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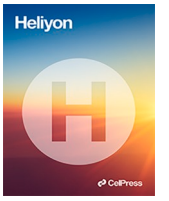

Research article

Testing the validity of Wagner's law in four income groups: A dynamic panel data analysis

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ABSTRACT

This study endeavors to examine the validity of Wagner's Law, which has received considerable attention in recent years. We develop a panel dataset of 20 countries, taking five countries from each income group defined by the World Bank, for the 1991–2018 periods. Five different versions of the law are tested using this dataset. We add further depth to the model by involve the government's revenue and the volume of trade as independent variables. We inquire into the subsistence of cross-sectional dependence. To determine the order of integration, we conduct LLC, IPS, and CADF tests. The results show that the dataset has I (0) and I (1) series, and no series is found to be of I (2). Then we perform the panel ARDL test, and calculate PMG and DFE estimates. We use the Hausman test to choose among the estimates. In each version of the law, the error correction term indicates the presence of both long-term associations within the variables and an economic convergence process. However, we find no evidence to support the law for any version. Additionally, we conduct the panel cointegration tests, such as Westerlund, Pedroni and Kao. These cointegration tests generate results accordant with the ARDL findings.

1. Introduction

A country's regulators have prioritized economic growth because of its close connection to its citizen's standard of living. Plenty of scholars have looked into what assists or hinders a nation's economy to progress. In the relevant field, a significant strand of studies has focused on the intense debate and controversies surrounding the theoretic as well as explorative associations within public spending and income growth [1,2]. During the last centenary, the growth of Government through rising spending relative to national income was documented and studied with great enthusiasm [3]. The historical trend shows a long-term aptitude of the Public Spending to upturn in almost all the countries of the world [4,5]. Especially in the early fifth decade of the last century when the Second World War just ended, governments, in their attempt to provide stimulus to the economy, ended up with greater control over the economy. The data identifies that governments intervention in the economy headways not only consumption but also investment outgrowth [6].

Researchers in latter half of the last centenary drew attention to the fact that government activities grow when a country gets richer [7,8]. Until then, the opposite view prevailed in the social sciences. Economists, along with the policymakers, since then, have become very much concerned about the growth process of the economy. Diversified thoughts emerged among economists leading to controversial theories regarding the existing associations within income growth and government spending. Two of the dominant theories are Wagner's Law and the Keynesian Hypothesis. These two theories are fundamentally different from each other, owing to

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their dissimilar approaches to defining the functional associations within government expenditure and income growth.

Within economic literature, a relatively new doctrine, alluding the long-term trend of the Public Spending to reseat a comparatively faster rate than income, has been being sanctioned frequently [9,10]. Adolph Wagner is the pioneer in this field who first assessed that the public spending increases in response to the expansionary shift of the economy [11]. In his 'Finanzwissenschaft' (1883) and 'Grundlegung der politischenwissenchaft' (1893), Wagner marked off the existence of positive association within the stage of economic advancement and the magnitude of government sector in industrialized market economies [12], which later was widely recognized as Wagner's Law. In Wagner's words, "*in our concern,* comprehensive comparisons of different countries and different times exhibits that constantly undertaking of new functions, by both the central and local governments, perpetuates from a regular increase in their activities, while performing both old and new functions. Economic needs of the people, in this way, to an increasing extent and in a more satisfactory fashion, are satisfied by the central and local governments." Three sources are responsible for this growing government expenditure: firstly, with industrialization and modernization, public intervention in protective and regulatory purposes increases; secondly, higher cultural and welfare expenditures, that hold elastic response to income; thirdly, government supervision of economic as well as technological development [9].

Keynes proposed a competing theory during the great depression, which states that expansionary fiscal policy, initiated by increased government expenditure, can accelerate economic growth [13]. Keynes argued that expansion of government can stimulate and take the economy on the track even at the time of recession. Hence, during a regular period, expansionary public spending is most probable to induce economic growth. Law of Wagner differs, mainly, from the Hypothesis of Keynes in terms of the causal relation and mode of influence.

Increased public spending exerts multiplier effects on the economy. Expansion of government expenditure promotes the mode of production, distribution, and consumption, which, as aftermath, administers economic outgrowth. Gross domestic product (GDP), one of the core indicators of economic development, is often used to identify economic wellbeing. The competing theories differ regarding their conviction for the nature and channel of influence within the public expenditure and income Growth. In the Keynesian hypothesis, public expenditure is a predictive factor that acts as a growth accelerating apparatus. Contrarily, in Wagner's Law, government spending takes the part of the response factor that descendant from income growth [14].

Since Wagner did not define and estimate an empirical model, many models of the Law have emerged subsequently. Different researchers approached Wagner's Law differently, and even for a single country, there is no consensus [15]. Scrutiny of previous attempts exposes a crucial fact that indicates the Law's validity to be vulnerable to the country, data type, and tests conducted. Consequently, scholars focusing on the same country produced different findings due to heterogeneous datasets and tests.

By dint of this attempt, we aim to investigate the cogency of Wagner's Law taking data from 1991 till 2018 on 20 countries that are in different groups of the World Bank's income-based classification. To verify the law and to examine the causal linkage spanning between public spending and GDP, we conduct Panel Autoregressive distributive lag (PARDL) approach. Also, we do the unit root tests, cointegration test, and cross-sectional dependence test. Our innovations are.

(a) the nature of the sample allows us the check the validity of the model in all income groups simultaneously, i.e., making our findings more general;
(b) the panel framework makes our results more reliable;
(c) we estimate both the short-term and the long-term causal relationships within public expenditure and GDP;
(d) we perform additional cointegration test to be definitive regarding the preceding outcome;
(e) we relate the enumerated outcomes to corresponding economic reasoning. All these, as aspired, will confront us to contribute a newish sequel in the growing debate of the financial literature bridged by Wagner's Law.

This paper has been organized in the following manner: this introduction is followed by section 2, where we provide a review of the literature. Section 3 details the methodological approaches to the study. Section 4 puts forward and recapitulates the results, while section 5 concludes.

2. Existed literature

To establish an in-depth knowledge of the subject matter at hand, we have planned to review the conclusions from multiple associated studies. As a rule, we classified the articles into three distinct categories that reflected what they discovered in respect to the Law: the ones that reported evidence in favor of the Law, others that identified proof in opposition to the Law, and the papers that realized mixed outcomes.

A number of papers have produced results supporting Wagner's law. As exemplar, ref. [16] for Europe, ref. [17] for G7 countries, ref. [18] for industrial countries, and. Some papers, focusing on the components of government spending, namely, ref. [19,20,21,22,23,and24]] found similar results. For convenience, we have entrusted some findings from a few similar papers as follows:

A work done by Ref. [25] eliminated five alternative specifications of Wagner's law to justify its validity. The dataset by covering such a long period is supposed to undermine a complete picturesque of the Greek economy say, from the very initial level to the present position, and that is why, the derived results, from proper testing, can easily opt to be more reliable and realistic. The findings confirm the persistence of causal relationship between public spending and income growth. Ref. [26] used disaggregated government expenditure data from 1958 to 1993 to testify the consequences of Wagner's law in Greece. Among variant aspects, his paper concluded that only the growth of defense expenditure supports the law. Also, ref. [27] attempted to realize characteristics of government spending concerning long-run. From their survey, on the U. K., they come to realize that, any discrepancy of the public

spending from its usual level, due to an instantaneous shock, is not going to be corrected instantly; rather, it will take its time to be converged. As aftermath of this, public expenditure goes through a stepwise increment process.

An attempt by Ref. [28] reported the presence of long-term relationship within government expenditure, and Income Growth. Causal relation, enumerated by the widely used Granger procedure, being directed from Economic Growth towards Public Spending ensures Wagner's law to be valid in the studied instance. Ref. [29] estimated the inferred familiarity within the public spending and income growth in Romania for 1991 till 2014 and employed ARDL methodology followed by Bounds testing procedure that ground on the unrestricted error correction model (ECM). The estimated results, being a contrast to the Keynesian Hypothesis, exhibit quite a good congruence with Wagner's law. Economic consequences of the outcome are backed up by the unilateral influence from income growth towards public spending. Ref. [30] investigated the law in Turkey and declared the Wagner's law to have its validity and a long run unilateral causality was reported from income growth to government spending.

