University of Victoria
Department of Economics

Econometrics Working Paper EWP0501

ISSN 1485-6441

GOVERNMENT SIZE AND ECONOMIC GROWTH: TIME-SERIES EVIDENCE FOR THE UNITED KINGDOM, 1830-1993

Wing Yuk

Department of Economics, University of Victoria
Victoria, B.C., Canada V8W 2Y2

January, 2005

Abstract

This study considers the long-run relationship between government expenditure and economic growth for the United Kingdom over the period 1830 to 1993. The causality analysis allows for the effects of exports, and for the presence of complex structural breaks in the data. The results support the export-led growth hypothesis. Although support for Wagner's Law is sensitive to the choice of sample period, there is evidence that GDP growth Granger-causes the share of government spending in GDP indirectly through exports' share of GDP during the period 1870-1930.

Keywords: Wagner's Law; Granger causality; size of government; structural breaks

JEL Classifications: C32, H50, O4

Author Contact:
Wing Yuk, P.O. Box 37063 RPO, Vancouver, BC, Canada V5P 4W7.
Tel: +1-604-782-8081; email: wingyuk2004@yahoo.com

I. INTRODUCTION

Economic growth is one of the most fascinating topics in macroeconomics. Among the factors that determine the growth of an economy, government spending is of particular interest in this paper. Empirical studies of the impact of government expenditure on long-run economic growth include, among others, Feder (1983), Landau (1983), Ram (1986), Grier and Tullock (1989), Romer (1990), Barro (1990, 1991), Levine and Renelt (1992), Devarajan *et al.* (1996), and Sala-i-Martin (1997). Most of these studies used cross-section data to link measures of government spending with economic growth rates. The disadvantage of such studies is that "cross-sectional analysis can identify correlation but not causation between variables" (Hsieh and Lai, 1994) because it provides only "pooled estimates of the effects of government size on economic growth" (Ghali, 1999), and it fails to disentangle the effects for each country.

Traditional OLS regression analysis is not sufficient to determine the flow(s) of causality. When economic growth is regressed on government spending, researchers tend to interpret this as a confirmation of causality from the latter to the former. However, a significant coefficient can be equally compatible with the Keynesian view (causality from government expenditure to growth), Wagner's Law (from growth to spending), and/or a bi-directional causality between the two variables. The proper way to deal with this, as suggested by Ghali (1999), is to use Granger causality testing. His results indicated that government size did matter in determining the economic growth for all OECD countries in a positive way, thereby supporting the Keynesian View. Hsieh and Lai (1994), on the other hand, concluded that there was no evidence of Granger causality from government expenditure to *per capita* output growth for the G-7 countries.

Building on Ghali's (1999) work, this paper models the relationship between GDP, the share of government spending in GDP, and the share of exports in GDP within a time-series framework. The remainder of this paper is organized as follows. In section II, we consider some of the past literature on Wagner's Law. Section III introduces our methodology and section IV discusses data issues (including non-stationarity, cointegration and structural breaks). The results of our causality analysis appear in section V, and the final section VI provides some conclusions and suggestions for further research.

II. WAGNER'S LAW

Writing in 1890, Adolph Wagner formulated the 'Law of the Increasing Extension of State Activity', commonly referred to as Wagner's Law. It is one of the theories that emphasize economic growth as the fundamental determinant of public sector growth, and has since been the focus of many empirical studies. Wahab (2004) intended to disentangle the effects of accelerating and decelerating economic growth in government expenditure for OECD, EU and G7 countries for the period 1950-2000. He found evidence of Wagner's law for EU countries only. However, his findings suggested that, for all countries in general, government expenditure increased less than proportionately with accelerating growth and decreased more than proportionately with decelerating economic growth. Quite contrary, the study by Kolluri *et al*. (2000), which focused on the relationship between economic growth and certain components of public expenditures[1] of the G7 countries[2] for the period 1960-1993, provided inconsistent results. Wagner's Law was confirmed for all 7 countries[3], *i.e.*, there were signs of long-run equilibrium relationships between different categories of government spending and economic growth. For the UK in particular, Wagner's Law was confirmed for all three categories of public expenditure given the positive signs on the coefficients.

A disadvantage of the studies by Wahab (2002) and Kolluri *et al.* (2000), however, is that it did not study the Keynesian View. In an earlier study by Ghali (1999), he studied the causal relationships between government expenditures and economic growth for ten OECD countries[4] using a quarterly data set covered the period 1970:1 to 1994:3. His results supported the Keynesian view, but there was no evidence of Wagner's Law. In another study by Oxley (1994), which focused on the UK exclusively for the period 1870 to 1913, his results suggested a uni-directional causality from national income (GDP) to public expenditure, thereby supporting Wagner's Law.

---

[1] The dependent variables that they used were: total government expenditure (GT), total government consumption (GC) and total government transfer expenditure (TE). The independent variable was nominal GDP.
[2] G-7countries include Canada, France, Italy, Japan, UK, USA and Germany.
[3] There were two exceptions; total government expenditure in France and total government transfer in Canada were not cointegrated with national income.

III. MODEL AND METHODOLOGY

Theoretical ties between international trade and growth have been formalized by Rivera-Batiz and Romer (1991), Grosman and Helpman (1990), and Romer (1990). It is obvious that the growth of an economy affects international trade in some way, however, the question of whether exports lead to growth of an economy or not remains an open question. Hence, the inclusion of such variable in the analysis gives us more valuable information of the interactions between international trade and government size. Given the purpose of this study, one limitation of the ordinary least squares (OLS) approach is that it ignores the fact that many economic systems exhibit feedback. Take our proposed trivariate model as an example, there appears to be inter-relationships between the series such that it is difficult to state which one should be the dependent variable. For example, GDP depends on government expenditure and exports; on the other hand, however, government expenditure depends on the economic performance of an economy (in terms of exports and GDP). Therefore, a trivariate VAR model enables us to treat all series systematically without making reference to the issue of dependence versus independence.

