by Baumol (1986). The methodology proposed in Phillips and Sul (2009) is based on a general nonlinear time-varying factor model, which admits the presence of transitional heterogeneity. If this is the case, standard unit root and cointegration statistics are no longer appropriate to test for convergence. Furthermore, this methodology can be interpreted as an asymptotic cointegration test that does not suffer from the well-known problems of standard unit root and cointegration tests. Additionally, it is flexible with respect the time properties of the variables under analysis because it does not impose any particular assumption about them, a crucial point if we take into account the results of Apergis et al. (2017). Finally, it is clearly free of the criticism received by the beta-convergence analysis in de Long (1988) and Quah (1993). As a consequence, the use of this methodology has recently become very popular in convergence analysis.[1]

Following Phillips and Sul (2007), let us consider that X_{it} represents the variable of interest (the different health expenditures we will consider in this paper) with i being the cross-section dimension (in our case, the 50 US states and, for the disaggregated data, we will add the District of Columbia) and t representing the sample covered by the data (our largest sample will cover 1966–2014). This variable can be decomposed as $X_{it} = \delta_{it}\,\mu_t$, where μ_t is a common component and δ_{it} is the idiosyncratic one. Phillips and Sul (2007) suggest testing for convergence by analyzing whether δ_{it} converges towards δ. To do so, they first define the relative transition component:

$$h_{it} = \frac{X_{it}}{N^{-1}\sum_{i=1}^{N} X_{it}} = \frac{\delta_{it}}{N^{-1}\sum_{i=1}^{N}\delta_{it}} \tag{1}$$

In the presence of convergence, h_{it} should converge towards unity, whilst its cross-sectional variation (H_{it}) should go to 0 when T moves toward infinity,

$$H_{it} = N^{-1}\sum_{i=1}^{N}(h_{it}-1)^2 \rightarrow 0, \ as \ \ T\rightarrow\infty \tag{2}$$

Further, we should estimate the following equation:

$$log\frac{H_1}{H_t} - 2log[\log(t)] = \alpha + \beta\log(t) + u_t, \quad t = [rT]+1,\ldots,T \tag{3}$$

[1] See Apergis and Payne (2017), Herrerias et al. (2017) and Tian et al. (2016) for good examples of the use of this methodology.

with r taking values in the (0.2, 0.3) interval. Equation (3) is commonly known as the log-t regression. The null hypothesis of convergence is tested by way of a standard t-statistic for testing the H_o: $\beta = 0$ null hypothesis versus the H_A: $\beta < 0$ alternative hypothesis. The null hypothesis is rejected whenever this t-statistic takes values lower than −1.65.

If we reject convergence, Phillips and Sul (2007) propose the following robust clustering algorithm for identifying clubs in a panel:

i. Order the N states according to their final values
ii. Starting from the highest-order state, add adjacent states from our ordered list and estimate model (3). Then, select the core group by maximizing the value of the convergence t-statistic, subject to the restriction that it is greater than −1.65.
iii. Continue adding one state at a time of the remaining states to the core group, and re-estimate model (3) for each formation. Use the sign criterion (t-statistic >0) to decide whether a state should join the core group.
iv. For the remaining states, repeat steps (ii)–(iii) iteratively and stop when clubs can no longer be formed. If the last group does not have a convergence pattern, conclude that its members diverge.

Phillips and Sul (2007, 2009) note that the use of a sign criterion in step (ii) may lead to an over-estimation of the number of clubs. Phillips and Sul (2007) recommend performing club merging tests after running the algorithm using equation (3).

Finally, we have followed the suggestion made in Phillips and Sul (2007) and we have extracted the trend components of the series by the Hodrick and Prescott (1997) filter. This technique is well-suited to extracting long-run trends from the data while eliminating short-run erratic behavior. We should note that this filter is quite sensitive to the selection of the smoothing parameter, as is observed in Ravn and Uhlig (2002). We have applied the standard value $\lambda = 400$ across the paper. However, the results are robust to the use of different values of this parameter, as can be seen in Table A.1. of the Appendix.

3. Data and empirical results

3.1. Data

The data have been obtained from the Center for Medicare and Medicaid Services Health Expenditures by State of Residence. This data base currently covers 1991–2014. However, we can extend this sample by taking into account the results of Freeman (2012), who provides information of health expenditure by state of residence for 1966–1990 for 50 states (the District of Columbia is not included). So, the sample for personal health care spending (PHCE hereafter) will cover the 1966–2014 for 50 states. Further, we consider it of interest to disaggregate this information and analyze the main components of the PHCE, namely Medicare, Medicaid and private health insurance expenditures (PHIE hereafter). These data are not considered in Freeman (2012) and, therefore, we cannot extend the official database. Thus, the sample will cover 1991–2014 for Medicaid and Medicare expenditures, whilst the sample for the PHIE that only covers 2001–2014. We have 51 states for this disaggregated analysis because we have information for the District of Columbia. We should note that in all the cases we will employ the state health expenditures in per capita terms, dividing the raw data by the population figures obtained from the regional database of the Bureau of Economic Analysis (BEA). Finally, we employ the aggregate US consumer price index to convert the nominal data into 2017 real values, given that this state-level index is not available during the entire period under study. An excellent descriptive analysis of these data can be found in Lassman et al. (2017).

Table 1
Testing for convergence.