However, ref. [31] succeeded in unveiling the fact that a solicited specification of Wagner's law, the Peacock-Wiseman (1961) hypothesis by precision, holds its validity in the studied case. Not surprisingly, strong causal relation is reported to persist in the long-run in favor of the aforecited version of the law. A paper by Ref. [32] worked on Italy from 1960 to 2008 and found the time-series approach to be more devisable while comparing, through econometric procedures, Wagner's law to the Keynesian Hypothesis. Through his estimation, Magazzino had been confirmed about the existence of long-run association for a few branches of government expenditure, as classified by the Bank of Italy. Alongside, Granger causality test, although varied between long term and short term, commended a favorable result to the Wagner's law.

Moreover, ref. [33] listed one hundred and fifty-five countries to form a panel for 1970 to 2010 periods. They attempted, through their study, to unveil the channel of long-run causal relationship that persists within government budget and income growth. Derived result accentuates the corroboration for Wagner's Law as it presages precedents of causality, at a satisfactory level, from neither spending nor revenue to per capita GDP. As concern, ref. [34] formed a panel of 27 OECD economies for 1995 to 2012 periods to examine Wagner's laws cogency. They surveyed the variant versions of the law and attempted to employ the usual stationarity test, cointegration test, and error correction techniques within panel data settings. The study provided strong evidence to declare the Wagner's law to be conclusive. Besides, in line with their expectancy and assertion of the law also, the estimated long-run statistics were found to be significantly positive.

By their estimated results, a few papers, although favored Wagner's Law, evidenced no support to the Keynesian Hypothesis. For instance: ref. [35] for Greece, ref. [36] for the Gulf countries, and ref. [37] for the USA found such results. Papers supporting both Wagner's Law and Keynesian Hypothesis are ref. [38] for postwar Greece.

In contrary, some papers explored mixed evidence. Statistically, ref. [39] for the UK, Ireland, and Greece, ref. [26] for Greece, ref. [40] for the USA; Lin (1995) and ref. [41] for 63 countries could not give any clear answer. Survey on some relative papers producing such outcomes will be convenient for our inferences. Accordingly, ref. [42], being sentient about contradictory results for using aggregated data while examining Wagner's law, reexamined the cointegration relationship and the direction of causal relationship within the public expenditure and income growth. Having this purpose in mind, they simulated disaggregated data from 1968 till 2004 for Turkey. Being scattered over the short-term and long-term, the result enumerates and reveals that, in the former period (the short-run) strong and bidirectional causality subsists within the variables; while in long-run, no common trend was found to exist. As following, ref. [43] entrapped public expenditures and GNP as the variable in a study rendered on Turkey from 1980 to 2008. Simultaneous use of both cointegration and granger causality testing procedures provided evidence about the existence of bilateral causal relation within public spending and income growth. The short term dynamics, although, maintains the consequences of Keynesian Hypothesis; the long-run estimates, being converse to the short run, stings to the metabolism of Wagner's law.

Also, ref. [44] formulated an econometric model while analyzing the behavior of government expenditure in Nigeria. They, however, managed to convey their study into three distinct theoretical formulae and applied Vector Autoregressive Technique for this purpose. Their findings, from there, reveal a crucial fact that rather than income growth, public spending in the Nigerian economy is exposed to be more vulnerable in response to fiscal decentralization and political consequences. Wagner's law, as an aftermath of this finding, can be theorized to be less reliable than the Leviathan and Peacock-Wiseman displacement hypothesis in explaining the nature of public spending in the case at hand.

On the other hand, again many papers did not generate findings supporting Wagner's Law. A list of such papers includes ref. [7,45,46,47,and48]]. Few initiatives of the working papers are: A justification of ref. [48] evaluated the cogency of Wagner's Law for Bangladesh over 1972-73 till 2007–08. They asserted that the law does not appear to be applicable in Bangladesh since cointegration analysis, for the accumulated dataset, recounts a result that fails to find any long-run association within public spending and income growth. The evidence reveals that short-run income does not cause public expenditure. Also, ref. [49] simulated disaggregated data of Public Spending along with the aggregated from 1961 till 2007 with a purpose to examine the cogency of Wagner's Law for Nigeria. From the result, although a long-term equilibrium relationship was confirmed, no further evidence was found in support of Wagner's law; thus, it (the law) turned to be invalid. Not surprisingly, the Keynesian Hypothesis was apprehended to be valid in the case at hand. Moreover, ref. [50] attempted to testify the causal relation within public spending and income growth for three countries, sampled from Africa. They instrumented the Granger causality approach along with the Holmes-Hutton test. The estimated result reports an outcome that contradicts to the Wagner's law, since, for the studied case, no causal relation within government spending and income growth has been found.

Empirically, ref. [47] extended their study to the European Union to verify whether the countries in it (EU) incorporate the consequences of Wagner's law. Appropriate testing, on the sampled data, could hardly find any causal relationship within the variables in the long-run. Instead, the disharmonious outcome was found relative to the law. Thus, the law is declared to be inappropriate in explaining the relationship for the case at hand.

In line with what has gone before, notwithstanding its relevance, there still exists a dearth of experiments seeking to validate Wagner's theory and uncover the causal patterns of public spending and GDP in the low-to high-income economies. In this work, an attempt is made to offer an effective answer to the hypothesis of Wagner's law for a number of nations.

3. Methodology

Relevant literature on Wagner's Law, in general, provides an exposition of the Law, i.e., increase in Government Expenditure (G), stems from per capita real income (Y/P) growth [9,51,and52]]. That means Government Expenditure (G) is an increasing function of GDP growth (Y). This connection has two testable implications. For instance: one of the implications requires a long-run equilibrium association between the two variables, while the other, in response, requires a causal linkage running from GDP growth to Public Expenditure. The general form of the connection can be presented as:

$$G = f(Y) \tag{1}$$

Equation (1), in log-linear functional form, with a time subscript (t), country subscript (i) and a random error term (μ), can be written as:

$$G_{it} = \alpha Y_{it}^{\beta} \mu_{it} \tag{2}$$

The logarithmic transformation of equation (2) turns out to be:

$$\ln G_{it} = \ln \alpha + \beta \ln Y_{it} + ln\, \mu_{it} \tag{3}$$

Equation (3), in this paper, serves as the basis to test the long-term associations among the variables and thus to testify the cogency of Wagner's Law [9,37,and53]]. This formulation, as tested by others, will provide necessary information to declare Wagner's law to be valid, if.

a. The elasticity coefficient exceeds zero: $\beta > 0$ [37,53].
b. The causality runs from Y to G [50,54,55,56,and57]].
c. The variables be stationary [9].
d. The residuals be homoscedastic and uncorrelated [9].

Table 1 displays the variant specifications of Wagner's law propounded by various researchers.

Here, G represents Public Spending, Y represents Gross Domestic Product (GDP), *GFCE* is the Government Final Consumption Expenditure, P is Population, and BDef denotes Government Budget Deficit. Additionally, Y/P is per capita real output or per capita real GDP, G/Y is the share of Public Spending in output, G/P represents per capita Public Spending and finally, $BDef/Y$ represents the ratio of government budget deficit to GDP. In this paper, we use the five versions of the law listed below in Table 2. In all the models, the variables are in their natural logs. α and β are the intercept and slope coefficient which measures elasticity in a double log model. Grounding to the stage of an economy's advancement, α can be positive or negative [58]. At the early stage of development, when the government plays an exigent role in the economy, the value of α is anticipated to be positive. Conversely, in countries where the private sector significantly deals with a reasonably high level of production, the value is found to be negative. However, the cogency of the law inevitably reclines on the value of β. The positive value of β lends support to the law.