Our VAR model, which includes GDP, share of government spending, and the share of exports to GDP, is as follows:

$$y_t = \psi_0 + \psi_1\, t + \Sigma\, \Gamma_i\, y_{t-i} + \varepsilon_t \qquad \textbf{(1)}$$

where $\varepsilon_t \sim iid\,(0, \Omega)$, and

$$y_t = \begin{bmatrix} LGDP_t \\ LSGOVEXP_t \\ LSEXPORTS_t \end{bmatrix},\ \psi_0 = \begin{bmatrix} A_{10} \\ A_{20} \\ A_{30} \end{bmatrix},\ \psi_1 = \begin{bmatrix} A_{11} \\ A_{21} \\ A_{31} \end{bmatrix},\ \Gamma_i = \begin{bmatrix} \gamma_{11i} & \gamma_{12i} & \gamma_{13i} \\ \gamma_{21i} & \gamma_{22i} & \gamma_{23i} \\ \gamma_{31i} & \gamma_{32i} & \gamma_{33i} \end{bmatrix},$$

$$\varepsilon_t = \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{bmatrix},\ \text{and}\ \Omega = \begin{bmatrix} \sigma_1^2 & \sigma_{12} & \sigma_{13} \\ \sigma_{12} & \sigma_2^2 & \sigma_{23} \\ \sigma_{13} & \sigma_{23} & \sigma_3^2 \end{bmatrix}$$

where "$LGDP_t$" denotes "log of GDP", "$LSGOVEXP_t$" denotes "the share of government spending to GDP (in logs)" and "$LSEXPORTS_t$" denotes "the share of exports to GDP (in logs)". The data are illustrated in Figures 1 to 3.

[4] OECD countries include US, Japan, UK, Australia, Canada, France, Italy, Spain, Switzerland, and Norway.

This estimation of the trivariate VAR model, however, has to take into account of the structural breaks in our data. Given the long time span of the study, the UK had been undergoing periods of different government structures and wars. If we fail to take account of any structural breaks, then “unit root tests will lead to a misleading conclusion that there is a unit root, when in fact there is not” (Perron, 1989). Two ways to deal with this issue, we could either estimate a VAR model on the whole sample period (1830-1993) with time dummies included or estimate one with “truncated” sample period[5]. To determine which model to use is subject to tests for autocorrelations.

After taking care of the unit roots and structural breaks of the data, a cointegration test can be applied to determine the existence of a long-run relationship between the variables. If there is evidence of cointegration, then this implies there must be Granger-causality from Y to X, or vice versa, or both ways.

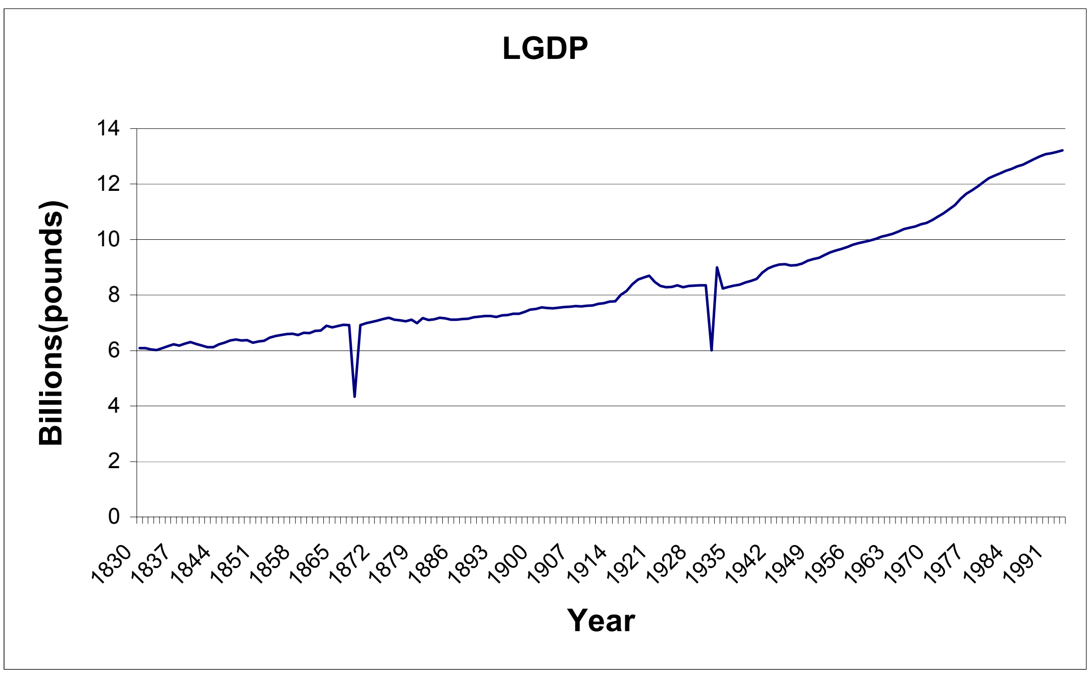

Figure 1 – LGDP (log of GDP)

[5] Truncated in the sense that we will not include those years that are outliers (either spikes or troughs).

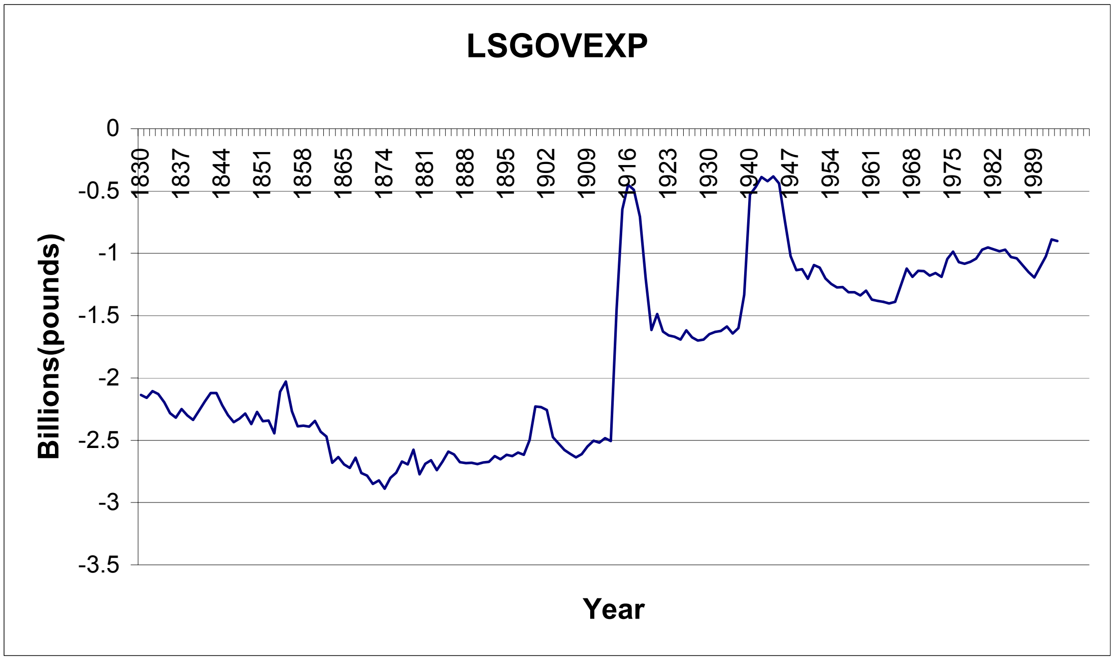

Figure 2 - LSGOVEXP (log of the share of government expenditure in GDP) in billion pounds