Variable	$\hat{\beta}$	t-stat
Panel I. Aggregated analysis.		
PHCE (sample 1966–2014)	−1.00	−23.28
Panel II. Disaggregated analysis. Sample 1991–2014		
Personal Health Care	−1.06	−249.33
Medicare	−0.49	−15.23
Medicaid	−0.85	−67.34
Sample 2001–2014		
Private Health Insurance	−1.18	−55.96

This table reports the statistic proposed by Phillips and Sul (2007) to test for convergence. The term log-t stands for a parameter which is twice the speed of convergence of this club towards the average. t-stat is the convergence test statistic, which is asymptotically distributed as a simple one-sided *t*-test with a critical value of −1.65. See Phillips and Sul (2007) for further details.
*means the rejection of the null hypothesis of convergence.

3.2. Results[2]

3.2.1. Personal health care expenditure

Panel I of Table 1 presents the results of applying the Phillips and Sul (2007) methodology to the PHCE. As we can see, the estimated value of the β parameter is-1.00 and it is statistically lower than 0, given that its corresponding t-statistic takes the value −23.38 (<-1.65). Thus, we can reject the null hypothesis of convergence, contrary to the results presented in Apergis et al. (2017) for 1966–2009, but in line with those obtained in Panopoulou and Pantelidis (2013). The presence of multiple patterns of behavior in health expenditure is implicitly assumed in the recent papers of Finkelstein et al. (2016) and Cutler et al. (2018) where the sources of the US regional health variations are analyzed. However, we should note that convergence clubs may exist, which leads us to use the algorithm in order to detect them. Table 2 presents the estimated clubs. Figs. 1 and 2 present the geographic distribution of the convergence clubs and the average values of the PHCE for the states included in the clubs, respectively.

Fig. 1. a shows that there is a clear geographical division between the states included in these clubs, club 2 being mostly composed of southern and western states. More precisely, club 2 includes the southern states in the Pacific and Mountain US Census divisions plus 6 states that belong to the South Region (AL, AR, GA, TN, TX and VA).

Fig. 2. a reflects the evolution of the average values of the per capita PHCE for the different estimated clubs. We can observe that the average expenditure of the states in club 1 is always greater than that of club 2. The evolution of the two indexes is quite similar until the beginning of the 1990s but after that, the distance between these average values grows continually until 2014, mainly because club 1 grew at a rate of 3.0% during 1991–2000, whilst club 2 did so at a rate of 1.9%. During the 21st century the two growth rates have been quite similar, 2.6% and 2.4%, respectively, for clubs 1 and 2.

3.2.2. Disaggregated analysis: medicare, medicaid and private health insurance

We consider it interesting to analyze the evolution of the three main payers of the PHCE, namely Medicare, Medicaid and private health insurance expenditures. We should recall that the available data is clearly smaller for these cases, covering 1991–2014 for Medicare and Medicaid expenditure and 2001–2014 for the private health insurance expenditure. Consequently, the results should be interpreted with more caution, especially for this latter component.

First, we can see that the values of the statistic proposed by Phillips

[2] The results of this section have been obtained by using the codes that can be found at: http://www.utdallas.edu/∼d.sul/papers/Recent%20Working%20Papers1.htm.

Table 2
Estimated Clubs for different health care expenditures.

Variable	Club 1	Club 2	Club 3	Club 4	Divergent States
Panel I. Sample 1966–2014					
PHCE	AK CT DE FL ID IL IN IA KS KY LA ME MD MA MI MN MS MO MT NE NH NJ NY NC ND OH OK OR PA RI SC SD VT WA WV WI WY	AL AZ AR CA CO GA HI NV NM TN TX UT VA			
Panel II. Sample 1991–2014					
PHCE	AK CT DE DC FL IL IN IA KY LA ME MD MA MI MN MS MO MT NE NH NJ NY ND OH OK OR PA RI SD VT VA WA WV WI WY	AL AZ AR CA CO HI ID KS NV NM NC SC TN TX	GA UT		
Medicare	AL AK AZ CT DE FL IN KY ME MD MA MI MN MS MO NE NH NJ NM NY NC OH OR PA RI SC SD TN VT WV WI	AR CA CO DC GA HI ID IL IA KS LA MT NV ND OK TX UT VA WA WY			
Medicaid	AK AZ AR CA CT DE DC IA KY LA ME MD MA MN MS MO NM NY OH OK OR PA RI VT WV	AL CO FL HI ID IL IN MI MT NJ NC ND SC TN TX VA WA WI WY	GA KS NE NV NH SD UT		
Private Health Insurance	MA NH ND	AK NY VT WI WY CT ME NJ	CA CO DE IL IA KS KY MD MN MO NE OR PA RI SD UT WA WV	AZ FL GA HI IN LA MI MT NM OH OK SC TN TX VA	AL AR DC ID MS NV NC

The clubs reported have been obtained by applying the algorithm proposed by Phillips and Sul (2007) which aims to find groups of regions with similar convergence speeds to the average. Adjacent clubs have been joined if suggested by the statistic proposed by Phillips and Sul (2007). Details of this club merging are given in the Appendix.

and Sul (2007), which are reported in Panel II of Table 1, lead us to reject the null hypothesis of convergence for these three variables. However, as occurred for PHCE, we can observe the presence of different clubs of convergence, the estimations of these clubs being reported in Table 2. According to these results, we can reject the existence of a single pattern of behavior, as occurred with the PHCE.

