Time series analysis of private healthcare expenditures and GDP: cointegration results with structural breaks

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Abstract

This paper analyses the time-series behaviour of private health expenditure and GDP to understand whether there is long-term equilibrium relationship between these two variables and estimate income elasticity of private health expenditure. The study uses cointegration analysis with structural breaks and estimates these relationships using FM OLS (fully modified ordinary least squares) method. The findings suggest that income elasticity of private health expenditures is 1.95 indicating that for every one per cent increase in per capita income the private health expenditure has gone up by 1.95 per cent. The private health expenditure was 2.4 per cent of GDP in 1960 and this has risen to 5.8 per cent in 2003. In nominal terms it has grown at the rate of 11.3 per cent since 1960 and during 1990's the growth rate is 18 per cent per annum. The study discusses four reasons for this high growth experience. These are: (i) financing mechanisms including provider payment system, (ii) demographic trends and epidemiological transition, (iii) production function of private health services delivery system, and (iv) dwindling financing support to public health system.

In developing countries where *per se* the need for spending on health is high, high levels of private health expenditures pose serious challenge to policy makers. The sheer size of these expenditures once it has risen to high levels can impede control of health expenditures itself. The high private health expenditures are also cause of concern because most of these expenditures are out-of-pocket, insurance mechanisms cover small segment of population, provider payment systems are primarily based on fee-for-services and the professional regulation and accountability systems are weak and non-functioning in many ways. It is not clear whether these expenditures are sustainable as it can have number of undesirable consequences making the health system high cost, unaffordable, and vulnerable to provider payment system.

Key words: Private health expenditure, Elasticity, Unit root, Structural break, Cointegration

1. Introduction

The analysis of financing of health care has assumed greater significance in recent times. In particular, the relationship between the income and health care expenditure has been focus of research for the reason that it helps us to understand the key determinants of healthcare expenditures and also provides insights into linkages between income factor and demand side of health. These understandings are important from view point of policy to contain costs and ensure that health financing achieves its desired goal. Using the standard demand theory framework research has focused on exploring the income elasticity of health care expenditures. Since the seminal work of Newhouse (1977) which estimated the relationship between health care expenditure and gross domestic product (GDP), a large number of studies have been carried out to examine this relationship in different contexts and answer the question why health care expenditure has increased so much in past half century. Most of these studies have been carried out in developed country context. In those settings the other motivation for carrying out such studies has been to examine the issue of whether health care expenditure at a margin has been providing “care” (denoted as luxury good) than “cure” (being a necessity good). A number of studies agree that there is a relationship between GDP and health care expenditure in various settings but disagree on whether the health is necessity or luxury good. These studies vary from country level analysis to a much-disaggregated level like province or state level analysis. Most of the studies in this field have focused health care expenditure including both private and public expenditures. Analysing the private and public expenditures may pose some methodological issues. Since in country like India where public expenditures represent the supply side provision of health care as governments are allocating fewer resources in comparison to the demand, the private expenditures on health and medical care on the other hand will truly represent demand side. Hence, analysis based on the combined expenditure (public and private) may not be appropriate and may produce erroneous results. In this paper we focus on analysis of relationship between private expenditure on healthcare and GDP.

We present econometric evidence using time series analysis of private health care expenditure and GDP. The objective of this paper is to analyse the private health expenditure and estimate whether private expenditure on health and medical care have any long-term relationship with the per capita income. Can the growth in private health expenditure in India be ascribed to the growth in income over the period? The analysis of time series poses a number of methodological issues of ensuring that series are stationary and do not have unit root. Some results in the literature using the concepts of non-stationarity and co-integration have also been explored. This analysis depends on unit root behaviour the time series under consideration exhibit. We also examine the properties of time series of private healthcare expenditures and income using alternative hypothesis of allowing for the presence of structural breaks. The paper is divided into eight sections. Section 2 discusses private sector role and healthcare financing in India. Section 3 reviews previous studies in this area. Section 4 presents description of data sources. Section 5 provides univariate time series analysis results. Section 6 presents cointegration results. Section 7 discusses structural break problem and estimates revised models with structural breaks. Section 8 discusses implications and provides summary of the paper.

2. Private sector role and healthcare financing in India

The epidemiological transition and changing health needs are putting considerable pressure on the health care system. Non-communicable diseases are becoming a major threat. The health infrastructure at present is facing daunting challenge of meeting the health goals and complexities emerging from the changing disease pattern. There are considerable demands on health care system to expand and upgrade facilities. To meet this challenge the health sector in India has witnessed an unparalleled increase in private clinical establishments all over the country. The utilisation surveys suggest that on an average 3/4th of out-patients and 1/3rd of in-patients seek care from private providers. About 75 per cent of health expenditure in the country is for private health care treatment. About 80 per cent of the qualified doctors in the country work in the private sector. The number of clinical establishments in the private sector in urban and semiurban areas today out-numbers the strength of government facilities. The reason for high growth of these establishments has been their ability to bring almost all types of health care services to the door-steps of patients. Most of these establishments use latest medical technologies in provision of health services. At the same time, these facilities have grown without having any appropriate and effective regulation in place. The quality of care provided by these facilities has become a major cause of concern. With the quantity growth of private medical facilities the quality of care has suffered. And in general the questions are raised whether India's private health sector has gone out of control? What has happened to private expenditures on medical and health care?

Public expenditure on health care in India is composed of spending by central government, state governments, and local bodies. Private health care spending includes the out-of-pocket costs incurred by households and expenditure by the private non-household institutional sector. Surveys on household expenditures indicate that spending on health care as a proportion of total GDP is quite significant, estimated at 5 to 6 percent. The data also show that government expenditure in the health sector is small in proportion to what is being spent out-of-pocket expenditures by household sector. The share of private household and non-household expenditure has frequently been reported to be more than two-thirds of the total health expenditure (de Ferranti 1985, Satia et al. 1987, and World Bank 1995).

In India, government expenditure on health increased from Rs. 28 billion in 1987 to Rs. 169 billion in 2003 at current prices prices. In comparison to this the private expenditure on health rose from Rs. 95 billion in 1987 to Rs.1282 billion in 2003 at current prices (see Exhibit 1 for per capita figures on private expenditures).

The private expenditure on health as per cent of per capita income has almost doubled since 1961. Table 1 shows average per capita private health expenditure as per cent of per capita income in different periods since 1961. The PHE as per cent of PCI has increased from 2.71 per cent during 1961-70 to 5.53 per cent during 2001-03. This has almost doubled.

Table 1: Private health expenditure (PHE) as per cent of per capita income (PCI) in different periods	
Period	Average
1961 to 1970	2.71%
1971 to 1980	3.27%
1981 to 1990	3.72%
1991 to 2000	3.26%
2001 to 2003	5.53%

This implies that PHE has grown at much higher rate than the per capita income over the years. Table 2 provides information about the growth rates of PHE, PCI and private consumption expenditure in different periods. During the period 1991-2003 PHE has grown at 10.88 per cent per annum in real terms whereas per capita income has grown at 3.76 per cent during the same period. The growth in private health expenditures has been much higher than the income growth or private final consumption expenditures.

Table 2: Growth rates in various sub periods

Variable	1961 – 2003	1961 – 1970	1971 – 1980	1981 – 1990	1991 – 2003
PHE_n	11.30	9.91	13.70	7.62	17.92
PHE_r	3.44	2.54	5.84	-0.01	10.88
PCI_n	10.22	8.73	8.89	10.74	10.83
PCI_r	2.36	1.37	1.03	3.11	3.76
PCE_n	9.21	7.86	8.24	9.17	10.29
PCE_r	1.35	0.50	0.37	1.54	3.22

PHE: private health expenditure, PCI: per capita income and PCE: private final consumption expenditure. Subscripts n and r denote variables expressed in nominal and real terms respectively.

3. Previous literature

Newhouse (1977) raises the question that what determines the quantity of resources any country devotes to medical care. From analysis provided in the study per capita GDP of the country is the single most important factor affecting this. The study finds a positive linear relationship between fraction of health care expenditure to GDP and GDP[1]. Results of Newhouse were consistent with an earlier study by Kleiman (1974) and both these papers worked as a base for a large literature, which have viewed income as a major determinant of health care expenditure. We can go to as back as in 1963 and 1967 when pioneering work of Abel-Smith brought out this issue in World Health Organisation studies. They found that after adjusting for inflation, exchange rates and population, GDP is a major determinant of health expenditure. This result has been verified by number of studies later on.