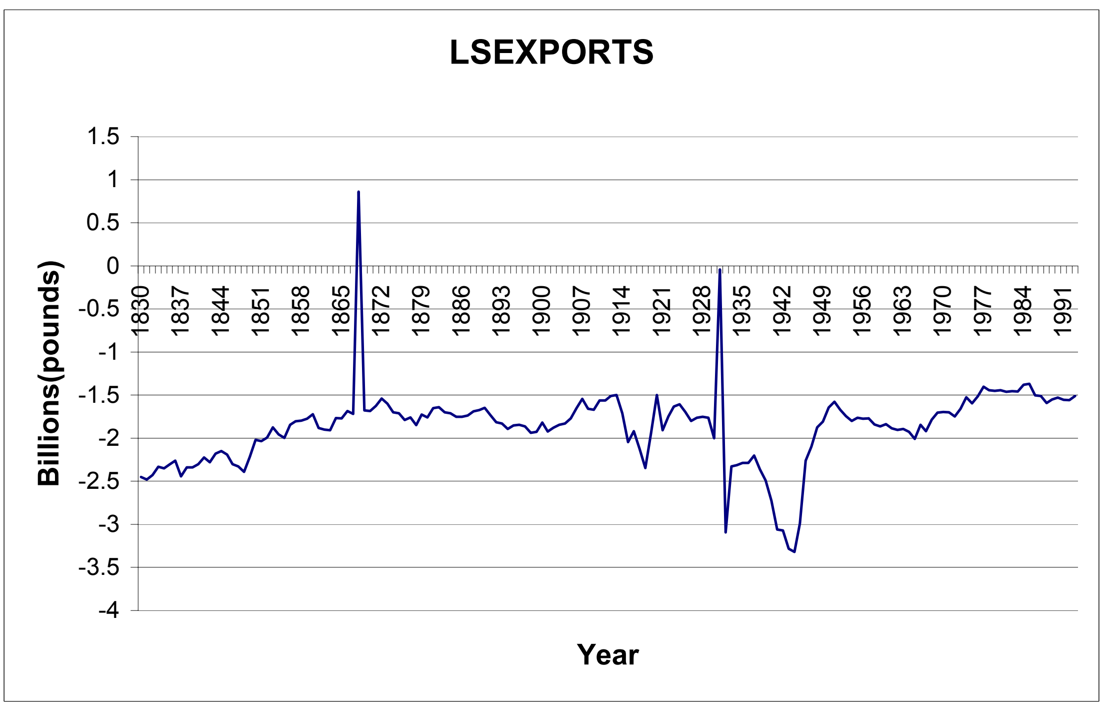

Figure 3 - LSEXPORTS (log of the share of exports to GDP) in billion pounds

IV. DATA NON-STATIONARITY AND STRUCTURAL BREAKS

The raw data used in this study are obtained from Mitchell (1998), who provides a good source for historic long time span data. The period 1830 to 1993 is chosen because as Ram (1992) and Henrekson (1993) point out, Wagner's postulate is essentially a statement about the long-run relationship between economic development and the relative size of the public sector. Hence, any empirical analysis should base on samples from a relatively longer time frame.

As noted by Granger and Newbold (1974), estimation of non-stationary data with a stochastic trend will cause spurious regression problems. First, the least squares estimators of the intercept and slope coefficients are not consistent[6]. Second, the conventional test statistics, such as the t-ratio, F-statistic, *etc.*, do not have distributions like t- and F-distributions that we expect to hold when the null hypothesis is true, not even asymptotically. Consequently, the critical values normally used are inappropriate. Third, there will be "an apparently high degree of goodness of fit, as measured by the coefficient of multiple correlation R^2 or the 'corrected' coefficient $\bar{R}^2$, but the Durbin-Watson d statistic will converge to zero as sample size grows[7]"(Granger and Newbold, 1974). Fourth, there will be spurious rejections by cointegration tests. In the presence of neglected structural breaks, Dickey-Fuller tests generate a spurious appearance of trend-stationarity when in fact the true generating process is difference-stationary - that is, integrated of order one (Leybourne and Newbold, 2003). Hence, before we could proceed with the Granger causality test, it is necessary to apply unit root tests on each series of data.

Unit Root Tests

If a time series is differenced *d* times to be stationary, then the original series is integrated of order d, denoted by I(d). In order to establish the order of integration, we employ the Augmented Dickey Fuller (ADF) test by considering the following regressions:

$$I(1)\ vs.\ I(0): \quad y_t = \delta\, y_{t-1} + [\, \alpha_0 + \alpha_1 t + \Sigma\, \beta_j \Delta\, y_{t-j}\,] + \varepsilon_t \qquad \textbf{(2)}$$

$$I(2)\ vs.\ I(1): \quad \Delta y_t = \delta\, \Delta y_{t-1} + [\, \alpha_0 + \alpha_1 t + \Sigma\, \beta_j \Delta^2\, y_{t-j}\,] + \varepsilon_t \qquad \textbf{(3)}$$

---

[6] A consistent estimator is one such that it approaches the true parameter value as the sample size gets larger.

[7] As the Durbin-Watson statistic (d) approaches zero, it is clear that there is evidence of positive serial correlation.

where ε_t denotes the errors that are assumed to be correlated across time, t is the linear deterministic trend, α_0 is the drift and Δ is the difference operator. One drawback of the test, however, is its assumption of no shift in either level or slope of the series. In reality, we know that this rarely happens, especially when we deal with this really long time span from 1830 to 1993.