These clubs are mapped in Fig. 1b–d. The analysis of these figures suggests that the estimated clubs are quite different for the three health expenditures that we have considered. To verify this point, we have employed some non-parametric statistics to test the null hypothesis of the equity of the medians. The Kruskal-Wallis and the van der Waerden statistics take the values 64.0 and 67.7 for testing the null that the distributions of the three main payers of the PHCE have the same median. Given that this statistic asymptotically goes towards a χ^2 distribution of G-1 degrees of freedom, with G being the number of variables under analysis, we can clearly reject this hypothesis. Similarly, when these estimated clubs are compared to those previously obtained for the PHCE, the Kruskal-Wallis statistic takes the values 2.0, 8.3 and 57.9, respectively for Medicare, Medicaid and personal health insurance expenditure. Similarly, the van der Waerden statistic takes the values 2.3, 9.8 and 56.6, for the three mentioned variables. Thus, we should conclude that the estimated convergence clubs for the Medicaid and the personal health insurance expenditure are different from those estimated for the PHCE and that the estimated clubs for the Medicare expenditure and for the PHCE are not statistically different.

Fig. 2b and c presents, respectively, the average values of the Medicare and the Medicaid health expenditure of the states in the estimated clubs. As we can see in Fig. 2. b, club 1 shows higher values than club 2, with the difference between them increasing over time. At the beginning of the sample, the distance between the average values of club 1 and 2 is only 91$ (2017 $US) but at the end of the sample this distance is 342$ (2017 $US), the maximum difference in the sample.

If we now consider the case of Medicaid expenditures, Fig. 2. c reports the average value of the health expenditure of the states included in clubs 1–3. The Medicaid expenditures of the members of club 1 grow at a rate of around 4.2% which is higher than the growth rate of the other clubs. Consequently, the distance between club 1 and the others increases over time. Something similar occurs with clubs 2 and 3, which show growth rates of 3.6 and 2.7, respectively. As a consequence, the final distance between the average health expenditure of these clubs multiplies the initial distance by almost 7. We can also appreciate that these average values exhibit a clear slowdown during the years prior to the Great Recession. Since then, the average values of clubs 1 and 2 continue to grow, but those of club 3 have not returned to the 901$, its maximum value in 2004.

Finally, we should analyze the results for the PHIE. We include it because it represents approximately one-third of the total PHCE, but the available sample is not very large and, therefore, the results obtained should be interpreted with some caution. First, we can observe the rejection of the null hypothesis of convergence and we find the presence

