New evidences regarding the tax-spending nexus in Romania through wavelet analysis

(draft version)

Mihai Mutascu

Le Studium Fellow, Loire Valley Institute for Advanced Studies,
Orléans and Tours, France

and

LEO, University of Orléans

Abstract

The paper investigates the causality between government revenues and government expenditures in the case of Romania, for the period 1991m1-2015m5, by following the wavelet approach. The study offers detailed information of this connection, for different sub-periods of time and frequencies, emphasizing the lead-lag nexus between variables under cyclical and anti-cyclical shocks.

The main findings show that the treasury goals should be controlled by using the individual taxation techniques under structural reforms. Separately, when the economic crisis arises, the expenditure adjustment is a more appropriate fiscal instrument. On medium and long terms, the taxation system of individuals is recommended to be used as control for budgetary deficits during crisis. At the same time, on medium term, the government expenditures represent also a suitable policy choice.

Key words: Government, Revenues, Expenditures, Nexus, Romania, Wavelet

JEL classification: H11, H62, C32

1. Introduction

Over the last decades, the causality between government revenues and government expenditures has been intensively explored for many researchers on fiscal policy area. Many studies focused on different countries and periods, with various empirical tools and time horizons.

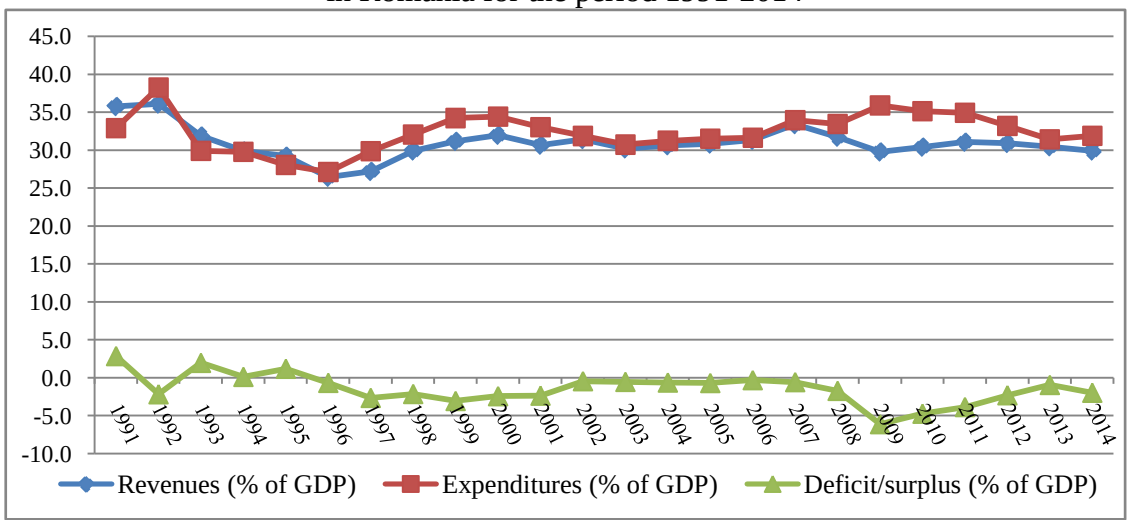
Between these countries, Romania arouses a special interest. This former ex-communist state exhibited sever budgetary deficit problem, which became accentuated especially during the international financial crisis.

Immediately after the '89 Revolution, the Romanian economy has been characterized by high rates of inflation and unemployment, with a serious damage of the economic equilibrium. Starting with 1997, as results of integration in the EU (European Union) area, the Romanian governments restructured the economy according to the free competitive market. As result of financial crisis, the good economic period of 2003-2007, with low level of unemployed and consistent economic growth, has been followed by systematic and complex budgetary liquidity goals. For needed corrections, a loan of 19.95 billion Euros has been contracted by the Romanian authorities from International Monetary Fund (IMF), European Commission (EC), World Bank (WB) and European Bank for Reconstruction and Development (EBRD).

This state left the planned economy for competitive market and changed the dictatorial political system with a pluralist democratic one. As Central and Eastern European country, it reveals other different characteristics, "the lack of capital, weak civil society and the impact of the European Union and other international organizations influencing the new member states", as Farkas (2011, p.15) shows.

Regarding the recent Romanian budgetary statements, Figure 1 below identifies four main periods. The first period indicates several surpluses (1991-1995), while the second period is characterised by accentuated deficits (1996-2001). The third period is characterized by moderate budgetary deficits (2002-2007). Finally, the fourth period highlights large deficits (2008-2014), which ameliorate towards the end of the interval.

Figure 1 - Revenues, expenditures and budgetary disequilibrium in Romania for the period 1991-2014



Source: data provided by World Bank, World Development Indicators, online data-base 2015.

According to Figure 1, after several years of budgetary surpluses (i.e. 1991-1995), Romania began registering deficits. Those deficits increased from 0.66% of GDP in 1996 to 3.06% in 1999. Furthermore, the disequilibrium is gradually absorbed, from 2.42% of GDP in 2000 to only 0.31% of GDP in 2006. In the next period, the deficits reached the level of 6.11% of GDP in 2009 subsequently reducing to 0.94% of GDP in 2013 and 1.97% of GDP in 2015.

Given this sinusoidal tendency of Romania's budgetary disequilibrium, two research directions capture the interest for exploration. The first one is the long-run relationship between government revenues and expenditures. The second direction is related to the asymmetry in the budgetary adjustment process.

On this ground, the study investigates the causality between government revenues and government expenditures in the case of Romania, for the period 1991m1-2015m5, by following the wavelet approach.