Gerdtham et al. (1992) used a single cross section of nineteen OECD countries in 1987. They found per capita income, urbanisation, and the share of public financing to total health expenditure as positive and significant variables. Gbesemete and Gerdtham (1992) used a cross section sample of thirty African countries in 1984. They found that per capita GNP was the most significant factor in explaining per capita health care expenditure. Hitris and Posnett (1992) used 560 pooled time series and cross section observations from 20 OECD countries over the period 1960-1987 and found a strong and positive correlation between per capita health spending and GDP. Later also many authors studied the performance of health function. Most of the works of these authors were based on the relationship between HCE and GDP. Some important works, which we can mention here, are Hansen and King (1996), McKoskey and Selden (1998), Gerdtham and Lothgren (2000) and Karatzas (2000).

Similarly another important issue in healthcare literature is that whether healthcare expenditure is a luxury or necessity good. Different studies have found different results. Some studies (like Newhouse, 1977; Gerdtham *et al.,* 1992) found the elasticity greater than one while many other studies (Manning *et al*., 1987; McLaughlin, 1987; Di Matteo

[1] As concerning the effect of per capita income, one major question of health economics (and applied econometrics) is the value of health care expenditure income elasticity. If this elasticity is greater than unity, health care are a luxury good and their increase is a natural outcome of economic growth

and Di Matteo, 1998) found elasticity much less than one. Getzen (2000) concluded that higher the level of aggregation higher is the elasticity of healthcare. But many studies do not support this. One reason can be also that in most of the studies healthcare expenditure has been taken as a whole. If we divide total healthcare expenditure into private and public and then analyse both of the separately then may be we will get more clarity on this issue. In this paper we will analyse relationship between private healthcare expenditure and GDP. The relationship between public healthcare expenditure and GDP will be dealt in a separate paper.

4. Data

National Accounts Statistics of India provide final private consumption expenditures of households and non-profit institutions serving households. It is estimated through the commodity flow method. Intermediate expenditure consumption for each industry and all final consumption (including imports and exports) other than household and non-profit institutions are taken from the total amount of goods and services at market prices. The subject expenditures are classified into eight categories: food; clothing and footwear; gross rent, fuel and power; furniture, furnishings, appliances, and services; medical care and health services; transportation and communication; recreation, education, and cultural activities; and miscellaneous goods and services. In the case of expenditure on medical care and health services, household expenditure on medicine and services is estimated on the basis of value of per capita consumption expenditure available in various reports of NSSO consumer expenditure surveys. To this, one third of expenditure on services is added for incidental expenditure on items like medical appliances. The receipts by central government on account of Central Government Health Scheme (CGHS) compiled from the Central government budget are also taken as an item of household consumption. The basic data on output and prices are mostly the same as those utilised for the preparation of GDP estimates and as such shortcomings in the GDP estimates would be inherent in the measurement of private consumption as well.

5. Univariate analysis of time series data

In order to estimate whether there is long-term equilibrium relationship between income and health expenditures, recent work in this area has used time-series analysis of these variables. However, the time-series analysis of these variables poses number of methodological problems in estimating their true equilibrium relationship. We can estimate relationships through regression method only if the series are stationary.

Stationarity in a time series refers to a condition where the series has a constant mean and constant variance. This implies that for a stationary time series the mean and variance do not vary over time. While estimating the relationship between PHE and PCI the stationarity property of the time-series variables is essential in model estimation because most of the statistical tests have been developed for stationary (time-invariant) time series. The stationarity or otherwise of a series can strongly influence its behaviour and properties - e.g., persistence of shocks will be infinite for nonstationary series.

Most of the time series data generally have trend, cycle, and/or seasonality. By removing these deterministic patterns, the remaining series must be stationary. In case the time series variables are not stationary, they can produce invalid inferences. Granger and Newbold (1974) have shown that in case the series are not stationary, the estimation can lead to a problem of spurious regression with a high R-square. The Durbin-Watson statistic near to zero is mainly due to the use of nonstationary data series. This means that the estimates of model may turn out to be statistically significant but the relationship may have no meaning. Hence, we first study the stationarity property of the time-series variables used in the study.

Unit root tests

The first step in these types of analysis is to plot the data and examine its behaviour. We have plotted the behaviour of per capita private health expenditure (PHE), per capita income (PCI) and private final consumption expenditure (PCE) in terms of their levels and first differences of levels (see Figures 1 to 9). Examination of these plots suggests that all these variables are not stationary in their behaviour. The graphs of these variables indicate that all the three time-series variables contain a linear trend. We need to incorporate this characteristic while specifying the model and analysing the data. The plot of their log values is also not stationary. The plots of first difference of these variables suggest their stationary characteristic. However, it is not possible to say anything conclusively about the stationary character of these series based on plots. We have therefore used statistical methods to test the stationary character of the series.

The first step in statistical testing the non-stationarity of time series data is to test for random walk. Testing this means is to find out whether the variables contain unit root. This is also called the Unit Roots Test. Once the unit root problem is identified, we take the first difference of time-series and same tests are used to test the unit root again. This tests stationary character of the series in its first difference. As discussed earlier using the non-stationery series in estimating relations may give spurious results. In case the first difference is stationary (has no unit root) then the series is described having integration of order 1 and is denoted I(1). If two time series are integrated of order or I(1), it is well known that the correlation coefficient between them will tend towards plus or minus unity, whether an economic relationship between them exists or not. In case we do find unit root presence in first differences, we carry out the process of taking further difference till the unit root problem persists. The stage at which we find the absence of unit root, we are able to identify the order of the integrated process for the series.

In order to test the unit root of a series it is useful to formulate its behavior as simple auto-regressive process. For example, if we consider a simple AR(1) process:

$$y_t = \rho y_{t-1} + x_t'\delta + \varepsilon_t \qquad (1)$$

where x_t'are optional exogenous regressors which may consist of constant, or a constant and trend, ρ and δ are parameters to be estimated, and the ε_t are assumed to be white noise. If $|\rho| >= 1$, y is a nonstationary series and the variance of y increases with time and approaches infinity. If $|\rho| < 1$, y is a stationary series. Thus, the hypothesis of stationarity can be evaluated by testing whether the absolute value of is ρ is strictly less than one.

Three tests which are standard in literature Augmented Dickey Fuller (ADF), Phillips Perron (PP) and Ng and Perron (NP) were done to find that whether unit root is present in the data or not (see Appendix 1 for the details of these tests). Table 3 presents the results of unit root tests of PHE and PCI. All the three tests indicated that there is a unit root in the data.

Table 3: Unit-root test statistics of levels and first difference of variables used in the study

	Augmented Dickey-Fuller		Phillips-Perron		Ng-Perron (MZ_t^{GLS})	
	t-statistics	probability	t-statistics	probability	intercept	intercept and trend
Per capita income (pci)						
pci	-2.3374	0.1659	2.6669	1.0000	1.8152	-1.1501
d(pci)	-0.9214	0.7713	-2.3228	0.4128	-0.5711	-1.9786
pci_r	0.1737	0.9970	1.2100	0.9999	4.5663	0.1593
d(pci_r)	-7.0050*	0.0000	-7.5871*	0.0000	-3.1407*	-3.2097**
ln(pci)	-1.9987	0.5847	-2.3943	0.3771	0.2403	-1.2062
d(ln(pci))	-5.7721*	0.0001	-5.7721*	0.0001	-2.7506**	-3.0038**
ln(pci_r)	-1.6610	0.7508	-1.4862	0.8186	2.9624	-1.2096
d(ln(pci_r))	-7.5441*	0.0000	-11.4397*	0.0000	-3.2815*	-3.2022**
Per capita private health expenditure (phe)						
phe	1.1943	0.9999	4.3162	1.0000	-5.7449	-12.6312
d(phe)	-3.1522	0.1115	-2.1994	0.4773	-1.0495	-1.9840
phe_r	-3.8501	0.0251	1.6278	1.0000	0.5394	-3.1391
d(phe_r)	-3.0428	0.1336	-2.9633	0.1546	-2.1213	-2.5357
ln(phe)	-1.5835	0.7823	-1.0436	0.9265	0.6218	-1.9859
d(ln(phe))	-4.2213*	0.0094	-4.1744*	0.0106	-2.7998	-2.9910**
ln(phe_r)	-4.3543*	0.0076	-0.7027	0.9663	1.2753	-1.9255
d(ln(phe_r))	-4.1385*	0.0116	-4.0853*	0.0133	-2.9374	-3.0006**