As mentioned in ref. [28], there can be four types of causalities between public spending and economic growth. Such as.

a. Neutralist Hypothesis: This occurs when no causality exists within Public expenditure and income growth.
b. Wagnerian Hypothesis: There is a unilateral causal relationship spanning from GDP towards Government Expenditure.
c. Keynesian Hypothesis: The unilateral causal relationship spans from Government Expenditure to GDP.
d. Feedback Hypothesis: A bidirectional causal relationship within GDP and Government Expenditure.

Following other literatures, we also include variables of Government Revenue (*GRev*) and Trade volume (T). *GRev, G, Y,* and T are in billions of US dollars. The data comes from the World Development Indicators (WDI) on the period of 1991–2018. The selected

Table 1
Alternative versions of Wagner's law.

Functional Forms	Source
$G = f(Y)$	Peacock-Wiseman [27]
$GFCE = f(Y)$	Pryor [59]
$G = f(Y/P)$	Goffman [60]
$G/Y = f(Y/P)$	Musgrave [61]
$G/P = f(Y/P)$	Gupta [62]
$G/Y = f(Y)$	Mann [63]
$G/Y = f\left(\frac{Y}{P}, \frac{BDef}{Y}\right)$	Murthy [64]

Table 2
Specifications of Wagner's law.

Functional Representation	Version
$\ln G = \alpha + \beta \ln Y$	Peacock-Wiseman (traditional) [27]
$\ln G = \alpha + \beta \ln(Y/P)$	Goffman [60]
$\ln(G/Y) = \alpha + \beta \ln(Y/P)$	Musgrave [61]
$\ln(G/P) = \alpha + \beta \ln(Y/P)$	Gupta [62], Michos [65]
$\ln(G/Y) = \alpha + \beta \ln Y$	Modified version of P–W suggested by Mann [63]

countries come from different income groups, categorized by the World Bank using the World Bank Atlas method, based on the Gross National Income (GNI) per capita. Countries having a Per Capita GNI of $1025 or less are classified as Low-Income economies. For Lower Middle-Income Countries, Per Capita GNI is happened to range from $1026 to $3995. The Upper Middle-Income group resides the countries for which Per Capita GNI is between $3996 and $12,375. The per capita GNI is $12,376 or more for the High-Income economies. For the empirical analysis, we form a sample of 20 countries taking five countries from each income group. We select the country of Benin, Burkina Faso, Guinea, Madagascar, and Mozambique as low income nations; Bangladesh, India, Kenya, Nigeria, and the Philippines as lower middle income nations; China, Jordan, Malaysia, Mexico, and Paraguay as upper middle income nations; Canada, France, Germany, Japan, and the UK as high income nations. The descriptive representation of the paper is reported in Table 3.

3.1. Testing for cross-sectional dependence

Prior to estimate the analysis, this article checks cross-section dependency (CD) test. CD is present if the cross-sectional units are correlated with each other, and shocks to one entity affect another entity. Results become unreliable for the existence of cross-section dependence. From the different CD testing, we work on Breusch and Pagan (BP) test [66]. The BP test is valid for fixed N as $T \to \propto$ [67]. In a fixed effect regression model, it calculates a statistic for cross-sectional independence in the residuals, provided that the errors are independent [68]. The B–P/LM test of independence infers a null hypothesis of no correlated residuals across entities. The alternative hypothesis, on the contrary, contemplates the residuals to be correlated. The test prerequisites assumption to be fulfilled which requires $T > N$. Our study, having a data set with 20 cross sectional data $(N = 20)$ and 28 time periods $(T = 28)$, fulfils the requirement of Breusch and Pagan testing.

3.2. Panel unit root test

For consistent long-term estimates, the variables are required to possess non-stationarity properties, and need to be integrated at the same level of integration. We use CIPS, IPS and. LLC unit root tests [67,69,and70]] since they are the frequently used methodologies of investigating stationary properties of the data in the panel literature. In the persistence of cross-sectional dependence in the data, there is a guideline to employ the second generation test in the case of identifying unit root or checking the stationarity properties of the variables under consideration [71]. Cross-Sectionally Augmented Dickey-Fuller (CADF) test, often regarded as to be a second-generation test, is applied in case of cross-section dependency. The null hypothesis of the CADF test is "each cross-section unit in the panel has a unit root" against the alternative "some cross-section units in the panel do not have a unit root."

3.3. Panel ARDL test

To verify the Wagner's law, this paper uses the panel Autoregressive Distributed Lag (ARDL) model. There are different versions of the ARDL model and we apply the cointegration border testing procedure, following ref. [72,73]. There are a couple of advantages to the procedure. Firstly, it is not only different from other cointegration techniques but also very much convenient to be used. Secondly, the test does not require unit root pretesting. Regardless the variables under study are cointegrated at level $I(0)$ or cointegrated at order one $I(1)$ or a combination of both $I(0)$ and $I(1)$, the test is still valid. Thirdly, for a miniaturized data sample, the test offers relatively efficient results. Moreover, panel ARDL methodology provides the long-run and the short-run coefficients simultaneously. A frequently used function of the panel ARDL methodology that ought to be analyzed for the bounds test method is presented as the following:

Table 3
Descriptive statistics.

Variables	Obs.	Mean	Std. Dev.	Min	Max
lnG	560	24.36743	2.727053	20.03574	28.93132
lnY	560	25.76961	2.468328	21.74042	30.01031
lnG/Y	560	−1.40218	.4,284,154	−2.44484	−.5,581,444
lnY/P	560	8.097231	1.699711	5.299806	10.84723
lnG/P	560	6.695051	2.035263	3.692448	10.10741
lnGRev	560	24.24168	2.742051	19.80524	28.77886
lnT	560	25.1979	2.400928	20.65388	29.04918

$$y_{it} = \sum_{j=1}^{p} \lambda_{ij} y_{i,t-j} + \sum_{j=0}^{q} \delta_{ij}^{'} X_{i,t-j} + \mu_i + \varepsilon_{it} \tag{4}$$

In the above equation (4), $i = 1, 2, 3, \ldots\ldots\ldots\ldots, n$ is the country index; , $t = 1, 2, 3, \ldots\ldots\ldots\ldots, T$ is the time index; X_{it} is a $k\times 1$ vector of explanatory variables; δ_{it} is the $k \times 1$ coefficient vectors; λ_{ij} are scalars and μ_i is the group-specific effect.

The error term in the prior equation is supposed to follow an $I(0)$ process, if the variables be $I(1)$ and cointegrated for all i. An error correction model is used to analyze the deviation from equilibrium. Thus, converting the equation into the error correction process:

$$\Delta y_{it} = \varnothing_i \left(y_{i,t-1} - \theta_i^{'} X_{it} \right) + \sum_{j=1}^{p-1} \lambda_{ij}^{*} \Delta y_{i,t-1} + \sum_{j=0}^{q-1} \delta_{ij}^{'*} \Delta X_{i,t-j} + \mu_i + \varepsilon_{it} \tag{5}$$

Where, $\varnothing_i = -(1 - \sum_{j=1}^{p} \lambda_{ij})$, $\theta_i = \sum_{j=0}^{q} \frac{\delta_{ij}}{\left(1 - \sum_k \lambda_{ik}\right)}$, $\lambda_{ij}^{*} = -\sum_{m=j+1}^{p} \lambda_{im}, \delta_{ij}^{*} = -\sum_{m=j+1}^{q} \delta_{im}$.

The speed of adjustment coefficient is represented by the parameter $\varnothing_i$ and for $\varnothing_i = 0$, no evidence for a long-term relationship is inferred from the test. Under the prior assumption that the variables converge to the long-run parity, this parameter $(\varnothing_i)$ is expected to possess a negative sign and be significant.