The paper extends the literature in the field in several directions. First, it offers for the first time a very detailed analysis regarding the tax-spending nexus in the case of Romania, by highlighting how the relationship between variables varies across different frequencies over time. The analysis generates short-, medium- and long-run frameworks regarding the Romanian fiscal policy. Also as add for the literature in the field, the investigation offers the second wavelet analysis on the fiscal policy area, after the contributions of Almasri and Shukur (2003). We note that the using of the wavelet tool is superior to the classical ones, because such approach allows us to see how the series interact at different frequencies and how they evolve over time. The method shows in the same time both the causality and sign of correlation between variables. Romania represents an interesting target for such a technique as it exhibited repeatedly both budgetary deficits and surpluses. With different types of fiscal policies and structural changes, Romania also crossed a long transition process from centralized economy to free competitive market. In this context, the approach depicts a particular framework and emphasizes the valence of wavelet by showing how the government revenues and expenditures interact at different frequencies and periods of time. Finally, the study reveals important information regarding the status of tax-spending connection from cyclical and anti-cyclical point of view.

The rest of the paper it is as follows: Section 2 illustrates the literature in the field, Section 3 presents the data and methodology, and Section 4 illustrates the empirical results. Finally, Section 5 concludes.

2. Literature review

Payne (2003), systematizing the literature in the field, identifies four directions of investigation regarding the "revenues-expenditures nexus": (i) tax-spend hypothesis, (ii) spend-tax hypothesis, (iii) fiscal synchronization hypothesis, and (iv) fiscal independence or institutional separation hypothesis.

The tax-spend hypothesis shows that there is a one-way causality direction between taxes and government expenditures, which runs from tax to spending (i.e. tax leads spending). The pioneer of this idea is Friedman (1978). He shows that taxes positively cause the government expenditures. More precisely, the deficit will not be attenuated when the tax increases, because this puts pressure on government expenditures. Thus, the best correction in such a situation is to

cut the tax level, which reduces the government spending. Buchanan and Wagner (1977) observed a negative causality of tax-spend hypothesis, introducing the idea of taxpayer fiscal illusion. When the government cuts taxes, the perceived price of public goods and services becomes lower. As consequence, the demand for public programs shifts upward, stimulating the government spending. By limiting the government control on deficit financing, provoked budgetary deficits are reduced.

The spend-tax hypothesis states that there is a one-way causality running form spending to tax (i.e. spending leads tax), a hypothesis formulated by Barro (1979). He claims that any additional expenditure is covered by future higher taxes. In this case, the government expenditures are the main instrument to control the budgetary deficits. Peacock and Wiseman (1979) find similar results. In a pure public choice approach, they emphasize that an increase in the level of expenditures is the result of the utility-maximizing behaviour of buyers and suppliers of public services, stimulating further tax increases.

The fiscal synchronization hypothesis reveals the bidirectional causality between tax and spending (i.e. tax leads spending and vice-versa). According to Musgrave (1966), the accent is put on the voters, who evaluate the marginal benefits in respect to marginal government cost. Based on this assessment, they will decide the appropriate levels of expenditures and revenues. This way, as Meltzer and Richard (1981) note, concurrent adjustments in tax revenues and expenditures will be done, reinforcing the fiscal synchronization hypothesis.

The fiscal independence or institutional separation hypothesis was put forth by Wildavsky (1988) and Baghestani and McNown (1994). They claim no connection between government revenues and government expenditures. The decisions regarding tax and spending are taken independently. Several separate institutions are involved in tax-spending decision making, and the collapse of consensus between them underlies the process of revenues and expenditures estimations.

The empirical literature regarding the tax-spending nexus is equally prolific. Two main groups of studies can be identifies. The first group investigates only one country, while the second one considers more than two countries.

Table 1 below presents the most relevant contributions which investigate the causality between government revenues and expenditures with one-country. The reviewed papers support all four hypotheses. They include many countries, different period of time and various econometric tools, from classical Granger causality to ARDL method.

Table 1. The main studies which investigate the connection between government revenues and expenditures with one-country

Author/s	Period	Countries	Methods	Outputs
Anderson et al. (1986)	1946-1983	US	Granger Causality	E→R
Manage and Marlow (1986)	1929-1982	US	Granger Causality	R↔E
Von Furstenberg et al. (1986)	1954-1982	US	VAR	E→R
Ram (1986)	1929-1983	US	Granger Causality	E→R
Blackley (1986)	1929-1982	US	Granger Causality	R→E
Ahiakpor and	1926-1985	US	Granger Causality	R→E

Amirkhalkhali (1989)				
Bohn (1991)	1792-1988	US	ECM	R→E
Baghestani and McNown (1994)	1955-1989	US	ECM	R↛E
Hondroyiannis and Papapetrou (1996)	1957-1993	Greece	Granger Causality	E→R
Payne (1997)	1950-1994	Canada	ECM	R→E
Hasan and Lincoln (1997)	1961-1993	UK	ECM	R→E
Katrakilidis (1997)	1974-1991	Greece	ECM	R↔E
Park (1998)	1964-1992	Korea	Granger Causality	R→E
Darrat (1998)	1967-1994	Turkey	Granger Causality	R→E
Li (2001)	1950-1997	China	ECM	R↔E
Chang and Ho (2002)	1977-1999	China	MVECM	R↔E
Almasri and Shukur (2003)	1960:Q1 - 1997:G2	Finland	Wavelet	Not conclusive
Hussain (2004)	1973-2003	Pakistan	Granger Causality	R→E
Carneiro et al. (2004)	1981-2002	Guinea-Bissau	Granger causality and VECM	E→R
Al-Quadir (2005)	1964-2001	Saudi-Arabia	ECM	R↔E
Taha and Loganathan (2008)	1970-2006	Malaysia	VAR	R↔E
Young (2009)	1955-2005	US	Granger Causality	R→E
Zapf and Payne (2009)	1959-2005	US	ECM	E→R
Saunoris and Payne (2010)	1955-2009	UK	ECM	E→R
Apergis et al. (2012)	1957-2009	Greece	TAR	R→E
Elyasi and Rahimi (2012)	1963-2007	Iran	Granger Causality and ARDL	R↔E
Parida (2012)	1970-2010	India	ECM	E→R
Richter and Dimitrios (2013)	1833-2009	Greece	Granger Causality	E→R
Aworinde (2013)	1961-2012	Nigeria	Granger Causality	R→E
Al-Zeaud (2015)	1990-2011	Jordan	Granger causality and VECM	R↛E
Obeng (2015)	1980-2013	Ghana	Granger causality and VAR	R→E

Note: R is the government revenue, E represents government expenditure, → reveals unidirectional causality, ↔ denotes bidirectional causality, while ↛ means no causality between R and E.