All estimation are with constant and trend. d(..) is first difference. r at the end of each variable is indicating variable at constant prices. * and ** indicate significance levels at 1 per cent and 5 per cent respectively. ADF test and PP test statistics have been estimated with constant and trend. Ng-Perron (MZ_t^{GLS}) is based on HAC corrected variance (Spectral GLS-detrended AR) and asymptotic critical values are as follows:

significance level	intercept	Intercept and trend
1%	-2.58	-3.42
5%	-1.98	-2.91
10%	-1.62	-2.62

The results indicate that PCI and PHE are not stationary in their levels. All three tests indicated in Table 3 suggest that first difference of log values of PCI and PHE (both expressed in real terms) are stationary. Hence both ln(PCI) and ln(PHE) are integrated of the order 1 or I(1). It is well documented in literature that unit root tests have low power to reject the null hypothesis. Hence, if the null hypothesis of a unit root is rejected, there is no need to proceed further.

One important property of variables having I(1) property is that their linear combination can be I(0). This means the linear combination non-stationary series of I(1) can be stationary. These variables are described as cointegrated variables. Cointegration analysis also helps us to perform analysis of long-run relationships in a set of variables. For multivariate time series, after testing unit roots for each variable, a cointegration test should be carried out to ensure that the regression model is not spurious.

The concept of cointegration was first introduced by Granger (1981), and has since then come to play a major role in economic research. An economic relationship can exit, however, when two I(1) series are cointegrated, such that a liner combination of the series is stationary and two series share a common stochastic trend. Several studies have estimated relationship between the health expenditures and income using this approach. The lack of cointegration, on the other hand, would imply that series could wander apart without having any fundamental relationship. To test whether the private health expenditure is having long-term and equilibrium relationship with per capita income we estimate the relationship between these tow variables and test for their cointegration. The Granger representation theorem also shows that any cointegrating relationship can be expressed as an equilibrium correction model (ECM).

For this purpose we use the following variables:

- Per capita income (PCI)
- Per capita private medical and health expenditure (PHE)

Both these variables are in real terms (i.e., at constant prices) and we use their log values. The data used in the study is reported in Exhibit 1. PHE represent demand side factors influencing expenditures on medical and health care.

6. Cointegration tests

In order to determine whether there is a long-run equilibrium relationship between private expenditure on health and income, we use the concept of cointegration. Cointegration analysis helps us to determine and analyse whether there is long-run relationship in a set of variables. Engle and Granger (1987), hereafter referred as EG, have developed a simple method whether two variables integrated of the same order are cointegrated. As per this method we first determine whether the two variables are having integration of the same order. The cointegration test is to be applied only for the same order integrated series. Given that both PHE and PCI series are integrated series of order one, the long-run relationship:

$$\ln(PHE_t) = \beta_0 + \beta_1 \ln(PCI_t) + \varepsilon_t$$

will be meaningful only if the error ε_t is free of unit root. The error ε_t represents the deviations from long-term relationship. Therefore, we test for the stationarity of these deviations. If these deviations are stationary then the two series are having cointegrated relationship and estimation is not spurious. Alternatively, one can also obtain regression residuals for unit root tests obtained from a cointegrating equation which includes a trend variable. By rejecting the null hypothesis of unit root on the residuals, the variables in the regression equation are said to be cointegrated. Table 4 presents the regression results of cointegrated model.

Table 4: Computation of income elasticity of private expenditure on health

	Per capita income

	Coefficient	t-value
Constant	-7.1816	-5.1137
Elasticity coefficient	1.4286	8.8097
Adjusted R2	0.8520	
F-Statistics	242.7024	
Standard errors and t-statistics are based on Newey-West HAC Standard Errors & Covariance (lag truncation=3)		

The regression estimates suggest that the income elasticity of private expenditures in India is 1.43. This implies that for every 1 per cent increase in per capita income the per capita private expenditure on health increases by 1.43 per cent. These results are acceptable if the error term of this regression does not have unit root. We use EG residual based test to examine this. Table 5 presents these results.

Table 5: Test of cointegration based on EG method

		Test critical values*
Augmented Dickey-Fuller test statistic	-3.26	1% level -4.24
	(Prob 0.090*)	5% level -3.54
		10% level -3.20
Phillips-Perron t-statistic	-1.53	1% level -4.19
	(Prob 0.805)	5% level -3.52
		10% level -3.19
Ng-Perron test statistics		Asymptotic critical values**
MZt statistic	-1.44	1% level -3.42
MZt statistic	-2.19	5% level -2.91
		10% level -2.62

*MacKinnon (1996) one-sided p-values
**Ng-Perron (2001, Table 1)
All computations are based on inclusion of constant and linear trend in computations.
The selection of lag length is based on SIC criterion and is 6.

Table 5 presents the values of the *t*-statistics that we obtain from applying augmented Dickey-Fuller tests to the fitted residuals of the above equation. We also present the Phillips-Perron and Ng-Perron (MZ_t^{GLS}) test statistics to test the unit-roots of these residuals. The EG results suggest that PCI and PHE are not cointegrated. The results can be used as they may be spurious. Since EG residual based test has low power, it is possible that Granger-Engle test may fail to detect cointegration, when it is actually present. This may happen because it is difficult to reject a unit root in the residual due to the low power of the unit root test. Thus, we have also used Johansen rank based test to find cointegration (see Appendix 1 for Johansen test). In this test we test null rank of zero for no cointegration against the alternative rank greater than zero for the presence of a cointegrating vector. Table 6 presents these results.

Table 6: Cointegration test using Johansen method

Unrestricted Cointegration Rank Test (Trace)				
Hypothesised number of coefficients		Trace Statistic	5% Critical Value	Prob.**
None		12.02	25.87	0.8104
At most 1		5.83	12.52	0.4822
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesised number of coefficients	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.14	6.19	19.39	0.9471
At most 1	0.13	5.83	12.52	0.4822

**MacKinnon-Haug-Michelis (1999) p-values
All computations are based on linear deterministic trend assumption

In addition to the residual-based tests, we also consider two likelihood-based test statistics using Johansen method. Table 6 reports the Johansen "trace" statistic, which tests the null hypothesis that the system in log (PHE) and log (PCI) contains no cointegrating relationship against the alternative hypothesis that one or more cointegrating vectors are present in the system. In constructing these tests, we assume that the data are trending and that a constant is present in the cointegrating vector. Trace test and Max-eigenvalue tests indicates no cointegration at the 0.05 level

The results reported in Tables 5 and 6 Table reports the results of stationary test based on EG method and Johansen test of null of no cointegration for PHE and PCI. The cointegration tests clearly do not reject the null hypothesis. Based on the unit-root and cointegration tests, the private expenditure on health and income are having integration of order one, i.e., I(1) but these time series variables are not cointegrated. Since the two series are not cointegrated these results can not be interpreted as they be spurious. Since we use a long time series data of 43 years it is possible that we are not able to reject the null hypotheses of unit root and no-cointegration because of the existence of structural breaks in the series. We examine this in next section.

7. Structural break analysis

The presence of structural breaks in time series do have implications for the unit root tests as these breaks can be mistaken fro non-stationary characteristic of time series. In the presence of structural breaks the power of unit root tests to reject the null hypothesis decreases (Perron 1989). According to Perron (1989) the ability of the usual ADF and Phillips-Perron unit root tests to reject the null hypothesis when the stationary alternative hypothesis is true is indeed compromised. In fact, the power of these tests reduces. There have been some attempts to provide alternative unit root test in the presence of structural breaks. Perron (1989) suggested a modified version of the Dickey-Fuller unit root test by including dummy variables to deal with one exogenous break point. This break-point is provided exogenously in Perron's (augmented type) Test. Amsler and Lee (1995) also developed Lagrange Multiplier (LM) based test assuming a given break-point. Later on, the literature on this issue evolved towards the development of test modifications allowing for break points endogenously determinate. The Zivot and Andrews (1992) minimum test is the endogenous procedure most widely used to select the break point when the t-statistic testing the null of a unit root is at its minimum value.