Moreover, having large N and T, dynamic heterogeneous panel estimation proposes variant specifications to form the equation that estimates Δy_{it}. A fixed-effects (FE) estimation approach has been frequently applied to the study in which each group runs in pooled time-series data, and only the intercepts are permitted to vary across groups. The FE approach is assumed to give inconsistent and potentially confusing results if the slope coefficients be fraternal. However, then, not surprisingly, for each group, a separate model can be fitted, and the coefficients, through a simple arithmetic average, may be calculated. All these peculiarities are leagued in the Mean Group Estimator (MGE) introduced by ref. [74]. This estimator permits the intercepts, slope coefficients, and error variances to differ across groups.

More recently, a more reliable estimator (extensively versed as PMG) was introduced by ref. [75,76] that adjoins pooled and averaged data in its action. This intermediate estimator albeit authorizes the intercepts, short-term coefficients and also the error variances to vary across groups the intercept, short-run coefficients, and error variances to vary across the groups (as would the MG estimator). However, it confines the long-term coefficients to remain unchanged across groups (as would the FE estimator). The Hausman test is used in sorting the model that is most likely to propagate efficiently consistent results.

3.4. Panel cointegration test

The ARDL test requires no further test of cointegration in general. However, we execute Panel cointegration tests to be more precise in our prediction. The Cointegration test aims to test whether the variables under study are integrated with a fashion, that in the long run, they show no tendency of discrepancy from equilibrium. Within the panel data set, the cointegration test is performed following Westerlund [77], Pedroni [78,79] and Kao [80]. All the tests share a common null hypothesis of no cointegration.

4. Results and discussion

4.1. Cross-sectional dependence (CD) test

The standard panel data estimators, no doubt, override spatial dependence in their verge of estimation. For the existence of spatial dependence, as ref. [81] signified, the test of hypothesis, grounded on these estimators, can be a cause for misleading inference [82]. Our data set having large T and relatively few N, as elucidated beforehand, disburses the proviso of Breusch-Pagan CD test. Our estimation of the test is executed on the five solicited specifications of Wagner's Law and the results are presented in Table 4.

The overhead outcomes notify that the inferred null hypothesis for the test has been castaway for all the series throughout all the five versions of the Law. We, at this emerging litigation, are obliged to presume that all series possess cross-sectional dependence. The results showing the existence of cross-sectional dependence within the series ignite us to perform second generation unit root tests besides the first-generation tests to be more precise about the stationarity properties of the variables [71].

Table 4
Cross-sectional dependence test.

Versions of Wagner's Law	χ^2 statistics	Probability	Decision
Peacock-Wiseman (traditional) [27]	580.779	0.00	H_0 rejected
Goffman [60]	649.13	0.00	H_0 rejected
Musgrave [61]	739.383	0.00	H_0 rejected
Gupta [62], Michos [65]	739.383	0.00	H_0 rejected
Mann [63]	580.779	0.00	H_0 rejected

4.2. Unit root test

Since the results of the CD test reveal that the series have cross-sectional dependence, we employ second-generation unit root tests, teamed with first-generation, to have a more precise and cognitive outcome. ARDL model becomes inapplicable in the case when the series be integrated at $I(2)$, or above [83]. Being gnostic of the fact, we intend to circulate unit root tests to make sure that the series is either $I(0)$ or, $I(1)$ but not $I(2)$ [73,76]. In our study, we manage to conduct Im-Pesaran-Shin (IPS), and Levin-Lin-Chu (LLC) methods from the first generation tests and Cross sectionally Augmented Dickey-Fuller (CADF) test from the second generations. The results are displayed in Table 5.

We are, in essence, versed that our data suffers from either $I(0)$ or $I(1)$ but not from $I(2)$. This affair blesses us with the possibility to estimate both short-run and long-run relationship among the determinants, and thus, we will be able to justify Wagner's Law using a Panel ARDL approach.

4.3. Panel ARDL test result

The underlying tables behold the outcomes grounded on the Pooled Mean Group (PMG) estimator, for prior specified detached specifications of Wagner's Law. Also, Dynamic Fixed Effect (*DFE*) estimates are calculated which, unlike the *PMG* estimates, permits only the intercepts to oscillate across groups. Thus, by comparing the outcomes derived from the PMG and DFE estimates, we will have a clear understanding of how the models show technique sensitivity, and in response, how the results differ.

4.4. Peacock-Wiseman version test results

Table 6 shows the panel-ARDL estimation (*PMG* and *DFE*) results for the Peacock-Wiseman version of Wagner's Law. Here, Government Revenue, Trade and GDP act as the regressors, whereas government expenditure personates the ancillary variable. Albeit we tabulated here the results drawn from the both (*PMG* and *DFE*) tests, we further executed the Hausman test, as anticipated beforehand, to choose between the tests. The probability value of χ^2, in the Hausman test, being 99.15 % insists us to accede *DFE* estimator as consistently efficient. Dynamic Fixed Effects (*DFE*) estimates report that GDP, government revenue and Trade all have positive impressions on government expenditure in the long-run; among which, GDP and government revenue have significant relation. However, Trade unfortunately results in being insignificant. On the other hand, *PMG* estimations declare the relationship for all the determinants to be significant in the long-term. At the same time, it unveils that Trade volume exerts a significant but negative impact on government expenditure whereas GDP and government revenue maintain a significantly positive relation.

The scenario turns out to be assorted in the short run. The short-run *DFE* estimators elicit that GDP has a significant and negative impression on government expenditure while government revenue exerts a significant positive impact. Trade volume on the verge dispenses an insignificant negative impact on government spending. Unlike the *DFE* estimators, the short-run *PMG* estimators identify the short-run relationship to be insignificant for all series. Although GDP has negative sign, government revenue and Trade share positive elasticities with government expenditure.

Aside from all these controversies, the error correction coefficient (ECT), representing the convergence parameter, is apprehended to be negative and significant. The estimator, thus, ignites that there is a tendency of the variables to be convergent to the equilibrium position in the long-run in response to any short-run discrepancy. Our estimation using the *DFE* estimator has found an average speed of adjustment of about 42.85 %. It signifies that 42.85 % of the misalignment (i. e. the deviation of variables from the long term relationship) of a variable, at any period, is going to be rectified within the immediate next period as if the variable gets at the steady-state position in the long-run. Edgeways, *PMG* estimator presages the speed of adjustment to be 28.08 %.

Table 5
Panel unit root tests.

Variables	Versions of the test					
	LLC		IPS		CADF	
	Level	1st difference	Level	1st difference	Level	1st difference
lnG	−0.3214 (0.37)	−7.9496 (0.00)	−0.6692 (1.00)	−5.3462 (0.00)	−1.85 (0.322)	−3.661 (0.00)
lnY	1.7991 (0.964)	−5.6712 (0.00)	0.2368 (1.00)	−4.3434 (0.00)	−1.548 (0.824)	−2.557 (0.00)
lnG/Y	−2.2583 (0.012)	−9.1143 (0.00)	−1.9415 (0.0202)	−5.4011 (0.00)	−2.108 (0.05)	−3.636 (0.00)
lnY/P	1.5869 (0.9437)	−5.3904 (0.00)	0.2657 (1.00)	−4.1391 (0.00)	−1.501 (0.875)	−2.517 (0.00)
lnG/P	0.014 (0.5056)	−7.9925 (0.00)	−0.855 (0.9998)	−5.3351 (0.00)	−1.741 (0.517)	−3.693 (0.00)
lnGRev	−0.3632 (0.3582)	−10.2972 (0.00)	−0.511 (1.00)	−4.9022 (0.00)	−2.482 (0.00)	−3.54 (0.00)
lnT	−3.4012 (0.0003)	−11.4698 (0.00)	−1.2358 (0.9514)	−4.7484 (0.00)	−2.241 (0.012)	−3.428 (0.00)

Notes: LLC means the Levin-Lin-Chu method. IPS and CADF denote the Im-Pesaran-Shin method and Cointegrated Augmented Dickey-Fuller (CADF) procedure of stationarity test. Adjusted t* and t-bar are taken to be the test statistics for LLC and both for the IPS and CADF method, respectively. Howsoever, figures within parentheses indicate the p-value of the respective tests.

Table 6
PMG and DFE estimation for traditional Peacock-Wiseman version.