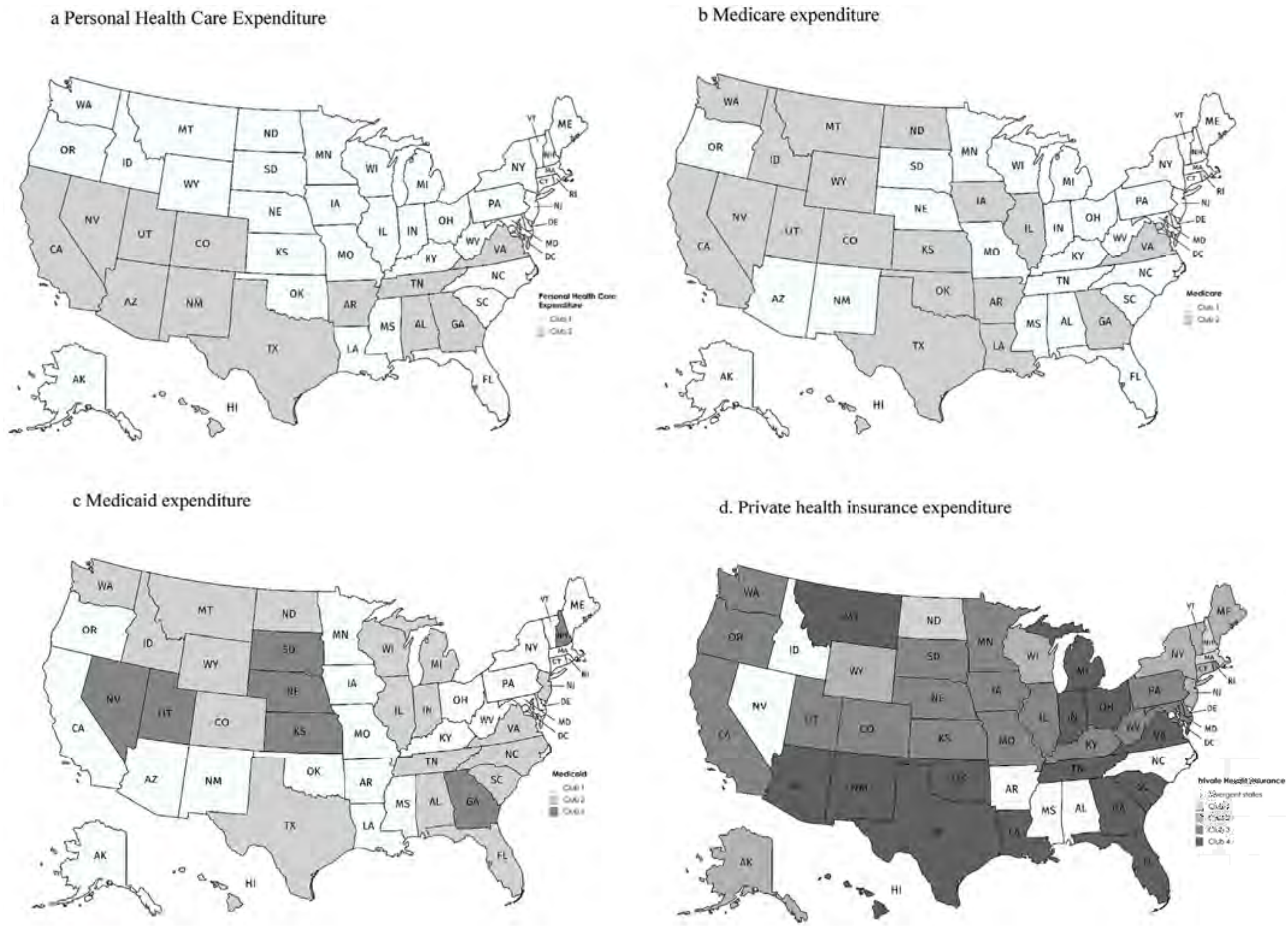

Fig. 1. Estimated clubs. Fig. 1a Personal Health Care Expenditure. Fig. 1b Medicare expenditure. Fig. 1c Medicaid expenditure. Fig. 1d. Private health insurance expenditure.

of 4 convergence clubs and, additionally, 7 divergent states, this result clearly related to the lack of information. Fig. 2d presents the geographical distribution of the states. This map is clearly different to the preceding ones. We can observe that the states included in the North East US Census Region, except PA, are included in clubs 1 and 2, the ones with the highest level of health expenditure. By contrast, club 4 contains most states located in the south of the country. Moreover, AR, MS and AL diverge, taking very low values at the end of the sample. A similar divergent trend is observed for NV, ID and NC, whilst DC diverges in the opposite direction.

If we now turn to the analysis of the average values of the estimated clubs, Fig. 2. d., we observe that the average values of clubs 1–4 are bounded between the data of two divergent states: DC and NV. The per capita personal health insurance expenditure of DC is around 6000$ (2017 $US) in 2014. The values of this state are clearly the greatest, in spite of showing a clear reduction since 2011 (around 10%). By contrast, the lowest values are those of NV, which exhibit a per capita personal health insurance expenditure of 2115$ (2017 $US) in 2014. Furthermore, the values of the rest of the divergent states are located between the values of NV and those of club 4. The average values of clubs 1 and 2 are not very different. In fact, both of them are almost identical up to 2007. They exhibit similar average growth rates (2.8 and 2.5), with those of club 1 showing a small reduction since 2011. Finally, the average values of clubs 3 and 4 are lower than those of clubs 1 and 2.

3.3. *Factors driving the club formation*

The previous results prove the existence of serious regional variations in health care expenditure in the US states. Whilst these regional variations have been analyzed recently,[3] relatively little is known about their causes. In order to contribute to this literature and to better understand the creation of the estimated clubs, Table 3 reflects the average values of the possible driving factors for each estimated club. We have included some variables in order to capture demographic differences: the percentage of Hispanic population over the total population (HISPA), the percentage of black population over the total population (BLACK), the percentage of population younger than 18 (L18), and the percentage of population older than 65 (G65). We have also taken into consideration some socioeconomic variables, such as the per capita GDP (GDPpc), the unemployment rate (UR), and the Cook Partisan Voting Index (CPVI). We have also considered some variables in order to capture the supply-side factors: the Acute Care Hospital Beds per 1000 Residents (HB), the number of physicians per 100,000 Residents (PHY), and the number of specialists per 100,000 Residents (SPEC). Finally, we have added some health care outcome variables in order to reflect the health status of the

[3] See Gottlieb et al. (2010), Skinner (2011), Finkelstein et al. (2016), Callison et al. (2018), Cutler et al. (2018) and Agha et al. (2019), in this regard. These papers assume the existence of health regional variations, although they do not prove it from a statistical point of view.