Recently, researchers have raised the possibility of the existence of more than one break point in economic time series (Lumsdaine and Papell 1999). It is possible to test for two structural breaks in a series (Lee and Strazicich 1999c). In this paper we focus on analysis of unit root with one structural break.

There are three structural break models developed in Perron (1989). These are: (i) model allowing for a one-time change in level, termed as crash model (CM); (ii) the changing model which considers a sudden change in slope of the trend function; and (iii) a third model that allows for changes in level and trend, called break-trend (BT) model. Since the third model incorporates the changing model, only the crash model and the break trend models are taken into account in this paper.

Based on Perron (1989) framework these two models can be constructed as follows:

$$PCI_t = \gamma + \theta\, DU_t + \beta\, T + \delta\, DUM_t + \alpha\, PCI_{t-1} + \sum \lambda_i\, \Delta PCI_{t-i} + \varepsilon_t$$

In the above specification DU_t is dummy variable assuming value 1 for all $t > T_b$ and DUM_t is taking value equal to 1 for $t = T_b + 1$. T_b is endogenously determined time of the break. The methodology searches over all possible break points and chooses the break point at the minimum value of the t statistic. The above model allows change in intercept only. The unit root test is performed using the t-statistic for null hypothesis that $\alpha = 1$ (a unit root) in the regression. The t statistics α is used for testing $\alpha = 1$, with a break date T_b and truncation lag parameter k. T_b and k are treated as unknown and are determined endogenously.

Under the BT Model both a change in the intercept and the slope are allowed and is constructed as follows:

$$PCI_t = \gamma + \theta\, DU_t + \beta\, T + \varphi\, DT_t + \delta\, DUM_t + \alpha\, PCI_{t-1} + \sum \lambda_i\, \Delta PCI_{t-i} + \varepsilon_t$$

We apply two tests based on Zivot and Andrews (1992) and Lee and Strazicich (1999b) to calculate break point. For each of them, we admit two possibilities for the model set up: crash model and break trend models. As discussed earlier that standard unit root tests do not take into account the existence of break points in the time series, these two tests consider these. The programmes automatically take into account the appropriate lag length.

The results of applying these procedures are presented in Table 7. The results for crash model with a change in the intercept only show an interesting pattern.

Table 7: Unit root under structural break based on two methods of endogenously determined breaks

	Crash Model			Break-trend Model		
Method and variables	Tb	lag (k)	t-statistics	Tb	lag (k)	t-statistics
Zivot and Andrews Model						
PHE	1987	7	-5.47*	1998	7	-4.76*
PCI	1992	4	-3.68**	1982	0	-4.05**
Lee and Strazicich Model						
PHE	1998	6	-3.92**	1983	6	-5.70*
PCI	1997	8	-2.75	1981	8	-4.33*

Significance level: * 1 per cent, ** 5 percent and *** 10 per cent.

We are not able to reject the null in case of PCI in Lee and Strazicich method where as under Zivot and Andrews method PCI is significant only at 10 per cent. For break-trend model we are bale to reject unit root null under both the methods. We view these results as generally consistent with the hypothesis that most of the series are best characterised as stationary around a breaking mean and/or trend function.

The econometric implications of this misspecification are relevant in that, following the structural break analysis of PCI and PHE, we can deduce that the acceptance of the no-cointegration null hypothesis may be caused by ignoring the presence of changes in the long-run relationship.

Also it was shown that the power of cointegration tests reduces if there is any structural break in the data (Gregory and Hansen, 1996)[2]. Since it is very difficult to know such break points *a priori*, Gregory and Hansen (1996) proposes a statistic that attempts to test the null hypothesis of no co-integration against the alternative co-integration with a structural break at an unknown point of time. It can lead us to draw appropriate inferences on cointegration when the parameters of the cointegrating vector are not constant. Adopting the original notation to the case of PHE and PCI, these statistics are based of the estimation of the OLS residuals of the following models:

$$\ln(PHE_t) = \beta_0 + \beta_1 \ln(PCI_t) + \beta_2 DU_t + \varepsilon_t$$
$$\ln(PHE_t) = \beta_0 + \beta_1 \ln(PCI_t) + \beta_2 DU_t + \beta_3 (DU_t * \ln(PCI_t)) + \nu_t$$

where PHE_t and PCI_t have been previously defined, and where DU_t is a dummy variable that takes the value 1 whenever $t >$ Time of Break (TB) and 0 otherwise.

Three different Gregory-Hansen test statistics are shown. Model (A) allows there to have been a level shift in the cointegrating relation, Model (B) augments model (A) with a trend in the cointegrating relation while model (C) allows for a regime shift (i.e., for the value of the cointegrating parameter to have changed). See Appendix 1 for details of Hansen test. In all these cases we get values of ADF*, Z_t* and Z_a*

The distribution of these statistics is derived in Gregory and Hansen (1996), where the asymptotic critical values are also tabulated. Thus, these statistics allow us to test for the non-cointegration null hypothesis when the parameters of the cointegration relationship

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[2] Chow, 1960 is attributed with testing for structural break in the data. His testing procedure was to split the sample in two sub-periods, estimate the parameters for each of sub-periods, and then tests the equality of the two sets of parameter using classic F statistic. However an important limitation of the chow test was that break date must be known a priori.

may change across the sample. All these aspects will play a crucial role in the following section, where we analyse the relationship between private health care expenditure and the GDP of India.

Results of Hansen Test

By adopting the test in the paper by Gregory and Hansen (1996) we get the ADF*, Z_a* and Z_t* values with the break points. Here we see that ADF*, Z_a* and Z_t* are significant at 1 per cent. So we can say that with the normal cointegration tests which take null of no cointegration again the cointegration we do not find any cointegration but when we consider structural break we find evidence of cointegration[3]. This has very important implications. It means that the two series after taking into account structural breaks are cointegrated and there is a long term relationship in the per capita income and private healthcare expenditure.

Table 8: Hansen test for structural break in case of regime shift

ADF Test	t-statistic	Breakpoint (ADF)	AR lag
C	-4.1434	0.3023	6.000
C/T	-4.8425	0.4884	6.000
C/S With regime shift	**-4.0063**	**0.3023**	**6.000**
Phillips Test (Z_t)	**Z_t**	**breakpoint(Z_t)**	
C	-3.1808	0.6279	
C/T	-3.0987	0.8605	
C/S With regime shift	**-3.4106**	**0.6512**	
Phillips Test (Z_a)	**Z_a**	**breakpoint(Z_a)**	
C	-18.4592	0.6279	
C/T	-18.4000	0.8605	
C/S With regime shift	**-19.4012**	**0.6512**	

[3] Please see Appendix 1 for Hansen statistics with critical values

Based on the results obtained after incorporating the structural breaks we estimate the relationship between PHE and PCI and estimate elasticity using following models:

$$\ln(PHE_t) = \beta_0 + \beta_1 \ln(PCI_t) + \beta_2 DU_t + \varepsilon_t$$
$$\ln(PHE_t) = \beta_0 + \beta_1 \ln(PCI_t) + \beta_2 DU_t + \beta_3 (DU_t \ln(PCI_t)) + \nu_t$$

In the above equation β_1 will give the elasticity. Another important point here is that dummy variable is chosen according to the break point suggested by Z_t* statistic because according to Hansen Z_t* statistic should be used. Table 9 presents these results. These results are based on fully modified OLS estimates. When traditional OLS is implemented with non-stationary variables, test statistics cannot be interpreted in the usual way as they are biased. Generally the asymptotic distributions of the OLS estimator involves the unit root distribution and it is also non-standard; because of which inferences on β using the usual t-tests in the OLS regressions will be invalid. The Phillips-Hansen methodology corrects these test statistics using a semi-parametric procedure by suggesting fully modified least squares (FM-OLS) regression method. This particular method is appropriate in situations of cointegrating regressions. The method modifies least squares to account for serial correlation effects and for the endogeneity in the regressors that result from the existence of a cointegrating relationship. The model also provides estimates when there is drift in independent variables.