Variables	Pooled Mean Group (PMG)				Dynamic Fixed Effects (DFE)			
	Coeff.	St. Error	Z-value	P- Value	Coeff.	St. Error	Z-value	P- Value
Dependent Variable: lnG rowhead								
Long-Run Coefficientsrowhead								
lnY	.5,693,723	.0883727	6.44	0.00	.4434645	.0687811	6.45	0.00
lnGRev	.6,855,969	.0743592	9.22	0.00	.6,494,236	.0551841	11.77	0.00
lnT	−.1,716,578	.0303356	−5.66	0.00	.0112733	.0433319	0.26	0.795
Hausman Test	$\chi^2 = 0.10$; Probability of $\chi^2 = 0.9915$							
ECT	−.280857	.0472396	−5.95	0.00	−.4,285,381	.0344955	−12.42	0.00
Short-Run Coefficientsrowhead								
ΔlnY	−.0171695	.164472	−0.10	0.917	−.3,117,726	.149653	−2.08	0.037
ΔlnGRev	.1,080,386	.085934	1.26	0.209	.131713	.0389791	3.38	0.001
ΔlnT	.0004998	.0373566	0.01	0.989	−.0150209	.0346415	−0.43	0.665
Intercept	−.6,997,052	.1,247,154	−5.61	0.00	−1.289783	.2,908,053	−4.44	0.00

4.5. Goffman version test results

The Goffman version shuffles the explanatory variable from GDP to per capita GDP and passed the explained variable to be static at government expenditure. Enumerated *PMG* and *DFE* estimates for this version, within panel ARDL framework, are summed up in Table 6.

Table 7 contains *PMG* and *DFE* estimates simultaneously. Hausman test, in line with the guideline, is performed to choose between the tests. Probability of χ^2 in the Hausman test is 99.95 %, and thus it indicates the *DFE* estimators to be more reliable and consistent than those of *PMG*. The *DFE* estimators, in their course of enumerating the long run coefficients, exhibit significant positive relationship between all the three regressors and the response variable. Elasticity coefficients of the Public Spending, in essence of the *DFE* estimators, are 0.35, 0.74, and 0.09 in response to per capita GDP, government revenue and Trade accordingly. This incidence points to the crucial economic facts that, at the phase of economic uprising, the government tries to accelerate the growth and coronate bangs of infrastructural development expenditures. Again, an increase in revenue blesses the government with spare discretionary currency to descendant its expenditure. Likewise, an increase in trade volume increases government income, which, as aftermath, sources the government expenditure to flourish.

The *PMG* estimators, on the other side, canvass a different scenario. The elasticities of government revenue and Trade although remain significant but become large enough than before (in the *DFE* test), almost 91.73 and 13.24 reportedly. The coefficient of the Per capita GDP surprisingly becomes insignificant and alters its sign into negative. This negative elasticity implies a percentage change in per capita GDP to bring about a negative response that calls for a cut in the government expenditure by almost 0.0942 %. This though seems absurd is not an aliening outcome. This may happen in reality when, with economic advancement, the government relies on the private sectors and intends to knock off its intervention in the market.

The short-run dynamics in line with the *DFE* estimators provide more or less the same outcomes such that, elasticities in response to all the three predictors are happened to remain positive and significant for Per capita GDP and Government Revenue, but for Trade, the statistic is unfortunately reported to be insignificant. A remarkable change, relative to its long-run coefficients, has been notified for the short run statistics of Trade, since, in line with *PMG* estimation, the coefficient not only alternates its sign from positive to negative (implying a negative elasticity) but also the test befits to be insignificant. Per capita GDP is reputed to be insignificantly negative and government revenue is observed to be positive but insignificant.

Nevertheless, the negative and significant outcome of the error correction coefficient comes forth as a blessing for the model since it guarantees the variables to be cointegrated in the long-run. The speed of adjustment, in line with *DFE* estimates, being 36.57 %,

Table 7
PMG and DFE estimation for Goffman version.

Variables	Pooled Mean Group (PMG) Estimates				Dynamic Fixed Effects (DFE) estimates			
	Coeff.	St. Error	Z-value	p-value	Coeff.	St. Error	Z-value	p-value
Dependent Variable: lnG rowhead								
Long-Run Coefficientsrowhead								
lnY/ P	−.0942411	.0978183	−0.96	0.335	.3,485,832	.1,046,359	3.33	0.001
lnGRev	.9,173,831	.062574	14.66	0.00	.7,359,708	.0656926	11.20	0.00
lnT	.1,324,665	.0375228	3.53	0.00	.0975177	.048036	2.03	0.042
Hausman Test	$\chi^2 = 0.02$; Probability of$\chi^2 = 0.9995$							
ECT	−.273352	.0585957	−4.67	0.00	−.365767	.0325329	−11.24	0.00
Short-Run Coefficientsrowhead								
ΔlnY/ P	−.0336797	.2,092,749	−0.16	0.872	−.254104	.1,507,796	−1.69	0.092
ΔlnGRev	.0271459	.0739675	0.37	0.714	.1,326,533	.0398358	3.33	0.001
ΔlnT	−.0614426	.0377532	−1.63	0.104	−.026150	.0353775	−0.74	0.460
Intercept	−.0977483	.0301714	−3.24	0.001	.4,861,596	.2,638,048	1.84	0.065

theorizes that any deviation of the government spending due to any economic outturn is going to be corrected at the speed of 36.57 % within the next period as if it comes at its long-run equilibrium. The *PMG* method, however, enumerates the speed of adjustment to be 27.33 %.

4.6. Musgrave version test results

Here appears the Musgrave's specification of the Law for justification. This version, as entitled afore, takes in Per Capita GDP to be the explanatory and the share of government expenditure to GDP as the explained variable. Table 8 sums up the outcome of the Panel ARDL approach, like the prior versions, along with two other explanatory variables.

On the verge of dealing with a schedule withholding the outcomes of both *PMG* and *DFE* estimates, Hausman test is needed to be rehashed to align the unfailing and consistent estimators. Not differently from the others, a 99.87 % probability value of χ^2 in the Hausman test sets forth the *DFE* test to be more comprehensive.

The long-run coefficients, as the *DFE* estimates expose, are significant. The long-run elasticity coefficients of the share of government expenditure to GDP in backwash of the per capita output and Trade volume are noticed to be negative (−0.3137 and −0.1029 respectively). This ignites a phase of economic advancement where, if the economy reaches, the government cuts back its expenditure. In the case of Trade volume, this is supposed to happen when imports surpass exports. However, the elasticity of government revenue is found to be significantly positive (0.0748) and thus signifies the situation when the government gets enough revenue to increase its expenditure. So, the share of Public Spending to GDP increases in turn. The *PMG* estimates, on the other side, elicit that the share of public spending to GDP holds significant negative long-run elasticity (−0.8814) against per capita output and significant positive elasticity against government revenue (almost 0.5157). The elasticity turns out to be insignificant in the case of Trade volume.

In line with the short-run dynamics, the DFE estimators provide significant negative elasticity (−0.9207) in response to per capita output and significant positive elasticity against government revenue (almost 0.2165). The elasticity turns out to be insignificant in the case of Trade volume. The PMG estimators, for the same case, provides significant relation only in case of per capita output and it turns out to be negative (roughly −0.5842). The other estimates, unfortunately, are found to be insignificant. Whatsoever, the significant negative value of the coefficient guarantees the congruency to the long-term steady-state position. The DFE technique, as before, signifies the speed of adjustment to be 32.53 %, whereas the adjustment speed is reported to be almost 29.72 % by the PMG technique.

4.7. Gupta/Michos version test results

Now, the turn is for Gupta/Michos version to be estimated. This version of Wagner's Law enrolls Per Capita GDP as the input variable and per capita government expenditure as the output variable. Hereafter, as this paper demands, including some other explanatory variables, we tabulated the outcome of this version in panel ARDL settings.

