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The relationship between healthcare expenditure and disposable personal income in the US states: a fractional integration and cointegration analysis

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Abstract This study examines the relationship between healthcare expenditure and disposable income in the 50 US states over the period 1966–2009 using fractional integration and cointegration techniques. The degree of integration and nonlinearity of both series are found to vary considerably across states, while the fractional cointegration analysis suggests that a long-run relationship exists between them in only 11 out of the 50 US states. The estimated long-run income elasticity of healthcare expenditure suggests that health care is a luxury good in these states. By contrast, the short-run elasticity obtained from the regressions in first differences is in the range (0, 1) for most US states, which suggests that health care is a necessity good instead. The implications of these results for health policy are also discussed.

Keywords Healthcare expenditure · Income elasticity · US states · Fractional integration · Fractional cointegration

Mathematics Subject Classification C22 · C32 · H51 · I18

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1 Introduction

According to the OECD Health Statistics (2014), in 2012 the USA spent 16.9% of its GDP on health care, which is far higher than the OECD average of 9.3%, while on a per capita basis it spent more than double the OECD average. Furthermore, from 1960, US healthcare expenditure has grown five times faster than GDP (from 7.1% in the late sixties to 16.9% in 2012), and faster than in other OECD countries, and is projected to grow at an average rate of 5.7% until 2023, 1.1% age points faster than the expected average annual growth rate of GDP. However, its level and growth rate have not been homogeneous across the US states, as pointed out in different papers analysing regional convergence in health spending (Wang 2009; Panopoulou and Patenlidis 2012, 2013). For instance, in 2009 per capita personal healthcare spending in Massachusetts ($9,278) was almost twice than in Utah ($5,031).

The existing literature (starting with Kleiman 1974 and Newhouse 1977) has suggested that disposable income, together with other demand and supply factors such as medical technological progress or demographic trends, is one of the key drivers of healthcare demand and therefore expenditure. However, the evidence on the existence of a long-run relationship between income and healthcare expenditure, as well as the income elasticity of healthcare expenditure and the relative importance of income as one of its drivers, is mixed (see, for example, Acemoglu et al. 2013; Wang 2009; Freeman 2012; Yavuz et al. 2013, among others). Whether health expenditure is a luxury (income elasticity above 1) or a necessity (income elasticity below 1) good has important policy implications: in the latter case, there is a strong argument for public health policies and more public involvement (Freeman 2012).

The contribution of this paper is threefold. First, we examine the long-memory properties of healthcare expenditure and disposable income in 50 US states, allowing for nonlinear deterministic trends in the form of Chebyshev polynomials. We take a fractional integration approach that has advantages relative to the standard unit root tests previously used, given the low power of the latter in the case of fractional and near unit root processes (see for example, Diebold and Rudebusch 1991; Hasslers and Wolters 1994; Lee and Schmidt 1996; and more recently, Ben Nasr et al. 2014). However, it is well known that the presence of structural breaks in the data can lead to spurious evidence of long memory (see for example, Cheung and Lai 1993; Diebold and Inoue 2001; Ben Nasr et al. 2014). Given the existing evidence suggesting the presence of structural breaks in both healthcare expenditure and personal income (Freeman 2012) and the small sample size in our study (forty-four annual observations, 1966–2009), we model them including nonlinear time trends in the form of Chebyshev polynomials; this approach is particularly appropriate at the annual frequency, for which the breaks are likely to be smooth rather than sharp and sudden, and does not require specifying a maximum number of breaks when testing for unit roots. Second, we analyse the long-run relationship between income and healthcare expenditure using both parametric (Gil-Alana 2003) and semiparametric (Robinson 1995a; Marinucci and Robinson 2001) methods to test for fractional cointegration. To our knowledge, this is the first study applying such methods for estimating the relationship between these two variables in the US states. Third, we obtain estimates of the income elasticity with the aim of establishing whether health care should be considered a luxury or a necessity good in each of the US states.

The remainder of the paper is structured as follows. Section 2 reviews the relevant literature. Section 3 describes the data and the empirical analysis. Section 4 summarises the main findings and discusses their policy implications.

2 Literature review

The relationship between healthcare expenditure (HCE) and disposable income has been extensively examined given its important policy implications. Estimates of income elasticities range from close to zero and below one (Di Matteo 2003; Baltagi and Moscone 2010; Freeman 2012) to higher than one (Ang 2010; Liu et al. 2010), depending on the choice of test statistics, whether or not deterministic trends are included and/or structural breaks allowed for, the sample of countries, etc.

As for the long-run relationship between healthcare spending and income, a number of papers have used time series approaches for various OECD countries (Blomqvist and Carter 1997; Hansen and King 1998; Gerdtham and Löthgren 2000; MacDonald and Hopkins 2002; Dreger and Reimers 2005) or the US states (Wang and Rettenmaier 2007; Moscone and Tosetti 2010; Freeman 2012). However, the results reported in such studies may not be robust if the underlying data generating process (DGP) for the two series is characterised by structural changes (Freeman 2012). Therefore, some more recent papers allow for structural breaks when testing for cointegration (Jewel et al. 2003; Narayan 2006; Wang and Rettenmaier 2007, among others). On the whole, the evidence is rather mixed. For example, Freeman (2012), using data for the US states over the period 1966–2009, obtains income elasticity estimates below one, while Wang and Rettenmaier (2007) report elasticities higher than one over the period 1980–2000. We revisit these issues using the more sophisticated econometric framework outlined below.

3 Data and empirical analysis

We use annual data on healthcare expenditure (HCE) and disposable personal income (DPI) from 1966 to 2009 for 50 US states. The sources for the former are the Centers for Medicare and Medicaid Services Health Expenditures by State of Residence. They report total personal healthcare spending by state and by service, which are expressed in per capita terms. Disposable income is obtained from the US Department of Commerce, Bureau of Economic Analysis. Both HCE and DPI are deflated using the Consumer Price Index.[1]

3.1 Univariate analysis

The first step is to estimate the fractional differencing parameter d in the following setup:

[1] We would like to thank Donald G. Freeman, Sam Houston State University, for providing the dataset.

$$y_t = \beta_0 + \beta_1 t + x_t, \quad (1-L)^d x_t = u_t, \quad t = 1,2,\ldots \tag{1}$$

where y_t is the original time series; β_0 and β_1 are the unknown coefficients on the intercept and the linear time trend, respectively; we consider the three standard assumptions of no regressors [$\beta_0 = \beta_1 = 0$ a priori in (1)], an intercept (β_0 unknown and $\beta_1 = 0$ a priori) and an intercept with a linear trend (β_0 and β_1 unknown). Specifically, we use a Whittle estimator in the frequency domain as suggested in Dahlhaus (1989).

The results for real disposable personal income for each of the 50 US states are reported in Table 1. In all but one case (Alaska), a linear time trend is required. Concerning the estimates of d (and their corresponding 95% confidence bands), three groups can be identified, including, respectively:

(a) the states with an order of integration significantly below 1, which indicates mean reversion [Iowa (0.51); Nebraska (0.54), North Dakota (0.66) and South Dakota (0.64)];
(b) those with a value of d significantly above 1 [Alaska (1.27), Hawaii (1.34) and Maryland (1.29)]; and
(c) all the others (the remaining 43), where the unit root null, i.e., $d = 1$, cannot be rejected.

Table 2 displays the results for the healthcare expenditure series. A linear time trend is required in all cases and two groups can be identified, including, respectively:

(a) 20 states with $d = 1$, namely Alaska, Colorado, Delaware, Hawaii, Idaho, Iowa, Kansas, Maine, Minnesota, Montana, New Mexico, Nebraska, North Dakota, Oklahoma, Oregon, Rhode Island, South Dakota, Washington and Wyoming, and
(b) the remaining ones where the estimated value of d is significantly above 1.

Summary results for both variables are presented in Table 3. Evidence of mean reversion (implying only transitory effects of shocks) is found for Iowa, Nebraska, North Dakota and South Dakota in the case of disposable income.

However, these results could be biased owing to the presence of structural breaks. Given the small number of observations (44), splitting the sample to test for them is not feasible. We follow instead an alternative approach allowing for nonlinearities modelled in the form of Chebyshev polynomials. The model specification is the following:

$$y_t = \sum_{i=0}^{m} \theta_i P_{iT}(t) + x_t, \quad t = 1, 2, \ldots, \tag{2}$$

with m indicating the order of the Chebyshev polynomial, θ_i denoting the Chebyshev coefficients in time and x_t following an $I(d)$ process of the form as in Eq. (1).