Table 9: Fully Modified OLS estimates of relationship between PHE and PCI with structural breaks

Variables	Model 0		Model 1		Model 2	
	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
Constant	-6.82*	-8.32	-13.69*	11.82	-11.61*	-8.61
ln(PHE)	1.39*	14.90	2.19*	16.30	1.95*	12.47
Dummy			-0.55*	-6.83	-6.88*	-2.96
ln(PHE)*Dummy					0.70*	2.72
Wald statistic (χ^2)	55.84		128.18*		88.61*	

Wald statistic (χ^2) @	17.27	78.38*	36.80*

Estimates are based on Fully Modified Phillips-Hansen Estimates using Parzen weights and zero truncation lag.

Wald statistic without any restrictions and tests whether all estimated coefficients together are significantly different from zero. @ Wald statistic is with one restriction: Coefficient of ln(PHE) = 1

* statistically significant at 1 per cent level

The regressions results after introducing the structural breaks dummy and regime shifts suggest that dummy variables in Model 1 (with level shift only) and both dummy variable and interaction variable in Model 2 are significant. The statistical significance of dummy variables in both models also provides evidence in favour of structural break. The evidence also suggests that long-term relationship between income and private health expenditure exhibit a structural break and therefore there is no stable relationship between income and private health expenditure across the sample period 1961 to 2003. The results based on without recognising the structural break would be distorted and raise questions on the validity of the conclusions. Table 9 provides estimates of elasticity coefficients and they are 2.19 in Model 1 and 1.95 in Model 2 and both these coefficients are significant at 1 per cent level. The results indicate increase in elasticity from 1.39 estimates based on fully modified OLS after introduction of dummy variables for structural break. Because of the significance of both dummy variables, we select Model 2 for the purpose of our estimation according to which the income elasticity of private health expenditures is 1.95. This elasticity is also statistically different from 1.

We have presented results which suggest that ln(PHE) and ln(PCI) are best characterised as stationary processes around a breaking trend function. We also find that these series are consistent with cointegrated representation and after introducing the structural breaks the two series are cointegrated.

8. Implications and conclusion

The basic objective of health care systems around the world is to meet country's health needs in most equitable and efficient manner. At the same time it is to be ensured that the health systems remain financially sustainable. Each country given its historical evolution of health care systems has embarked on different strategies to achieve this goal. Despite these differences one common characteristic of health care systems in developing countries has been significant growth of private sector. These countries where health needs are significant and many people can not afford health, the expenditure requirements to sustain health provision are considerable. Over the years it has also become clear that public expenditures in these countries can not cope up with these growing demands. In some countries private sector participation has been encouraged in health sector because governments are short of resources, governments are not having inadequate systems to manage the delivery of care effectively and therefore passively disengage from health provision, and lack of political commitment. As a result we have seen that privates sector has become a major player is health sector either because of government policy or lack of it. In India the share of private health expenditure is around 88 per cent. Similarly a large number of health functioning health facilities are in private sector. About 80 per cent of qualified doctors work in private sector. The other reasons for higher participation of private sector in health sector are: (i) to fill the gap as public sector as it does not have adequate resources, (ii) no clear cut policies and (iii) huge opportunities to be tapped.

Health financing is not a goal, it is a means to an end - facilitating the provision of the types, quantities, and qualities of health services that are consistent with achieving national health sector goals (Jeffers 1997). Given the evolution and character of health systems in developing countries some trends are clear. One trend is the emergence of hybrid system having both public and private sectors with different incentive systems and provider payment mechanisms. These systems sometimes complement each other and in some areas compete with each other. Second trend which is quite clear in most developing countries is that private sector does not consist of only formal qualified providers but do have significant presence of huge informal and less-qualified providers providing various types of services to the population. Third trend which is quite visible in these settings is that private sector has grown with out having any effective regulations in place. Fourth trend tells us that based on demand supply conditions and given the financing position of governments in developing countries; public sector reflects more of supply side of health care provision and private sector represents demand side factors. This is because governments decide how much to spend, on whom to spend, what will be the terms and conditions and also who will be allowed to consume those services. On the other hand private sector is more market driven system in which consumer takes the decision through the market forces of supply and demand. However, experiences in many countries, especially developed ones, have shown that this may not be exactly the case. Private sector also has been found to be supply driven rather than demand driven. This is because consumers here also are not at par with the producers and they do not have complete information about their illness and the kind of health services offered to them (Rosenthal and Newbrander 1997). Another important point is that consumers only have access to health services only with the permission of private providers. So, in reality private sector may be more supply driven than public sector. Fifth trend suggests that in most situations the most preferred provider payment systems is fee for service with very little insurance coverage. The market failure problem is well known in the field of health sector. Therefore an important point which comes out here is that in the absence of any kind of policy intervention by the government, private sector would behave in the manner which servers only their purpose. There is a high chance that it will not work towards achieving sector related health goals especially related to equity in health and focus on various public health issues. In effect we can see efficiency more in the operations than in allocation. So quality services will be offered but only to those who can afford them (Newbrander and Parker 1992). Because of these reasons it is argued that government has role in modulating the performance of private sector keeping public goals in mind. Competition, natural or managed, is insufficient in healthcare markets to reconcile the conflicting interests of the society (Jeffers 1997). Some kind of countervailing power is needed to make a balance between public and private health sectors.

This study suggests that private health sector in India has grown very fast, faster than the real incomes. For each one per cent increase in real per capita income the real per capita expenditure on health has gone up by 1.95 per cent. During last decade private expenditure on health has grown by 18 per cent per annum in nominal terms and about 11 per cent in real terms. Four reasons can be offered for high income elasticity of private health expenditures. These are:

- Financing mechanisms including provider payment system
- Demographic trends and epidemiological transition
- Production function of private health services delivery system
- Dwindling financing support to public health system

The way health care expenditures are financed has important implications for the health care system. For example, insurance coverage for health care expenditure is very limited in India. About 4 to 5 per cent of total health expenditure is reimbursable under any insurance or reimbursement schemes. Although the government initiated comprehensive health insurance schemes for the employees in the government and formal private sectors, the data show that these schemes cover only small percent of workers. Most of the informal sector remains inadequately covered. Many studies have shown that in the absence of reimbursement mechanisms, people borrow substantial amounts to finance their health care. In some individual cases, borrowing has been as high as their annual incomes. For this the concern is that with relatively large amount out-of-pocket costs incurred by households, are people getting value for their money and what happens in case of catastrophic illnesses where financial burden is high. As seen earlier, private health expenditure has frequently been reported to be more than two-thirds of the total health expenditure. What is being spent on these services? Do people get their value of money? What do people do in case of catastrophic illnesses?

There are obviously both positive and negative aspects about the role of private health care sector. On the negative side, various concerns arising out of the growth of private sector focus on quality and cost of care, equity and efficiency. With the growth of private sector one of the concerns is the scale at which private health care services are produced since it is considered to have significant effect on the cost and quality. In a competitive market, the scale of operations is expected to be optimised by employing the best number and mix of services. This optimisation should minimise the overall cost of operations and affect cost efficiency and effectiveness. The data on private sector suggest that many health facilities are small in size (Bhat 1994). These hospitals are small and may not be the most efficient size to optimise the mix of resources and minimise the cost. The role of private providers in public health issues has also been raised.

Given the morbidity and mortality conditions India will certainly need more resources to meet the health needs of population. In the absence of any regulation and monitoring of performance of private sector health spending, it is possible that additional income buys costlier treatments at the margin that produces very little impact on health outcomes. This to some extent gets reflected by the high income elasticity of private health expenditures. Newhouse suggests the high elasticity may imply that people do not buy "cure" but buy "care". Since the private expenditure on health represent demand side factors it may be so. It also diverts resources from more important health needs. However, the role of supply side factors in the growth of private health sector can not be neglected. The high expenditure may be also driven by the higher investments in technology. For example, it is not clear whether the higher private expenditures on health are driven by income alone or there is an impact of technology. The date on medical equipment imports during last 13 years suggests that it has increased by about 25 per cent per annum (see Figure 9). Number of government policies and liberalisation of imports post 1990s would have also influenced the significant increase in imports. The substantial investment in medical technologies is certainly one factor which would have fueled the growth of private spending. The total imports of medical equipments during 2003 have been in the range of about Rs. 150 billion. This is about 12 per cent of total private health expenditure. Each year we are adding medical equipments worth 12 per cent of the private expenditures. The implications of these investments are not clear and will need further analysis in terms of its geographic distribution and utilisation. There are number of concerns about the inequitable geographic distribution of these facilities and unnecessary and undesirable use of these equipments.