Source: Bolat (2014, p.6), with personal update.

It is notable that only one paper, belonging to Almasri and Shukur (2003), uses the wavelet methodology in order to explore the case o Finland. Unfortunately, the results are not conclusive.

In the case of contributions which consider more than two countries, the outputs also offer support for all four hypotheses, as Table 2 illustrates. Quasi-all investigations are relied on panel samples, with different countries and various period of time. The used econometric tools follow panel Granger causality, cointegration, panel ECM, TAR and MTAR, or bootstrap panel Granger causality approaches.

Table 2. The main studies which investigate the connection between government revenues and expenditures with more than two countries

Author/s	Period	Countries	Methods	Outputs
Owoye (1995)	1961-1990	G7 Countries	ECM	E↔R : US, Germany, UK, France, and Canada. R→E : Japan, Italy.
Payne (1998)	1942-1992	US States	Engle-Granger ECM	R→E: 24 states. E→R: 8 states. R↔E: 11 states.
Chang et al. (2002)	1951-1996	10 Industrialized Countries	Granger Causality	R→E: Japan, S. Korea, Taiwan, UK, and US. E→R: Australia, and S. Africa. R↔E: Canada. R ⇿ E: New Zealand, and Thailand.
Narayan and Narayan (2006)	1950-2000	12 Developing Countries	Granger Causality	R→E: Mauritius, El Salvador, Haiti, Chile, and Venezuela. E→R: Haiti. R↔E: Peru, South Africa, Guatemala, Uruguay, and Ecuador.
Konukcu-Önal and Tosun (2008)	1999:01-2007:04	Belarus, Kazakhstan, the Kyrgyz Republic and the Russian Federation	Granger Causality	R→E: Belarus, the Russian Federation. R↔E: Kazakhstan, and the Kyrgyz Republic.
Afonso and Rault (2009)	1960-2006	EU-25	Panel Causality	E→R: Italy, France, Spain,

				Greece, and Portugal. R→E: Germany, Belgium, Austria, Finland, UK.
Chang and Chang (2009)	1992-2006	15 OECD Countries	Granger Causality	R↔E
Westerlund et al. (2011)	1963-1997	50 US state-local government s	Cointegration	R→E
Mehrara and Elyasi (2011)	1995-2008	40 Asian countries	Cointegration	R↔E
Paleologou (2013)	1965-2009	Greece, Sweden, Germany	TAR, MTAR	R→E: Greece. R↔E: Sweden, and Germany.
Bolat (2014)	1980-2013	10 EU countries	Bootstrap panel Granger causality	R→E: Germany, Italy, and Netherlands. E→R: France and Portugal. R ↮ E: Austria, Belgium, Denmark, Finland, and UK.
Mutascu (2015a)	1995-2012	10 EU ex-communist countries	Bootstrap panel Granger causality	R→E: Czech Republic, Hungary, and Slovenia. E→R: Bulgaria. R↔E: Slovak Republic. R ↮ E: Estonia, Latvia, Lithuania, Poland, and Romania.
Mutascu (2015b)	1988-2014	PIIGS countries	Bootstrap panel Granger causality	R→E: Greece, and Italy. E→R: Portugal. R ↮ E Ireland, and Spain.

Note: R is the government revenue, E represents government expenditure, → reveals unidirectional causality, ↔ denotes bidirectional causality, while ↮ means no causality between R and E.

Source: Bolat (2014, p.6), with personal update.

Several papers are devoted to Romanian case, offering different findings. One of the first work belongs to Campeanu and Catarama (2007). They test the causality between government revenues and expenditures in the case of Romania and find there is strong evidence of

synchronization hypothesis. More precisely, government revenues Granger causes the government expenditure and vice versa. The sample covers the monthly period 1991-2005, while the econometric tool includes the Granger causality test, cointegration test and unrestricted VAR approach.
Stoian (2008) tests the same connection, but uses quarterly data, the sample covering the period 1991-2005. The main output reveals that the tax leads spending, which means there is significant support for tax-spend hypothesis. The results are enforced by the same classical Granger causality and cointegration tests, followed by ECM estimations.
Another study focused on the same topic is offered by Dima et al. (2009). The authors investigate the period 1993-2013 (current and expected values), by following Johansen co-integration test and ECM model. The estimations demonstrate the sustainability between tax and spending and show there is a one-way causality, which runs from tax to spending. Thus, the tax-spending hypothesis is validated. Hye and Jalil (2010) investigate the causality between government revenues and expenditures, but use, as novelty, an autoregressive distributive lag approach to cointegration, variance decomposition and rolling regression method. They use quarterly time series data, which covers the period 1998q1 to 2008q3. The authors validate the synchronization hypothesis. This means there is a bidirectional long run causal connection between the revenues and expenditures of the government.
Another technique introduces Tiwari and Mutascu (2013), which use Threshold Autoregressive (TAR) and Momentum-TAR (MTAR) estimations. Their study explores the relationship between revenues and government spending, in the case of Romania, for the period 1999q1-2012q1. For the first time, the results offer support for the spend-tax hypothesis in Romania, with long-run asymmetric adjustment.
The last recent work in the area belongs to Rosoiu (2014), who analyses the causality between government revenues and expenditures in the case of Romania in a VAR approach. The dataset includes quarterly data, from 1998q1 - 2014q1. The findings are similar to Hye and Jalil's (2010) ones, claiming for synchronization hypothesis.
The literature regarding the causality between tax and spending in Romania generally offers support for synchronization hypothesis. Two contributions confirm the tax-spending causal direction, while only one the spending-tax assumption. No fiscal independence hypothesis is found.