The Chebyshev polynomials $P_{i,T}(t)$ in (2) are defined as:

$$P_{0,T}(t) = 1,$$
$$P_{i,T}(t) = \sqrt{2}\cos\left(i\pi(t-0.5)/T\right), \quad t = 1, 2, \ldots, T; i = 1, 2, \ldots \tag{3}$$

(see Hamming (1973) and Smyth (1998) for a detailed description of these polynomials). Bierens (1997) uses them in the context of unit root testing. According to

Table 1 Estimates of d for each state: real disposable personal income

State	No regressors	An intercept	A linear time trend
Alabama	0.91 (0.72, 1.18)	1.29 (0.82, 1.67)	**1.20 (0.95, 1.60)**
Alaska	0.93 (0.74, 1.19)	**1.27 (1.06, 1.57)**	1.25 (1.05, 1.57)
Arizona	0.92 (0.73, 1.19)	1.31 (0.98, 1.72)	**1.26 (0.99, 1.70)**
Arkansas	0.92 (0.73, 1.19)	1.00 (0.66, 1.43)	**1.01 (0.78, 1.36)**
California	0.91 (0.72, 1.19)	1.10 (0.84, 1.45)	**1.07 (0.81, 1.44)**
Colorado	0.90 (0.72, 1.18)	1.27 (0.96, 1.64)	**1.22 (0.93, 1.65)**
Connecticut	0.91 (0.72, 1.18)	1.01 (0.81, 1.39)	**0.99 (0.73, 1.36)**
Delaware	0.91 (0.71, 1.19)	1.16 (0.91, 1.49)	**1.15 (0.86, 1.49)**
Florida	0.92 (0.73, 1.19)	1.18 (0.70, 1.56)	**1.13 (0.89, 1.50)**
Georgia	0.91 (0.71, 1.19)	1.26 (0.92, 1.65)	**1.21 (0.92, 1.62)**
Hawaii	0.93 (0.74, 1.21)	1.39 (1.18, 1.67)	**1.34 (1.15, 1.61)**
Idaho	0.91 (0.72, 1.19)	1.07 (0.83, 1.37)	**1.05 (0.84, 1.35)**
Illinois	0.91 (0.71, 1.18)	0.90 (0.77, 1.25)	**0.82 (0.48, 1.24)**
Indiana	0.91 (0.71, 1.19)	0.89 (0.74, 1.26)	**0.83 (0.52, 1.24)**
Iowa	0.91 (0.72, 1.19)	0.69 (0.60, 0.85)	**0.51 (0.29, 0.79)**
Kansas	0.91 (0.72, 1.19)	0.96 (0.68, 1.32)	**0.97 (0.76, 1.27)**
Kentucky	0.92 (0.73, 1.21)	0.77 (0.65, 1.32)	**0.91 (0.66, 1.23)**
Louisiana	0.92 (0.73, 1.20)	1.04 (0.71, 1.44)	**1.05 (0.85, 1.42)**
Maine	0.91 (0.72, 1.19)	1.20 (0.85, 1.59)	**1.16 (0.85, 1.55)**
Maryland	0.92 (0.71, 1.19)	1.34 (1.04, 1.64)	**1.29 (1.04, 1.59)**
Massachusetts	0.91 (0.72, 1.19)	1.24 (0.96, 1.62)	**1.25 (0.95, 1.64)**
Michigan	0.90 (0.71, 1.19)	1.12 (0.82, 1.68)	**1.11 (0.67, 1.68)**
Minnesota	0.91 (0.72, 1.18)	0.84 (0.71, 1.23)	**0.79 (0.48, 1.19)**
Mississippi	0.92 (0.73, 1.19)	1.13 (0.67, 1.51)	**1.09 (0.87, 1.40)**
Missouri	0.91 (0.72, 1.19)	0.79 (0.69, 1.18)	**0.67 (0.24, 1.16)**
Montana	0.92 (0.72, 1.18)	0.93 (0.74, 1.20)	**0.92 (0.75, 1.18)**
New Hampshire	0.91 (0.71, 1.19)	1.02 (0.84, 1.36)	**1.01 (0.75, 1.34)**
New Jersey	0.91 (0.72, 1.18)	0.98 (0.78, 1.36)	**0.97 (0.69, 1.32)**
New Mexico	0.91 (0.72, 1.19)	1.08 (0.74, 1.46)	**1.05 (0.84, 1.39)**
New York	0.92 (0.72, 1.19)	1.10 (0.86, 1.46)	**1.10 (0.82, 1.48)**
Nebraska	0.91 (0.72, 1.19)	0.74 (0.65, 0.89)	**0.54 (0.29, 0.84)**
Nevada	0.90 (0.72, 1.17)	1.06 (0.76, 1.51)	**1.03 (0.71, 1.50)**
N. Carolina	0.91 (0.72, 1.19)	1.23 (0.89, 1.59)	**1.17 (0.91, 1.55)**
N. Dakota	0.92 (0.73, 1.19)	0.63 (0.47, 0.98)	**0.66 (0.41, 0.98)**
Ohio	0.91 (0.72, 1.20)	1.06 (0.77, 1.62)	**1.03 (0.65, 1.59)**
Oklahoma	0.91 (0.73, 1.18)	0.87 (0.67, 1.11)	**0.89 (0.77, 1.08)**
Oregon	0.91 (0.72, 1.19)	1.17 (0.85, 1.57)	**1.14 (0.85, 1.56)**
Pennsylvania	0.90 (0.72, 1.18)	1.03 (0.73, 1.51)	**1.03 (0.70, 1.46)**
Rhode Island	0.92 (0.72, 1.20)	1.13 (0.88, 1.61)	**1.15 (0.83, 1.66)**

Table 1 continued

State	No regressors	An intercept	A linear time trend
S. Carolina	0.92 (0.72, 1.19)	1.27 (0.82, 1.62)	**1.20 (0.95, 1.54)**
S. Dakota	0.91 (0.72, 1.19)	0.71 (0.59, 0.95)	**0.64 (0.42, 0.94)**
Tennessee	0.91 (0.72, 1.19)	1.18 (0.82, 1.63)	**1.12 (0.83, 1.60)**
Texas	0.91 (0.72, 1.19)	0.91 (0.71, 1.26)	**0.93 (0.75, 1.19)**
Utah	0.91 (0.72, 1.18)	1.29 (0.93, 1.86)	**1.28 (0.88, 1.99)**
Vermont	0.92 (0.72, 1.20)	0.89 (0.76, 1.28)	**0.87 (0.58, 1.26)**
Virginia	0.92 (0.72, 1.19)	1.35 (0.81, 1.76)	**1.26 (0.94, 1.73)**
W. Virginia	0.92 (0.72, 1.19)	1.06 (0.69, 1.45)	**1.05 (0.82, 1.38)**
Washington	0.91 (0.72, 1.19)	0.93 (0.80, 1.29)	**0.81 (0.50, 1.30)**
Wisconsin	0.92 (0.71, 1.20)	1.11 (0.81, 1.53)	**1.08 (0.79, 1.48)**
Wyoming	0.91 (0.73, 1.18)	1.15 (0.98, 1.45)	**1.15 (0.97, 1.47)**

We report in this table the estimates of d in the model given by Eq. (1) along with their 95% confidence bands for the three cases of no deterministic terms (2nd column), with an intercept (3rd column) and with a linear time trend (4th column). In bold are the significant coefficients according to the deterministic terms. In parentheses, the 95% confidence band for the estimated values of d

Bierens (1997) and Tomasevic and Stanivuk (2009), it is possible to approximate highly nonlinear trends with rather low-degree polynomials. If $m = 0$ the model contains an intercept, if $m = 1$ it also includes a linear trend, and if $m > 1$ it becomes nonlinear—the higher m is the less linear the approximated deterministic component becomes.

The results with $m = 3$ are displayed in Table 4 (for disposable income) and in Table 5 (for healthcare expenditure). For disposable income, the estimated value of d is significantly below 1 in five states, namely Iowa, Nebraska, North Dakota, South Dakota and Oklahoma, i.e., the same four as in Table 1 as well as Oklahoma. There are also six cases when d is significantly higher than 1 (in Table 1, this happens in all three cases). More importantly, there is some evidence of nonlinear behaviour in 29 out of the 50 states examined.

The corresponding results for healthcare expenditure are reported in Table 5. There are six states for which the unit root null hypothesis cannot be rejected, namely Alaska, Idaho, Minnesota, Montana, South Dakota and Wyoming. However, for the remaining ones, the estimated value of d insignificantly higher than 1. Less evidence of nonlinearity is found than for disposable income: significant nonlinear coefficients are only estimated in the cases of Alaska, Minnesota, Nebraska, Nevada, South Dakota and Wyoming. Table 6 summarises the nonlinear results for both variables.

3.2 Multivariate analysis

Next, we analyse the long-run relationship between disposable income and healthcare expenditure. Table 7 reports the orders of integration of the two series for each state and provides information on the homogeneity condition. We test for homogeneity in