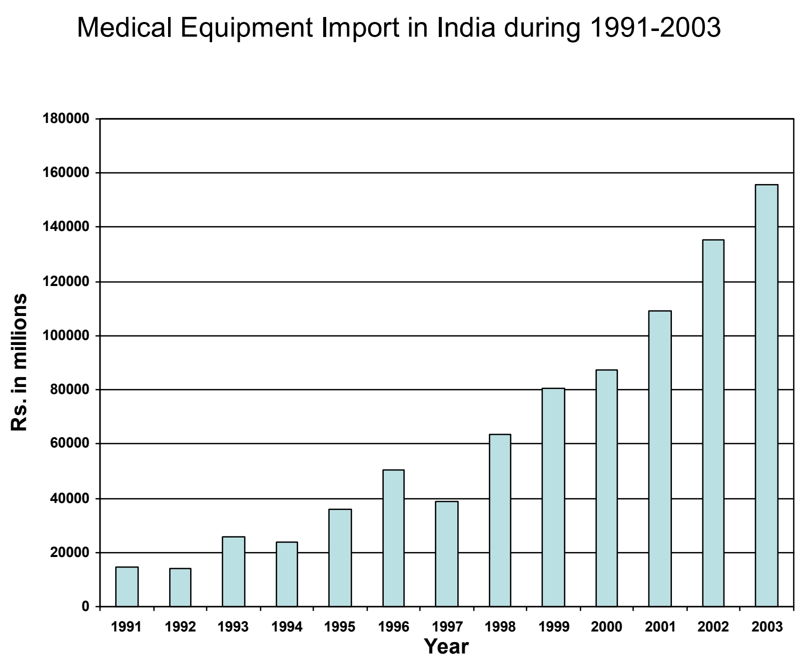

Figure 9: Medical equipment imports (Rs. in millions)

Understanding the relationship between private health expenditures and income is important because it helps us to understand the linkages between the real economy and health sector. Health expenditures have to have some relationship with given income levels, ensuring that they remain sustainable in the long-run. While it is correct that private sector participation in health sector has the potential to provide high quality services and can also allow government to utilise its resources in other places where they are more needed, it is also important to note that customers do not have sufficient information about the quality and services offered by the private sector. There is lot of information asymmetry in this market. Some possible issues with private sector participation is as follows: (i) competition for public sector for quality personnel and resources, (ii) middle and high income group prefer private sector, (iii) a private sector catering to high income groups and predominantly urban population may create a situation giving rise to two totally different standards and systems of care. The short-term increase in private health expenditures at much higher rate than the increase in income may fuel the inflationary growth in health expenditures leading to number of undesirable outcomes, such as increase in healthcare costs and with little improvement in health indicators. As discussed the private health sector is subject to serious market failure problem. Given the relationship between income and health expenditure private health insurance are likely to increase the vulnerabilities of this sector further. The role of the government, therefore, to mitigate the negative consequences of the private sector growth becomes important, particularly given the relationship between income and private health expenditures. This role assumes that governments develop institutional mechanisms, which focus on: (i) providing adequate information to health care seekers and protecting their interest; (ii) regulating the private medical practice with the objective to strengthen the quality of care; (iii) ensuring that policy initiatives are adopted to minimise the input and other market driven inefficiencies affecting the private sector adversely; and (v) ensuring mechanisms of continuous medical education programmes. One of the interventions proposed to strengthen and ensure quality of care is appropriate regulation. Health being state subject in India, regulations in this sector has to be promulgated by each state. In the absence of public policy towards private healthcare sector, the entire process of instituting appropriate and uniform regulatory frame to strengthen the private health care sector has become a difficult task. The concerns for private health sector regulation and reform process is likely to continue as a result of private sector insurance liberalisation and number of concerns about the role of private providers in health care provision. The growing consumerism and catastrophic financial burden arising because of poor-quality or sub-standard care is likely to put considerable amount of pressures on governments to regulate this sector more effectively.

In conclusion, this paper provides analysis of time series behaviour of private health expenditure and per capita income to understand whether there is long-term equilibrium relationship between these two variables and estimate income elasticity of private health expenditure. The study uses cointegration analysis with structural breaks and estimates these relationships. The findings suggest that after incorporating the structural breaks the two series are cointegrated and elasticity estimate is 1.95. This implies that for every one per cent increase in per capita income the private health expenditure has increased by 1.95 per cent.

The private health expenditure as percent of per capital income was 2.4 per cent in 1960 and has risen to 5.8 per cent in 2003. This expenditure in nominal terms has grown at the rate of 11.3 per cent since 1960. During the period 1990-2003 the private health expenditure has grown at 18 per cent per annum. As a result last ten years have seen significant increase in the private expenditure on healthcare. These findings suggest that the elasticity coefficient is high and such high level of expenditure poses serious challenge to policy makers to ensure that private sector works with public goal in mind and inflationary tendencies of these expenditures remain under control. Rapid increase in private expenditure on medical and health is also reflection of serious market failure problem which this sector is seriously exposed to. These trends pose serious problems to the sustainability of the system. Given the existing linkages between income and private health expenditures, the private health insurance system can magnify the vulnerabilities of the health care system making it high cost and affordable by only high income groups. The sheer size of health expenditures once it has risen to high levels would also impede control of these expenditures itself. This is particularly relevant for developing countries where *per se* the need for spending on health is high but when most of these expenditures are out-of-pocket, insurance mechanisms cover small segment of population, provider payment systems are based on fee-for-services, and the public and professional regulation and accountability systems are weak and non-functioning in many ways. The high growth of private health expenditures can be cause of concern. It is not sure whether these expenditures are sustainable as it can have number of undesirable consequences making the health system high cost, unaffordable, and vulnerable to provider payment system. One can summarise these implications as follows: if one were to ask, as an intellectual exercise, how to design a cost-maximising health care system, a likely response might be: have a combination of health insurance, fee for service remuneration of providers and minimal state intervention to regulate fees and monitor the volume of services rendered (Rodwin 1981).

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Appendix 1

The Augmented Dickey Fuller Test

The standard DF test is carried out by estimating equation 1 after subtracting y_{t-1} from both sides of the equation:

$$\Delta y_t = \alpha y_{t-1} + x_t'\delta + \varepsilon_t$$

Where $\alpha = \rho - 1$. The null and alternative hypotheses may be written as:

$$H_0: \alpha = 0$$

$$H_1: \alpha < 0$$

and evaluated using the conventional *t* -ratio for

$$t_\alpha = \bar{\alpha} \ / \ \{se(\bar{\alpha})\}$$

where $\bar{\alpha}$ is the estimate of α, and $se(\bar{\alpha})$ is the coefficient standard error.

Dickey and Fuller (1979) show that under the null hypothesis of a unit root, this statistic does not follow the conventional Student's t-distribution, and they derive asymptotic results and simulate critical values for various test and sample sizes. More recently, MacKinnon (1991, 1996) implements a much larger set of simulations than those tabulated by Dickey and Fuller. In addition, MacKinnon estimates response surfaces for the simulation results, permitting the calculation of Dickey-Fuller critical values and *p*-values for arbitrary sample sizes.

The simple Dickey-Fuller unit root test described above is valid only if the series is an AR(1) process. If the series is correlated at higher order lags, the assumption of white noise disturbances ε_t is violated. The Augmented Dickey-Fuller (ADF) test constructs a parametric correction for higher-order correlation by assuming that the *y* series follows an AR(*p*) process and adding *p* lagged difference terms of the dependent *y* variable to the right-hand side of the test regression:

$$\Delta y_t = \alpha y_{t-1} + x_t'\delta + \beta_1 \Delta y_{t-1} + \beta_2 \Delta y_{t-2} + \ldots + \beta_p \Delta y_{t-p} + v_t$$

This augmented specification is then used to test using the *t*-ratio. An important result obtained by Fuller is that the asymptotic distribution of the *t*-ratio for α is independent of the number of lagged first differences included in the ADF regression. Moreover, while the assumption that *y* follows an autoregressive (AR) process may seem restrictive, Said and Dickey (1984) demonstrate that the ADF test is asymptotically valid in the presence of a moving average (MA) component, provided that sufficient lagged difference terms are included in the test regression.

