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The Validity of Wagner's Law in Greece During the Last 2 Centuries

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Abstract

In this paper we investigate the long-run relationship between national income and government spending by using Greek data from 1833 until 2010. We use 5 different formulations of Wagner's law (the long run tendency for government expenditure to expand relative to economic growth) and find that empirical results are supportive for Wagner's law. The data set span covers a period of almost 2 centuries; the long data set thus ensures the reliability of our results in terms of statistical and economic conclusions. Furthermore, the data set covers the early periods of development of the Greek economy, a period of growth, industrialisation and modernisation of the economy, conditions which should be conducive to Wagner's law. Our analysis provides evidence of long run relationship between government spending and national income, while the Granger causality tests indicate that causality runs from the national income to spending. Moreover we include tests for structural changes to take into account regime changes that occur over time. Our empirical results are in accordance with other studies examined the validity of Wagner's law in Greece and in other economies by using long data set.

Introduction

One of the most debated issues in public economics literature is the size and the role of government activity. Over the last century the size of state activity relative to the economy has expanded in most developed and developing countries. This expansion has evoked the interest of both economists and political scientists. Hence, several theories and hypotheses have been suggested in order to explain the growth of the public economy and a large amount of empirical studies has been written. Most of the analyses have focused on the different formulations and empirical tests of the state growth over time, across countries or across group of countries (EU, OECD, Sub-Saharan). These studies have examined several features of state activity such as economic, political, institutional, fiscal and international.

The relationship between government spending and national income is very important for many economic and policy issues. Nowadays European Countries are in recession and government authorities (In Greece, Portugal and Italy) have to stimulate their economies through extra fiscal measures. The government spending and national output relationship is also crucial for the sustainability of public deficits, thus the detection of this relationship will provide a theoretical and empirical framework which can be used in order governments succeed in the budgetary objectives. It is an old issue of classical economics and many economists (Landau (1983), Barro and Sala-I-Martin (2004), Folster and Henrekson (2001)) claimed that the growth of government spending has a significant negative impact on economic growth of a country and the state activities are required to be kept on the least possible.

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Many studies have investigated the relationship between government spending and economic growth across countries (Kolluri and Wahab (2007), Shelton (2007)). A strand of literature examined the determinants of the size of government by focusing on alternative explanations such as per capita income (Borcherding (1985)) or focusing on the relative price of government provided goods and services (Baumol(1967)), on demographic factors, or the size (Alesina and Wacziarg (1998)) or finally the degree of openness of the economy. Another branch investigated the relationship between expenditure and economic growth over time (some studies focused on the description of long-run tendencies). Finally other studies Bird (1971), Georgakopoulos and Loizides (1994) attempted to estimate the elasticity of government expenditure with respect to output and tried to find evidence of the empirical test called "Wagner's law", the hypothesis that government spending increases more than proportionally with higher economic activity.

Greece during the period of our analysis was a country in the process of industrialisation and experienced a positive economic growth with increased government spending because of the rising demand for changes. These changes took place in law and order, in welfare services, in defence spending, and in the participation of the public ownership in material production. Other important assumptions of the law are the increase in population density and urbanization that led to increased state (public) expenditures and on economic regulation. Thus, the examination of the validity of Wagner's law in Greece is very important. This is the first attempt of empirical analysis of the validity of Wagner's law in Greece by using data span covers a period of almost two centuries and includes five different versions of the law. The long data set ensures the reliability of our results in terms of statistical and economic conclusions. Moreover the data set covers the early periods of development of the Greek economy which is one of the assumptions of Wagner's law. Previous researchers that examined this topic used data for short-term period and probably their results were not accurate.

The remainder of this paper is organized as follows. In section 2, we consider some of the past theoretical and empirical literature on Wagner's Law. Section 3 introduces our methodology and describes our data. Section 4 discusses data issues (including non-stationarity, cointegration and structural breaks, granger causality tests). The final section (5) provides some conclusions and suggestions for further research.

Literature review

Previous theoretical work

Over 140 year ago Adolph Wagner (1883), a German economist, formulated a "Law of expanding state expenditures", and the main point of his work is the growing importance of government activity and expenditure as an inevitable feature of a "progressive" state. A modern formulation of Wagner's "law", proposed by Bird (1971), might run as follows: as per capita income rises in industrializing nations, their public sectors will grow in relative importance.

Wagner included in his work three reasons why the development of public spending will take place. Firstly, an expansion of state expenditures would come about with respect to the administrative and protective functions of the state. His explanation based on substitution of public for private activity. After some years, new factors have been added, such as the increase in population density and urbanization, consequently that leads to increased state (public) expenditures and on economic regulation. Secondly, he explained why he predict a considerable relative expansion of "cultural and welfare" expenditures (especially redistribution of income and education). He assumed that these goods are "luxury goods", hence, the income elasticity of demand is greater than unity. Finally, Wagner claimed that the inevitable changes in technology and investment required in many activities would generate an increasing number of private monopolies. This effect would have to be offset, or the monopolies taken over, by the state interests of economic efficiency (his main example was the railroad).Wagner in his original study also recognised that the state expansion has some limits. He mentioned that the proportion between government spending and national income may not be permanently overstepped. Hence, this suggests that there must be some sort of balance in the individual's outlays for the satisfaction of his/hers various needs. He thought that there has to be an upper limit of spending as a share of national income but he noted that "all earlier attempts to lay down absolute figures of expenditure or to define an upper limit of its proportion to national income, have always miscarried" ((Cooke 1958, pp. 8)).

According to Dutt and Ghosh (1997), Wagner did not present any mathematical form in order to examine his hypothesis and he also was not explicit in the formulation of his hypothesis. However, there are several versions that tested the Wagner's hypothesis and the most important of them are the followings: Peacock and

Wiseman(1961), Gupta (1967b), Goffman (1968) , Pryor (1969), Musgrave (1969), Goffman and Mahar (1971) and Mann (1980). These different interpretations include different measures of spending (real government spending, real government consumption spending or government spending per capita) or national income (real GDP, GDP as a share of GDP, GDP per capita) and include different functional form of the relationship between state activity and income. Finally, they have different limits of the state activity, or they do not have any limits at all.

Versions of Wagner's Law

1. **Peacock-Wiseman version**

Peacock and Wiseman (1979) charted public spending against income. The validity of Wagner's "law" requires that the parameter $a_1 > 1$, a_1 is the elasticity of government expenditures with respect to output.

$$LG_t = a_0 + a_1 LY_t + e_t \qquad a_1 > 1 \qquad \textbf{(1)}$$

The following studies used this formulation: Bird (1971), Courakis et al.(1993), Mann (1980), Oxley (1994) .

Notes: LG is the log of real government expenditures, LGC is the log of real government consumption expenditure, LP is log of population, L(G/Y) is the log of the share of government spending in total output, L(Y/P) is the log of the per capita real output, L(G/P) is the log of the per capita real government expenditures ,L Y is the log of real GDP.