Table 2 Estimates of *d* for each state: healthcare expenditure

State	No regressors	An intercept	A linear time trend
Alabama	0.94 (0.69, 1.24)	1.76 (1.43, 2.33)	**1.49 (1.27, 1.94)**
Alaska	0.91 (0.69, 1.21)	1.08 (0.89, 1.45)	**1.09 (0.87, 1.42)**
Arizona	0.96 (0.76, 1.24)	1.51 (0.69, 1.83)	**1.39 (1.19, 1.65)**
Arkansas	0.93 (0.69, 1.23)	1.48 (0.80, 1.83)	**1.25 (1.08, 1.51)**
California	0.96 (0.76, 1.24)	1.62 (1.35, 2.12)	**1.45 (1.23, 1.87)**
Colorado	0.93 (0.72, 1.22)	1.28 (0.77, 1.64)	**1.16 (0.92, 1.47)**
Connecticut	0.94 (0.71, 1.24)	1.54 (1.21, 1.95)	**1.39 (1.15, 1.75)**
Delaware	0.92 (0.70, 1.22)	1.43 (0.87, 1.85)	**1.25 (0.98, 1.58)**
Florida	0.95 (0.73, 1.25)	1.72 (1.44, 2.22)	**1.45 (1.26, 1.80)**
Georgia	0.95 (0.72, 1.25)	1.74 (1.47, 2.20)	**1.51 (1.32, 1.83)**
Hawaii	0.95 (0.74, 1.23)	0.90 (0.67, 1.76)	**1.10 (0.96, 1.51)**
Idaho	0.93 (0.70, 1.23)	1.12 (0.81, 1.61)	**1.09 (0.80, 1.49)**
Illinois	0.93 (0.72, 1.22)	1.53 (0.75, 2.01)	**1.28 (1.06, 1.62)**
Indiana	0.93 (0.69, 1.22)	1.58 (1.16, 2.14)	**1.38 (1.08, 1.82)**
Iowa	0.92 (0.69, 1.22)	1.22 (0.80, 1.76)	**1.00 (0.82, 1.50)**
Kansas	0.94 (0.72, 1.23)	1.41 (0.74, 1.86)	**1.21 (0.93, 1.63)**
Kentucky	0.92 (0.65, 1.24)	1.69 (1.32, 2.32)	**1.42 (1.18, 1.82)**
Louisiana	0.95 (0.72, 1.24)	1.63 (1.38, 2.03)	**1.39 (1.21, 1.74)**
Maine	0.93 (0.70, 1.23)	1.48 (0.88, 1.97)	**1.29 (0.99, 1.68)**
Maryland	0.95 (0.74, 1.24)	1.64 (1.37, 2.06)	**1.42 (1.20, 1.75)**
Massachusetts	0.94 (0.74, 1.23)	1.65 (1.28, 2.22)	**1.47 (1.17, 1.94)**
Michigan	0.94 (0.72, 1.22)	1.55 (1.24, 2.04)	**1.28 (1.08, 1.62)**
Minnesota	0.92 (0.59, 1.22)	1.12 (0.79, 1.56)	**1.05 (0.85, 1.34)**
Mississippi	0.93 (0.57, 1.24)	1.39 (0.79, 1.72)	**1.19 (1.01, 1.46)**
Missouri	0.95 (0.73, 1.24)	1.42 (0.69, 1.83)	**1.21 (0.98, 1.54)**
Montana	0.93 (0.71, 1.23)	0.89 (0.77, 1.61)	**1.01 (0.71, 1.41)**
New Hampshire	0.93 (0.69, 1.22)	1.44 (1.05, 1.88)	**1.35 (1.09, 1.73)**
New Jersey	0.92 (0.68, 1.22)	1.63 (1.36, 2.02)	**1.49 (1.26, 1.82)**
New Mexico	0.94 (0.71, 1.24)	0.89 (0.77, 1.63)	**1.05 (0.77, 1.44)**
New York	0.94 (0.72, 1.24)	1.79 (1.42, 2.44)	**1.56 (1.28, 1.94)**
Nebraska	0.93 (0.71, 1.22)	1.42 (0.78, 1.85)	**1.22 (0.96, 1.59)**
Nevada	0.96 (0.76, 1.24)	1.39 (1.15, 1.71)	**1.27 (1.10, 1.51)**
N. Carolina	0.93 (0.67, 1.24)	1.55 (1.24, 1.95)	**1.36 (1.14, 1.66)**
N. Dakota	0.95 (0.73, 1.25)	1.41 (1.04, 1.86)	**1.25 (0.98, 1.67)**
Ohio	0.92 (0.69, 1.23)	1.66 (1.30, 2.30)	**1.38 (1.12, 1.89)**
Oklahoma	0.95 (0.73, 1.24)	1.17 (0.72, 1.67)	**1.08 (0.79, 1.43)**
Oregon	0.95 (0.74, 1.24)	1.32 (0.84, 1.82)	**1.16 (0.87, 1.54)**
Pennsylvania	0.92 (0.69, 1.23)	1.58 (1.30, 1.98)	**1.35 (1.15, 1.66)**
Rhode Island	0.93 (0.71, 1.22)	1.35 (0.79, 1.77)	**1.19 (0.88, 1.58)**
S. Carolina	0.93 (0.66, 1.24)	1.61 (1.32, 1.94)	**1.40 (1.19, 1.72)**

Table 2 continued

State	No regressors	An intercept	A linear time trend
S. Dakota	0.92 (0.69, 1.23)	0.85 (0.78, 1.71)	**0.89 (0.62, 1.33)**
Tennessee	0.92 (0.68, 1.22)	1.45 (1.21, 1.81)	**1.26 (1.10, 1.49)**
Texas	0.95 (0.73, 1.24)	1.57 (1.27, 1.93)	**1.29 (1.10, 1.59)**
Utah	0.93 (0.70, 1.23)	1.51 (1.03, 1.97)	**1.33 (1.04, 1.76)**
Vermont	0.92 (0.70, 1.22)	1.39 (1.06, 1.81)	**1.36 (1.11, 1.74)**
Virginia	0.95 (0.72, 1.24)	1.59 (1.32, 1.80)	**1.33 (1.14, 1.64)**
W. Virginia	0.93 (0.68, 1.24)	1.56 (1.22, 2.03)	**1.33 (1.11, 1.62)**
Washington	0.94 (0.73, 1.24)	1.44 (0.75, 1.89)	**1.25 (0.91, 1.64)**
Wisconsin	0.93 (0.73, 1.23)	1.44 (1.07, 1.93)	**1.25 (1.02, 1.51)**
Wyoming	0.92 (0.69, 1.21)	1.04 (0.93, 1.28)	**1.06 (0.91, 1.32)**

We report in this table the estimates of d in the model given by Eq. (1) along with their 95% confidence bands for the three cases of no deterministic terms (2nd column), with an intercept (3rd column) and with a linear time trend (4rd column). In bold are the significant coefficients according to the deterministic terms. In parentheses, the 95% confidence band for the estimated values of d

Table 3 Grouping of the states according to the degrees of integration

d	Disposable personal income	HC expenditure
$d < 1$	Iowa, Nebraska, North Dakota, South Dakota	
$d = 1$	Alabama, Arizona Arkansas, California, Colorado, Connecticut, Delaware, Florida, Georgia, Idaho, Illinois, Indiana, Kansas, Kentucky, Louisiana, Maine, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, New Hampshire, New Jersey, New Mexico, New York, Nevada, North Caroline, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Caroline, Tennessee, Texas, Utah, Vermont, Virginia, West Virginia, Washington, Wisconsin, Wyoming	Alaska, Colorado, Delaware, Hawaii, Idaho, Iowa, Kansas, Maine, Minnesota, Missouri, Montana, New Mexico, Nebraska, North Dakota, Oklahoma, Oregon, Rhode Island, South Dakota, Washington, Wyoming
$d > 1$	Alaska, Hawaii, Maryland	Alabama, Arizona, Arkansas, California, Connecticut, Florida, Georgia, Illinois, Indiana, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Mississippi, New Hampshire, New Jersey, New York, Nevada, North Caroline, Ohio, Pennsylvania, South Caroline, Tennessee, Texas, Utah, Vermont, Virginia, West Virginia, Wisconsin

d refers to the estimates of the fractional differencing parameter in Eq. (1)

the order of integration of the variables by using an adaptation of Robinson and Yajima (2002) statistic $\hat{T}_{xy}$ to log-periodogram estimation (Robinson 1995b). The statistic is the following:

Table 4 Estimates of d based on a nonlinear model for disposable personal income

State	Income	θ_0	θ_1	θ_2	θ_3
Alabama	1.30 (1.05, 1.59)	**4.443 (26.57)**	**−0.222 (−2.09)**	−0.008 (−0.22)	−0.032 (−1.42)
Alaska	0.98 (0.60, 1.43)	**4.969 (39.22)**	−0.091 (−1.24)	−0.041 (−1.10)	**−0.094 (−3.74)**
Arizona	1.28 (0.97, 1.62)	**4.561 (23.82)**	−0.172 (−1.42)	0.007 (0.17)	**−0.047 (−1.78)**
Arkansas	1.05 (0.78, 1.40)	**4.451 (39.24)**	**−0.223 (−3.32)**	−0.011 (−0.37)	**−0.045 (−2.20)**
California	0.96 (0.62, 1.35)	**4.882 (86.48)**	**−0.150 (−4.62)**	−0.021 (−0.12)	**−0.038 (−3.29)**
Colorado	1.12 (0.84, 1.45)	**4.778 (52.32)**	**−0.226 (−4.10)**	0.001 (0.04)	**−0.043 (−2.84)**
Connecticut	1.05 (0.77, 1.38)	**4.967 (48.86)**	**−0.231 (−3.85)**	−0.014 (−0.50)	−0.015 (−0.81)
Delaware	1.13 (0.85, 1.46)	**4.801 (42.21)**	**−0.176 (−2.56)**	−0.001 (−0.06)	−0.009 (−0.48)
Florida	1.21 (0.94, 1.58)	**4.633 (28.23)**	**−0.194 (−1.91)**	−0.009 (−0.22)	−0.031 (−1.29)
Georgia	1.24 (0.93, 1.57)	**4.549 (27.95)**	**−0.228 (−2.25)**	−0.005 (−0.14)	−0.012 (−0.54)
Hawaii	1.41 (1.22, 1.60)	**4.582 (18.51)**	−0.039 (−0.24)	−0.002 (−0.05)	−0.009 (−0.33)
Idaho	1.07 (0.87, 1.34)	**4.524 (38.60)**	**−0.170 (−2.44)**	−0.016 (−0.49)	**−0.031 (−1.70)**
Illinois	0.87 (0.58, 1.22)	**4.855 (96.16)**	**−0.179 (−6.28)**	0.002 (0.15)	**−0.020 (−1.77)**
Indiana	0.83 (0.54, 1.22)	**4.690 (83.49)**	**−0.173 (−5.50)**	−0.001 (0.08)	−0.015 (−1.13)
Iowa	0.42 (0.13, 0.77)	**4.744 (226.69)**	**−0.176 (−13.36)**	0.009 (0.83)	**−0.038 (−4.10)**
Kansas	0.98 (0.72, 1.30)	**4.706 (59.23)**	**−0.190 (−4.13)**	−0.007 (−0.30)	**−0.043 (−2.76)**
Kentucky	0.99 (0.68, 1.33)	**4.503 (54.89)**	**−0.207 (−4.35)**	−0.008 (−0.34)	**−0.031 (−1.95)**
Louisiana	0.98 (0.60, 1.39)	**4.568 (67.51)**	**−0.225 (−5.75)**	−0.002 (−0.10)	**−0.058 (−4.29)**
Maine	1.23 (0.94, 1.59)	**4.583 (30.09)**	**−0.209 (−2.20)**	−0.001 (−0.03)	−0.020 (−0.93)
Maryland	1.37 (1.14, 1.61)	**4.733 (22.84)**	−0.185 (−1.39)	−0.003 (−0.08)	−0.029 (−1.11)
Massachusetts	1.28 (1.01, 1.57)	**4.812 (27.01)**	**−0.228 (−2.03)**	0.007 (0.17)	−0.011 (−0.46)
Michigan	1.02 (0.57, 1.56)	**4.775 (48.39)**	**−0.147 (−2.54)**	−0.001 (−0.04)	−0.007 (−0.40)
Minnesota	0.83 (0.50, 1.20)	**4.777 (77.52)**	**−0.222 (−6.44)**	−0.02 (−0.09)	**−0.032 (−2.13)**
Mississippi	1.19 (0.96, 1.54)	**4.291 (28.27)**	**−0.223 (−2.39)**	0.005 (0.14)	**−0.039 (−1.67)**
Missouri	0.76 (0.30, 1.21)	**4.718 (115.75)**	**−0.194 (−8.54)**	−0.004 (−0.28)	**−0.024 (−2.22)**
Montana	0.79 (0.56, 1.08)	**4.621 (84.05)**	**−0.163 (−5.33)**	0.013 (0.72)	**−0.056 (−4.03)**
New Hampshire	0.95 (0.63, 1.30)	**4.813 (61.62)**	**−0.256 (−5.71)**	−0.018 (−0.78)	−0.019 (−1.23)
New Jersey	1.07 (0.82, 1.38)	**4.904 (51.03)**	**−0.219 (−3.85)**	−0.004 (−0.18)	−0.014 (−0.86)
New Mexico	0.97 (0.66, 1.35)	**4.552 (75.44)**	**−0.194 (−5.56)**	−0.006 (−0.37)	**−0.050 (−4.11)**
New York	1.16 (0.92, 1.48)	**4.845 (37.18)**	**−0.177 (−2.22)**	0.028 (0.08)	−0.005 (−0.23)
Nebraska	0.58 (0.29, 0.90)	**4.775 (148.82)**	**−0.206 (−11.30)**	0.004 (0.29)	**−0.034 (−3.06)**
Nevada	1.05 (0.74, 1.44)	**4.795 (45.62)**	**−0.139 (−2.24)**	0.006 (0.22)	−0.025 (−1.32)
N. Carolina	1.22 (0.94, 1.61)	**4.521 (29.27)**	**−0.231 (−2.41)**	−0.011 (−0.31)	−0.01 (−0.47)
N. Dakota	0.56 (0.22, 0.95)	**4.677 (63.66)**	**−0.202 (−4.76)**	0.017 (0.53)	**−0.074 (−2.79)**
Ohio	1.05 (0.66, 1.56)	**4.723 (57.14)**	**−0.162 (−3.31)**	−0.005 (−0.23)	−0.016 (−1.08)
Oklahoma	0.39 (−0.01, 0.77)	**4.663 (390.38)**	**−0.186 (−24.10)**	**−0.01 (−1.65)**	**−0.067 (−11.77)**
Oregon	1.16 (0.88, 1.52)	**4.669 (38.73)**	**−0.172 (−2.34)**	0.006 (0.21)	**−0.027(−1.66)**
Pennsylvania	1.16 (0.86, 1.52)	**4.705 (46.07)**	**−0.184 (−2.96)**	−0.002 (−0.07)	−0.021 (−1.30)
Rhode Island	1.19 (0.88, 1.55)	**4.738 (38.36)**	**−0.193 (−2.53)**	0.005 (0.16)	−0.012 (−0.64)
S. Carolina	1.30 (1.05, 1.57)	**4.415 (25.85)**	**−0.215 (−1.98)**	−0.003 (−0.09)	−0.020 (−0.89)

Table 4 continued

State	Income	θ_0	θ_1	θ_2	θ_3
S. Dakota	0.61 (0.32, 0.94)	**4.673 (84.04)**	**−0.234 (−7.42)**	0.017 (0.76)	**−0.052 (−2.80)**
Tennessee	1.17 (0.87, 1.60)	**4.548 (33.56)**	**−0.237 (−2.86)**	0.01 (−0.31)	−0.020 (−0.94)
Texas	0.74 (0.39, 1.09)	**4.705 (140.63)**	**−0.215 (−11.58)**	−0.016 (−1.32)	**−0.052 (−5.70)**
Utah	1.13 (0.71, 1.62)	**4.576 (47.19)**	**−0.179 (−3.05)**	0.014 (0.55)	**−0.043 (−2.69)**
Vermont	0.98 (0.65, 1.32)	**4.5547 (59.88)**	**−0.231 (−5.12)**	0.009 (0.38)	**−0.024 (−1.68)**
Virginia	1.34 (1.03, 1.58)	**4.664 (27.16)**	**−0.218 (−1.99)**	−0.012 (−0.31)	**−0.035 (−1.68)**
W. Virginia	1.11 (0.85, 1.44)	**4.462 (42.76)**	**−0.185 (−2.94)**	0.004 (0.02)	**−0.035 (−1.99)**
Washington	0.73 (0.30, 1.22)	**4.853 (168.69)**	**−0.199 (−12.42)**	0.008 (0.008)	**−0.032 (−4.01)**
Wisconsin	1.07 (0.78, 1.46)	**4.698 (57.20)**	**−0.184 (−3.76)**	0.004 (0.19)	**−0.031 (−2.11)**
Wyoming	0.80 (0.53, 1.16)	**4.782 (82.06)**	**−0.200 (−6.17)**	0.023 (1.14)	**−0.096 (−6.53)**

The 2nd column refers to the estimates of d (and their associated 95% confidence intervals in the model given by Eq. (2) with $I(d)$ x_t. The values in columns 3, 4, 5 and 6 refers to the Chebyshev coefficients in Eq. (2) (t values in parenthesis). In bold are significant coefficients at the 5% level

$$\hat{T}_{xy} = \frac{m^{1/2}\left(\hat{d}_x - \hat{d}_y\right)}{\left(\frac{1}{2}\left(1 - \hat{G}_{xy}/(\hat{G}_{xx}\hat{G}_{yy})\right)\right)^{1/2} + h(n)} \tag{4}$$

where m is a bandwidth parameter, d_x and d_y are the orders of integration of each of the series, $I(\lambda_j)$ is the cross-periodogram in the bivariate representation of the series, h(n) > 0 and $\hat{G}_{xy}$ is the (xy)th element of

$$\hat{G} = \frac{1}{m}\sum_{j=1}^{m} \mathrm{Re}\left[\hat{\Lambda}(\lambda_j)^{-1} I(\lambda_j)\hat{\Lambda}(\lambda_j)^{-1*}\right],$$

$$\hat{\Lambda}(\lambda_j) = \mathrm{diag}\left\{\mathrm{e}^{i\pi\hat{d}_x/2}\lambda^{-\hat{d}_x}, \mathrm{e}^{i\pi\hat{d}_y/2}\lambda^{-\hat{d}_y}\right\},$$

with a standard normal limit distribution (see Gil-Alana and Hualde 2009, for evidence on the finite sample performance of this procedure). This is satisfied in all cases with the exception of Iowa, Nebraska and North Dakota, where the orders of integration for disposable income (0.51, 0.54 and 0.66, respectively) are much lower than for healthcare expenditure (1.00, 1.22 and 1.25, respectively). Therefore, cointegration between the two series can be ruled out in these three cases. For the remaining states, we test for cointegration using a two-step method, similar in spirit to the one proposed by Engle and Granger (1987): first, we regress healthcare expenditure on disposable income, and then, in the second step, we test the order of integration of the estimated residuals. This approach is followed, for instance, in Gil-Alana (2003). Specifically, we first run the regression:

$$\log(\mathrm{HEALTH})_t = \beta_0 + \beta_1 \log(\mathrm{INCOME})_t + x_t, \quad t = 1,2,\ldots \tag{5}$$

and then the fractional differencing parameter d is estimated for the residuals from the above equation.