Filling in the Gaps

Given all series display spikes at certain points in time (refer to Figure 1, 2 and 3), we have to take that into account to avoid any biased results. Fill-up the gaps, delete missing observations, and linearly interpolate across the gaps are three common options. The last option, however, ranks the last in terms of size-distortion and power[8] (Ryan and Giles, 1998). With regard to the second option, Vogelsang (1994) showed that the model led to misleading inferences. Hence, the first option seems to be a better method.

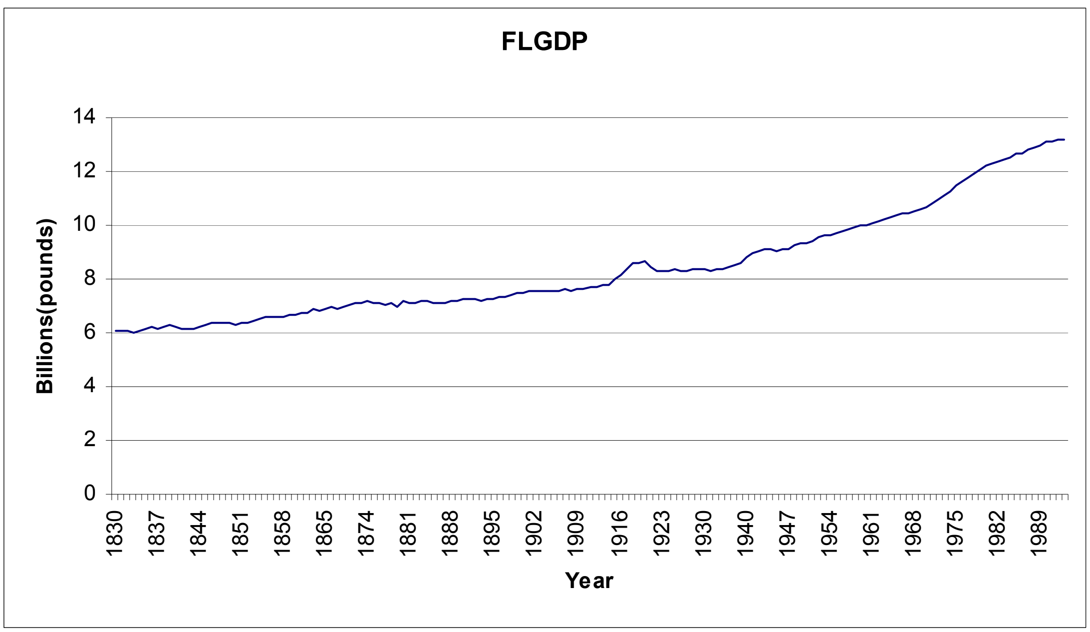

Figure 4 - FLGDP (Filled log of GDP)

[8] At certain points in time, the values were below the significance level (10%).

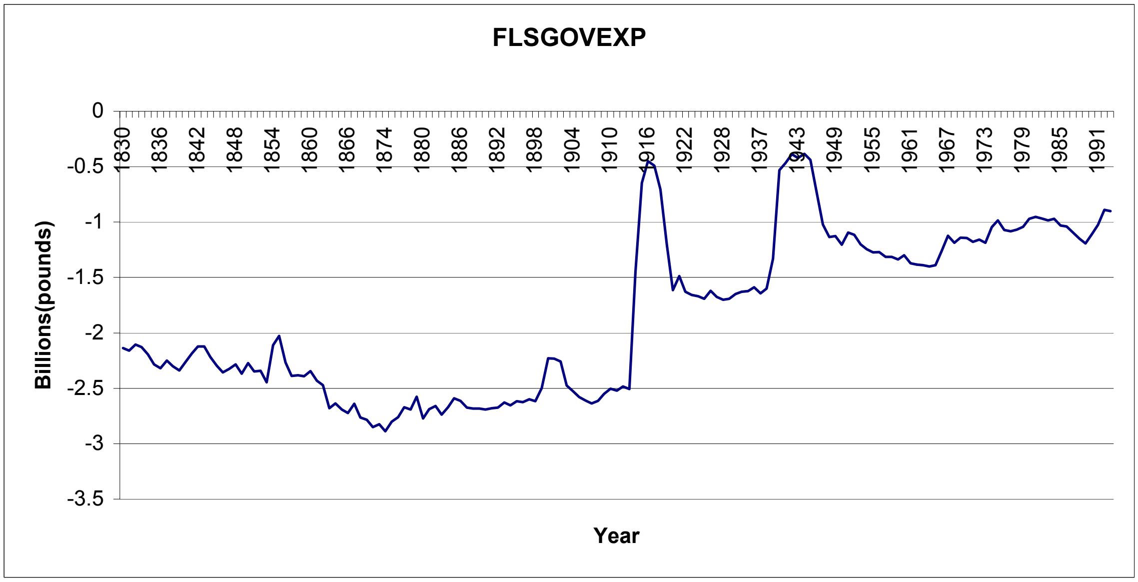

Figure 5 - FLSGOVEXP (Filled log of share of government expenditure to GDP)