2. **Peacock-Wiseman share version (Mann version)**

Mann (1980)(Mann 1980) proposed a related specification of Peacock and Wiseman (1979) (Peacock, Wiseman 1979)model, the share version. In his model the share of government expenditures in total output is a function of real output. Support of Wagner's "law" requires that the elasticity of government share in total output with respect to output exceed zero, $\beta_1 > 0$.

$$L(\tfrac{G}{Y}) = \beta_0 + \beta_1 LY_t + e_t \qquad \beta_1 > 0 \qquad \textbf{(2)}$$

Goffman and Mahar (1971) and Oxley (1994) used this formulation.

3. **Musgrave version**

Another specification of Wagner's hypothesis is proposed by Musgrave (1969). According to this model, the share of real government expenditures to output is a function of real per capita output. The requirement to support Wagner's hypothesis is that the elasticity of government expenditures with respect to real output per capita exceed zero, $\gamma_1 > 0$

$$L(\mathrm{G/Y})_t = \gamma_0 + \gamma_1\, \mathrm{L(Y/P)}_t + e_t \qquad \gamma_1 > 0 \qquad \textbf{(3)}$$

This formulation used from Mann (1980), Murthy (1993) and Lin (1995).

4. **Gupta version**

Gupta (1967a) models real per capita government expenditures as a function of real per capita output. In that case, the validity of Wagner's hypothesis requires the elasticity of per capita real government expenditures with respect to real per capita output exceed unity, $\delta_1 > 1$.

$$L(\mathrm{G/P})_t = \delta_0 + \delta_1 \mathrm{L(Y/P)}_t + e_t \qquad \delta_1 > 1 \qquad \textbf{(4)}$$

This formulation is taken from Henrekson (1993).

5. **Goffman version**

Goffman and Mahar (1971) model the real government expenditures as a function of real per capita output. Support for this hypothesis requires that the elasticity of real government expenditures with respect to per capita output exceed unity, $\lambda_1 > 1$.

$$LG_t = \lambda_0 + \lambda_1 \ L(Y/P)_t + e_{\ t} \qquad \lambda_1 > 1 \qquad (5)$$

Lin (1995) used Goffman version.

6. **Pryor version**

Finally, Pryor (1969) models the real government consumption expenditures as a function of real output. The validity of Wagner's "law" requires that the elasticity of government consumption with respect to income exceed unity, $\theta_1 > 1$.

$$LGC_t = \theta_0 + \ \theta_1 LY_t + e_t \qquad \theta_1 > 1 \qquad (6)$$

Previous empirical work

Since the translation of Wagner's "law" in 1950's, a large number of authors tested various specifications of the law. These studies used both time series and cross-sectional data sets and empirically examined the law for a single country or a group of countries. Finally, there are studies using data on government expenditure at the provincial or state level (Yousefi and Abizadeh (1992)). Existing studies in this topic vary in the country selection. They used data for developed, developing countries or group of both, while most of them examined developed or industrial countries. However, during the last 5 years there are an increased number of studies examining the case of developing countries from Africa or from South Asia.

There are two types of analysis used to examine Wagner's law validity, time series and cross section analysis. Studies using time series analysis (Chletsos and Kollias (1997), Islam (2001), Liu et al. (2008)) examine the effect of the national income growth on the expansion of government expenditures over time for a particular country or group of countries. The cross-section analysis (Michas (1974), AbIzabeh and Gray (1985), Dao (1995), Shelton (2007)) investigates the relationship between national income and government expenditures across different countries at the same point in time. Bird (1971) implied that studies using cross-sectional data in order to examine the validity of Wagner's law are irrelevant, since a postulated change in the public sector happens over time. Henrekson (1993) used long-term data for the Swedish economy and claimed that the growth of public sector is a process occurring over time in a single country.

On the other hand, Michas (1975) argued that cross section analysis is more relevant because there is an examination of a number of countries and the law can be generalized. Wahab (2004) claimed that by including the cross section analysis in his study he maximized sample size and increased the power of empirical tests. Ram (1987) suggested that most authors examining developing countries prefer cross section analysis since long-time series for these countries are unavailable. However, studies using crossed section analysis in order to test developing countries and find evidence of positive relationship between national income and spending, does not necessarily mean that this country will have increased growth over time.

Several authors (Georgakopoulos and Loizides (1994), Dritsakis and Adamopoulos (2004), Katrakilidis and Tsaliki (2009)) examined the Wagner's law in Greece. During the last century, Greece was a country in the process of industrialisation. Also, there was an increase on economic growth and government spending since there was an increased demand of public services. The majority of the studies applied time series analysis in order to examine the relationship between national income and the expansions of government spending in the country. The results obtained from these studies were mixed, Georgakopoulos and Loizides (1994), Hondroyiiannis and Papapetrou (1995) found no supportive evidence of Wagner's law in Greece. On the other hand, Dritsakis and Adamopoulos (2004) and Sideris (2007) found that the law is valid, while Chletsos and Kollias (1997) and Loizides and Vamvoukas(2005) found mixed results across different versions of the law.

The majority of previous studies used post World-War II data and tested periods less than 50 years. However there are several studies (Henrekson (1993), Bohl (1996), Sideris (2007)) that examined long data sets for single countries or group of countries. One of the most important assumptions of original Wagner's hypothesis is that the tested country has to be in early stages of development, urbanisation and modernization. Hence, Wagner's law might be more applicable to newly industrialized and developing countries or developed countries by using data for the period between late 19^{th} century and World War II. During this period we expect to find support of the law in most of the countries, since they transformed their economies from rural agricultural to urban industrial with increased demand for public services (infrastructure). However, focusing on empirical results of studies that used long series we realise that results are mixed and do not follow any common pattern.

Furthermore, one might expect that any examination of the validity of Wagner's hypothesis in a developed country for the period after the World War II will lead to results indicate no support of the law. This is because most of the developed countries would have less demand for public services, since there is a weak relationship between government spending and national income in high levels of development and industrialisation. However, many studies on developed countries such as the U.K (Chow et al. (2002), U.S.A (Islam (2001)) and other developed European Union countries (Maggazino (2010)) show supportive evidence of the validity of the law for the period after World War II.

Among a large number of studies that examined Wagner's law for various countries, there have been used many methods of analysis. The most important of them are the following: ordinary least squares for stochastic modelling (Wagner and Weber (1977), Courakis et al. (1993)) cointegration approach for examining if there is any long run relationship between spending and national income (Henrekson (1993), Ansari (1997), Wahab (2004), Katrakilidis and Tsaliki (2009)) and finally Granger causality tests (Biswal et al. (1999) Sideris (2007)) for identifying the direction of the causality. The majority of the studies used recent econometric techniques such as cointegration analysis and Granger causality tests, while studies before 1985 mostly used Ordinary least squares method.