Table 5 Estimates of d based on a nonlinear model for healthcare expenditure

State	Health	θ_0	θ_1	θ_2	θ_3
Alabama	1.68 (1.40, 1.74)	**1.907 (3.23)**	−0.277 (−0.70)	−0.072 (−0.65)	0.060 (−1.08)
Alaska	0.82 (0.53, 1.27)	**2.836 (42.63)**	**−0.523 (−14.04)**	−0.005 (−0.23)	**−0.098 (−5.99)**
Arizona	1.49 (1.29, 1.71)	**2.109 (5.49)**	−0.195 (−0.77)	−0.048 (−0.61)	−0.020 (−0.48)
Arkansas	1.45 (1.22, 1.73)	**2.097 (6.65)**	**−0.390 (−1.89)**	−0.048 (−0.74)	−0.025 (−0.70)
California	1.56 (1.32, 1.72)	**2.202 (5.41)**	−0.068 (−0.25)	−0.054 (−0.68)	−0.034 (−0.81)
Colorado	1.35 (1.12, 1.57)	**2.429 (11.36)**	**−0.300 (−2.19)**	−0.021 (−0.45)	−0.019 (−0.71)
Connecticut	1.54 (1.29, 1.70)	**2.276 (5.27)**	−0.236 (−0.83)	−0.026 (−0.30)	0.023 (0.50)
Delaware	1.47 (1.24, 1.71)	**2.361 (7.49)**	**−0.352 (−1.71)**	−0.014 (−0.23)	−0.009 (−0.25)
Florida	1.61 (1.38, 1.73)	**2.061 (4.43)**	−0.161 (−0.52)	−0.080 (−0.90)	0.002 (0.05)
Georgia	1.61 (1.40, 1.74)	**1.933 (3.96)**	−0.229 (−0.70)	−0.070 (−0.75)	0.002 (0.05)
Hawaii	1.38 (1.14, 1.67)	**2.287 (7.45)**	−0.277 (−1.40)	−0.039 (−0.59)	−0.010 (−0.27)
Idaho	1.24 (0.96, 1.57)	**2.164 (7.88)**	**−0.477 (−2.61)**	0.016 (0.25)	−0.020 (−0.51)
Illinois	1.51 (1.29, 1.68)	**2.305 (7.33)**	−0.262 (−1.26)	−0.029 (−0.46)	−0.018 (−0.53)
Indiana	1.56 (1.28, 1.70)	**2.144 (5.08)**	−0.282 (−1.00)	−0.024 (−0.29)	−0.011 (−0.24)
Iowa	**1.31 (1.02, 1.64)**	**2.416 (10.21)**	**−0.415 (−2.76)**	−0.005 (−0.10)	−0.028 (−0.90)
Kansas	1.45 (1.17, 1.76)	**2.266 (6.75)**	**−0.326 (−1.67)**	−0.010 (−0.15)	−0.023 (−0.60)
Kentucky	1.57 (1.31, 1.72)	**2.031 (5.47)**	−0.336 (−1.37)	−0.023 (−0.32)	0.001 (0.02)
Louisiana	1.57 (1.37, 1.70)	**2.01 (4.82)**	−0.264 (−0.95)	−0.063 (−0.77)	−0.015 (−0.34)
Maine	1.54 (1.26, 1.72)	**2.141 (5.25)**	−0.361 (−1.34)	0.025 (0.30)	−0.024 (−0.55)
Maryland	1.57 (1.40, 1.73)	**2.095 (5.05)**	−0.207 (−0.75)	−0.034 (−0.42)	−0.021 (−0.50)
Massachusetts	1.59 (1.38, 1.72)	**2.307 (5.10)**	−0.185 (−0.61)	−0.031 (−0.36)	0.0008 (−0.01)
Michigan	1.48 (1.25, 1.70)	**2.319 (8.12)**	−0.255 (−1.36)	−0.049 (−0.85)	−0.025 (−0.79)
Minnesota	1.13 (0.81, 1.47)	**2.661 (2.45)**	**−0.463 (−5.88)**	−0.031 (−0.94)	**−0.053 (−2.51)**
Mississippi	1.39 (1.16, 1.68)	**2.041 (6.09)**	**−0.492 (−2.27)**	−0.031 (−0.43)	−0.048 (−1.18)
Missouri	1.38 (1.08, 1.70)	**2.369 (8.43)**	**−0.328 (−1.81)**	−0.045 (−0.75)	−0.041 (−1.20)
Montana	1.26 (0.98, 1.57)	**2.335 (9.99)**	**−0.437 (−2.98)**	−0.003 (−0.05)	−0.035 (−1.06)
New Hampshire	1.48 (1.29, 1.71)	**2.234 (6.81)**	**−0.337 (−1.76)**	−0.012 (−0.18)	0.006 (−0.02)
New Jersey	1.56 (1.35, 1.72)	**2.231 (5.54)**	−0.318 (−1.19)	−0.035 (−0.44)	−0.012 (−0.28)
New Mexico	1.32 (1.10, 1.57)	**2.187 (8.27)**	**−0.412 (−2.45)**	−0.019 (−0.33)	−0.019 (−0.55)
New York	1.61 (1.48, 1.72)	**2.244 (5.25)**	−0.132 (−0.46)	−0.014 (−0.17)	0.023 (0.53)
Nebraska	1.42 (1.15, 1.72)	**2.359 (8.80)**	**−0.379 (−2.18)**	−0.013 (−0.23)	**−0.055 (−1.72)**
Nevada	1.29 (1.01, 1.57)	**2.381 (9.57)**	**−0.311 (−1.98)**	−0.049 (−0.87)	**−0.072 (−2.14)**
N. Carolina	1.55 (1.29, 1.71)	**1.968 (4.50)**	−0.363 (−1.25)	−0.015 (−0.17)	−0.005 (−0.11)
N. Dakota	1.38 (1.04, 1.70)	**2.393 (6.67)**	**−0.351 (−1.72)**	−0.04 (−0.51)	−0.047 (−1.07)
Ohio	1.56 (1.24, 1.70)	**2.286 (6.04)**	−0.282 (−1.12)	−0.053 (−0.71)	−0.030 (−0.76)
Oklahoma	1.36 (1.13, 1.68)	**2.211 (7.64)**	**−0.342 (−1.84)**	−0.001 (−0.16)	−0.022 (−0.61)
Oregon	1.39 (1.11, 1.71)	**2.267 (7.82)**	**−0.305 (−1.86)**	−0.005 (−0.08)	−0.040 (−1.12)
Pennsylvania	1.49 (1.26, 1.74)	**2.384 (8.00)**	**−0.347 (−1.77)**	−0.055 (−0.91)	−0.011 (−0.33)
Rhode Island	1.41 (1.18, 1.72)	**2.499 (8.82)**	**−0.358 (−1.95)**	−0.010 (−0.17)	−0.027 (−0.82)
S. Carolina	1.57 (1.34, 1.72)	**1.871 (4.16)**	−0.377 (−1.26)	−0.018 (−0.21)	−0.006 (−0.14)

Table 5 continued

State	Health	θ_0	θ_1	θ_2	θ_3
S. Dakota	1.24 (0.91, 1.57)	**2.428 (13.14)**	**−0.466 (−4.04)**	−0.010 (−0.23)	**−0.038 (−1.65)**
Tennessee	1.35 (1.09, 1.63)	**2.367 (9.41)**	**−0.466 (−4.04)**	−0.060 (−1.08)	−0.032 (−1.01)
Texas	1.52 (1.28, 1.71)	**2.087 (6.27)**	**−0.447 (−2.78)**	−0.032 (−0.49)	−0.021 (−0.58)
Utah	1.48 (1.21, 1.70)	**2.074 (6.36)**	−0.246 (−1.12)	−0.027 (−0.41)	−0.026 (−0.72)
Vermont	1.44 (1.15, 1.74)	**2.265 (6.83)**	**−0.399 (−1.85)**	0.064 (−0.93)	−0.013 (−0.34)
Virginia	1.56 (1.31, 1.75)	**2.003 (5.14)**	−0.263 (−1.02)	−0.055 (−0.72)	−0.032 (−0.80)
W. Virginia	1.59 (1.31, 1.74)	**2.009 (4.39)**	−0.301 (−0.99)	−0.032 (−0.36)	0.011 (−0.23)
Washington	1.47 (1.23, 1.71)	**2.257 (6.98)**	−0.228 (−1.08)	−0.026 (−0.39)	−0.013 (−0.36)
Wisconsin	1.47 (1.23, 1.72)	**2.292 (7.15)**	**−0.350 (−1.68)**	0.0001 (0.01)	−0.040 (−1.11)
Wyoming	0.90 (0.21, 1.28)	**2.494 (23.09)**	**−0.524 (−10.40)**	**0.064 (2.27)**	−0.009 (−0.46)

The 2nd column refers to the estimates of d (and their associated 95% confidence intervals in the model given by Eq. (2) with $I(d)$ x_t. The values in columns 3, 4, 5 and 6 refers to the Chebyshev coefficients in Eq. (2) (t values in parenthesis). In bold are significant coefficients at the 5% level

Table 6 Summary of the nonlinear results

	Disposable personal income	Healthcare expenditure
Linear	Alabama, Connecticut, Delaware, Florida, Georgia, Hawaii, Indiana, Maine, Maryland, Massachusetts, Michigan, New Hampshire, New Jersey, New York. Nevada, North Carolina, Ohio, Pennsylvania, Rhode Island, South Carolina, Tennessee	Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, Florida, Georgia, Hawaii, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Mississippi, Missouri, Montana, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, Tennessee, Utah, Vermont, Virginia, West Virginia, Washington, Wisconsin
Nonlinear	Alaska, Arizona, Arkansas, California, Colorado, Idaho, Illinois, Iowa, Kansas, Kentucky, Louisiana, Minnesota, Mississippi, Missouri, Montana, New Mexico, Nebraska, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Vermont, Virginia, West Virginia, Washington, Wisconsin, Wyoming	Alaska, Minnesota, Nebraska, Nevada, South Dakota, Wyoming

