THE RELATIONSHIP BETWEEN HEALTHCARE EXPENDITURE AND DISPOSABLE PERSONAL INCOME IN THE US STATES: A FRACTIONAL INTEGRATION AND COINTEGRATION ANALYSIS

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May 2015

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 non-linearity of both series are found to vary considerably across states, whilst 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.

JEL classification: C22, C32, H51, I18

Keywords: Healthcare expenditure; income elasticity; US states; fractional integration; fractional cointegration

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Luis Gil-Alana gratefully acknowledges financial support from gratefully acknowledges financial support from the Ministerio de Economía y Competitividad (ECO2014-55236). Juncal Cuñado gratefully acknowledges financial support from gratefully acknowledges financial support from the Ministerio de Economía y Competitividad (ECO2014-55496).

1. Introduction

According to the *OECD Health Statistics* (2014), in 2012the US spent 16.9 percent of its GDP on healthcare, 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 percent in 2012), and faster than in other OECD countries, and is projected to grow at an average rate of 5.7 percent until 2023, 1.1 percentage 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 Pantelidis, 2012, 2013). For instance, in 2009per 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 non-linear 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; Hassler 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 non-linear 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, 1995; 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;Tosetti and Moscone, 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 change (Freeman, 2012). Therefore, some more recent papers allow for structural breaks when testing for cointegration (Jewell 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 source for the former are the Centers for Medicare and Medicaid Services Health Expenditures by State of Residence. They report total personal health care spending by state and by service, and 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 set-up:

$$y_t = \beta_0 + \beta_1 t + x_t, \qquad (1 - L)^d x_t = u_t, \qquad t = 1, 2, .. \qquad (1)$$

under 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:

(Insert Table 1 around here)

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

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.

(Insert Table 2 around here)

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.

(Insert Table 3 around here)

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 non-linearities modelled in the form of Chebyshev polynomials. The model specification is the following:

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

with m indicating the order of the Chebyshev polynomial, and x_t following an I(d) process of the form as in equation (1).

The Chebyshev polynomials $P_{i,T}(t)$ in (1) are defined as:

$$P_{0,T}(t) \;=\; 1,$$

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

(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 Bierens (1997) and Tomasevic and Stanivuk (2009), it is possible to approximate highly non-linear 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 non-linear - 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 non-linear behaviour in 29 out of the 50 states examined.

(Insert Table 4 around here)

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 is significantly higher than 1. Less evidence of non-linearity is found than for disposable income: significant non-linear coefficients are only estimated in the cases of Alaska, Minnesota, Nebraska, Nevada, South Dakota and Wyoming. Table 6summarises the non-linear results for both variables.

(Insert Table 5 around here)

(Insert Table 6 around here)

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. 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:

$$log(HEALTH)_t \;=\; \beta_0 \;+\; \beta_1 \, log(INCOME)_t \;+\; x_t, \qquad t \;=\; 1, 2, ..$$

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

(Insert Table 7 around here)

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 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, 1995) 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.

(Insert Table 8 around here)

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 (1995). Marinucci and Robinson (2001) showed that

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

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.

(Insert Table 9 around here)

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.

(Insert Table 10 around here)

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.

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 non-linearities 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, whilst there is stronger evidence of cointegration in the latter case: when using the Hausman test for no cointegration of Marinucci and Robinson (2001), fractional 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 healthcare 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 healthcare 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, whilst 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 healthcare is a necessity good, which requires more redistribution of resources and more active health policies.

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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)**
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)**

In bold the significant coefficients according to the deterministic terms. In parentheses, the 95% confidence band for the estimated values of d.

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)**
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)**

In bold 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, HAWAI, 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

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)	-0.0110 (-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)**	-0.020 (-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)	-0.010 (-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)**	**-0.010 (-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)
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)**	0.010 (-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 (0.80)	**-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)**

In bold significant coefficients at the 5% level.

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)	**2.010 (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)**	-0.040 (-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)
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)

In bold 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
NON-LINEAR	ALASKA, ARIZONA, ARKANSAS, CALIFORNIA, COLORADO, IDAHO, ILLINOIS, IOWA, KANSAS, KENTUCKY, LOUISIANA, MINNESOTA, MISSISSIPPI, MISSOURI, MONTANA, NEW MEXICO, NEBRASKA, NORHTH DAKOTA, OKLAHOMA, OREGON, SOUTH DAKOTA, TEXAS, UTAH, VERMONT, VIRGINIA, WEST VIRGINIA, WASHINGTON, WISCONSIN, WYOMING	ALASKA, MINNESOTA, NEBRASKA, NEVADA, SOUTH DAKOTA, WYOMING

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
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

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

State	β (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**
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 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$T^{0.6}$.

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**
MASSACHUSETT	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	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
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 second and third 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, 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)***
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)***
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)**
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)***
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)

*: We cannot reject the null of a slope coefficient equal to 1 at the 5% level.