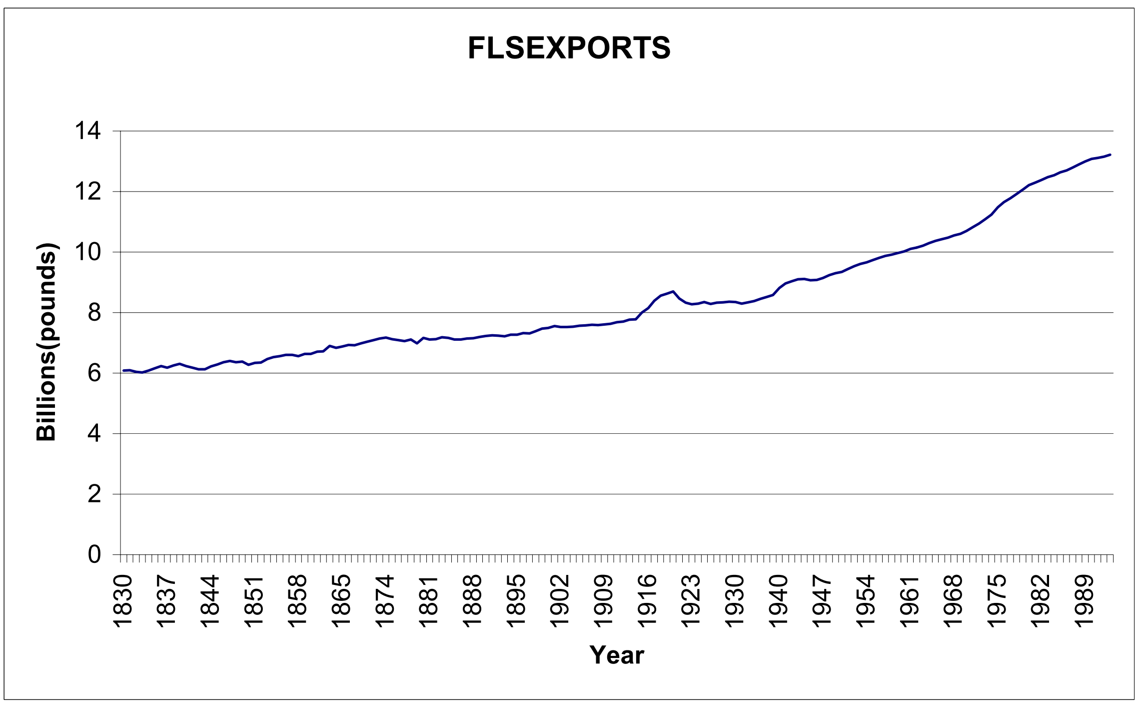

Figure 6 - FLSEXPORTS (Filled of log of the share of exports to GDP)

To deal with the structural breaks, Perron (1989) proposed a modified DF test[9] with three types of deterministic trend functions, namely Type "A" (the Crash model), Type "B" (the Changing

[9] With Perron's approach, there are two underlying assumptions: first, any shift in level or trend is exogenous; and second, there can only be a one-time change in level and/or trend.

Growth model) and Type "C" (combination of Type "B" and Type "A"). The resulting t-ratios are to be compared with the critical values[10] calculated by Perron.

Different Time Periods

Another technique we use is to test for unit roots in the original data by ignoring the spikes. In particular, we will separate the whole sample into different time periods. The way we specify each period is based on the location of the spikes. For the "filled" series of FLGDP, the three sub-sample periods are 1830-1867, 1869-1930, and 1932-1993. For the "filled" series of FLSGOVEXP, the three sub-sample periods are 1830-1867, 1869-1930, and 1933-1993. And for the last series FLSEXPORTS, there are four sub-sample periods: 1830-1867, 1868-1930, 1933-1993, and 1948-1993.

Bootstrapping Unit Root Tests

For the LGDP series, the unit root test results of both "filled-up" and separate period methods confirm that the series is non-stationary. The other two series, LSGOVEXP and LSEXPORTS, however, results are mixed (refer to Table 1). Given these mixed results, a re-sampling bootstrap (Maddala and Kim, 1998) is employed that takes account of the finite sample characteristics of our data[11]. Given our small sample size, bootstrapping enables us to obtain small sample critical values from the actual data generating process (DGP). The rule is to reject the null hypothesis if the calculated t-ratio is more negative than the bootstrapped critical value. As seen in Table 2, the three "filled-up" series are each integrated of order one (nonstationary) whereas the three "truncated" series are each integrated of order zero (stationary). In the presence of structural changes, bootstrapping without taking account of those changes would bias the validity of the results. Hence, it does not make much sense for us to draw conclusions base on the results of the three truncated series (LGDP, LSEXPORTS, and LSGOVEXP). As a result, we conclude that all three series are integrated of order one, the i.e. they are difference stationary which implies they have to be differenced once to be stationary.

[10] Asymptotically, these critical values depend on λ, the proportion of the way through the sample that the particular break occurs.

[11] Refer to Table 1where we have used two sets of critical values (Perron's and Mackinnon's). The Mackinnon values, unlike Perron's, are not asymptotic. But they assume there are no structural breaks in the data set. Hence, the Perron test is preferred in terms of handling data with structural breaks. The drawback of the Perron test is that given our finite sample size, results are not tailored to accommodate this fact. Therefore, we have to consult bootstrapping exercise.

Table 1 – Augmented Dickey-Fuller & Perron unit root test results

	LGDP				
		Type of Perron's Structural change	t_{dt}	10% CV	Outcome
1830-1993	FLGDP*		0.633027	-3.1279	reject I(0)
	1st diff	n.a.	-15.43645		I(1)
1830-1867	LGDP	n.a.	-2.761137	-3.1279	reject I(0)
	1st diff		-4.942245		I(1)
1869-1930	LGDP	"A"	-3.059363	-3.51	reject I(0)
			λ=0.7		I(1)
1932-1993	LGDP	n.a.	-3.949505	-3.1279	reject I(0)
	1st diff		-11.50681		I(1)
	LSGOVEXP				
			t_{dt}		
1830-1993	FLSGOVEXP*	"C"	-4.201571	-3.96	reject I(1)
			λ=0.5		I(0)
1830-1867	LSGOVEXP	"A"	-4.677158	-3.46	reject I(1)
			λ=0.8		I(0)
1869-1930	LSGOVEXP	"A"	-3.134395	-3.51	reject I(0)
			λ=0.7		I(1)
1933-1993	LSGOVEXP	"A"	-3.133681	-3.4	reject I(0)
			λ=0.1		I(1)
	LSEXPORTS				
			t_{dt}		
1830-1993	FLSEXPORTS*	"A"	-2.600226	-3.51	reject I(0)
			λ=0.7		I(1)
1830-1867	LSEXPORTS	n.a.	-3.013707	-3.1279	reject I(0)
	1st-diff		-6.36353	-3.1279	I(1)
1868-1930	LSEXPORTS	"A"	-3.640196	-3.51	reject I(1)
			λ=0.7		I(0)
1933-1993	LSEXPORTS	"A"	-2.346726	-3.47	reject I(0)
			λ=0.2		I(1)
1948-1993	LSEXPORTS	"C"	-2.666825	-3.95	reject I(0)
			λ=0.4		I(1)

Note: n.a. = not available; t_{dt} = t-statistics with drift and trend; λ = location of the break relative to the whole sample.