Table 8 reports the estimates of β_1 and those of d based on both parametric and semiparametric methods, in the latter case using three different bandwidth parameters, $T^{0.4}$, $T^{0.5}$ and $T^{0.4}$. The β_1 coefficients are all statistically significant, and

Table 7 Estimates of d for each state and homogeneity in the value of d

State	DPI	HCE	Homogeneity
Alabama	1.20 (0.95, 1.60)	1.49 (1.27, 1.94)	γ
Alaska	1.27 (1.06, 1.57)	1.09 (0.87, 1.42)	γ
Arizona	1.26 (0.99, 1.70)	1.39 (1.19, 1.65)	γ
Arkansas	1.01 (0.78, 1.36)	1.25 (1.08, 1.51)	γ
California	1.07 (0.81, 1.44)	1.45 (1.23, 1.87)	γ
Colorado	1.22 (0.93, 1.65)	1.16 (0.92, 1.47)	γ
Connecticut	0.99 (0.73, 1.36)	1.39 (1.15, 1.75)	γ
Delaware	1.15 (0.86, 1.49)	1.25 (0.98, 1.58)	γ
Florida	1.13 (0.89, 1.50)	1.45 (1.26, 1.80)	γ
Georgia	1.21 (0.92, 1.62)	1.51 (1.32, 1.83)	γ
Hawaii	1.34 (1.15, 1.61)	1.10 (0.96, 1.51)	γ
Idaho	1.05 (0.84, 1.35)	1.09 (0.80, 1.49)	γ
Illinois	0.82 (0.48, 1.24)	1.28 (1.06, 1.62)	γ
Indiana	0.83 (0.52, 1.24)	1.38 (1.08, 1.82)	γ
Iowa	0.51 (0.29, 0.79)	1.00 (0.82, 1.50)	NO HOMOG.
Kansas	0.97 (0.76, 1.27)	1.21 (0.93, 1.63)	γ
Kentucky	0.91 (0.66, 1.23)	1.42 (1.18, 1.82)	γ
Louisiana	1.05 (0.85, 1.42)	1.39 (1.21, 1.74)	γ
Maine	1.16 (0.85, 1.55)	1.29 (0.99, 1.68)	γ
Maryland	1.29 (1.04, 1.59)	1.42 (1.20, 1.75)	γ
Massachusetts	1.25 (0.95, 1.64)	1.47 (1.17, 1.94)	γ
Michigan	1.11 (0.67, 1.68)	1.28 (1.08, 1.62)	γ
Minnesota	0.79 (0.48, 1.19)	1.05 (0.85, 1.34)	γ
Mississippi	1.09 (0.87, 1.40)	1.19 (1.01, 1.46)	γ
Missouri	0.67 (0.24, 1.16)	1.21 (0.98, 1.54)	γ
Montana	0.92 (0.75, 1.18)	1.01 (0.71, 1.41)	γ
New Hampshire	1.01 (0.75, 1.34)	1.35 (1.09, 1.73)	γ
New Jersey	0.97 (0.69, 1.32)	1.49 (1.26, 1.82)	γ
New Mexico	1.05 (0.84, 1.39)	1.05 (0.77, 1.44)	γ
New York	1.10 (0.82, 1.48)	1.56 (1.28, 1.94)	γ
Nebraska	0.54 (0.29, 0.84)	1.22 (0.96, 1.59)	NO HOMOG.
Nevada	1.03 (0.71, 1.50)	1.27 (1.10, 1.51)	γ
N. Carolina	1.17 (0.91, 1.55)	1.36 (1.14, 1.66)	γ
N. Dakota	0.66 (0.41, 0.97)	1.25 (0.98, 1.67)	NO HOMOG.
Ohio	1.03 (0.65, 1.59)	1.38 (1.12, 1.89)	γ
Oklahoma	0.89 (0.77, 1.08)	1.08 (0.79, 1.43)	γ
Oregon	1.14 (0.85, 1.56)	1.16 (0.87, 1.54)	γ
Pennsylvania	1.03 (0.70, 1.46)	1.35 (1.15, 1.66)	γ
Rhode Island	1.15 (0.83, 1.66)	1.19 (0.88, 1.58)	γ
S. Carolina	1.20 (0.95, 1.54)	1.40 (1.19, 1.72)	γ

Table 7 continued

State	DPI	HCE	Homogeneity
S. Dakota	0.64 (0.42, 0.94)	0.89 (0.62, 1.33)	γ
Tennessee	1.12 (0.83, 1.60)	1.26 (1.10, 1.49)	γ
Texas	0.93 (0.75, 1.19)	1.29 (1.10, 1.59)	γ
Utah	1.28 (0.88, 1.99)	1.33 (1.04, 1.76)	γ
Vermont	0.87 (0.58, 1.26)	1.36 (1.11, 1.74)	γ
Virginia	1.26 (0.94, 1.73)	1.33 (1.14, 1.64)	γ
W. Virginia	1.05 (0.82, 1.38)	1.33 (1.11, 1.62)	γ
Washington	0.81 (0.50, 1.30)	1.25 (0.91, 1.64)	γ
Wisconsin	1.08 (0.79, 1.48)	1.25 (1.02, 1.51)	γ
Wyoming	1.15 (0.97, 1.47)	1.06 (0.91, 1.32)	γ

Columns 2 and 3 display the estimated values of d (and 95% confidence intervals) for each series obtained from Tables 1 and 2 above. Column 4 indicates if the homogeneity condition is satisfied or not

range between 1.699 (in the case of Colorado) and 2.985 (Ohio); as for the estimates of d, in the parametric case they are all within the $I(1)$ interval, and there are only two states with estimates significantly below 1 (Missouri, 0.63, and South Dakota, 0.62). The fact that the unit root null cannot be rejected in the majority of the states is not surprising given the wide intervals resulting from the small sample size. By contrast, the semiparametric estimates (Robinson 1995a) provide more evidence of fractional cointegration: in five states (Connecticut, Ohio, South Dakota, Vermont and Wisconsin), this hold for all three bandwidth parameters, and in a large number of states (including Delaware, Idaho, Florida, Illinois, Indiana, Kansas, Maine, Maryland, Minnesota, Missouri, New Jersey, New York, North Caroline, Oregon, South Caroline, South Dakota, Tennessee), there is at least one case of fractional cointegration.

Finally, Table 9 shows the results of the Hausman test for no cointegration of Marinucci and Robinson (2001) which compares the estimates of d_x and d_y (for healthcare expenditure and disposable income) with those obtained using the estimated residuals, all of them based on the semiparametric Whittle approach of Robinson (1995a). Marinucci and Robinson (2001) showed that

$$H_{im} = 8m\left(\hat{d}_* - \hat{d}_i\right)^2 \rightarrow_d \chi_1^2 \;\text{ as }\; \frac{1}{m} + \frac{m}{T} \rightarrow 0, \tag{6}$$

where $m <$ [T/2] is again a bandwidth parameter; $\hat{d}_i$ are the univariate estimates of d_x and d_y, $\hat{d}_*$ is an estimate obtained from the residuals of the cointegrating regression. Using this approach, we find evidence of fractional cointegration in the following cases: Connecticut, Delaware, Indiana, Maine, Maryland, New Jersey, New York, Nevada, North Caroline, Tennessee and Vermont. Cointegration does not appear to hold in the remaining states.