There is a large volume of literature examined the validity of Wagner's law but there is no clear pattern on the empirical results. There is a group of studies[3] that found supportive evidence of the validity of the law. Their results suggest that there is a long run relationship between national income and public spending, furthermore there is causality runs from income to growth. There is another group of empirical studies[4] found evidence that do not support the Wagner's hypothesis. They found negative relationship between economic growth or they do not find any relationship between them. There is another strand of the literature found mixed results in the relationship between spending and national income. These studies used data from different countries and found positive relationship for some of them and different results for other ones[5]. Or they used different versions of the law for a specific country but some versions support the law and other has contradictory results[6]. Finally, there are a number of studies that tested the Wagner's law against the Keynesian hypothesis. The Keynesian theoretical framework of economic growth suggests a long-run relationship between national income and government expenditures. However, this causal relationship runs from expenditures to income which is in contrast with Wagner's law. There are some studies such as Liu et al. (2008), Katrakilidis and Tsaliki (2009), Samudran et al. (2009) that found evidence of bi-directional causality between national income and government spending , hence support for Wagner's and Keynesian hypothesis. There are also some studies (Afxentiou and Serletis (1996)) that did not find any causal relationship between these variables and suggest that both hypothesis are invalid.

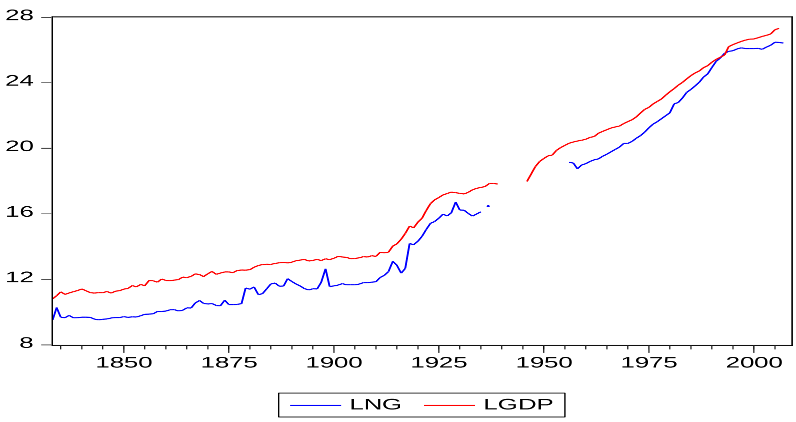
Data

Our empirical analysis has been carried out using annual data for Greece for the period 1833-2009. We employ the following variables: LG (real government spending), LGD (real GDP), LP (population), L (GDP/P) (real GDP per capita), L (G/GDP) (government spending as a share of real GDP) and L (G/P) (government spending per capita). The data that we use in our paper is for the period 1833-1935 and has been obtained from several issues of the National Accounts of Greece published by the National Statistical Service of Greece while the overall government expenditures and the overall revenues of the general government are obtained from several issues of the "Budget Proposal" which is published from the Ministry of Finance on annual basis, Dertilis (2005) and Kostelenos et al. (2007). For the period 1960-2005 the data were obtained from Greek Ministry of Finance. We examine the period 1830 to 2009 because according to Ram (1992) and Henrekson (1993) the original Wagner's hypothesis is essentially a statement about the long-run relationship between economic development and the relative size of the public activities. Thus, any empirical analysis should be based on data samples from a relatively longer time frame. The main characteristics of the economy in Greece during the last 5 decades and especially after 1974, is the weak economic activity, the high levels of gross

[3] For instance: Gyles (1991), Oxley (1994) and Dritsakis and Adamopoulos (2004).
[4] Henrekson (1993), Courakis et al. (1993), Hondroyiiannis and Papapetrou (1995).
[5] Ram (1987), Bohl (1996), Ansari (1997).
[6] Man (1980) and Chletsos and Kollias (1997).

deficits of overall government budget as percentage of GDP (1960: 0.30 %, 1970: 0.7%, 1980: 2.5%, 1990: 15.7 %, 2000: 4.10%, 2009: 14.8%) , the huge public debt (1970: 20 %, 1980: 24.4%, 1990: 74.9%, 2000: 110.2%, 2009: 133.8%). and the persistence of high inflation rates (1960: 2.3%, 1970: 1.6%, 1980: 24.4%, 1990: 20.4%, 1993: 14.4%).

Figure 1: Government spending and GDP during 1833-2009



Greek nation began its history at 1829 and was an underdeveloped area. During 1835-1860 it was the beginning of modernisation, rising infrastructure and welfare activities and development of the country. In 1864 there was an increase of population due to more peripheries added in Greek nation, while in 1925 there was another increase of the population because of the wave of Greek refugees came from Asia. During the participation of the country in World War I (1914) the government spending increased. In 1932 the Great depression impacts hit Greece and faced unsustainable large budget and trade deficits. Greek government adopted strict protectionist policies, which helped the weak Greek industries to increase their output during 1930-1940. After 1936 the Greek economy started to have again increased growth until the start of World War II. During the War the country suffered much more than other countries and the population declined for almost 8%, also Greece experienced one of the worst hyperinflation in world economic history. Thus, Greek income per capita experienced a significant decline during the period 1940-1950.

During the period 1950-1970 the "Greek Economic Miracle" took part and there was reported an average rate of economic growth of 7%, one of the highest across world, While the industrial production also increased. The most important Greek industries were: shipping, tobacco, textiles, metal and chemicals products. During 1980s economic growth declined, however was higher than the EU average. Greece joined the European Monetary Union on 2000, and during this decade faced many problems, such as huge public deficits (increased government spending), increased public debt, rising unemployment, tax evasion and corruption. Finally, government spending also increased in 2004 because of the Olympic Games in Athens.

Empirical results

Unit root tests

Before empirical work can be undertaken is required discovering if the series are stationary, the reasons for unit root testing were analysed in the methodology section. Several tests for a presence of unit roots in time-series data have appeared in literature, some of them are Dickey and Fuller (1979), Phillips-Perron (1988) tests. The first step of our analysis is to verify the order of integration of the variables since the causality tests are only valid if the variables have the same order of integration. Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests are applied in order to determine the order of integration of the tested variables. The tested series are LG (government spending), LGD (real GDP), LP (population), L (GDP/P) (real GDP per capita), L (G/GDP) (government spending as a share of real GDP) and L (G/P) (government spending per capita) for the period of 1833-2009.

Table 1: ADF and PP Unit root tests with Intercept

1833-2009(ADF							1833-2009 PP						
Variables	**t(ADF)**	**P-Value**	**Variables**	**t(ADF)**	**P-Value**	**Critical value**	**Variables**	**PP**	**P-Value**	**Variables**	**PP**	**P-Value**	**Critical value**
LG(0)**	1,88	0,99	**ΔLG(0)**	-12,02*	0	-2,88	**LG(2***)**	1,95	0,99	**ΔLG(5)**	-12,87*	0	-2,88
LGDP(3)	2,05	0,99	**ΔLGDP(2)**	-4,66*	0,0002	-2,87	**LGDP(8)**	2,68	1	**ΔLGDP(8)**	-10,31*	0	-2,87
LP(0)	-1,7	0,429	**ΔLP(0)**	-13,43*	0	-2,87	**LP(6)**	-1,83	0,36	**ΔLP(4)**	-13,44*	0	-2,87
L(G/GDP)(2)	-2,87	0,05	**ΔL(G/GDP)(3)**	-10*	0	-2,88	**L(G/GDP)(5)**	-2,6	0.25	**ΔL(G/GDP)(19)**	-48*	0,001	-2,88
L(G/P)(2)	2,046	0,99	**ΔL(G/P)(1)**	-12,06*	0	-2,88	**L(G/P)(16)**	1,62	0,99	**ΔL(G/P)(3)**	-18,57*	0	-2,88
L(GDP/P)(0)	4,55	1	**ΔL(GDP/P)(2)**	-4,78*	0,0001	-2,87	**L(GDP/P)(7)**	3,11	1	**ΔL(GDP/P)(8)**	-11,04*	0	-2,87