Table 9 holds in the long-term and short-term outcomes of *PMG* and *DFE* estimates. What we should do now is to institute a Hausman test to decide among estimates. In line with the guideline of the test, the probability value of χ^2 being 99.87 % grade *DFE* estimators to be consistently efficient. Long-run Coefficients, as the *DFE* estimates report, all in a row, are found to be significant. The test also unveils a fact that per capita government expenditure shares positive elasticities with per capita output (0.6862) and government revenue (0.5021); whereas, at the same time, it maintains negative elasticity against trade volume. The economic consequences behind such outcome, being addressed afore, beg no reasonable cause to be repeated. On the other hand, the *PMG* estimates, although reports the long-run elasticity to be positive but, at the same time, the relation turns to be insignificant for per capita output and trade volume, however and not surprisingly let alone government revenue be significant (elasticity is 0.5157).

Table 8
PMG and DFE estimation for Musgrave Version.

Variables	Pooled Mean Group (PMG)				Dynamic Fixed Effects (DFE)			
	Coeff.	St. Error	Z-value	p-value	Coeff.	St. Error	Z-value	p-value
Dependent Variable: lnG/Y								
Long-Run Coefficients								
lnY/P	-.881485	.107262	-8.23	0.00	-.3137037	.1192712	-2.63	0.009
lnGRev	.5157072	.0455799	11.31	0.00	.5021508	.074869	6.71	0.00
lnT	.0046749	.0312161	0.15	0.881	-.1029453	.0547464	-1.88	0.06
Hausman Test	$\chi^2 = 0.03$; Probability of$\chi^2 = 0.9987$							
ECT	-.297257	.0601349	-4.94	0.00	-.325382	.0309471	-10.51	0.00
Short-Run Coefficients								
ΔlnY/P	-.584205	.2113115	-2.76	0.006	-.9207606	.1514531	-6.08	0.00
ΔlnGRev	.139579	.0912515	1.53	0.126	.2165768	.0378323	5.72	0.00
ΔlnT	-.051622	.044743	-1.15	0.249	-.0043665	.0359537	-0.12	0.903
Intercept	-1.99898	.4215397	-4.74	0.00	-2.732471	.3573237	-7.65	0.00

Table 9
PMG and DFE estimation for Gupta/Michos version.

Variables	Pooled Mean Group (PMG) Estimates				Dynamic Fixed Effects (DFE) estimates			
	Coeff.	St. Error	Z-value	p-value	Coeff.	St. Error	Z-value	p-value
Dependent Variable: lnG/P								
Long-Run Coefficients								
lnY/ P	.1,185,133	.1,071,261	1.11	0.269	.6,862,963	.1,192,712	5.75	0.00
lnGRev	.5,157,073	.0455799	11.31	0.00	.5,021,508	.074869	6.71	0.00
lnT	.0046753	.0312161	0.15	0.881	−.1,029,453	.0547464	−1.88	0.06
Hausman Test	$\chi^2 = 0.03$; Probability of $\chi^2 = 0.9987$							
ECT	−.2,972,574	.0601349	−4.94	0.00	−.3,253,822	.0309471	−10.51	0.00
Short-Run Coefficients								
ΔlnY/ P	.118537	.1,916,362	0.62	0.536	−.2,461,427	.1,533,084	−1.61	0.108
ΔlnGRev	.139579	.0912515	1.53	0.126	.2,165,768	.0378323	5.72	0.00
ΔlnT	−.0516223	.044743	−1.15	0.249	−.0043665	.0359537	−0.12	0.903
Intercept	−1.998987	.4,215,399	−4.74	0.00	−2.732471	.3,573,237	−7.65	0.00

The short-run dynamics, hither, tell a different story. Among the short-run coefficients, derived by the DFE method, only Government Revenue alike, in the long run, is found to share significant positive relation (elasticity is 0.2165). Elasticity's in relation to per capita output and trade volume turned out to be insignificant and negative. The PMG estimates hearsay all the short-run coefficients to be insignificant, although they are positive for per capita output and Government Revenue and negative for trade volume.

The adjustment coefficient, presented by the Error Correction term, being significant and negative, confirms the variables to hold long-run relationship towards equilibrium. The DFE estimates report the adjustment speed to be 32.53 %, whereas, in the estimation of PMG, the speed of adjustment is found to be 29.72 %. The speed of adjustment is not satisfactory and reminds us that any sudden shock in the economy will take a good deal of time to recovery.

4.8. Mann version test results

This version assigned GDP to be the explanatory variable and the share of public spending to GDP to be the explained variable. Also, for this version, the Panel ARDL results are placed below in Table 10.

We are obliged to repeat the Hausman test to choose estimates as long as several versions of the ARDL model are used simultaneously. The probability of χ^2, not differently, declares the DFE estimators to be more efficient and reliable since the probability value is 99.15 %.

Let us look at the long-run coefficients first. The *DFE* estimates elicit that the share of Public Spending to GDP holds significant negative elasticity against GDP (valued −0.5565); significant positive elasticity against government revenue (0.6494) but insignificant and negative elasticity against Trade volume. The PMG estimates introduce a slightly changed outcome. It reports that the long-run coefficients of all the variables are significant. At the same time, the elasticity is negative in response to GDP (almost −0.4306) and Trade volume (−0.1716) but is positive relative to government revenue (0.6855). The aforecited economic impression is not extraneous here.

In the case of the short-run dynamics, the *DFE* estimates provide more or less the same results in line with the long run. The short-term statistic of GDP has been reported as significant and negative (−0.8832). The coefficient of government revenue is, as expected, significant and positive (0.1317), but in the case of Trade volume, the coefficient is insignificantly negative. The *PMG* estimates enumerate the short-run coefficient of GDP is significant and it holds negative elasticity (−0.7363). The coefficients of government revenue and Trade are reported to be positive, although insignificant. The error correction coefficient, as per expectation, is found to be significant and negative in the essence of both tests, and thus, it sets out the variables to have a long-run equilibrium relationship. The

Table 10
PMG and DFE estimation for Mann version.

Variables	Pooled Mean Group (PMG)				Dynamic Fixed Effects (DFE)			
	Coeff.	St. Error	Z-value	p-value	Coeff.	St. Error	Z-value	p-value
Dependent Variable: lnG/Y								
Long-Run Coefficients								
lnY	−.4,306,284	.0883727	−4.87	0.00	−.5,565,355	.0687811	−8.09	0.00
lnGRev	.6,855,981	.0743591	9.22	0.00	.6,494,236	.0551841	11.77	0.00
lnT	−.1,716,581	.0303357	−5.66	0.00	.0112733	.0433319	0.26	0.795
Hausman Test	$\chi^2 = 0.10$; Probability of $\chi^2 = 0.9915$							
ECT	−.280857	.0472396	−5.95	0.00	−.4,285,381	.0344955	−12.42	0.00
Short-Run Coefficients								
ΔlnY	−.7,363,126	.1,685,775	−4.37	0.00	−.8,832,345	.1,481,573	−5.96	0.00
ΔlnGRev	.108038	.085934	1.26	0.209	.131713	.0389791	3.38	0.001
ΔlnT	.0004999	.0373565	0.01	0.989	−.0150209	.0346415	−0.43	0.665
Intercept	−.6,997,054	.1,247,153	−5.61	0.00	−1.289783	.2,908,053	−4.44	0.00

adjustment speed towards the long-term equilibrium growth path, being responsive to any short-term default, is estimated to be 42.85 % by the *DFE* test and 28.08 % by the *PMG* test.

Now, to appraise the validity of Wagner's Law, we look over the country-specific detailed *PMG* test (see in Table 11). Focusing on the Peacock-Wiseman version, this paper finds that China comes with a significant negative inelastic result with the law.

On contrary, France provide significant positive inelasticity. In the Goffman law, country specific detailed investigation of the short-run dynamics, through *PMG* technique, disrobes that Guina (elastic), India (inelastic), Philippines (inelastic) report the positive significant findings, whereas China (elastic) and Jordan (elastic) hold significant negative response in the short run. However, a detailed investigation into the country-specific short-run dynamics for Musgrave law confirms that India, China, Paraguay, Canada, France, and UK reveal a negative elasticity, while Mozambique and Jordan, and Malaysia maintain a significant negative inelastic results. On the other hand, the paper states that Burkina Faso come with a significant positive elastic results in line with the law.