2. Data and methodology

Two time series are considered for analysing the connection between tax and spending in the case of Romania, by following a wavelet approach: government revenues *(x)* and government expenditures *(y)*. The dataset has monthly frequency and covers the period 1991m1-2015m5.
The sources of data are the Nation Bank of Romanian Monthly and Annual Bulletins, from 1991 to 2015. Both series are treated in real terms to avoid the inflation, being converted from Lei[1] in US dollars. These series, expressed in million US dollars, have been adjusted for seasonal components by using Census X12 methodology and log transformed to address issues skewed

[1] Lei is the name is Romanian national currency.

nature of the data. We did not adopt the classical method of weighting variables relative to the GDP for two reasons: to remove the cyclical effect of GDP from the analysis, and to address the shortcoming of unavailable GDP with monthly frequency in Romania.

According to Aguiar-Conraria et al. (2008, p. 2877), the wavelet transformation is used 'to quantify the degree of linear relation between two non-stationary time series in the time-frequency domain', several researchers reinforcing this idea (e.g. Crowley and Mayes, 2008; Hughes Hallett and Richter, 2008 or Boashash, 2015). The statistical stationarity of the series is probed with the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests. As we expect, the existence of structural breaks, Zivot-Andrew (ZA) test for unit root with structural break is also incorporated.

The governmental revenues-expenditures nexus has been explored generally by using conventional time domain approaches, but this dynamic connection can also vary across different frequencies (i.e. some relationships may exist at different ranges of frequency). Moreover, as Dar et al. (2014, p.3) argue, the ”true economic relationship among variables can be expected to hold at disaggregated (scale) level rather than at the usual aggregation level”. It is clear that the fiscal policies need adjustments on short-run term, especially to cover the treasury goals, but the fiscal strategies may be also targeted on long-run, for deficits/surpluses reasons.

In order to deal with these two aspects, we follow the wavelet tool for exploring the connection between tax and spending in Romania.

Comparatively with the classical techniques, the wavelet offers several advantages: (1) generates short-, medium- and long-run frameworks, (2) indicates how the relationship between variables varies across different frequencies over time, (3) reveals the direction of causality between at different frequencies over time, and (4) illustrates the lead-lag status of the connection (i.e. cyclical or counter-cyclical status).

The wavelet is a function focused on both time and frequency, with zero mean. The literature in the field offers different types of wavelet functions, with various characteristics (e.g. Morlet, Mexican hat, Haar or Daubechies).

The selection of the function is crucial and depends by targeted application as the wavelet coefficients $Wx(s, \tau)$ have mixed information about the function $x(t)$ and the analyzing wavelet $\psi(t)$, with t representing the time (here, s is a scaling or dilation factor which controls the length of the wavelet, while τ illustrates a location parameter which indicates where the wavelet is centered).

One of the most exploited wavelet function is the Morlet wavelet, as this type of wavelet function is a complex one, which allow us to obtain information on both the amplitude and phase. These aspects are essential for investigation of the business cycle synchronism between different time series.

The simplified version of Morlet function has this form:

$$\psi_\eta(t) = \pi^{-\frac{1}{4}} e^{i\eta t} e^{-\frac{1}{2}t^2}, \quad (1)$$

where η represents the dimensionless frequency and i denotes $\sqrt{-1}$.

There are two classes of wavelet transformation: the discrete wavelet transformation (DWT) and continuous wavelet transformation (CWT). According to Tiwari et al. (2013), the second class performs better for feature-extraction purposes, while the first one is characteristic for noise reduction and data compression.

Following for our propose the continuous wavelet transformation, the CWT transformation of a discrete time series $\{x_n\}$, with $\{x_n, n=0, ..., N-1\}$ of N observations and uniform time step δt and scale s, is as follows:

$$w_m^x(s) = \frac{\delta t}{\sqrt{s}} \sum_{n=0}^{N-1} x_n \psi^* \left((n-m) \frac{\delta t}{s} \right), \text{ with } m=0, 1, ..., N-1. \quad (2)$$

Given the CWT, based on the proposal of Torrence and Campo (1998), our investigation tool comprises: the wavelet power spectrum, the cross-wavelet power, the wavelet coherency and the phase difference.

2.1. Wavelet power spectrum

The wavelet power spectrum can be simply defined as $|W_n^x|^2$ and captures the level of the local variance. The edge effects of the observations are indicated through a cone of influence (i.e. below cone the observations are impacted with the edge effects). The null hypothesis serves to identify the statistical significance of wavelet power (i.e. the data generating process is given by a stationary process with a certain background power spectrum P_f).
Torrence and Compo (1998) offer performed white and red noise wavelet power spectra. Under the null hypothesis, the related distribution for the local wavelet power spectrum is:

$$D\left(\frac{|W_n^x(s)|^2}{\sigma_x^2} < p \right) = \frac{1}{2} P_f \chi_v^2 , \quad (3)$$

at each time n and scale s. P_f represents the mean spectrum at the Fourier frequency f related to the wavelet scale s (i.e. $s \approx 1/f$), whereas σ is the variance. The v is equal to 1 for real wavelet or has level 2 for complex wavelet one. We also note that the Monte-Carlo simulations are the base for general processes.