Note: * indicate rejection of the null hypothesis at the 5% level of significance. .** parentheses in ADF indicate the lag length based on SIC.***Parentheses in PP indicate the Bandwinth, Newey-West using Barlett kernel

Table 2: ADF and PP Unit root tests with trend and intercept

1833-2009 ADF							1833-2009 PP						
Variables	**t(ADF)**	**P-Value**	**Variables**	**t(ADF)**	**P-Value**	**Critical value**	**Variables**	**PP**	**P-Value**	**Variables**	**PP**	**P-Value**	**Critical value**
LG(0)**	-1.56	0.802	**ΔLG(0)**	-13.49*	0.0000	-3.43	**LG(1***)**	-1.54	0.809	**ΔLG(3)**	-13.59	0.0000	-3.43
LGDP(3)	-1.229	0.900	**ΔLGDP(2)**	-5.36*	0.0001	-3.43	**LGDP(8)**	-1.39	0.85	**ΔLGDP(7)**	-10.97	0.0000	-3.43
LP(0)	-0.90	0.952	**ΔLP(0)**	-13.58*	0.0000	-3.43	**LP(5)**	-0.73	0.968	**ΔLP(6)**	-13.70	0.0000	-3.43
L(G/GDP)(0)	-2.50	0.090	**ΔL(G/GDP)(0)**	-9.99*	0.0000	-3.44	**L(G/GDP)(4)**	-2.55	0.08	**ΔL(G/GDP)(9)**	-23.26	0.0001	-3.44
L(G/P)(3)	-1.22	0.90	**ΔL(G/P)(2)**	-5.36*	0.0001	-3.43	**L(G/P)(10)**	-1.53	0.812	**ΔL(G/P)(11)**	-20.01	0.0000	-3.43
L(GDP/P)(0)	-1.00	0.93	**ΔL(GDP/P)(0)**	-11.54*	0.0000	-3.43	**L(GDP/P)(7)**	-1.084	0.927	**ΔL(GDP/P)(7)**	-11.80	0.0000	-3.43

Note: * indicate rejection of the null hypothesis at the 5% level of significance. .** parentheses in ADF indicate the lag length based on SIC.***Parentheses in PP indicate the Bandwinth, Newey-West using Barlett kernel

Table 1 presents the results of ADF and PP unit root test conducted with intercept on the logged values of the tested series. These results show that all the series were found to have a unit root and are non–stationary at the 5% level and the hypothesis of existence of a unit root cannot be rejected. However, the unit root test for the first difference of the series in both unit root tests (ADF and PP with intercept) shows evidence of stationarity and the rejection of the hypothesis for the existence of a unit root in all the tested series. Thus, is considered that according the ADF and PP with intercept, all the series are integrated of first order. In Table 2 are reported the results of ADF and PP tests with intercept and trend which also indicate that all the tested series are integrated I (1).

Unit root test with breaks

The long–run relationship between two tested variables can be affected by the presence of structural breaks in the data. These possible breaks can be a result of economic regime or a change in the factors (government spending, taxation, population etc.) that determine and affect the tested series. Hence, if structural breaks are not taken into account when investigating the existence of a long–run relationship, there is a possibility that linear methods may fail to confirm the relationship when in fact it does exist. We use the term “structural change” in the sense that the values of the parameters of our model do not remain the same through entire the tested time period of 1833-2009. Sometimes the change may be due to external forces, or changes in the government policy or any other.

In the context of this paper, if we will not take account the possible structural breaks the Johansen cointegration approach may fail to establish a relationship between spending and national income. Thus the accounting of structural breaks could help establish the robustness of our empirical results. To identify these breaks, we will use Zivot and Andrews test and Recursive Chow test. The empirical results of our unit root tests (ADF and PP) assume that there is no structural break in our tested series. However this may not be the case in some countries (Afonso (2005b)). Correia et al. (2008) claim that since we are analysing a long time series, we cannot assume that the time series properties remain constant over the entire sample period. In the presence of structural changes in the trend function, the unit root tests such as ADF and PP do not take into account the break in the series and as result they have low power and are biased toward the non-rejection of a unit root. Zivot and Andrews (1992) recursive approach is used in order to examine the null hypothesis that series have a unit root against the alternative of stationarity with structural change at some unknown break date denoted by T_b. The break date is chosen endogenously as the value, over all possible break points, which minimises the test statistic for testing $\rho = 1$ for the following regression:

$$\mathbf{Y_t = \mu + \beta t + \rho Y_{t-1} + \theta DU_t + \gamma DT_t + \delta D(T_b)_t + \sum_{i=1}^{k} c_i \Delta Y_{t-1} + \varepsilon_t} \qquad \textbf{(15)}$$

Where DT_t is the shift in trend and is equal with t-$T_b$if t > T_b and 0 otherwise, DU_t is the shift in the mean and $DU_t = 1$ if t > $T_b$and 0 otherwise. T_b is equals one at the observation after the break point, while the additional one-time dummy $D(T_b)_t$*=1* if *t=* T_b*+1* and 0 otherwise. This "innovational outlier" model specifies that the change to the new trend function is gradual. Table 2 reports the ADF test statistics proposed by both Zivot and Andrews (1992) for the best fitted regression, alongside the estimated break dates.

Table 3: Zivot and Andrews test, Wagner's law

1833-2009		
Variable	***Break date***	**ADF Break point test**
LG	*1973*	-3,26*
LGDP	*1867*	-2,78*

The number of lags in the unit root tests selected as 0 through AIC and SBC. Critical values for testing the unit root null hypothesis are taken from Zivot and Andrews (1992). Furthermore, the results indicate that the null of non-stationarity can be rejected at 5% level of significance. According to Zitov and Adrews test the break date for LG is at 1973, while for LGDP is at 1867.

This Chow test considers the estimation of multiple structural changes in linear models and is considered an improvement to the classical test attributed to Chow (1960). According to Hansen (2001) and Afonso (2005b), the Chow procedure splits the sample into two sub-periods, estimates the parameters of the model in each sub-period. Finally, the two sets of parameters are tested by using standard F-statistics in order to determine statistical differences. One problem with this procedure is that the break point will have to be known before the separation for the sub-periods. Hansen (2001) considered two options to identify the possible structural breaks. Firstly, an arbitrary choice of the break date, however this approach might lead in a break date which is not accurate. Secondly, the usage of a known event in the data to expose the possible break dates, however even in this option the break dates could be inaccurate. Finally Afonso (2005a) implied that there is a major problem that the degrees of freedom are diminished for each of the parts.