The Phillips-Perron (PP) Test

Phillips and Perron (1988) propose an alternative (nonparametric) method of controlling for serial correlation when testing for a unit root. The PP method estimates the nonaugmented DF test equation, and modifies the t-ratio of the α coefficient so that serial correlation does not affect the asymptotic distribution of the test statistic. The PP test is based on the statistic:

$$\tau_\alpha = t_\alpha \left(\frac{\gamma_0}{f_0}\right)^{1/2} - \frac{T(f_0 - \gamma_0)(se(\overline{\alpha}))}{2 f_0^{1/2} s}$$

where $\overline{\alpha}$ is the estimate, and the -ratio of , is $se(\overline{\alpha})$ coefficient standard error, and s is the standard error of the test regression. In addition, γ_0 is a consistent estimate of the error variance in (equation 1) (calculated as $(T- k)s^2/T$, where k is the number of regressors). The remaining term, f_0,, is an estimator of the residual spectrum at frequency zero. The asymptotic distribution of the PP modified t-ratio is the same as that of the ADF statistic.

Ng and Perron (NP) Tests

Ng and Perron (2001) construct four test statistics that are based upon the GLS detrended Data y_t^d . These test statistics are modified forms of Phillips and Perron Z_α and Z_t statistics, the Bhargava (1986) R_1statistic, and the ERS Point Optimal statistic. First, define the term:

$$k = \sum_{t=2}^{i} (y^d_{t-1})^2 / T^2 (y^d_{t-1})^2 / \mathrm{T}^2$$

The modified statistics may then be written as

$$MZ_d^\alpha = (T^{-1}(y^d T)^2 - f_0)/(2k)$$

$$MZ_t^\alpha = MZ_\alpha \times MSB$$

$$MSB^d = (k / f_o)^{1/2}$$

$$MP_T^d \begin{cases} (\bar{c}^2 k - \bar{c}\, T^1 (y^d T)^2) / f_0 & \text{if } x_t = \{1\} \\ (\bar{c}^2 k + (1- \bar{c}) T^1 (y^d T)^2) / f_0 & \text{if } x_t = \{1, t\} \end{cases} =$$

The NP tests require a specification for x_t and a choice of method for estimating f_0

Johansen's cointegration tests

Soren Johansen's approach is to estimate the VECM by maximum likelihood, under various assumptions about the trend or intercept parameters and the number r of cointegrating vectors, and then conduct likelihood ratio tests. Assuming that the VECM errors U_t are independent $N_k[0,\Sigma]$ distributed, and given the cointegrating restrictions on the trend or intercept parameters, the maximum likelihood $L_{max}(r)$ is a function of the cointegration rank r. Johansen proposes two types of tests for r:

- The lambda-max test – This test is based on the log-likelihood ratio $\ln[L_{max}(r)/L_{max}(r+1)]$, and is conducted sequentially for $r = 0,1,..,k-1$. The name comes from the fact that the test statistic involved is a maximum generalized eigenvalue. This test tests the null hypothesis that the cointegration rank is equal to r against the alternative that the cointegration rank is equal to $r+1$.
- The trace test – This test is based on the log-likelihood ratio $\ln[L_{max}(r)/L_{max}(k)]$, and is conducted sequentially for $r = k-1,...,1,0$. The name comes from the fact that the test statistic involved is the trace (= the sum of the diagonal elements) of a diagonal matrix of generalized eigenvalues. This test tests the null hypothesis that the cointegration rank is equal to r against the alternative that the cointegration rank is k. The latter implies that X_t is trend stationary.

Both tests have non-standard asymptotic null distributions. Moreover, given the cointegration rank r Johansen also derives likelihood ratio tests of the cointegrating restrictions on the intercept or trend parameters.

Hansen Test

Gregory and Hansen (1996) tests for cointegration allows for the possibility of regime shifts. They test the null of no cointegration against the alternative of cointegration in the presence of possible regime shifts. In particular they have considered the case where there is a single break of unknown timing.

They consider four cointegration models:

Model 1: Standard cointegration (see Engle and Granger, 1987)

$$y_{1t} = \mu + \alpha_2 y_{2t} + e_t \quad t = 1, ..., n \tag{1}$$

where y_{1t} and y_{2t} are I(1), μ and α are the cointegrating parameters and $e_t \sim I(0)$.

In model 2 to 4 it is useful to model the structural break using a dummy $\varphi_{t\tau}$

$$\varphi = \begin{cases} 0 & \text{if} \quad t \leq [n\tau] \\ 1 & \text{if} \quad t > [n\tau] \end{cases}$$

where the unknown parameter $\tau \in (0,1)$ denotes the relative timing of the break point, and [ ] denotes the integer part. Hence in model 2 we allow for the shift in the constant in the long run relationship.

Model 2: Level shift (C)

$$y_{1t} = \mu_1 + \mu_2 \varphi_{t\tau} + \alpha y_{2t} + e_t \qquad t = 1, ..., n \tag{2}$$

Here μ_1 represents the intercept before the shift and μ_2 represents the change in the intercept at the time of the shift.

We can also introduce a time trend here in the level shift model.

Model 3: Level shift with trend (C/T)

$$y_{1t} = \mu_1 + \mu_2 \varphi_{t\tau} + \beta t + \alpha y_{2t} + e_t \qquad t = 1, \ldots, n \qquad (3)$$

Model 4: Regime shift (C/S)

$$y_{1t} = \mu_1 + \mu_2 \varphi_{t\tau} + \alpha_1 y_{2t} + \alpha_2 y_{2t} \varphi_{t\tau} + e_t \qquad t = 1, \ldots, n \qquad (4)$$

In Model C/S we let the long run relationship rotate (that is, a shift in a) together with a level shift in μ.

Although the cointegration tests (2) through (4) allow for a more flexible data generation process than the original Engle-Granger test, there is a slight problem since they all have power against the same alternative hypothesis, which is of cointegration. To deal with this problem Gregory and Hansen (1996) suggested that testing for cointegration with a structural break should be carried out in two steps. In the first step the researcher tests for cointegration using model (1). If the null of no cointegration is not rejected then one proceeds with testing for cointegration using models (2)-(4). If the null of no cointegration is now rejected then we may conclude that a structural break is likely to have occurred in the series. The Gregory and Hansen (1996) test is then carried out as follows. We will estimate any of the Models 2 through 4 for each break point in the interval [(0.15n),(0.85n)] (15% trimming of data from both ends) and perform an Augmented Dickey-Fuller (ADF) test on each of the associated residual series. Then we pick the smallest of the ADF-statistics (which is labelled ADF.) and use this as test statistic and compare it with the critical value. If we reject the null of no cointegration using models (2)-(4) but not with model (1) then this may be interpreted as evidence in favour of a structural break.

The main limitation of the test is that it can only be applied if there is a single break in the data; hence multiple breaks are not allowed. Thus the method would be unsuitable if a country has performed multiple permanent contractions.