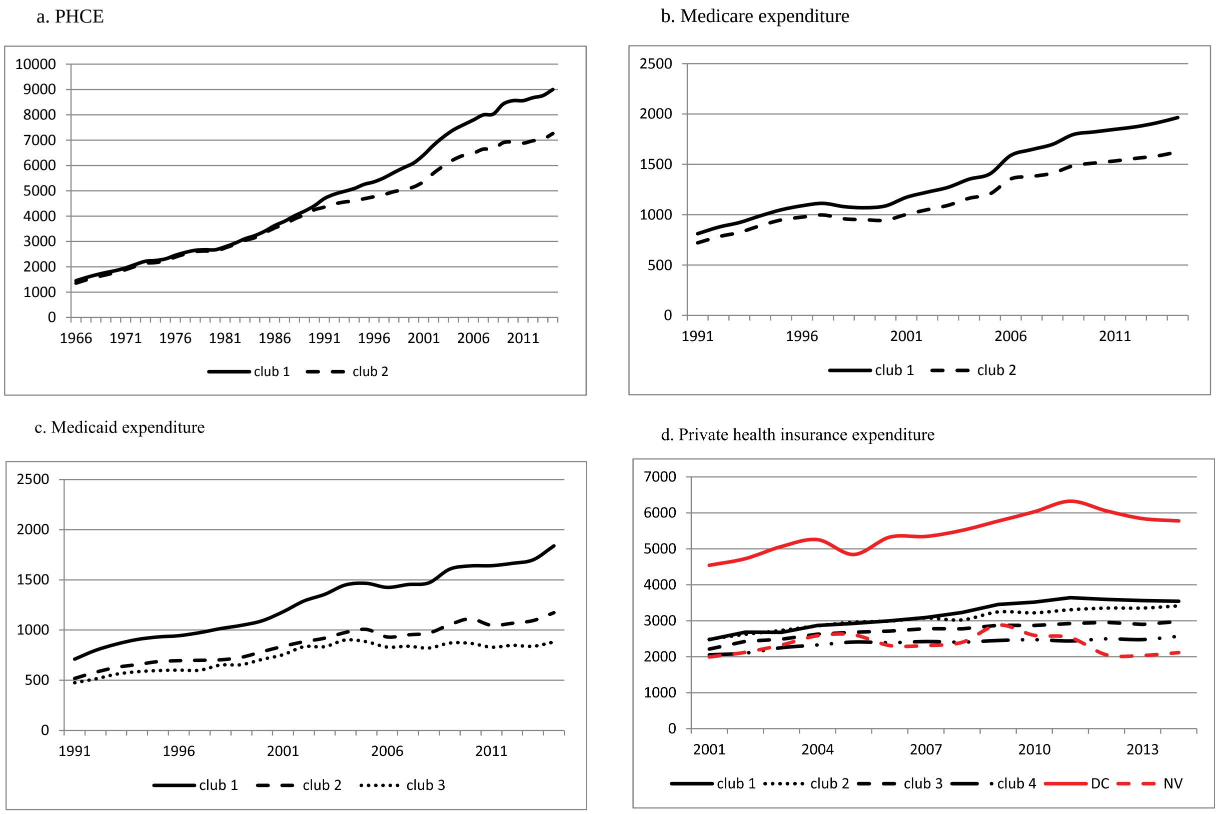

Fig. 2. Average value of the estimated clubs. Fig. 2a. PHCE. This figure presents the average values of the per capita PHCE of the states included in clubs 1 and 2 when the 1966–2014 sample is considered. Fig. 2b. Medicare expenditure. This figure presents the average values of the per capita Medicare health expenditure of the states in clubs 1 and 2 when the 1991–2014 sample is considered. Fig. 2c. Medicaid expenditure. This figure presents the average values of the per capita Medicaid health expenditure of the states in clubs 1–3, when the 1991–2014 sample is considered. Fig. 2d. Private health insurance expenditure. This figure presents the average values of the per capita private health insurance of the states included in clubs 1–4, as well as the values of the non-convergent states, when the 2001–2014 sample is considered.

US states. These variables are infant mortality rate per 100,000 inhabitants (IMR) and the life expectancy of each state (LE).

If we begin by analyzing the factors associated with the estimated clubs of PHCE, we can observe that the states included in club 1 exhibit a better economic situation than those in club 2 because the average per capita GDP is higher, whilst the average unemployment rate is slightly lower. By contrast, the states included in club 1 show lower values of young people and Hispanic population. If we take into account the supply-side factors, the average number of hospital beds does not vary much, but we find statistical differences in the number of physicians and specialists. Finally, we cannot appreciate differences in the health care outcome variables, the average values of infant mortality rates and life expectancy being almost identical in both estimated clubs.

If we now focus on the estimated clubs for Medicare expenditures, the results change slightly. The average value of the per capita GDP and the education level do not allow us to appreciate any differences between the characteristics of the two estimated clubs. By contrast, the average values of the unemployment rates are slightly different. The influence of the supply-side factors seems to be important and the number of specialists and physicians is greater in the states in club 1, although the differences are not statistically significant. Finally, we have found some differences in the average values of the CPVI and, as a consequence, Medicare expenditures are higher in states where the Republican Party received comparatively low support. The average values of the healthcare outcome variables are similar for both estimated clubs.

The results for the Medicaid expenditures are in line with those of Medicare expenditures. However, we can observe that the average values of SPEC and, to a lesser extent, of PHY are lower in the states included in the clubs with the lowest levels of expenditure. We can see that unemployment rates are clearly different, as could be expected. We also find a great dependence on the CPVI and the bigger the support for the Republican Party, the lower the Medicaid expenditures. Lastly, we should note that the average values of the infant mortality rates and those of life expectancy are statistically similar. Consequently, there is no relationship between health expenditures and improvement in health status, as occurred with PHCE and Medicare expenditures.

Finally, the results related to the estimated clubs for private health insurance expenditures are somewhat different to the previous ones. First, we observe that per capita GDP is significantly greater in the states in club 1, the one with the highest level of expenditure. Second, the average values of PHY and SPEC are also greater in the states in club 1. But, the most outstanding result is related to the values of the two variables which measure the health status of the states. We can appreciate that the infant mortality rates and the life expectancy of the states in clubs 1 and 4 are different to those of the other clubs. The states in club 1 show significantly lower infant mortality rates and greater values of life expectancy. By contrast, the states in club 4 show significantly greater infant mortality rates and lower values of life expectancy. This suggests the existence of a clear connection between health expenditure and health status, which was not found for the other health expenditures considered in this paper.