The Chow test (1960) assumes that: the residuals from the two sub-period regressions are normally distributed with the same variance and that the residuals are independently distributed. We obtain the F value of the test and then we conclude if there is or not a structural change in our model. Our null hypothesis is that there are no structural changes at specified breakpoints. We reject the null hypothesis if the calculated F value is higher than the critical F value. In our model the critical value is 3.07 for the first period (1833-2009). Our empirical results (Figure 5) of Chow test for the logged values of government spending and GDP indicate that the break points in LG are 1836, 1905, 1917, while in LGDP are 1843, 1894 and 1972.

Figure 2: Chow test for GDP

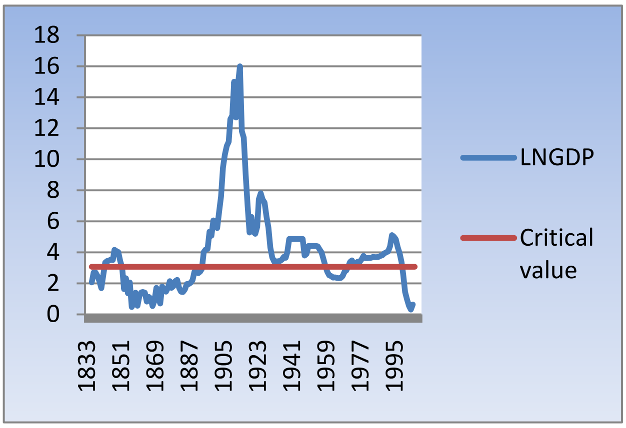
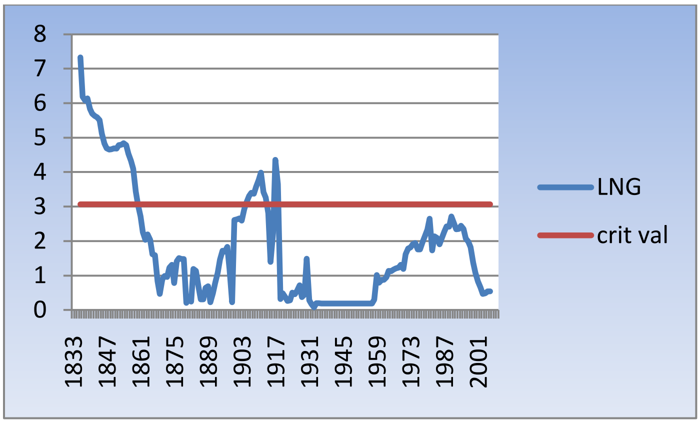


Figure 3: Chow test for Government spending



Cointegration

Johansen's cointegration approach uses the maximum likelihood estimation in a VAR model. There are two statistics created by this approach: the trace statistic and maximum Eigenvalue. The Trace statistic examine the null hypothesis that there is at most r number of cointegrating vectors and the alternative hypothesis of r or more than r number of cointegrating vectors. The maximum Eigenvalue statistics examine for r number of cointegrating vectors against the alternative of r+1 number of cointegrating vectors. The Johansen's cointegration test will demonstrate if there exists a long run relationship between government spending and national income.

We found evidence from ADF and PP tests that all the series are integrated of order one (I(1)). We will test the five specifications of the Wagner's law that are available in the literature. Firstly, will have five two dimensional VARs for the 5 versions. In order to determine the optimal number of lags in the 5 VARs, which is very important ensure that the residuals are uncorrelated and homoskedastic across time. We try several selection criteria[7], with each test performed at the five percent significance level. In Table 7 (see Appendix) are illustrated the results of these criteria[8]. Moreover we include one dummy variable (D1894)[9] in order to account for specific structural breaks in the Greek economy (GDP) during the tested period. In all the estimated models the dummy is kept in the respective VARs as they turned to be significant, whereas its absence will mean non normal residuals for the relevant VARs. Finally, VARs satisfy all the statistical assumptions required for the Johanshen approach and we can apply the cointegration analysis. In table 8 (see Appendix) are reported the diagnostic tests for heteroskedasticity and autocorrelation in all the VARs.

The results of Johansen approach are reported at tables 9, 10, 11, 12, 13 for all the models and indicate that there is one cointegration vector between the tested series during 1833-2009. This happens because we reject the null hypothesis that r=0, so we have at least one cointegrating vector.

Table 4: Calculated income elasticities from Johansen approach

Peacock version	**LG**	**LGDP**	**St. Errors**
	1	1,27	-0,136
Goffman version	**LG**	**L(GDP/P)**	**St. Errors**
	1	1,43	0,31
Gupta version	**L(G/GDP)**	**L(GDP/P)**	**St. Errors**

7 A sequentially modified Likelihood Ratio (LR) test, a Final Prediction Error (FPE) test, an Akaike Information Criterion (AIC) test, the Hannan-Quinn (HQ) Information Criterion test, and the Schwartz Information Criterion (SIC) test

8 The criteria indicate that the optimal number of lags are 5 for Peacock and Goffman versions, 1 lag for Musgrave and Gupta versions and 8 for Mann version.

9 We included only one dummy variable because with more (3 or 4) we had non-normal residuals in VARs, hence our results would be inaccurate.

	1	1,22	0,16	
Musgrave version	**L(G/P)**	**L(GDP/P)**	**St. Errors**	
	1	0,22	0,16	
Mann version	**L(G/GDP)**	**LGDP**	**St. Errors**	
	1	0,27	0,17	

Table 4 interpret the calculated income elasticities in 5 versions of the law. Our results are in accordance with theory, the income elasticities derived from versions of Peacock, Goffman and Gupta are exceed unity. While, the calculated income elasticities of Musgrave and Mann versions are exceed zero. Versions of Peacock and which express the hypothesis in absolute terms, the estimated income elasticity implies that an increase in income (GDP) will lead to an almost equal expenditure rise (1.2). In versions of Musgrave and Gupta which express the hypothesis in per capita values we can conclude that government expenditures are clearly output elastic. Finally in Goffman's version an increase of 1% growth of income per capita will lead to an increase of 1.43% in government spending.

One other simple method of cointegration is Engle-Gragner (EG) or Augmented Engle-Gragner (AEG) test (1987). This approach is based in the idea that if there is a cointegration between the variables, the residuals that will be obtained from OLS equations, has to be stationary. So, in order to test for long run relationship between the variables government spending and GDP, we are testing the stationarity of residuals with the help of ADF.

All the calculated income elasticities have values consistent with the hypotheses as expressed in the theoretical models. The calculated coefficients of Peacock, Goffman and Gupta versions have to exceed unity and coefficients of Mann version and Musgrave version have to exceed zero. As expected and accordance to the literature the calculated b of the version Mann is equal with the b of the Peacock version minus 1 (1.06-1=0.06) and the coefficient of Musgrave is equal with the coefficient of Gupta minus 1(1.07-1=0.07). Table 14 (see Appendix) illustrates the calculated elasticities from Engle and Granger method.