2.2. Cross-wavelet power

As seminal work of Hudgins et al. (1993), the cross-wavelet power (XWT) of two time series, $x=\{x_n\}$ and $y=\{y_n\}$, can be written as follows:

$$W_n^{xy} = W_n^x W_n^{y*}, \quad (4)$$

where, W_n^x and W_n^y represents the wavelet transforms of x and y, respectively. In this case, the cross-wavelet power is $\left|W_n^{xy}\right|$. Furthermore, the cross-wavelet power spectrum of two series shows the confined covariance between them at each scale or frequency and can be obtained having as background the Fourier power spectra P_f^x and P_f^y.

The theoretical distribution, as Torrence and Campo (1998) illustrate, is given by:

$$D\left(\frac{|W_x W_y^*|}{\sigma_x \sigma_y} < p\right) = \frac{Z_v(p)}{v}\sqrt{P_f^x P_f^y}, \quad (5)$$

where the confidence level associated with the probability *p* is *Zv(p)*, for a *pdf* as the square root of the product of two χ^2 distributions.

2.3. Wavelet coherency

The wavelet coherency (WTC) illustrates "the ratio of the cross-spectrum to the product of the spectrum of each series, and can be thought of as the local correlation, both in time and frequency, between two time series" (Aguiar-Conraria et al., 2008, p. 2872).
The mathematical form is:

$$R_n(s) = \frac{|S(s^{-1}W_n^{xy}(s))|}{S(s^{-1}|W_n^x|)^{\frac{1}{2}} S(s^{-1}|W_n^y|)^{\frac{1}{2}}} \quad (6)$$

where *S* is a smoothing operator in both time and scale.

2.4. Phase difference

Aguiar-Conraria et al. (2008) emphasize that the phase ϕ_x of time series $x=\{x_n\}$ should be treated as the position in the pseudo-cycle of the series. The phase difference $\phi_{x,y}$ of two time series is relied on the mean and confidence interval of phase difference.
The $\phi_{x,y}$ has this form:

$$\phi_{x,y} = tan^{-1}\left(\frac{I\{W_n^{xy}\}}{R\{W_n^{xy}\}}\right) \text{ and } \phi_{x,y} \in [-\pi, \pi]. \quad (7)$$

The time series move together at the specified frequency when the phase difference is zero. The series move in phase and *y* leads *x* when $\phi_{x,y} \in \left[0, \frac{\pi}{2}\right]$, while series move in phase but the *x* leads *y* when $\phi_{x,y} \in \left[-\frac{\pi}{2}, 0\right]$. Conversely, the series are in anti-phase when the phase difference is π or $-\pi$. In this case, when $\phi_{x,y} \in \left[\frac{\pi}{2}, \pi\right]$, *x* leads *y*, and *y* leads x, when $\phi_{x,y} \in \left[-\pi, -\frac{\pi}{2}\right]$, respectively.

3. Data analysis and findings

The sample proprieties of the Romanian government revenues *(x)* and expenditures *(y)*, in their brut level, with monthly frequency, for the period 1991m1-2015m5, are illustrated by using the descriptive statistics and plot of time-series (Table A1 and Figure A1, in Appendix).
The results of the ADF, PP, KPSS and ZA tests are reported in the Table 3. The non-stationary status is checked testing the variables only in level, with intercept, and also with trend and intercept, respectively.

Table 3: The unit root tests of ln government revenues and expenditures

Variable	Test							
	ADF (H_0 = the series has unit root)		PP (H_0 = the series has unit root)		KPSS (H_0 = the series is stationary)		Zivot-Andrew (H_0 = the series has unit root with structural break)	
	Intercept	Trend and intercept	Intercept	Trend and intercept	Intercept	Trend and intercept	Intercept	Trend and intercept
ln(x)	-0.989	-3.901*	-2.365	-7.600***	1.772***	0.290***	-3.839* (k=5)	-3.496*** (k=5)
ln(y)	-0.584	-3.250*	-1.594	-6.982***	1.773***	0.283***	-3.841*** (k=7)	-3.160* (k=7)
Breakpoint in ln(x)							2004m11	2003m05
Breakpoint in ln(y)							2005m01	2006m04

Note:
(a) ***, **, and * denote significance at 1, 5 and 10% level of significance, respectively;
(b) k is the optimal lag according to Schwarz Info Criterion.

For both variables, the null hypothesis of ADF and PP tests is not rejected, excepting the PP test with intercept and trend. The KPSS test rejects the null hypothesis of stationarity for both series. The ZA test does not reject the null of unit root with structural break at 10% level of significance for ln(x) with intercept and ln(y) with intercept and trend. Given that the ZA test is conclusive only under unit root propriety, we identify two structural breaks: 2004m11 for ln(x) and 2006m04 for ln(y). The break point in government revenues is related to the flat tax introduced in 2005, while the break point in expenditures signals the extension of public investments during 2006-2007. To conclude, both series are non-stationary in their level and present structural breaks. As a consequence, based on the wavelet tool requirements, the variables are considered non-stationary series.

The CWT power spectra[2] of the *ln(x)* and *ln(y)*, in the case of Romania, with monthly frequency, are presented in the Figures 2 and 3 below.