However, according to the country-specific short-run dynamics of Gupta/Michos version, we find that Burkina Faso and Bangladesh hold significant positive elastic attributes, whereas France and UK exhibit significant negative inelastic response. Lastly, Mann law clarifies that India, China, Malaysia, Canada, France, and UK maintain significant negative elasticity, whereas Mozambique, Jordan, and Mexico hold a significant negative inelasticity.

More precisely, this paper applies Wagner law with relation Y/P and without relation Y/P. Comparing the findings in the short run, we find that with Y/P, the laws hold more inelastic behavior than elastic behavior. When it comes to the line without Y/P, the laws maintain similar attributes in the context of elastic and inelastic response.

4.9. Cointegration test results

Here are the results of cointegration tests through employing Westerlund, Pedroni and Kao techniques. In the literature for Kao test, we intimate the statistics for five alternative versions and herein, the coming table runs in with their earned results (see in Table 12).

Kao test presumes a usual null hypothesis like the other tests by inferring no cointegration. The obtained Kao statistics for the five solicited specifications of Wagner's Law, five statistics for each version, manifest the null hypothesis not to be accepted (since the corresponding p-values are found to be less than 5 %) and inscribe to accept the alternative hypothesis. Thus, in line with the chosen (alternative) hypothesis, it is substantiated that the variables in all the versions of the law, as per expectations, have long run associations.

Here comes the Pedroni test (see in Table 13). We enumerated all the three statistics of the tests since we pronounced in the test literature, and the findings are scheduled below.

Note that, MPP_t, PP_t and ADF_t are the subscripts for Modified Phillips-Perron, Phillips-Perron, and Augmented Dickey-Fuller Statistics thoroughly. P-values of the respective tests have been figured in the parenthesis.

The results of the Pedroni test, as engrossed in the table above, contradict among themselves. The Modified Phillips Perron statistics, for all the specifications of Wagner's Law, set forth the inferred null hypothesis of no cointegration to be accepted. The Augmented Dickey-Fuller (ADF), and the Phillips-Perron (PP) tests, being together, diverges from the previous one. The statistics, derived from both the PP and ADF test, nominate the alternative hypothesis (that infers variables in all the panels to be cointegrated) to be accepted. Thus, since the majority of the tests inscribe, we feel relied on that, all the variables in all the panels share long-term associations.

The results of the Westerlund (see in Table 14), at the last phase, have been listed below. An inference within the test is drawn from the variance ratio statistic. From the results above, we can readily reject the null hypothesis of no cointegration for all the specifications of Wagner's law for p-values in no case exceeds the range of 0.005 or above. This frees us to accept the alternative hypothesis, slightly different from the previous two versions, that the variables are integrated with some of the panels.

Thus far from these results and also in line with the indication of the prior studies, we can, at large, be definitive that the variables under study share long run associations in order that they can reach the long-run steady-state position.

Table 11
Short run outcomes of country specifics.

Model	PMG results	Low income	Lower-middle income	Upper-middle income	High income
	Long-run	Short-run			
$\ln G = \alpha + \beta \ln Y$	.5,693,724***			-0.596^{*China}, $0.671^{***France}$	
$\ln G = \alpha + \beta \ln(Y/P)$	−0.094	$2.688^{**Guinea}$	$0.657^{**India}$, $0.728^{*Philippines}$	$-1.124^{**China}$, $-1.062^{**Jordan}$	
$\ln(G/Y) = \alpha + \beta \ln(Y/P)$	−0.881***	$1.253^{**Burkina\ Faso}$, $-0.693^{**Mozambique}$	$-1.435^{***India}$	$-1.592^{***China}$, $-0.929^{**Jordan}$, $-0.892^{**Malaysia}$, $-1.065^{***Paraguay}$	$-1.016^{***Canada}$, $-1.20^{***France}$, -1.559^{***UK}
$\ln(G/P) = \alpha + \beta \ln(Y/P)$	0.118	$1.354^{**\ Burkina\ Faso}$	$2.464^{**Bangladesh}$		$-0.462^{**France}$, -0.777^{*UK}
$\ln(G/Y) = \alpha + \beta \ln Y$	−0.431***	$-0.716^{**Mozambique}$	$-1.421^{***India}$	$-1.449^{***China}$, $-0.937^{**Jordan}$, $-1.325^{***Malaysia}$, $-0.580^{**Mexico}$, $-0.923^{**Paraguay}$	$-1.02^{***Canada}$, $-1.38^{***France}$, -1.41^{***UK}

Note: *, **, *** denote as 10 %, 5 %, and 1 % significance level.

Table 12
Kao test results.

Versions (↓)	Statistics (→)	MDF_t	DF_t	ADF_t	$UMDF_t$	UDF_t
$\ln G = \alpha + \beta \ln Y$		−6.4445 (0.00)	−6.8333 (0.00)	−5.3361 (0.00)	−13.8802 (0.00)	−9.0526 (0.00)
$\ln G = \alpha + \beta \ln(Y/P)$		−5.6004 (0.00)	−5.9165 (0.00)	−3.8062 (0.0001)	−12.5108 (0.00)	−8.1237 (0.00)
$\ln(G/Y) = \alpha + \beta \ln(Y/P)$		−3.1215 (0.0009)	−3.9398 (0.00)	−3.0103 (0.0013)	−8.8074 (0.00)	−6.2454 (0.00)
$\ln(G/P) = \alpha + \beta \ln(Y/P)$		−3.3575 (0.0004)	−4.0878 (0.00)	−3.1535 (0.0008)	−8.8074 (0.00)	−6.2454 (0.00)
$\ln(G/Y) = \alpha + \beta \ln Y$		−6.1966 (0.00)	−6.7076 (0.00)	−5.2165 (0.00))	−13.8802 (0.00)	−9.0526 (0.00)

Note that, MDF_t, DF_t, A DF_t, $UMDF_t$ and UDF_t in the above table reminiscent the Modified Dickey-Fuller, Dickey-Fuller, Augmented Dickey-Fuller, Unadjusted Modified Dickey-Fuller, and Unadjusted Dickey-Fuller statistics consequently. P-values of the tests have been resided in the parenthesis.

Table 13
Pedroni test results.

Versions (↓)	Statistics (→)	MPP_t	PP_t	ADF_t
$\ln G = \alpha + \beta \ln Y$		−0.0460 (0.4816)	−5.0927 (0.00)	−5.0314 (0.00)
$\ln G = \alpha + \beta \ln(Y/P)$		−0.0675 (0.4731)	−4.8595 (0.00)	−5.3798 (0.00)
$\ln(G/Y) = \alpha + \beta \ln(Y/P)$		0.1743 (0.4308)	−4.3574 (0.00)	−4.4197 (0.00)
$\ln(G/P) = \alpha + \beta \ln(Y/P)$		0.1743 (0.4308)	−4.3574 (0.00)	−4.4197 (0.00)
$\ln(G/Y) = \alpha + \beta \ln Y$		−0.0460 (0.4816)	−5.0927 (0.00)	−5.0314 (0.00)

Table 14
Westerlund test results.

Versions	*Variance Ratio*	
	Statistics	p-value
$\ln G = \alpha + \beta \ln Y$	−2.8590	0.0021
$\ln G = \alpha + \beta \ln(Y/P)$	−2.5958	0.0047
$\ln(G/Y) = \alpha + \beta \ln(Y/P)$	−2.6212	0.0044
$\ln(G/P) = \alpha + \beta \ln(Y/P)$	−2.6212	0.0044
$\ln(G/Y) = \alpha + \beta \ln Y$	−2.8590	0.0021

Additionally, this article also checks the existence of heteroscedasticity issues and the results reject the null hypothesis of homoscedasticity (see in Table A1). However, to figure out the heteroskedasticity-robust standard errors, this paper applies Feasible generalized least squares (FGLS) and panel-correlated standard error (PCSEs) methods. The estimated findings of the FGLS and PCSE tests are reported in Table A2, and it concludes that the PMG and DFE models are consistent and reliable.