Table 8 Estimates of *d* for each state and homogeneity in the value of *d*

State	β_1 (*t* value)	Parametric	Semiparametric		
		d	$(T)^{0.4}$	$(T)^{0.5}$	$(T)^{0.6}$
Alabama	2.248 (57.63)	0.91 (0.68, 1.30)	0.825	0.751	0.876
Alaska	2.578 (6.71)	1.29 (1.05, 1.69)	0.987	0.997	1.234
Arizona	2.104 (28.50)	1.18 (0.87, 1.68)	0.650	0.742	0.969
Arkansas	2.316 (39.18)	0.87 (0.65, 1.23)	0.945	0.801	0.858
California	2.193 (31.63)	1.17 (0.89, 1.51)	1.054	1.290	1.314
Colorado	1.699 (36.32)	1.27 (0.94, 1.75)	1.262	0.942	1.166
Connecticut	2.115 (56.58)	0.83 (0.52, 1.34)	**0.318**	**0.500**	**0.694**
Delaware	2.942 (43.46)	0.92 (0.61, 1.27)	**0.500**	**0.394**	0.995
Florida	2.353 (41.98)	0.92 (0.66, 1.38)	**0.260**	0.714	**0.691**
Georgia	2.109 (44.59)	1.06 (0.79, 1.45)	0.939	1.043	1.130
Hawaii	2.807 (25.04)	1.08 (0.86, 1.37)	1.500	1.232	0.981
Idaho	2.734 (29.55)	0.80 (0.59, 1.10)	0.777	1.088	**0.712**
Illinois	2.431 (42.91)	0.83 (0.54, 1.19)	**0.300**	1.088	**0.712**
Indiana	2.845 (39.22)	0.65 (0.37, 1.07)	**0.237**	**0.424**	1.015
Kansas	2.378 (35.05)	0.90 (0.68, 1.20)	**0.606**	0.809	1.049
Kentucky	2.674 (41.19)	0.92 (0.72, 1.21)	1.219	1.018	0.949
Louisiana	2.275 (29.43)	1.24 (1.04, 1.65)	1.397	1.493	1.174
Maine	2.530 (53.09)	0.96 (0.67, 1.33)	**0.445**	**0.558**	0.931
Maryland	2.110 (54.09)	1.07 (0.79, 1.41)	**0.500**	**0.558**	0.931
Massachusetts	1.889 (46.55)	1.21 (0.96, 1.52)	1.054	1.242	1.392
Michigan	2.858 (26.93)	1.11 (0.73, 1.62)	0.946	0.921	0.834
Minnesota	2.150 (42.37)	0.68 (0.45, 1.04)	0.634	**0.418**	**0.545**
Mississippi	2.469 (51.60)	0.90 (0.69, 1.20)	1.100	1.165	0.849
Missouri	2.434 (48.23)	**0.63 (0.42, 0.96)**	0.853	**0.418**	**0.686**
Montana	2.790 (21.40)	0.88 (0.73, 1.09)	1.058	1.103	1.111
New Hampshire	2.115 (44.46)	0.96 (0.74, 1.25)	0.868	1.205	1.062
New Jersey	2.404 (54.05)	0.90 (0.64, 1.26)	**0.138**	**0.610**	0.881
New Mexico	2.609 (32.92)	1.09 (0.89, 1.43)	1.500	1.003	1.166
New York	2.372 (42.96)	0.90 (0.64, 1.28)	**0.316**	**0.545**	0.949
Nevada	2.582 (24.18)	1.03 (0.71, 1.54)	0.672	0.724	1.045
N. Carolina	2.311 (62.88)	1.03 (0.67, 1.53)	**−0.045**	**0.371**	0.776
Ohio	2.985 (44.27)	0.92 (0.51, 1.54)	**0.142**	**0.280**	**0.378**
Oklahoma	2.345 (34.78)	0.92 (0.77, 1.14)	1.488	1.273	1.257
Oregon	2.457 (39.17)	1.07 (0.73, 1.55)	**0.595**	0.708	0.931
Pennsylvania	2.615 (48.95)	0.95 (0.73, 1.27)	0.698	0.892	0.937
Rhode Island	2.332 (46.91)	1.07 (0.82, 1.47)	1.066	1.067	0.910
S. Carolina	2.547 (61.36)	1.03 (0.74, 1.43)	**−0.054**	0.835	0.842
S. Dakota	2.130 (24.45)	**0.62 (0.44, 0.80)**	**0.609**	**0.662**	**0.672**
Tennessee	2.118 (56.09)	0.91 (0.63, 1.42)	0.810	**0.632**	**0.702**

Table 8 continued

State	β_1 (t value)	Parametric	Semiparametric		
		d	$(T)^{0.4}$	$(T)^{0.5}$	$(T)^{0.6}$
Texas	2.090 (38.28)	0.95 (0.74, 1.36)	1.117	0.925	1.121
Utah	2.450 (28.32)	1.44 (0.99, 2.21)	0.658	0.718	1.056
Vermont	2.268 (54.46)	0.84 (0.56, 1.23)	**0.542**	**0.529**	**0.695**
Virginia	2.050 (73.63)	0.95 (0.67, 1.40)	**0.313**	0.987	0.789
W. Virginia	2.894 (36.53)	1.00 (0.79, 1.30)	1.260	0.842	0.970
Washington	2.162 (41.95)	0.94 (0.68, 1.35)	0.641	1.228	1.101
Wisconsin	2.598 (54.22)	0.88 (0.57, 1.33)	**0.552**	**0.576**	**0.640**
Wyoming	2.077 (13.35)	1.16 (0.99, 1.40)	1.462	1.500	1.361

The 2nd column displays the estimated of β_1 (and their t values) in Eq. (4) with $I(d)$ x_t. The 3rd column displays the estimates of d using the parametric approach, while the values in columns 4, 5 and 6 refers to the estimates of d with a semiparametric method. The confidence bands for the $I(1)$ hypothesis are (0.632, 1.367), (0.689, 1.310) and (0.739, 1.269), respectively, for $T^{0.4}$, $T^{0.5}$ and $T^{0.6}$

Finally, we run OLS regressions in first differences of log healthcare expenditure on log-disposable income to shed light on the short-run income elasticities. The estimation results are displayed in Table 10.[2]

In 40 states, the estimated elasticities are statistically significant and positive, ranging from 0.107 (Nebraska) to 0.752 (Georgia); in the remaining ten states (Alaska, Hawaii, Idaho, Iowa, Kansas, Oklahoma, West Virginia, Washington and Wyoming), the null of a zero slope coefficient cannot be rejected. For three states (Alabama, Georgia and South Caroline), the null of an elasticity equal to 1 cannot be rejected at the 5% level. In brief, the evidence points to an income elasticity lower than one in most US states, which implies that health is a normal (rather than a luxury) good. Table 11 reports the estimated long-run and short-run income elasticities for healthcare expenditure in each of the 50 US states, showing in which of the states health care can be considered a luxury (Alabama, Connecticut, Delaware, Georgia, Indiana, Maine, Maryland, New Jersey, New York, Nevada, North Caroline, South Caroline, Tennessee and Vermont) or a necessity good (the rest of the states). If health care is a luxury good, demand will increase more rapidly than income, and public health policies can only have a subsidiary role. However, if it is a necessity good, more redistribution of healthcare resources and greater public involvement in health care might be needed. That is, the size of the income elasticity offers key information on the optimal level of health expenditure and on the potential role of public health policies in providing health care.

[2] At this stage, it is important to point out that the short-run and the long-run elasticities displayed, respectively, in Tables 8 and 10 refer to two different models. Note that the β_1-coefficients presented in Table 8 refer to those based on the long-run relationship, while those in Table 10 refer to the slope and the intercept in the first differenced model. In the fractional cointegration context, we can build up a fractional VECM model as the one suggested in Johansen and Nielsen (2010, 2012), but under some strong assumptions, that are not incorporated in the present work. This is a possible direction in which our work could be extended in the future.

Table 9 Estimates of d and tests of no cointegration against fractional cointegration

States	d_x (HCE)	d_y (DPI)	d (Resid.)	H_{ox}	H_{oy}
Alabama	1.207	0.866	0.751	10.520	0.669
Alaska	1.161	1.090	0.997	1.360	0.437
Arizona	1.432	0.813	0.742	24.088	0.255
Arkansas	1.361	0.850	0.801	15.867	0.121
California	1.500	1.069	1.190	4.862	0.740
Colorado	1.097	1.102	0.942	1.215	0.182
Connecticut	**1.400**	**0.898**	**0.500**	**40.983**	**8.014**
Delaware	**1.065**	**1.286**	**0.394**	**22.780**	**40.257**
Florida	1.427	0.857	0.714	25.721	1.034
Georgia	1.500	1.096	1.043	10.576	1.034
Hawaii	1.298	1.500	1.232	2.231	0.142
Idaho	1.070	1.500	1.088	0.016	8.586
Illinois	1.161	0.887	0.819	xxx	xxx
Indiana	**1.015**	**0.649**	**0.424**	**17.672**	**5.344**
Kansas	0.917	0.823	0.809	0.590	0.099
Kentucky	1.194	0.905	1.018	1.567	0.646
Louisiana	1.415	1.286	1.193	2.493	0.437
Maine	**0.862**	**0.935**	**0.558**	**4.675**	**7.191**
Maryland	**1.500**	**1.061**	**0.558**	**44.897**	**12.801**
Massachusetts	1.448	1.168	1.242	8.340	0.803
Michigan	1.340	0.995	0.921	8.882	0.277
Minnesota	1.279	0.680	0.418	37.508	3.473
Mississippi	1.205	1.241	1.165	0.080	0.292
Missouri	1.153	0.670	0.418	27.333	3.213
Montana	1.037	1.111	1.103	0.220	0.032
New Hampshire	1.314	1.344	1.205	0.601	0.977
New Jersey	**1.477**	**0.917**	**0.610**	**38.032**	**4.768**
New Mexico	0.855	0.864	0.803	0.136	0.188
New York	**1.450**	**0.980**	**0.545**	**41.439**	**9.574**
Nevada	**1.411**	**1.036**	**0.724**	**54.725**	**22.375**
N. Carolina	**1.371**	**1.048**	**0.371**	**50.596**	**23.189**
Ohio	1.189	0.500	0.280	41.806	2.448
Oklahoma	1.331	1.318	1.273	0.170	0.102
Oregon	1.183	0.908	0.708	11.415	2.023
Pennsylvania	1.374	0.942	0.892	11.745	0.126
Rhode Island	1.017	1.069	1.067	0.126	0.020
S. Carolina	1.175	1.069	0.835	5.848	2.770
S. Dakota	0.645	0.801	0.662	xxx	xxx
Tennessee	**1.346**	**0.933**	**0.632**	**25.793**	**4.584**
Texas	1.347	0.975	0.925	9.010	0.126

Table 9 continued

States	d_x (HCE)	d_y (DPI)	d (Resid.)	H_{ox}	H_{oy}
Utah	0.954	0.984	0.718	2.818	3.580
Vermont	**1.271**	**0.890**	**0.529**	**27.856**	**6.593**
Virginia	1.247	1.267	0.987	3.420	3.966
W. Virginia	1.180	0.848	0.842	5.780	0.001
Washington	1.003	0.804	0.808	1.923	0.001
Wisconsin	1.500	0.711	0.576	43.198	0.922
Wyoming	1.290	1.306	1.100	1.826	2.147