The elasticities of each version are:

$$E\ (Peacock) = \frac{\left\{\frac{d(lnG_t)}{d(lnY_t)}\right\}}{\left\{\frac{lnG_t}{lnY_t}\right\}} = 1.064,\ E\ (Mann) = \frac{\left\{\frac{d(\ln(\frac{G}{Y})t)}{d(lnY_t)}\right\}}{\left\{\frac{\ln(\frac{G}{Y})t}{lnY_t}\right\}} = 0.065,\ E\ (Musgrave) = \frac{\left\{\frac{d(\ln(\frac{G}{Y})t}{d(\ln(Y/P)_t)}\right\}}{\left\{\frac{\ln(\frac{G}{Y})t}{\ln(Y/P)_t}\right\}} = 0.076,$$

$$E\ (Gupta) = \frac{\left\{\frac{d(\ln(G/P)_t)}{d(\ln(Y/P)_t)}\right\}}{\left\{\frac{\ln(G/P)_t}{\ln(Y/P)_t}\right\}} = 1.07,\ E\ (Goffman) = \frac{\left\{\frac{d(lnG_t)}{d(\ln(Y/P)_t)}\right\}}{\left\{\frac{lnG_t}{\ln(Y/P)_t}\right\}} = 1.257$$

We are testing if the residuals $e_t = -lnG_t - c - blnY_t$ have a unit root, by performing a unit root test. The results reported in Table 15 (see Appendix) indicate that we cannot reject the null hypothesis that there is unit root in 5% critical value for the tested period. Since the computed t value for the first period is much higher than the critical value, our conclusion is that the residuals from the equation ($lnG_t = c + blnY_t + e_t$) are stationary. According to Gujarati (Gujarati 2003), hence the equation ($lnG_t = c + blnY_t + e_t$)) is a cointegrating regression and this regression is not spurious. Hence, we can reject the null hypothesis for the tested period, so ε_t is stationary and there is evidence of long run relationship between government spending and GDP.

Granger causality tests

We discussed in methodology section that if two variables are cointegrated, we can use the Granger causality test (Granger 1969) in order to check the short run relationship between variables. The Granger causality test examine whether variable Y's current value can be explained by its own past value and whether the explanatory power could be improved by adding the past value of another variable X. If the coefficient of X is statistically significant, X is said to Granger cause Y.

The Granger causality test is very sensitive to the lags used in the OLS regressions (Gujarati 2003)). In our analysis, various lag length selection criteria are used in order to determine the lags for Granger causality test.

The tests we use are the following: LR – sequential modified LR test statistic, FPE – Final prediction error, AIC – Akaike information criterion, SC – Schwarz information criterion and HQ – Hannah-Quinn information criterion. These tests determined one lag.

We run the Granger causality test for all the versions of the law by using 5 lags for Peacock-Wiseman and Goffman versions, 1 lag for Musgrave and Gupta versions and 8 for Mann version, in order to ensure uncorrelated residuals. We found in the previous section that there is one cointegration vector for all the models, so we can define the Granger causality tests as joint test (F-tests) for the significance of the lagged value of the assumed exogenous variable and for the significance of the error correction term. The results are reported in table 6 and indicate that Granger causality is running from income to spending in Peacock, Musgrave, Gupta and Mann versions and so provide support of the validity of Wagner's law. In Goffman version there is evidence of bilateral causality between the two tested variables.

Table 5: Granger causality test, Wagner's Law

		F-stat	P-value		F-stat	P-value
Peacock Version	**LGDP causes LG**	18,67*	0	**LG causes LGDP**	1,13	0,32
Goffman Version	**L(GDP/P) causes LG**	3,8*	0,02	**LG causes L(GDP/P)***	4,9	0,0087
Musgrave Version	**L(GDP/P) causes L(G/GDP)**	8,96*	0,0002	**L(G/GDP) causes L(GDP/P)**	0,82	0,43
Gupta Version	**L(GDP/P) causes L(G/P)**	17,26*	0,82	**L(G/P) causes L(GDP/P)**	0,82	0,43
Mann Version	**LGDP causes L(G/GDP)**	9,37*	0,0001	**L(G/GDP) causes LGDP**	1,13	0,324

Note: * indicate rejection of the null hypothesis at the 5% level of significance.

According to the Greek economy, the government expenditures consists the highest determinant of GDP, for instance in 2005 the government expenditure as a share of GDP was about 43%. Thus, we disaggregate the government expenditures from GDP and create a new variable GDPGG. We run the same tests; unit root tests, Johansen and Engle-Granger techniques and we obtained the same empirical results as those which the government spending is included in GDP[10]. In Table 6 we presented the Granger causality test with the new variables (GDP-G), and we can see that the results now are clearer and according to all tested versions there is support of the validity of the law. In the previous table, one version supported the bi-directional causality between spending and GDP.

Table 6: Granger causality test when government spending is subtracted from GDP.

		F-stat	P-value		F-stat	P-value
Peacock Version	**LGDP causes LG**	13.91*	0.00	**LG causes LGDP**	0.87	0.42
Goffman Version	**L(GDP/P) causes LG**	3.26*	0.01	**LG causes L(GDP/P)**	2.39	0.09
Musgrave Version	**L(GDP/P) causes L(G/GDP)**	5.19*	0.00	**L(G/GDP) causes L(GDP/P)**	0.92	0.39
Gupta Version	**L(GDP/P) causes L(G/P)**	11.15*	0.00	**L(G/P) causes L(GDP/P)**	0.91	0.40
Mann Version	**LGDP causes L(G/GDP)**	4.84*	0.00	**L(G/GDP) causes LGDP**	1.92	0.14

Note: * indicate rejection of the null hypothesis at the 5% level of significance.

[10] These results can be provided upon request.

Conclusion and future research

In this paper we investigate the long-run relationship between national income and government spending by using Greek data from 1833 until 2010. We have used 5 different formulations of the law and find that the estimated signs and magnitudes are supportive for the Wagner's law. One very important advantage of this empirical analysis is that the data set span covers a period of almost 2 centuries; the long data set thus ensures the reliability of our results in terms of statistical and economic conclusions. Moreover the data set covers the early periods of development of the Greek economy which is one of the assumptions of Wagner's law. In our analysis we used the most recent econometric techniques such as unit root tests (ADF and PP) in order to examine the stationarity of time series because the presence of non-stationary regressors invalidates many standard hypotheses tests. Moreover we included unit root tests with structural breaks. Since we are analysing a long time series, we cannot assume that the time series properties remained constant over the entire sample period. In the presence of structural changes in the trend function, the unit root tests such as ADF and PP do not take into account the break in the series and as result they have low power and are biased toward the non-rejection of a unit root.

Secondly we have use the Johansen cointegration technique and the Engle-Granger approach in order to examine if there is a long run relationship between the tested variables in the 5 different versions of the law and find that the tested variables are cointegrated. Furthermore, we calculate the income elasticities by using both the cointegration approaches. The results of all tested versions are in accordance with the theory and provide support of the validity of Wagner's law. At the last stage of our empirical analysis we use the Granger causality tests and examine the direction of causality between the tested variables. Our empirical results indicate that Granger causality is running from income to spending in Peacock, Musgrave, Gupta and Mann versions, hence provide support of the validity of Wagner's law. In Goffman version we find a bilateral causality between the two tested variables, which mean that in this model we found evidence that support Wagner's law and Keynesian hypothesis.