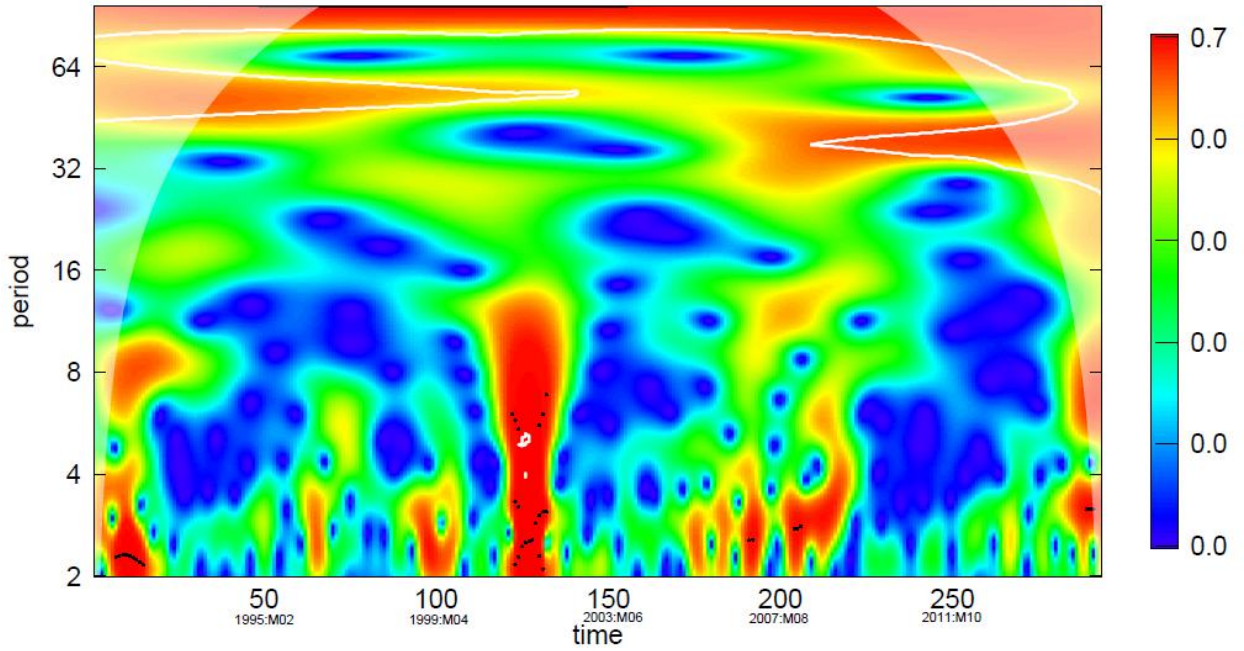


Figure 2: CWT power spectrum of *ln(x)* - government revenues, monthly series

Note:
(1) The thick white contour depicts the 5% significance level against red noise, while the cone of influence (COI) where the edge effects might distort the picture is designed as a lighted shadow;
(2) The colour code for power ranges goes from blue (low power) to red (high power);
(3) The X-axis denotes the studied time period, whereas the Y-axis illustrates the frequency.

[2] For all wavelet estimations, we used the R-codes proposed by Rösch and Schmidbauer (2014), in "WaveletComp: A guide tour through the R-package".

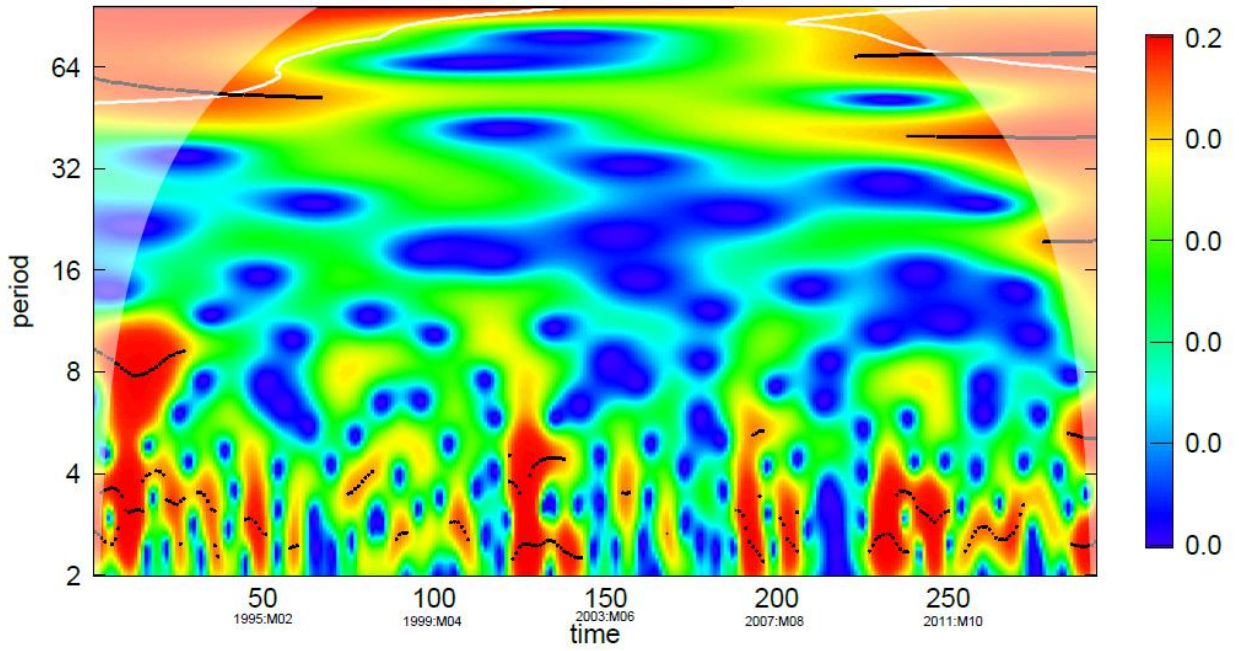


Figure 3: CWT power spectrum of *ln(y)* - government expenditures, monthly series

Note:
(1) The thick white contour depicts the 5% significance level against red noise, while the cone of influence (COI) where the edge effects might distort the picture is designed as a lighted shadow;
(2) The colour code for power ranges goes from blue (low power) to red colour (high power);
(3) The X-axis denotes the studied time period, whereas the Y-axis illustrates the frequency.

Figure 2 shows that the wavelet power of *ln(x)* is high and significant at 2-16 for the period 1991-1992, 2001-2002 and 2006-2008. Over an interval of 64 months during 1996-2010, the series registers high wavelet power. Figure 3 illustrates the wavelet power of *ln(y)*, with high and significant power at almost the same frequencies as in the previous case. Additionally, high power is also present at 2-16 months of scale (band), for the period 2009-2011.