4. Conclusions and policy implications

The literature that analyzes differences in health expenditure between territories has grown recently. This kind of study is especially relevant for the US given the dimension of health care expenditure in this country, significantly higher than other countries, and the peculiarities of the US health system, in which the main public programs Medicare and

Table 3
Factors driving the clubs.

	Club	PCHE	Medicare	Medicaid	PHIE		Club	PCHE	Medicare	Medicaid	PHIE
BLACK	1	9.8	11.1	10.4	**3.3**	HB12	1	2.2	2.1	2.2	2.0
	2	11.2	8.7	10.8	6.1		2	2.0	2.2	2.1	2.0
	3			7.6	7.7		3			2.1	2.1
	4				**13.5**		4				2.2
HISPA	1	**8.2**	9.8	11.2	**5.4**	PHY	1	**206**	209	210	**230**
	2	**20.1**	13.8	11.5	9.9		2	**191**	191	**197**	**232**
	3			11.2	11.0		3			**189**	201
	4				14.1		4				193
L18	1	**24.1**	**23.8**	24.0	**22.7**	SPEC	1	127	129	130	**139**
	2	**25.6**	**25.6**	24.5	**23.4**		2	119	118	123	**144**
	3			**26.4**	24.8		3			**115**	124
	4				24.7		4				120
G65	1	14.8	14.6	14.4	14.3	IMR	1	5.9	6.0	6.0	**4.6**
	2	14.4	14.9	14.8	14.5		2	6.0	5.9	6.0	5.5
	3			15.4	14.9		3			5.6	5.6
	4				14.5		4				**6.4**
GDPpc	1	**46,959**	45,757	46,208	**56,337**	LE	1	78.7	78.6	78.5	**80.1**
	2	**42,962**	46,185	45,894	**53,521**		2	78.5	78.6	78.7	79.7
	3			45,005	46,332		3			79.1	79.0
	4				**42,384**		4				**78.0**
UR	1	5.6	6.0	6.1	**4.2**						
	2	**6.1**	5.5	**5.6**	5.7						
	3			**4.9**	5.6						
	4				6.0						
CPVI	1	3.5	1.7	0.9	1.7						
	2	3.5	6.3	4.6	−1.1						
	3			**9.3**	2.6						
	4				4.9						

This table presents the average values of the variables employed to analyze the forces driving the formation of the clubs. The bold values for the PHCE and Medicare clubs reject the null hypothesis that the differences between club averages are 0, using a 5% significance level. The bold values for the Medicaid and PHIE clubs imply that the club average is not included in a 95% confidence interval of the largest club.

Medicaid coexist with an extensive system of private insurance. Most of the previous papers consider the existence of regional variations, although they do not prove statistically its existence.

In order to provide evidence of the existence of significant regional variations, we have first studied the evolution and convergence of the US state health expenditure. We test for convergence in the health expenditures of the US states by using the methodology recently developed in Phillips and Sul (2007) for a sample that covers 1966–2014, employing per capita health data by State of Residence. Our results provide robust evidence against the null hypothesis of convergence. Rather, we can observe the existence of different convergence clubs. This conclusion is somewhat different to the one obtained in Apergis et al. (2017) where some modifications of the panel data statistics proposed by Im et al. (2003) are used in order to test for convergence for a sample that covers 1966–2009. According to these authors, there is robust evidence in favor to the convergence hypothesis. However, the use of a different methodology and the extension of the sample have allowed us to provide robust evidence against the presence of a single pattern of behavior.

If we disaggregate the PHCE, we can also reject the null of convergence for the three main payers of the US total health expenditure: Medicare, Medicaid and private health insurance expenditure. We also observe the presence of different convergence clubs in these cases.

The analysis of the causes of the creation of these estimated clubs has led us some interesting insights. We have observed that the economic situation is an important factor determining the formation of clubs. The per capita GDP is helpful to explain the differences between the estimated clubs of PHCE and private health insurance expenditures. In both cases, the higher the per capita GDP, the larger the health expenditure. The unemployment rate is a key variable to explain the formation of clubs of Medicaid expenditure, as could be expected.

The percentage of people younger than 18 is also important to explain the estimated clubs of both Medicare and Medicaid expenditure. Moreover, we find that the larger the support for the Republican party, the lower the Medicaid and, to lesser extent, the Medicare expenditures. This result suggests the possible existence of a partisan behavior. However, we consider that it might be reflecting a much more general aspect, namely, the influence of environment-level factors on health expenditures, as has been recently studied in Molitor (2018).

Similarly, supply-side factors are important to understand the formation of clubs of PHCE, Medicaid and private insurance health expenditures. The greater these expenditures, the more physicians and, to lesser extent, specialists.

Finally, we have not found significant differences between the estimated clubs of PHCE, Medicare and Medicaid expenditures with respect to the values of the variables employed to measure the health status of the states, that is, infant mortality rates and life expectancy. Therefore, we should conclude that the health status is independent of these three types of health expenditures.