Our empirical results are in accordance with those reported by Dritsakis and Adamopoulos (2004), Loizides and Vamvoukas (2005), Sideris (2007) and support the Wagner's law, while are in contrast with those found by Courakis et al. (1993), Georgakopoulos and Loizides (1994), Hondroyiannis and Papapetrou (1995) and Katrakilidis and Tsaliki (2009). Greece during the period of our analysis was a country in the process of industrialisation and experienced a positive economic growth with increased government spending because of the rising demand for changes. These changes took place in law and order, in the welfare services, in the defence spending, and in the participation of the public ownership in material production. Other important assumptions of the law are the increase in population density and urbanization that led to increased state (public) expenditures and on economic regulation. However, the Wagner's law analysis concerns especially to the new European countries that joined the European Union and not the developed previous countries member. The results of the Goffman version indicate that the Keynesian hypothesis proves to be true in Greece and means that the public sector and the government spending have positive impact on economic growth and development of a country. Thus, countries can increase their growth if they increase the spending in infrastructure, education and increase the investment. For future research, it would be interesting to investigate the relationship between various levels of government expenditures such as government transfer, warfare expenditure and the economic growth of an economy. Furthermore, it's worth also to investigate whether our empirical results can be generalized to other similar economies.

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Appendix 1:

Table 7: VAR Lag Order Selection Criteria

	VAR Lag Order Selection Criteria					
	Peacock Version					
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	-3.133.645	NA	0.019670	4.584993	4.648629	4.610853
1	263.7457	1120.765	5.22e-06	-3.648.488	-3.393944*	-3.545048*
2	268.6529	9.316632	5.55e-06	-3.589.172	-3.143.721	-3.408.152
3	277.5025	16.41656	5.56e-06	-3.586.992	-2.950.633	-3.328.391
4	295.5055	32.61416	4.88e-06	-3.717.471	-2.890.203	-3.381.290
5	312.6926	30.38888*	4.34e-06*	-3.836125*	-2.817.950	-3.422.364
6	318.1300	9.377528	4.58e-06	-3.784.493	-2.575.410	-3.293.152
7	320.0272	3.189433	5.10e-06	-3.681.553	-2.281.562	-3.112.632

8	322.7452	4.451175	5.60e-06	-3.590.509	-1.999.611	-2.944.008
	Goffman version					
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	-3.747.493	NA	0.047883	5.474627	5.538263	5.500487
1	241.9886	1197.723	7.16e-06	-3.333.169	-3.078625*	-3.229729*
2	243.7476	3.339438	7.96e-06	-3.228.226	-2.782.774	-3.047.205
3	253.2137	17.56039	7.91e-06	-3.234.982	-2.598.622	-2.976.381
4	271.7065	33.50136	6.90e-06	-3.372.558	-2.545.290	-3.036.377
5	289.4827	31.43046*	6.08e-06*	-3.499.750	-2.481.575	-3.085.989
6	298.6120	15.74461	6.08e-06	-3.501623*	-2.292.540	-3.010.281
7	300.8208	3.713405	6.73e-06	-3.403.200	-2.003.209	-2.834.278
8	303.4038	4.230121	7.42e-06	-3.310.200	-1.719.301	-2.663.698
	Musgrave version					
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	-3.444.177	NA	0.030851	5.035039	5.098674	5.060899
1	167.8859	994.9084	2.10e-05*	-2.259216*	-2.004673*	-2.155776*
2	169.9174	3.856762	2.32e-05	-2.158.223	-1.712.771	-1.977.202
3	173.5603	6.757872	2.51e-05	-2.080.584	-1.444.224	-1.821.983
4	182.1033	15.47650	2.53e-05	-2.073.961	-1.246.694	-1.737.780
5	190.0177	13.99353	2.57e-05	-2.058.227	-1.040.052	-1.644.466
6	190.9269	1.568081	2.90e-05	-1.940.970	-0.731887	-1.449.628
7	193.6246	4.535331	3.18e-05	-1.849.633	-0.449642	-1.280.711
8	227.0428	54.72830*	2.24e-05	-2.203.519	-0.612620	-1.557.017
	Gupta Version					
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	-3.444.177	NA	0.030851	5.035.039	5.098.674	5.060.899
1	1.678.859	9.949.084	2.10e-05*	-2.259216*	-2.004673*	-2.155776*
2	1.699.174	3.856.762	2.32e-05	-2.158.223	-1.712.771	-1.977.202
3	1.735.603	6.757.872	2.51e-05	-2.080.584	-1.444.224	-1.821.983
4	1.821.033	1.547.650	2.53e-05	-2.073.961	-1.246.694	-1.737.780
5	1.900.177	1.399.353	2.57e-05	-2.058.227	-1.040.052	-1.644.466
6	1.909.269	1.568.081	2.90e-05	-1.940.970	-0.731887	-1.449.628
7	1.936.246	4.535.331	3.18e-05	-1.849.633	-0.449642	-1.280.711
8	2.270.428	54.72830*	2.24e-05	-2.203.519	-0.612620	-1.557.017
	Mann Version					
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	-3.651.089	NA	0.041639	5.334911	5.398547	5.360771
1	182.1753	1062.842	1.70e-05	-2.466.309	-2.211765*	-2.362868*
2	186.5951	8.391204	1.82e-05	-2.399.929	-1.954.477	-2.218.908
3	193.2437	12.33362	1.89e-05	-2.365.851	-1.729.491	-2.107.250
4	201.2015	14.41635	1.92e-05	-2.350.747	-1.523.479	-2.014.566
5	212.6653	20.26923	1.85e-05	-2.386.453	-1.368.278	-1.972.692
6	214.4220	3.029746	2.06e-05	-2.281.478	-1.072.395	-1.790.137
7	216.1457	2.897750	2.30e-05	-2.176.024	-0.776033	-1.607.103
8	251.4468	57.81207*	1.57e-05*	-2.557201*	-0.966302	-1.910.699

*** indicates lag order selected by the criterion**

LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 8: Diagnostic Tests

	Heteroskedasticity	F-critical	Autocorrelation		
Peacock Version	F(13,134)= 1,01	2,19		**LM-STAT**	**Critical (Chi-sq)(df=9)**
Goffman Version	F(16,133)=1,72	2,19	**Peacock Version**	15,47	16,91
Musgrave Version	F(16,133)=0,32	2,19	**Goffman Version**	4,5	16,91
Gupta Version	F(16,133)=0,46	2,19	**Musgrave Version**	7,41	16,91
Mann Version	F(16,133)=0,41	2,19	**Gupta Version**	7,41	16,91
		Chi-sq critical	**Mann Version**	11,87	16,91
Peacock Version	Chi-sq(13)=13,21	22,36			
Goffman Version	Chi-sq(16)=24,72	26,29			
Musgrave Version	Chi-sq(16)=5,96	26,29			
Gupta Version	Chi-sq(16)=7,91	26,29			
Mann Version	Chi-sq(16)=7,20	26,29			