Table 2 – Bootstrapping of unit root test results

		Lag Length	t_{dt}	Outcome
LGDP*	1830-1867,1869-1930, 1932-1993	2	-8.19584	I(0)
		10%	(-1.14417)	
		5%	[-1.32578]	
FLGDP**	1830-1993	1	0.169773	I(1)
			(-2.75076)	
			[-3.15107]	
LSGOVEXP	1830-1867,1869-1930, 1932-1993	1	-6.09624	I(0)
			(-2.8058)	
			[-3.30493]	
FLSGOVEXP	1830-1993	1	-2.48096	I(1)
			(-3.00251)	
			[-3.37429]	
LSEXPORTS	1830-1867,1869-1930, 1932-1993	1	-7.03992	I(0)
			(-2.92415)	
			[-3.4319]	
FLSEXPORTS	1830-1993	1	-2.53532	I(1)
			(-2.97519)	
			[-3.51395]	

Cointegration

Cointegration (Engle and Granger, 1987) explains how a set of economic variables (given a particular model) behaves in the long-run equilibrium. If several variables are cointegrated, then they may drift apart in the short run. But in the long run, economic forces will draw them back to their equilibrium relationship. Given the nature of our data (refer to Figures 4, 5 and 6), we will test both the "filled" series (from 1830-1993), and the "truncated" series (1830-1868, 1869-1930, and 1931-1993). As can be seen in Table 3, the results are, similar to the unit root tests, mixed. For the entire sample period (1830-1993), there is no evidence of cointegration. When testing on subsequent sub-sample periods, however, we get inconsistent results.

Table 3 – Cointegration test results

		t_{dt}	t_d	Outcome
1830-1993	FLGDP*	-1.41811	-2.81703	No Cointegration
	10%	(-3.8344)	(-3.4518)	
	5%	[-4.1193]	[-3.7429]	
	FLSGOVEXP	-3.26411	-3.15763	No Cointegration
		(-3.8344)	(-3.4518)	
		[-4.1193]	[-3.7429]	
	FLSEXPORTS	-3.51857	-3.51409	No Cointegration*
		(-3.8344)	(-3.4518)	
		[-4.1193]	[-3.7429]	
Sub-samples				
1830-1868				
	FLGDP	-0.09597	-4.94716	Mixed*
		(-3.86)	(-3.61)	
	FLSGOVEXP	-4.31894	-4.27459	Cointegration
		(-3.86)	(-3.61)	
	FLEXPORTS	-3.23185	-4.62887	Mixed
		(-3.86)	(-3.61)	
1869-1930				
	FLGDP	-4.24846	-2.69778	Mixed
		(-3.98)	(-3.55)	
	FLSGOVEXP	-3.39881	-3.16609	No Cointegration
		(-3.98)	(-3.55)	
	FLSEXPORTS	-4.23302	-4.21606	Mixed
		(-3.98)	(-3.55)	
1931-1993				
	FLGDP	-4.25753	-1.81996	Mixed
		(-3.99)	(-3.55)	
	FLSGOVEXP	-2.373398	-2.3734	No Cointegration
		(-3.99)	(-3.55)	
	FLSEXPORTS	-2.68233	-2.46609	No Cointegration
		(-3.99)	(-3.55)	

Note: *t_{dt} = critical value with drift and trend; t_d = critical value with drift only (with no trend); no cointegration* = for the series FLSEXPORTS, we reject the null hypothesis of no cointegration (with drift only) at 5%, but not at 10%; mixed* = results are different based on choices of (i) with both drift and trend or (ii) with drift only.*

Bootstrapping for Cointegration

Bootstrapping for cointegration gives us direct (bootstrap) estimates of p-values that are much more informative than the fixed threshold critical values (Pynnönen and Vataja, 2002). The bootstrap p-values, unlike Mackinnon's asymptotic p-values (1991), are free from the assumptions about the distributional properties of the test statistic, yet being asymptotically equivalent to asymptotic ones only if the distributional assumptions behind the large sample approximation are valid (Efron and Tibshirani, 1993). However, we have to add a restriction of no cointegration among the variables, which leads to the desired null hypothesis that the variables are not cointegrated (Basawa *et al.*, 1991). Our results (refer to Table 4) confirm that there is no evidence of cointegration. Therefore, there is no long-run equilibrium relationship between the three series; they did not display similar patterns of growth over the entire sample period (from 1830 to 1993).

Table 4 – Bootstrapping of cointegration test results

	Augmented	Lags	t_{dt}	t_d	Outcome
1830-1993	FLGDP*	0	-1.418113	-2.81703	No Cointegration
	10%		(-3.704909)	(-3.337672)	
	5%		[-3.982564]	[-3.670844]	
	FLSGOVEXP	0	-3.264106	-3.157632	No Cointegration
	10%		(-3.754477)	(-3.254783)	
	5%		[-4.032972]	[-3.548255]	
	FLSEXPORTS	0	-3.518566	-3.21409	No Cointegration
	10%		(-3.981651)	(-3.381923)	
	5%		[-4.296548]	[-3.616135]	

Note: t_{dt} = critical values with drift and trend; t_d = critical values with drift only.

V. RESULTS OF GRANGER CAUSALITY TESTING

In the last section, cointegration test led to the conclusion that there was no evidence of any long-run equilibrium relationships among the three variables for the United Kingdom over the study period. In the absence of a long-run relationship between the variables, it still remains of interest to examine the short-run linkages between them. Without evidence of cointegration, an error correction model can not be used. It is still, however, to model any short-run behavior of the relationship between them by applying the Granger causality test.

Prior to the application of the test, however, we have to determine the appropriate VAR model. Recall from section III, a well-specified VAR model has to take into account of the structural breaks of the data. Among the two VAR models, one with time dummies and the other with "truncated" sample periods, the latter appears to be a better model specification (refer to Table 5). Hence, the Granger causality test will be applied using this VAR model.

In testing for causality, results are sensitive to the number of lags used in the analysis. Moreover, given the non-stationary data that we have, "care must be taken in the way that this testing is performed if the usual test statistics are to have standard asymptotic distributions" (Giles *et al.*, 2002). Toda and Yamamoto (1995) show that this standard asymptotic theory holds if the lags in the VAR equations are determined in the usual way, but then extra lags of the variables are added into the estimation of the VAR model[12].