To summarize, both CWT power spectra reveal several common features of the series. First common pattern covers the periods 1991-1992, 2001-2002 and 2006-2008, at 2-16 months of scale. The second period is 1996-2010, over 64 months of scale.

As these common features might be the result of a simple coincidence, the cross-wavelet power can offer additional information about the covariance and co-movement between the considered variables. The XWT of the pair *ln(x)* - *ln(y)* is plotted in Figure 4.

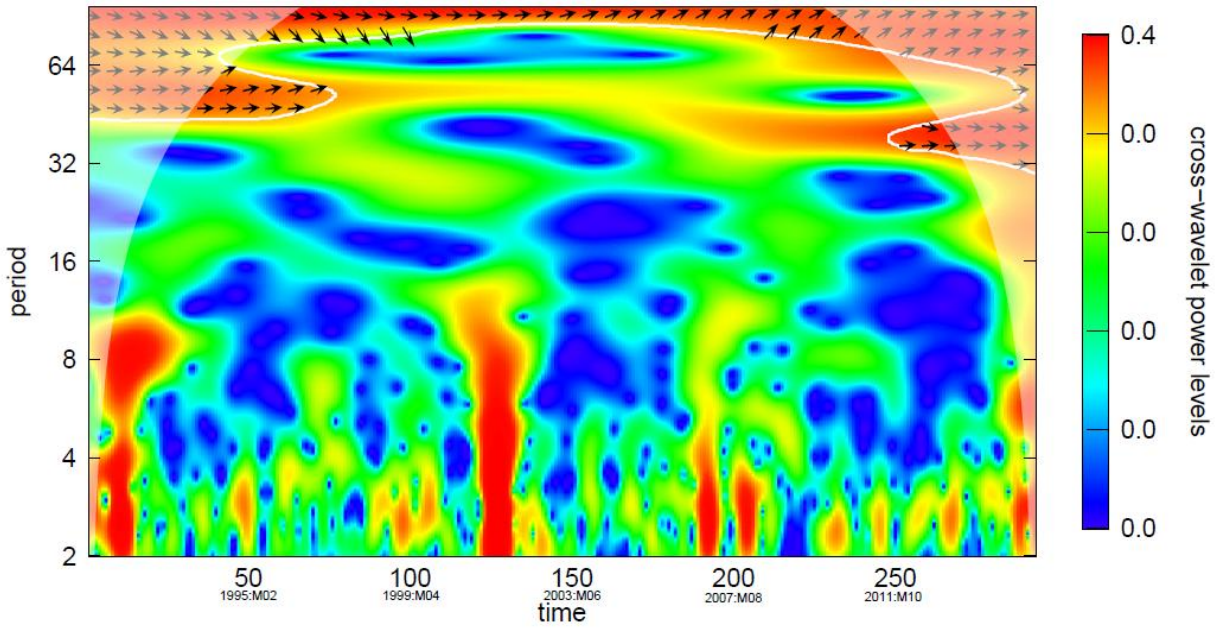


Figure 4: XWT of the pair *ln(x) - ln(y)*, monthly series

Note:
(1) The thick white contour depicts the 5% significance level estimated from Monte Carlo simulations by following phase randomized surrogate series, while the cone of influence (COI) where the edge effects might distort the picture is designed as a lighted shadow;
(2) The colour code for power ranges goes from blue (low power) to red colour (high power);
(3) The arrows indicate the phase difference between the two series. The variables are in phase when the arrows are pointed to the right (positively related). In this case, the government revenues are leading when the arrows are oriented to the right and up, while the government expenditures are leading when the arrows are pointed to the right and down.
(4) The variables are out of phase when the arrows are pointed to the left (negatively related). The government expenditures are leading when the arrows are pointed to the left and up, while the government revenues are leading when the arrows are oriented to the left and down.
(5) The variables have each other cyclical effect in the phase and anti-cyclical effect in the anti-phase or out of phase.
(6) The X-axis denotes the studied time-period, whereas the Y-axis illustrates the frequency.

The XWT of the pair *ln(x) - ln(y)* indicates some interesting findings. More specifically, there are powerful and significant relationships between variables only on the long term (i.e. at low frequency), corresponding to the period of 1993-2011, around 64 months of band. Figure 4 indicates that the variables are in phase during the period of 1993-2011, as the arrows are pointed to the right (i.e. cyclical effects).
Unfortunately, the XWT approach has been intensively criticised, because such tool depicts the power of two processes without normalization to the wavelet power spectrum. More precisely, when one spectrum is locally and another one presents peaks, the XWT can generate misleading outputs, the peaks producing spurious correlation between variables which actually are not correlated.

For such reasons, the XWT approach fails to describe the relationship between considered variables and requires a superior wavelet power tool: the WTC.
The Figure 5 illustrates the wavelet coherency of the pair *ln(x) - ln(y)* and reveals the connection in both frequency and time within which two variables are correlated.