Table 9: Cointegration test on Peacock Version, Wagner's law

1833-2009									
Unrestricted Cointegration Rank Test (Trace)					**Unrestricted Cointegration Rank Test (Maximum Eigenvalue)**				
Hypothesized		**Trace**	**0.05**		**Hypothesized**		**Max-Eigen**	**0.05**	
No. of CE(s)	**Eigenvalue**	**Statistic**	**Critical Value**	**Prob.****	**No. of CE(s)**	**Eigenvalue**	**Statistic**	**Critical Value**	**Prob.****
r=0	0.1833	43.99*	35.01	0.043	**r=0**	0.1833	29.169*	24.25	0.0103
r=1	0.087	14.82	18.39	0.1473	**r=1**	0.087	13.24	17.14	0.1692
r=2	0.010	1.57	3.841	0.2093	**r=2**	0.010	1.57	3.841	0.2093

Note: * indicate rejection of the null hypothesis at the 5% level of significance.

Table 10: Cointegration test on Goffman Version, Wagner's law

1833-2009									
Unrestricted Cointegration Rank Test (Trace)					**Unrestricted Cointegration Rank Test (Maximum Eigenvalue)**				
Hypothesized		**Trace**	**0.05**		**Hypothesized**		**Max-Eigen**	**0.05**	
No. of CE(s)	**Eigenvalue**	**Statistic**	**Critical Value**	**Prob.****	**No. of CE(s)**	**Eigenvalue**	**Statistic**	**Critical Value**	**Prob.****
r=0	0.1817	45.52*	35.01	0.0027	**r=0**	0.1817	28.89*	24.25	0.0113
r=1	0.102	16.63	18.39	0.0867	**r=1**	0.102	15.58	17.14	0.0833
r=2	0.007	1.056	3.841	0.3040	**r=2**	0.007	1.056	3.841	0.3040

Note: * indicate rejection of the null hypothesis at the 5% level of significance.

Table 11: Cointegration test on Musgrave Version, Wagner's Law

1833-2009	
Unrestricted Cointegration Rank Test (Trace)	**Unrestricted Cointegration Rank Test (Maximum Eigenvalue)**

Hypothesized		Trace	0.05		Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**	No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
r=0	0.1921	41.68*	35.01	0.0084	**r=0**	0.1921	33.708*	24.25	0.021
r=1	0.048	7.97	18.39	0.6852	**r=1**	0.048	17.14	17.14	0.6234
r=2	0.001	0.16	3.841	0.6863	**r=2**	0.001	3.841	3.841	0.6863

Note: * indicate rejection of the null hypothesis at the 5% level of significance.

Table 12: Cointegration test on Gupta Version, Wagner's law

1833-2009									
Unrestricted Cointegration Rank Test (Trace)					**Unrestricted Cointegration Rank Test (Maximum Eigenvalue)**				
Hypothesized		**Trace**	**0.05**		**Hypothesized**		**Max-Eigen**	**0.05**	
No. of CE(s)	**Eigenvalue**	**Statistic**	**Critical Value**	**Prob.****	**No. of CE(s)**	**Eigenvalue**	**Statistic**	**Critical Value**	**Prob.****
r=0	0.1913	44.19*	35.010	0.0040	**r=0**	0.1913	30.58*	24.25	0.0064
r=1	0.0822	13.61	18.39	0.2052	**r=1**	0.0822	12.35	17.14	0.2179
r=2	0.0087	1.261	3.841	0.2614	**r=2**	0.0087	1.261	3.841	0.2614

Note: * indicate rejection of the null hypothesis at the 5% level of significance.

Table 13: Cointegration test on Mann Version, Wagner's law

1833-2009									
Unrestricted Cointegration Rank Test (Trace)					**Unrestricted Cointegration Rank Test (Maximum Eigenvalue)**				
Hypothesized		**Trace**	**0.05**		**Hypothesized**		**Max-Eigen**	**0.05**	
No. of CE(s)	**Eigenvalue**	**Statistic**	**Critical Value**	**Prob.****	**No. of CE(s)**	**Eigenvalue**	**Statistic**	**Critical Value**	**Prob.****
r=0	0.1935	46*	35.01	0.0023	**r=0**	0.1935	30.97*	24.25	0.0056
r=1	0.087	15.035	18.39	0.1389	**r=1**	0.087	13.11	17.14	0.1760
r=2	0.0132	1.92	3.841	0.1655	**r=2**	0.0132	1.92	3.841	0.1655

Note: * indicate rejection of the null hypothesis at the 5% level of significance

Table 14: Engle-Granger technique in 5 versions of Wagner's Law(1st step)

Peacock Version	**Coefficient**	**t-stat**	**Std.Error**	**Mann Version**	**Coefficient**	**t-stat**	**Std.Error**
LGDP	1,064	-223,4	0,004	**LGDP**	0.065	9.87	0.006
C	-2,43	(-29,1)	0,083	**C**	-2.44	-21.16	0.115
N	155			**N**	155		
R-squared	0,99			**R-squared**	0.38		
Adjusted R-squared	0,99			**Adjusted R-squared**	0.38		
Durbin-Watson	0,63			**Durbin-Watson**	1.15		
F-stat	49927,2			**F-stat**	97.47		
Musgrave Version	**Coefficient**	**t-stat**	**Std.Error**	**Gupta Version**	**Coefficient**	**t-stat**	**Std.Error**
LGDP/P	0.076	-9.844	0,007	**LGDP/P**	1,076	137.7	0,007
C	-1.48	- 39.69	0,037	**C**	-1.48	-39.69	0,037
N	155			**N**	155		
R-squared	0,38			**R-squared**	0,99		
Adjusted R-squared	0,38			**Adjusted R-squared**	0,99		
Durbin-Watson	1.15			**Durbin-Watson**	1.15		

F-stat	96.91			**F-stat**	18970.3
Goffman Version	**Coefficient**	**t-stat**	**Std.Error**		
LNGDP/P	1,257	128.9	0,009		
C	13.25	284.04	0,046		
N	155				
R-squared	0,99				
Adjusted R-squared	0,99				
Durbin-Watson	0,23				
F-stat	16633.03				

Table 15: Unit root tests in residuals (Engle-Granger 2nd step)

Peacock Version		**Mann Version**	
t-statistic	-5.37* (0.00)	t-statistic	-7.79* (0.00)
t-critical	-2,88	t-critical	-2,88
Conclusion	Stationary	Conclusion	Stationary
Musgrave Version		**Gupta Version**	
t-statistic	-7.77* (0.00)	t-statistic	-7.77 *(0.00)
t-critical	-2,88	t-critical	-2,88
Conclusion	Stationary	Conclusion	Stationary
Goffman Version			
t-statistic	-2.92* (0.00)		
t-critical	-2,88		
Conclusion	Stationary		

Note: * indicate rejection of the null hypothesis at the 5% level of significance.