Our findings suggest that government size *does* Granger-cause economic growth in the United Kingdom. However, our results are quite contrast with that obtained by Ghali (1999). In his analysis of the period 1970-1994, government spending did not Granger-cause growth in the United Kingdom, but he found evidence for Japan, Canada, France, Switzerland, and Norway. His study, however, failed to mention using any methods to handle his quarterly data prior to the estimation. Our analysis, however, is based on data that are handled in a way to take account of the structural changes happened during the sample period.

[12] This specific order is subject to VAR lag order selection criteria (based on the AIC and SC criteria).

Table 5 - Estimates of VAR model (without time dummies)

Vector Autoregression Estimates Sample(adjusted): 1835 1867 1870 1930 1934 1993			
	LGDP	LSEXPORTS	LSGOVEXP
LGDP(-1)	1.248866	-0.257307	0.607179
	[20.3139]	[-2.06895]	[3.79569]
LGDP(-2)	-0.20857	0.476153	-0.803909
	[-2.22752]	[2.51378]	[-3.29962]
LGDP(-3)	0.06149	-0.487983	0.245059
	[0.64829]	[-2.54325]	[0.99296]
LGDP(-4)	-0.12168	0.523677	-0.071084
	[-1.30586]	[2.77815]	[-0.29319]
LSEXPORTS(-1)	0.099384	0.984133	-0.025697
	[2.43472]	[11.9181]	[-0.24194]
LSEXPORTS(-2)	-0.07573	-0.154097	-0.072641
	[-1.35037]	[-1.35831]	[-0.49781]
LSEXPORTS(-3)	0.053298	0.127251	0.043219
	[0.98345]	[1.16070]	[0.30648]
LSEXPORTS(-4)	-0.05562	0.041289	0.005564
	[-1.03803]	[0.38090]	[0.03990]
LSGOVEXP(-1)	0.166709	-0.351788	1.448303
	[4.94536]	[-5.15868]	[16.5117]
LSGOVEXP(-2)	-0.11844	0.613469	-0.729127
	[-1.91731]	[4.90909]	[-4.53615]
LSGOVEXP(-3)	0.030456	-0.606322	0.189233
	[0.44722]	[-4.40121]	[1.06793]
LSGOVEXP(-4)	-0.05934	0.492313	-0.098284
	[-0.90906]	[3.72839]	[-0.57868]
C	0.132061	-0.32381	-0.595002
	[1.17443]	[-1.42352]	[-2.03361]
LGDP(-5)	0.019462	-0.242695	0.052423
	[0.35784]	[-2.20587]	[0.37044]
LSEXPORTS(-5)	0.010013	-0.115047	-0.02503
	[0.28133]	[-1.59791]	[-0.27027]
LSGOVEXP(-5)	0.003848	-0.157318	0.083893
	[0.10790]	[-2.18065]	[0.90408]
R-squared	0.999296	0.909032	0.965402

Note: Numbers in parentheses are the t-ratios obtained from the estimation results.

As outline in Table 5, coefficients on the lagged LSGOVEXP (the share of government spending to GDP) induce variations in the economic growth of the United Kingdom (LGDP). Though signs of the coefficients are of mixed magnitudes, this presupposes the existence of causality between these variables[13]. To verify, we conduct both 2-way and 3-way Granger-causality tests. Results suggest that as the British government spent more on its public sector, its economy would grow (except for the bivariate case for the period 1934-1993). Thus, there is evidence of the Keynesian View.

Looking at the other direction of causality, economic growth Granger-causes government size in all cases (validation of the Wagner's Law), except for the period 1830-1867 (for both bivariate and trivariate cases). Previous studies such as Oxley (1994) and Thornton (1999) for the United Kingdom included the period 1830-1867 as part of their samples. Both studies focused on mainly the last half of the nineteenth century and up to and include 1913. Their results suggested that there was evidence of Wagner's Law. Though we find no evidence of Wagner's Law for the period 1830-1867, however, Wagner's Law is confirmed for the period 1870-1930. In another study by Chang (2002), his results (base on a sample period 1951-1996) are consistent with ours, which supports Wagner's Law.

In terms of international trade, a two-way Granger-causality between growth and exports is observed in the United Kingdom for the following three cases: (1) for the trivariate case for the period 1830-1867; (2) for the bivariate case for the same period; (3) for the trivariate case for the period 1870-1930. The "export-led-growth" hypothesis is supported in all trivariate cases, but the evidence is only recognizable in the bivariate case during the period 1830-1867. In general, what hold in bivariate cases also hold in trivariate cases[14]. Our results are consistent with those found in Ghali (1999). Despite the use of different sample periods, the results from both studies indicate that, with the introduction of a multi-variate model, the "export-led-growth" hypothesis is supported.

---

[13] The fact that this is a trivariate VAR model might have caused the mixed magnitudes of the estimated coefficients.

[14] An exception occurs with the period 1934-1993. In a bivariate system, LGDP Granger-causes LSEXPORTS. However, as a third series (LSGOVEXP) is introduced, the flow of Granger-causality changes in an opposite direction from LSEXPORTS to LGDP. In this trivariate system, as economy grows, government expenditure increases. These increases in government expenditure later translate into further economic growth of the economy. This circular flow cannot be captured by the bivariate system.

VI. CONCLUSIONS

This study attempts to untangle the long-run relationship between growth and government spending by examining interactions among GDP, the share of government spending to GDP and the share of exports to GDP for the UK from 1830 to 1993. At a first glance, there had been spikes and troughs in all three series that we have to take care of. Two methods are used to deal with any structural changes; "fill-up" and "truncate" the series. However, we get mixed results from the unit root tests. Thus, we perform the bootstrapping exercise and our results suggest that all three series are integrated of order one (non-stationary in levels). In terms of cointegration, bootstrapping indicates that there is no sign of cointegration. That is, there is no long-run equilibrium relationship among variables.

The Granger-causality tests suggest that government spending Granger-causes growth. That is, as government spending increases (as a share to GDP), GDP growth increases as well. This causality supports the Keynesian View holds. On the other hand, only three (except for the period 1830-1867) out of four cases indicate that there is evidence of Wagner's Law (where economic growth Granger-causes government spending). In terms of international trade, the "export-led growth" hypothesis is confirmed in each of the trivariate cases. As the volume of exports increase, GDP increases as well. Another interesting point is that in general, the results from trivariate cases are consistent with those obtained in the bivariate cases.