The values in the 2nd and 3rd columns refer to the estimated values of d for the two individual series; the following column refers to the estimate of d for the residuals; finally, the last two columns refers to the test statistics for Hx and Hy, respectively, using the Hausman test of Marinucci and Robinson (2001). $\chi_1^2(5\%) = 3.84$. In bold are those cases where we reject the null hypothesis of no cointegration at the 5% level

Table 10 Regression based on first differences

State	Intercept	Slope
Alabama	0.029 (5.57)	**0.713 (3.80)**[a]
Alaska	0.042 (7.63)	0.018 (0.14)
Arizona	0.028 (5.94)	**0.415 (2.61)**
Arkansas	0.038 (9.00)	**0.284 (2.24)**
California	0.025 (5.96)	**0.516 (2.74)**
Colorado	0.029 (7.35)	0.122 (0.79)
Connecticut	0.030 (6.74)	**0.509 (3.39)**
Delaware	0.036 (10.83)	**0.413 (3.08)**
Florida	0.033 (7.67)	**0.444 (3.14)**
Georgia	0.026 (5.81)	**0.752 (4.72)**[a]
Hawaii	0.034 (7.08)	0.162 (0.89)
Idaho	0.036 (5.98)	0.218 (1.08)
Illinois	0.031 (10.71)	**0.278 (2.70)**
Indiana	0.035 (9.27)	**0.351 (2.72)**
Iowa	0.036 (9.44)	0.138 (1.49)
Kansas	0.034 (7.80)	0.245 (1.60)
Kentucky	0.037 (9.77)	**0.358 (2.72)**
Louisiana	0.035 (7.03)	**0.419 (2.39)**
Maine	0.038 (9.04)	**0.428 (2.78)**
Maryland	0.030 (6.80)	**0.579 (3.67)**
Massachusetts	0.029 (6.90)	**0.550 (3.75)**
Michigan	0.033 (11.65)	**0.282 (2.74)**
Minnesota	0.034 (8.69)	**0.220 (1.87)**
Mississippi	0.037 (7.10)	**0.596 (3.62)**
Missouri	0.032 (8.19)	**0.414 (2.90)**
Montana	0.035 (8.11)	**0.308 (2.31)**

Table 10 continued

State	Intercept	Slope
Nebraska	0.036 (10.56)	**0.206 (2.31)**
New Hampshire	0.036 (9.18)	**0.356 (2.87)**
New Jersey	0.032 (7.09)	**0.492 (2.90)**
New Mexico	0.035 (7.11)	**0.449 (2.32)**
New York	0.031 (8.30)	**0.365 (2.56)**
Nevada	0.028 (6.21)	**0.534 (3.27)**
N. Carolina	0.031 (7.64)	**0.687 (4.87)**
N. Dakota	0.038 (8.00)	**0.107 (1.91)**
Ohio	0.035 (9.34)	**0.342 (2.12)**
Oklahoma	0.036 (8.04)	0.123 (0.83)
Oregon	0.031 (7.93)	**0.440 (2.81)**
Pennsylvania	0.033 (8.33)	**0.462 (2.69)**
Rhode Island	0.030 (7.90)	**0.571 (3.72)**
S. Carolina	0.034 (7.15)	**0.665 (3.80)**[a]
S. Dakota	0.039 (11.40)	**0.122 (2.05)**
Tennessee	0.029 (6.73)	**0.600 (4.06)**
Texas	0.033 (8.38)	**0.247 (1.74)**
Utah	0.033 (7.86)	**0.259 (1.79)**
Vermont	0.033 (6.87)	**0.391 (2.30)**
Virginia	0.029 (6.68)	**0.648 (4.08)**
W. Virginia	0.040 (8.91)	0.278 (1.61)
Washington	0.032 (7.78)	0.212 (1.23)
Wisconsin	0.031 (8.36)	**0.570 (3.58)**
Wyoming	0.039 (6.69)	−0.075 (−0.50)

The 2nd column refers to the intercept and the third to the slope for the OLS regression based on first differences of long healthcare expenditures on log-disposable income. t values in parenthesis

[a] We cannot reject the null of a slope coefficient equal to 1 at the 5% level

4 Conclusions

This paper examines the relationship between healthcare expenditure and disposable income in the US states over the period 1966–2009 using fractional integration and cointegration techniques. First, we estimate the fractional order of integration for each of the two series in each of the US states and find that it is equal or higher than 1 for healthcare expenditure in all states and for disposable income in most of them (except Iowa, Nebraska, North Dakota and South Dakota), which suggests that these two variables are non-stationary. These findings are confirmed when nonlinearities are introduced into the model.

Second, we test for fractional cointegration between healthcare expenditure and disposable income using various methods. The results change depending on whether a parametric or a semiparametric approach is followed. Specifically, the null of no cointegration cannot be rejected in the former case except for Missouri and South Dakota, while there is stronger evidence of cointegration in the latter case: when using the Hausman test for no cointegration of Marinucci and Robinson (2001), fractional

Table 11 Long-run and short-run elasticities

State	Long-run	Short-run	Luxury/ necessity
Alabama		**0.713 (3.80)**[a]	Luxury
Alaska		0.018 (0.14)	
Arizona		**0.415 (2.61)**	Necessity
Arkansas		**0.284 (2.24)**	Necessity
California		**0.516 (2.74)**	Necessity
Colorado		0.122 (0.79)	
Connecticut	2.115 (56.58)	**0.509 (3.39)**	Luxury
Delaware	2.942 (43.46)	**0.413 (3.08)**	Luxury
Florida		**0.444 (3.14)**	Necessity
Georgia		**0.752 (4.72)**[a]	Luxury
Hawaii		0.162 (0.89)	Necessity
IDAHO		0.218 (1.08)	Necessity
Illinois		**0.278 (2.70)**	Necessity
Indiana	2.845 (39.22)	**0.351 (2.72)**	Luxury
Iowa		0.138 (1.49)	
Kansas		0.245 (1.60)	
Kentucky		**0.358 (2.72)**	Necessity
Louisiana		**0.419 (2.39)**	Necessity
Maine	2.110 (54.09)	**0.428 (2.78)**	Luxury
Maryland	1.889 (46.55)	**0.579 (3.67)**	Luxury
Massachusetts		**0.550 (3.75)**	Necessity
Michigan		**0.282 (2.74)**	Necessity
Minnesota		**0.220 (1.87)**	Necessity
Mississippi		**0.596 (3.62)**	Necessity
Missouri		**0.414 (2.90)**	Necessity
Montana		**0.308 (2.31)**	Necessity
Nebraska		**0.206 (2.31)**	Necessity
New Hampshire		**0.356 (2.87)**	Necessity
New Jersey	2.372 (42.96)	**0.492 (2.90)**	Luxury
New Mexico		**0.449 (2.32)**	Necessity
New York	2.311 (62.88)	**0.365 (2.56)**	Luxury
Nevada	2.985 (44.27)	**0.534 (3.27)**	Luxury
N. Carolina	2.345 (34.78)	**0.687 (4.87)**	Luxury
N. Dakota		**0.107 (1.91)**	Necessity
Ohio		**0.342 (2.12)**	Necessity
Oklahoma		0.123 (0.83)	Necessity
Oregon		**0.440 (2.81)**	Necessity

Table 11 continued

State	Long-run	Short-run	Luxury/ necessity
Pennsylvania		**0.462 (2.69)**	Necessity
Rhode Island		**0.571 (3.72)**	Necessity
S. Carolina		**0.665 (3.80)**[a]	Luxury
S. Dakota		**0.122 (2.05)**	Necessity
Tennessee	2.268 (54.46)	**0.600 (4.06)**	Luxury
Texas		**0.247 (1.74)**	Necessity
Utah		**0.259 (1.79)**	Necessity
Vermont	2.162 (41.95)	**0.391 (2.30)**	Luxury
Virginia		**0.648 (4.08)**	Necessity
W. Virginia		0.278 (1.61)	
Washington		0.212 (1.23)	
Wisconsin		**0.570 (3.58)**	Necessity
Wyoming		−0.075 (−0.50)	

Column 2 shows the long-run income elasticities for those states in which a cointegration relationship exists, and column 3 shows the short-run income elasticities, based on the regression in first differences. t values in parenthesis

[a] We cannot reject the null of a slope coefficient equal to 1 at the 5% level. The last column shows whether health is a luxury or a necessity good in each of the US states on the basis of the estimated long-run and short-run income elasticities

cointegration is found in 11 US states (Connecticut, Delaware, Indiana, Maine, Maryland, New Jersey, New York, Nevada, North Caroline, Tennessee and Vermont).

Finally, in the US states for which cointegration holds, the income elasticity is in all cases above 1, which suggests that health care is a luxury rather than a necessity good. Elsewhere, the lack of cointegration implies that factors other than disposable income drive healthcare expenditure, and therefore, health care is instead a necessity good. As for the short-run elasticities from the regressions in first differences, in most cases they are estimated to lie in the interval (0, 1), being significantly positive in 40 states, while in only three states (Alabama, Georgia and South Caroline) the null hypothesis of an income elasticity equal to one cannot be rejected. The implication is that in most US states health care is a necessary good, which requires more redistribution of resources and more active health policies.

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