This result is quite important because it casts some doubts on the efficiency of a very important part of the US health expenditures. It suggests that increasing health expenditures in programs such as Medicare and Medicaid does not result in a comparatively similar improvement of the health status. Consequently, similar levels of infant mortality rates and life expectancy could be achieved with lower health expenditure levels. This result is consistent with those of Cutler et al. (2018). According to these authors, a possible explanation for regional health expenditure differences is the existence of some beliefs of physicians which are not supported by clinical evidence. Thus, they cause an increase in expenditures, but without benefiting patients. Although more evidence in this line is necessary, these results invite policymakers to adopt policies aimed at favoring regional health expenditure convergence by controlling the health risk that arises from the use of scantly effective or, simply, unnecessary health care services.

Finally, we should note that the states with the highest private health insurance expenditures also show the lowest infant mortality rates and the largest life expectancy values. Therefore, private insurance health expenditures seem to be much more efficient, because they result in clear improvements in health status, than the other expenditures.

Appendix ASupplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.econmod.2019.02.011.

Appendix

As we have mentioned, we have employed the Hodrick and Prescott (1997) filter in order to extract the trend component of the variables. Given that this filter is quite sensitive to the selection of the smoothing parameter, it is advisable to consider different values of this parameter and analyze the robustness of the results obtained. Following Ravn and Uhlig (2002), we consider that $\lambda = \{100, 25, 6.25\}$. Table A.1 presents the results that we have obtained, together with the ones presented in the paper, which were obtained using the standard $\lambda = 400$. As we can observe, the effect of the selection of the parameter λ is quite small in this case and, consequently, we should conclude that the results are robust to its selection, at least as far as the estimation of the parameter β in model (3) is concerned. A larger variation can be observed for the t-statistic, especially if we consider the value $\lambda = 6.25$. However, we can reject the null hypothesis of convergence in all the cases, so our conclusion is robust in this regard.

Additionally, we have included the club-merging analysis for the different health expenditures in Tables A.2-A.6. Finally, Figures A.1.a–A.1.d present the transition path curves for the different estimated clubs we have obtained. The analysis of these figures lead us to similar conclusions that those drawn for Fig. 2a–d.

Table A.1
Testing for convergence for different values of the parameter λ.

λ	Estimated β	t-ratio
400	−1.004	−23.279
100	−0.979	−21.499
25	−0.968	−23.186
6.25	−0.968	−30.354

This table presents the values of the estimation of the parameter β and its corresponding t-ratio when we employ equation (3) to test the null hypothesis of convergence for the PCHE. These values are obtained under the application of the Hodrick-Prescott filter for the values of the parameter λ reflected in the first column.

Table A.2
Club Convergence of PCHE. Sample 1966–2014.

Estimated clubs	Estimated β	t-ratio
Club 1.	0.278	3.780
AK CT DE FL ID IL IN IA KS KY LA ME MD MA MI MN MS MO MT NE NH NJ NY NC ND OH OK OR PA RI SC SD VT WA WV WI WY		
Club 2.	0.648	16.822
AL AZ AR CA CO GA HI NV NM TN TX UT VA		

The estimated β and the t-ratio are obtained from the estimation of equation (3). Statistical significance at the 5% level is denoted by 'a', rejecting the null hypothesis of convergence.

Table A.3
Club Convergence of PCHE. Sample 1991–2014.

	Estimated β	t-ratio
Panel A. Estimated clubs		
Club 1.	0.162	4.543
AK CT DE DC FL IL IN IA KY LA ME MD MA MI MN MS MO MT NE NH NJ NY ND OH OK OR PA RI SD VT VA WA WV WI WY		
Club 2.	0.096	1.117
AL AZ AR CA CO HI ID KS NV NM NC SC TN TX		
Club 3.	1.457	15.145
GA UT		
Panel B. Club merging analysis		
Club 1 + 2	−1.027	−207.556[a]
Club 2 + 3	−0.596	−28.981[a]

The estimated β and the t-ratio are obtained from the estimation of equation (3). Statistical significance at the 5% level is denoted by 'a', rejecting the null hypothesis of convergence.

Table A.4
Club Convergence of medicare expenditures. Sample 1991–2014.

Estimated Clubs	Estimated β	t-ratio
Club 1.	0.099	2.649
AL AK AZ CT DE FL IN KY ME MD MA MI MN MS MO NE NH NJ NM NY NC OH OR PA RI SC SD TN VT WV WI		
Club 2.	0.056	1.078
AR CA CO DC GA HI ID IL IA KS LA MT NV ND OK TX UT VA WA WY		

The estimated β and the t-ratio are obtained from the estimation of equation (3). Statistical significance at the 5% level is denoted by 'a', rejecting the null hypothesis of convergence.

Table A.5
Club Convergence of Medicaid expenditures. Sample 1991–2014

	Estimated β	t-ratio
Panel A. Estimated Clubs		
Club 1.	−0.011	−0.321
AK AZ AR CA CT DE DC IA KY LA ME MD MA MN MS MO NM NY OH OK OR PA RI VT WV		
Club 2.	0.460	4.825
AL CO FL HI ID IL IN MI MT NJ NC ND SC TN TX VA WA WI WY		
Club 3.	0.341	2.696
GA KS NE NV NH SD UT		
Panel B. Club merging analysis		
Club 1 + 2	−0.702	−28.648[a]
Club 2 + 3	−0.454	−12.686[a]

The estimated β and the t-ratio are obtained from the estimation of equation (3). Statistical significance at the 5% level is denoted by 'a', rejecting the null hypothesis of convergence.

Table A.6
Club Convergence of private health insurance expenditures.