This study shows that time-series analysis of an individual country is a much more insightful learning process than averaging data in a cross-country analysis. In particular, this time-series analysis gives us more fruitful information regarding the development of an economy. For example, it allows us to determine whether there is any sign of a long-run relationship among variables, whether the variables Granger-cause one another, and how one series would react to the shocks generate by another series.

As for future research, it would be interesting to examine the relationship between various levels of government expenditures (for example, government expenditure, government transfer expenditure, and warfare expenditure) and the economic growth of an economy. Given the long time span of our analysis, it will be impossible for government expenditure to remain stable over time (refer to Figure 2). The fact that government expenditures compose of the above three categories, it makes sense to disaggregate expenditures into their proportions and then test for the validity of Wagner's Law respectively.

ACKNOWLEDGEMENT

I am indebted to Dr. David Giles for his invaluable suggestions and comments. Also, I would like to thank my family (Winnie, Gigi and Anna) and colleague Yue Zhang for their support throughout the write-up of this paper.

.

REFERENCES

Barro, R. J. (1991) Economic growth in a cross section of countries, *Quarterly Journal of Economics*, 106, 407-44.

Barro, R. J. (1990) Government spending in a simple model of endogenous growth, *Journal of Political Economy*, 98, S103-S124.

Basawa, I. V., Mallik, A. K., McCormick, W. P., Reeves, J. H. and Taylor, R. L. (1991) Bootstrapping unstable first order autoregressive processes, *Annals of Statistics*, 19, 1098-1101.

Chang, T. (2002) An econometric test of Wagner's law for six countries based on cointegration & error-correction modeling techniques, *Applied Economics*, 34, 9, 1157-1169.

Devarajan, S., Swaroop, V., and Zou, H. (1996) The composition of public expenditure and economic growth, *Journal of Monetary Economics*, 37, 313-344.

Efron, B. and Tibshirani, R. J. (1993) *An Introduction to the Bootstrap*, Chapman & Hall, London.

Engle, R. F. and Granger, C. W. J. (1987) Co-integration and error correction: representation, estimation and testing, *Econometrica*, 22, 251-76.

Feder, G. (1983) On exports and economic growth, *Journal of Development Economics*, 12, 59-73.

Ghali, K. H. (1999) Government size and economic growth: Evidence from a multivariate cointegration analysis, *Applied Economics*, 31, 975-987.

Giles, D. E. A. (2002) The Canadian underground and measured economies: Granger causality results, *Applied Economics*, 34, 2347-2352.

Granger, C. W. J. and Newbold, P. (1974) Spurious Regression in Econometrics *Journal of Econometrics*, 2, 111-120.

Grier, K. and Tullock, G. (1989) An empirical analysis of cross-national economic growth 1951-80, *Journal of Monetary Economics*, 24, 259-276.

Grosman, G.M. and Helpman, E. (1990) Trade, innovation, and growth, *Applied Economic Review*, 80, 86-91.

Henrekson, M. (1993) Wagner's law - a spurious relationship, *Public Finance*, 48, 406-15.

Hsieh, E. and Lai, K. (1994) Government spending and economic growth, *Applied Economics*, 26, 535-42.

Kim, I-M. and Maddala, G. S. (1998) *Unit Roots, Cointegration, and Structural Change*, Cambridge University Press, Cambridge.

Kolluri, B. R., Panik, M. J. and Wahab, M. S. (2000) Government expenditure and economic growth: Evidence from G7 countries, *Applied Economics*, 32, 1059-1068.

Landau, D. (1983) Government expenditure and economic growth: A cross-country study, *Southern Economic Journal*, 49, 783-92.

Levine, R. and Renelt, D. (1992) A sensitivity analysis of cross-country growth regressions, *American Economic Review*, 82, 943-63.

Leybourne, S. J. and Newbold P. (2003) Spurious rejections by cointegration tests induced by structural breaks, *Applied Economics*, 35, 1117-1121.

Mackinnon, J. G. (1991). Critical values for co-integration tests, in *Long-Run Economic Relationships* (Eds.) R. F. Engle and C. W. J. Granger, Oxford University Press, Oxford, pp. 267-276.

Mitchell, B. R. (1998) *International Historical Statistics: Europe 1750-1993*, Cambridge University Press, Cambridge.

Oxley, L. (1994) Cointegration, causality and Wagner's Law: A test for Britain 1870-1913, *Scottish Journal of Political Econom*y, 41, 286-298.

Pynnönen, S. and Vataja, J. (2002) Bootstrap testing for cointegration of international commodity prices, *Applied Economics*, 34, 637-647.

Perron, P. (1989). The great crash, the oil price shock and the unit root hypothesis, *Econometrica*, 57, 1361-1401.

Ram, R. (1986) Government size and economic growth: A new framework and some evidence from cross-section and time-series. *American Economic Review*, 76, 191-203.

Ram, R. (1992) Use of Box-Cox models for testing Wagner's hypothesis: A critical note, *Public Finance*, 47, 496-504.

Rivera-Batiz, L. and Romer, P. M. (1991) Economic integration and endogenous growth, *Quarterly Journal of Economics*, 106, 531-36.

Romer, P. M. (1990) Endogenous technological change, *Journal of Political Economy*, 98, 71-102.

Ryan, K. F. and Giles, D. E. A. (1998) Testing for unit roots in economic time series with missing observations, in *Advances in Econometrics*, Vol. 13 (Eds.) T. B. Fomby and R. C. Hill, JAI Press, Stamford CT, pp. 203-242.

Sala-i-Martin, X. (1997) I just ran two million regressions, *American Economic Review*, 87, 178-183.

Thornton, J. (1999) Cointegration, causality and Wagner's Law in 19th century Europe, *Applied Economic Letters*, 6, 413-416.

Toda, H. Y. and Yamamoto, T. (1995) Statistical inference in vector autoregressions with possibly integrated processes, *Journal of Econometrics*, 66, 225-250.

Volgesang, T.J. (1994) On testing for a unit root in the presence of additive outliers, CAE working paper no. 94-13, Cornell University.

Wagner, A. (1890) *Fiannzwissenschaft* (3rd ed.), partly reprinted in *Classic in the Theory of Public Finance* (Eds.) R. A. Musgrave and A. T. Peacock, Macmillan, London, 1958.

Wahab, M. (2004) Economic growth and expenditure: evidence from a new test specification, *Applied Economics*, 36, 2125-2135.