5. Conclusions

This study concentrates on the focal point of cross-examining the celebrated Wagner's Law of increasing state activities to the countries of the World, through a sample of twenty countries formed by picking up five from every group (grouped based on per capita income by the World Bank). We align five sophisticated versions of the law, introduced by different economists at different periods. We, through concentrated inquisition on the prior literature, come to induce that government revenue and trade volume may most probably be earnest to exert a significant impact on public spending and so incorporated them as explanatory variables along with GDP (which is referred by the law). In line with the essence of the versions, as cited before, we articulate data on the variables under study, from the sampled countries, from 1991 to 2018.

We perform cross-sectional dependence tests and then stationarity tests in order that make ourselves definitive about the fact that our data confirms the prerequisites of the Panel ARDL testing procedure. Outcomes of the stationarity tests enfranchise us to adopt the Panel ARDL test for procedural rituals. In our discretion, we prosecuted Pooled Mean Group (PMG) and Dynamic Fixed Effects (DFE) estimation techniques.

Now, for the first one known as the Peacock-Wiseman version, the DFE estimates reveal a significant positive elasticity of the government expenditure with respect to GDP in the long run. This outcome, as expected, confirms it's (the Law) pertinence in the long run. In an economic sense, this outcome can be explained with reference to Wagner's Law, such that, at earlier stages of development, the government seeks to dilate its expenditure in order to keep the path of the economic outgoing fugitive. The short-run dynamics introduces an extraneous situation, in which the elasticity coefficient of GDP, being diverged away Wagner's law, is found to be significantly negative.

As a segment of the strait, now comes the Goffman version. The DFE estimates, in line with this assertion, also warrant the outcome variable (government expenditure) holds significant and positive long-run elasticity against all the three explanatory variables each. The elasticity in response to the model specified explanatory variable, per capita GDP here, being 0.3485 exerts an economic upshot

that a 1 % change in per capita GDP is going to bring forth a positive but inelastic response from government expenditure. The short-run coefficients turn back in the case of per capita GDP and it becomes significantly negative (−0.2541). Although the short-run coefficient of government revenue remains significantly positive (0.1326), but it turns to be insignificant and negative in the case of Trade.

As the findings of the Musgrave version, this test prescribes that elasticity of the share of public expenditure to GDP in relation to per capita output, in the long run, is significantly negative (−0.3137). Not by providence, the long-run estimates of government revenue are found to be significant; 0.5021 and −0.1029, respectively. The significant and negative value of the error correction term signifies the presence of such a long-term association. The short-term coefficients, as if being enchanted with the long-run outcome, elicit that the share of government expenditure to GDP holds significant negative elasticity with per capita output, whereas the elasticity turns out to be significant and positive in case of government revenue.

Let us go for Gupta/Michos version in regard to which the DFE estimates elicit that the long-run coefficients, for all the variables, are significant. It also reveals that the elasticity with respect to per capita output and government revenue, besides being significant, are positive. Conversely, the elasticity is, as usual, negative for Trade. Surprisingly, the short-run coefficient of per capita output is found to be insignificant and negative, while it remains significant and positive in case of government revenue.

Lastly, we have the Mann version to inscribe. DFE estimates report an identical result to Musgrave version for this Mann version. The long-run coefficient of GDP is reported to be significant and negative. The long-run elasticity of government revenue is significantly positive but for Trade, it is insignificant. The short-run coefficients also support long-run consequences. Short-run elasticity in response to GDP and government revenue, although differs in sign i. e., negative (−0.8832) for the former and positive (0.1317) for the later, but they both are significant. As before, the elasticity of Trade is reported to be insignificant.

However, country specific detailed study through PMG estimates reveals that China, examining Peacock-Wiseman variant, has a significantly negative inelastic effect in the short run. But France actually affords significant positive inelasticity. In the Goffman law, Guina (elastic), India (inelastic), and Philippines (inelastic) indicate positive significant behavior, whereas China and Jordan (elastic) indicate negative significant discoveries. Musgrave law indicates that countries like India, China, Paraguay, Canada, France, and the UK generate negative elasticity, while countries like Mozambique, Jordan, and Malaysia tend to display significantly negative inelastic decisions.

It turns out that, in accordance with the Gupta/Michos model, Burkina Faso and Bangladesh have highly positive elastic characteristics, while France and the UK have notably negative inelastic reactions. Finally, Mann law elucidates that India, China, Malaysia, Canada, France, and the UK all keep considerable negative elasticity, while Mozambique, Jordan, and Mexico all keep significant negative inelasticity.

Moreover, government revenue is found to be significant in explaining the growth of public spending and is reported to be positive in both long-run and short-run processes throughout all the versions. This happens not to be an extraneous instance; since the government, if be able to generate additional revenues, can also be successful in affixing their expenditures in turn. Trade volume, contrarily, is hardly apprehended to be significant, both in the short-run and long-run, throughout whole testing procedure. Yet, it is observed to negatively affect the growth of government expenditure. Import in many countries exceeds the export in total. This incidence, through an economic mechanism, along with other reasons, can act as a pretext for such an outcome.

Prior studies theorized that the validity of Wagner's Law will be ascertained only if the elasticity coefficients of the outcome variables (which differ among versions) with reference to the (version specified) explanatory variables exceed unity (be greater than one) [48]. With utter misfortune, in no version, we hardly found any elastic coefficient that can refer the data to support Wagner's Law.

While this study does contribute to the existing body of information, it does have several limitations that can be addressed in future studies. Future research may wish to investigate a big dataset to verify the Wagner law, as this one only includes a subset of countries. For a finer point, academics can focus on either underdeveloped or advanced economies. In addition, non-linear autoregressive distributive lag model or other asymmetric econometric models may be used by researchers. Here, the up and down movement of a specific variable is plain to see.

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5.1. Data availability statement

Data will be made available on request.

Additional information

No additional information is available for this paper.

CRediT authorship contribution statement

Md. Akter Hossain: Formal analysis, Data curation, Conceptualization. **M.M.K. Toufique:** Writing – original draft, Software, Investigation, Formal analysis. **Dilruba Yesmin Smrity:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation. **Md. Golam Kibria:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Formal

analysis.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix

Table A.1
Heteroscedasticity test

Versions of Wagner's Law	X^2 statistics	Probability	Decision
$\ln G = \alpha + \beta \ln Y$	3423.56	0.0000	H_0 rejected
$\ln G = \alpha + \beta \ln(Y/P)$	1700.52	0.0000	H_0 rejected
$\ln(G/Y) = \alpha + \beta \ln(Y/P)$	24577.81	0.0000	H_0 rejected
$\ln(G/P) = \alpha + \beta \ln(Y/P)$	24577.81	0.0000	H_0 rejected
$\ln(G/Y) = \alpha + \beta \ln Y$	3423.56	0.0000	H_0 rejected

Table A.2
Robustness Check by GLS and PCSE methods

Variables	Model-1		Model-2		Model-3		Model-4		Model-5	
	GLS	PCSE	GLS	PCSE	GLS	PCSE	GLS	PCSE	GLS	PCSE
lnG										
lnY	0.1706***	0.171***							−0.829***	−0.829***
lnG/Y										
lnY/P			−0.513***	−0.05***	0.172***	0.172***	1.172***	0.172***		
lnG/P										
lnGRev	0.8814***	0.881***	1.023***	1.02***	0.221***	0.221***	0.221***	0.221***	0.881***	0.881***
lnT	−0.047**	−0.047***	−0.005***	−0.01***	−0.244***	−.244***	−0.24***	−.244***	−0.047***	−0.047***

Note: *,**,*** denote as 10 %, 5 %, and 1 % significance level.

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