	Estimated β	t-ratio
Panel A. Estimated Clubs		
Club 1.	0.520	2.539
MA NH ND		
Club 2.	0.500	3.366
AK NY VT WI WY		
Club 3.	0.100	0.782
CT ME NJ		
Club 4.	0.057	0.581
CA CO DE IL IA KS KY MD MN MO NE OR PA RI SD UT WA WV		
Club 5.	0.333	2.547
AZ FL GA HI IN LA MI MT NM OH OK SC TN TX VA		
Panel B. Club merging analysis		
Club 1 + 2	−0.199	−1.906[a]
Club 2 + 3	−0.075	−0.635
Club 2 + 3+4	−0.747	−17.305[a]
Club 4 + 5	−0.743	−16.009[a]

The estimated β and the t-ratio are obtained from the estimation of equation (3). Statistical significance at the 5% level is denoted by 'a', rejecting the null hypothesis of convergence.

Data Source.

Acronym	Definition	Source
HB	Acute Care Hospital Beds per 1000 Residents in 2012.	https://www.dartmouthatlas.org/
PHY	All physicians per 100,000 Residents in 2011	https://www.dartmouthatlas.org/
SPEC	All specialist per 100,000 Residents in 2011.	https://www.dartmouthatlas.org/
GDPpc	Per capita GDP of the state in 2014	https://fred.stlouisfed.org
UR	Unemployment rate of the state in 2014	https://beta.bls.gov
CPVI	The Cook Partisan Voting Index in each states based on the 2012 and 2016 presidential election. We have randomly assigned positive values to those states supporting the Republican party.	https://www.cookpolitical.com/
L18	Percentage of population in the states younger than 18 in 2014.	https://www.kff.org/
G65	Percentage of population in the state older than 65 in 2014.	https://www.kff.org/
BLACK	The percentage of black population over the total population of the state in 2014	https://www.kff.org/
HISPA	The percentage of hispanic population over the total population of the state in 2014	https://www.kff.org/
IMR	Infant Mortality rate of each state in 2014	http://wonder.cdc.gov
LE	Life expectancy of each state in 2014	http://wonder.cdc.gov

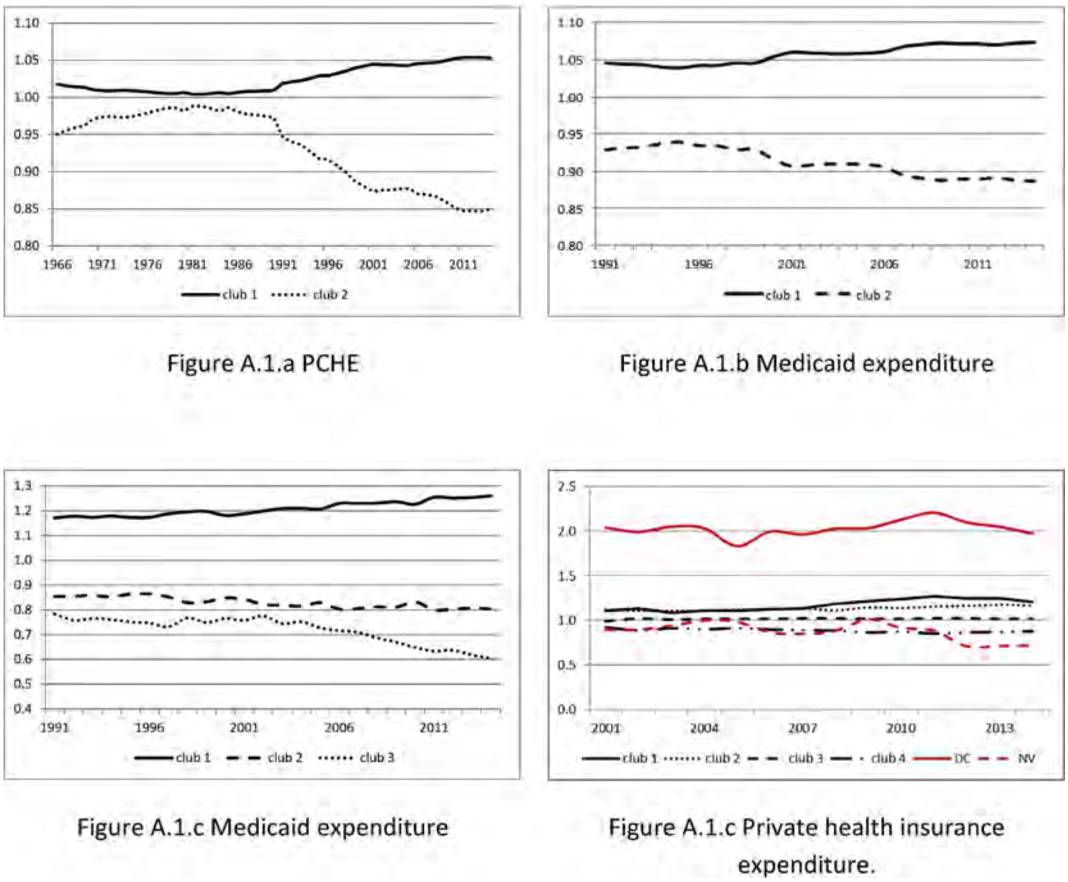

Fig. A.1. Transition paths for the estimated convergence clubs.

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