Approximate asymptotic critical values for Hansen Statistics

ADF*, Z_t* Test	1%	5%	10%
C	-5.13	-4.61	-4.34
C/T	-5.45	-4.99	-4.72
C/S With regime shift	-5.47	-4.95	-4.68
Z_α* Test	**1%**	**5%**	**10%**
C	-50.07	-40.48	-36.19
C/T	-57.28	-47.96	-43.22
C/S With regime shift	-57.17	-47.04	-41.85

Source: Gregory, A.W., and B.E. Hansen (1996). "Residual-based tests for cointegration in models with regime shifts". Journal of Econometrics 70, Page 109

Exhibit 1
Per capita private medical and health expenditure (PHE) as % of Per capita income (PCI)

1961	2.57%
1962	2.50%
1963	2.65%
1964	2.61%
1965	2.70%
1966	2.84%
1967	3.10%
1968	2.85%
1969	2.77%
1970	2.53%
1971	2.55%
1972	2.81%
1973	3.07%
1974	2.95%
1975	2.90%
1976	3.25%
1977	3.53%
1978	3.65%
1979	3.90%
1980	4.14%
1981	4.02%
1982	4.00%
1983	4.19%
1984	4.18%
1985	3.87%
1986	3.63%
1987	3.43%
1988	3.32%
1989	3.43%
1990	3.13%
1991	2.89%
1992	2.78%
1993	2.65%
1994	2.56%
1995	3.09%
1996	3.12%
1997	3.07%
1998	3.38%
1999	4.20%
2000	4.85%
2001	5.26%
2002	5.54%
2003	5.79%

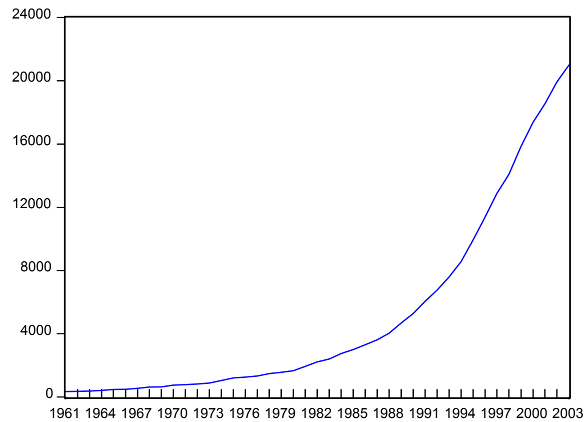

Figure 1: Per capita income at current prices

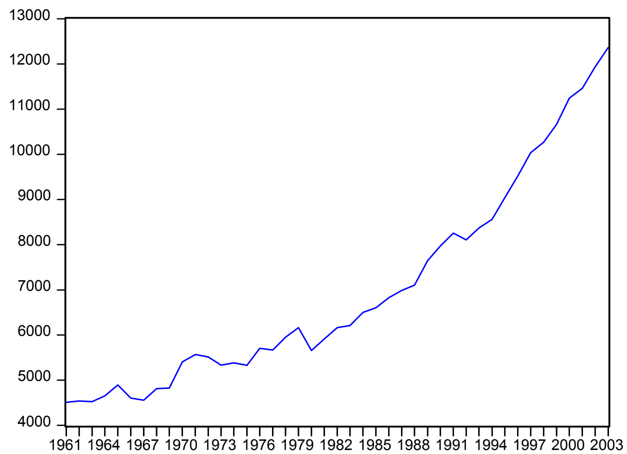

Figure 2: Per capita income at constant prices

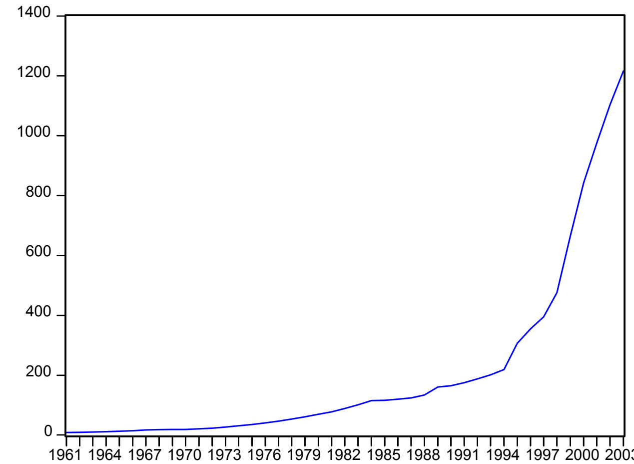

Figure 3: Private health expenditure at current prices

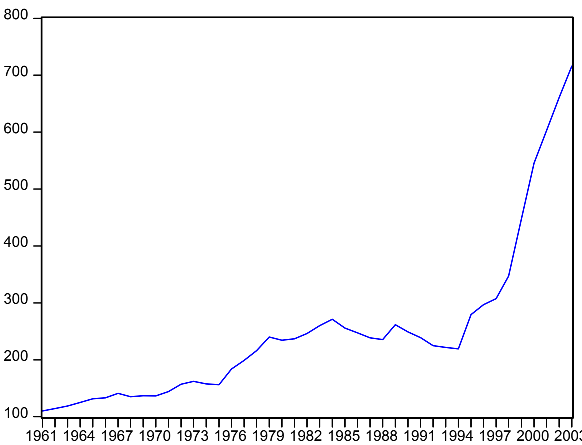

Figure 4: Private health expenditure
at constant prices

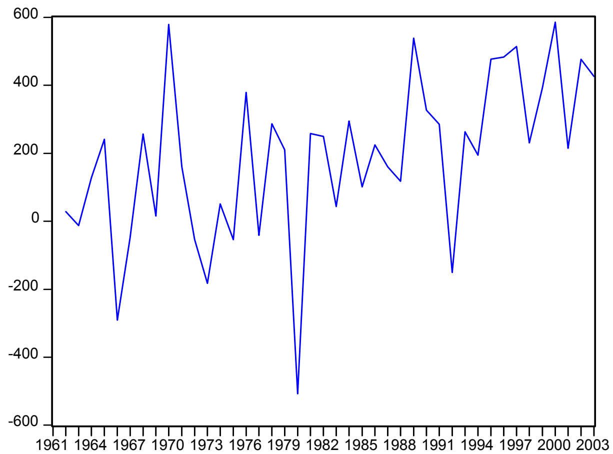

Figure 5: First difference per capita income

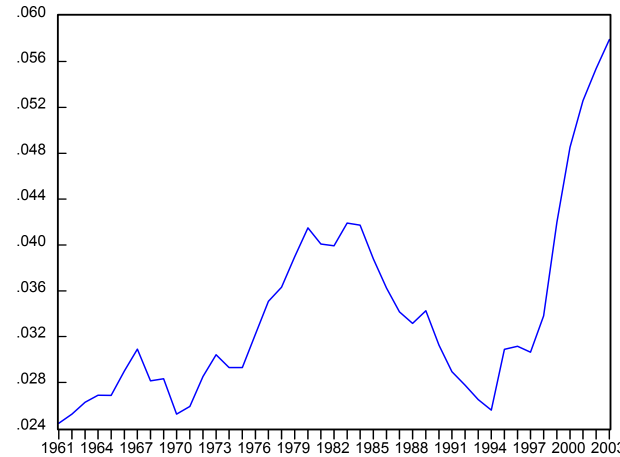

Figure 7: Private health expenditure as percent of per capita income

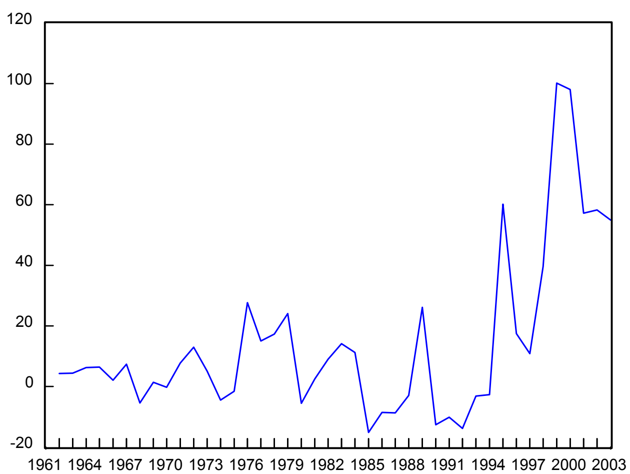

Figure 6: First difference private health expenditure

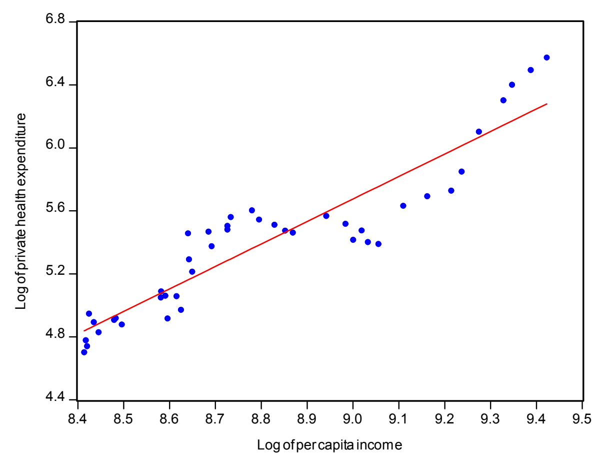

Figure 8: Per capita income and private health expenditure both at constant prices