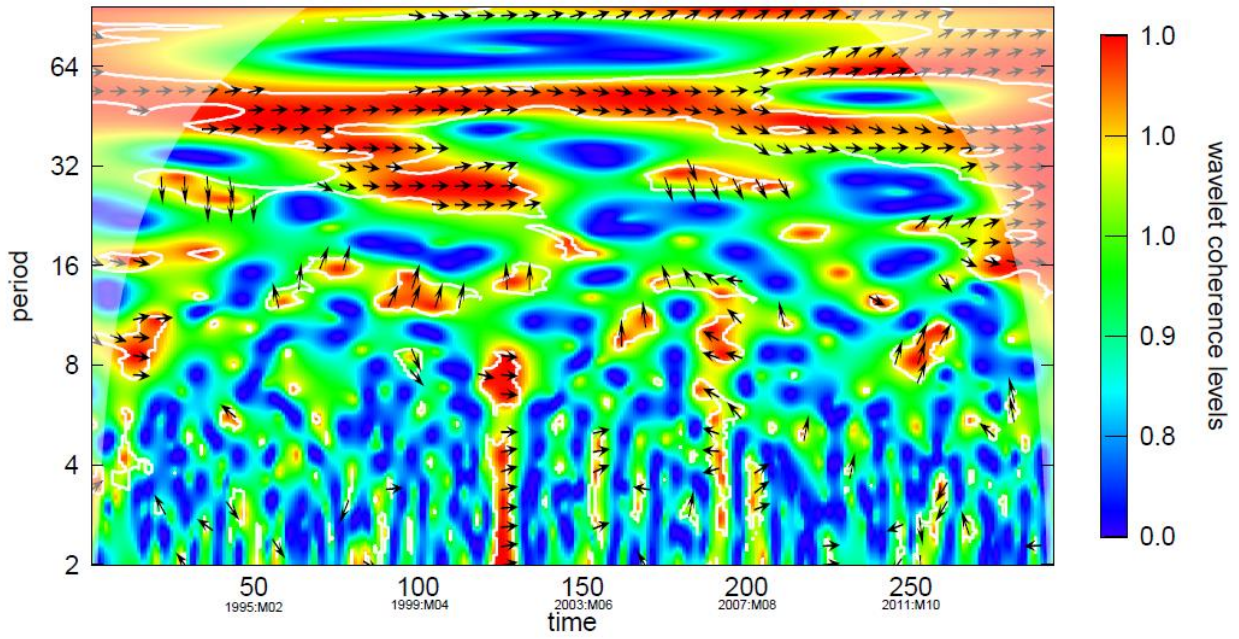


Figure 5: WTC of the pair *ln(x) - ln(y)*, monthly series

Note:
(1) The thick white contour depicts the 5% significance level estimated from Monte Carlo simulations by following phase randomized surrogate series, while the cone of influence (COI) where the edge effects might distort the picture is designed as a lighted shadow;
(2) The colour code for power ranges goes from blue (low power) to red colour (high power);
(3) The arrows indicates the phase difference between the two series. The variables are in phase when the arrows are pointed to the right (positively related). In this case, the government revenues are leading when the arrows are pointed to the right and up, while the government expenditures are leading when the arrows are to the right and down.
(4) The variables are out of phase when the arrows are pointed to the left (negatively related). The government expenditures are leading when the arrows are pointed to the left and up, while the government revenues are leading when the arrows are to the left and down.
(5) The variables have each other cyclical effect in the phase and anti-cyclical effect in the anti-phase or out of phase.
(6) The X-axis denotes the studied time-period, whereas the Y-axis illustrates the frequency.

The new results are very interesting. Comparatively with the XWT findings, new significant relations appear on short and medium time scales (i.e. at low and medium frequencies).
In the short term (i.e., high frequency), at 2-12 months of scale, the variables are in phase, with high wavelet power in the periods 1992-1993, 2001, 2003-2004, 2007-2008 and 2011-2012.
The arrows are oriented to the right and up for 2001, 2003-2004, 2007-2008 and 2011-2012. This suggests that the government revenues positively lead expenditures. Tax adjustments during

2001-2004 included the introduction of global income taxation, reduction of corporate tax rate (i.e. from 38% to 25%) and unification of VAT rates at 19%. As Romania became a member of the EU in 2007, the removal of duty taxes towards other EU members and excise harmonization characterised the Romanian tax policy in 2007-2008. Subsequently, VAT tax increased from 19% to 24% from 2011 onwards.

In 1992-1993 and 2001 (here, only at 6-8 months of band), the arrows are pointed to the right and down revealing that the government expenditures run revenues with the same sign. As the government tried to rapidly cover the social demands resulting from system reforms, an expenditure-focused fiscal policy was preferred. Unfortunately, the pressure of expenditures determined the need for new resources. Conversely, the variables are out of phase during the period 2006-2007. As arrows are oriented to the left and up, the government expenditures have a negative impact on the revenues. This is a distinctive period, reinforced also by ZA test, when the economic crisis arose. The government accepted deliberated deficits in order to stimulate public investments instead of tax-based control, covering deficits by massive international loans.

On medium term (medium frequency), at 13-64 months of scale, different situations arise. For 13-24 months of scale, the variables are in phase during 1995-2002 and out of phase over 2005-2007. The arrows are oriented to the right and up for 1995-2002, government revenues lead the expenditures with the same sign. At that time, the main tax adjustment related to the company tax reform, by changing the progressive taxation with the flat one in 1994. For 2005-2007, the arrows are pointed to the left and up, expenditures negatively lead the revenues. This also confirms the structural break point in government expenditures from 2006, supporting the public appetite for public investments. Between 24 and 32 band of scale, for 1993-1995, 1997-2002 and 2005-2008, the variables are in phase. The arrows are oriented to the right and down for 1993-1995 and 2005-2008, the expenditures impacting positively the revenues. This confirms the positive effects of productive expenditures, which extend the tax base. For 1997-2002, the arrows depict a horizontal tendency to the right presenting non-conclusive results.

At 32-64 band of scale, the arrows are still horizontally oriented and do not offer conclusive results until 2005-2007. Over 2005-2007, the arrows are oriented to the right and down, suggesting that the government expenditures positively drive revenues. As the frequency increases, the orientation changes, the arrows being pointed to the right but up. In this second sequence, the revenues lead expenditures with the same sign. The fiscal measures are related to the positive effects of introducing the flat tax starting with 2005, after a strong pressure on productive expenditures.

Very interesting, on long term (low frequency), over 64 months of scale, the variables are in phase only, registering each other a cyclical effect. This effect becomes stronger especially after 2004. Here, the arrows are pointed to the right and up, denoting the government revenues positively cause the expenditures. The flat tax introduced for individuals in 2005 stimulated the tax base and, as consequence, the tax inputs. On this ground, additional resources were spent.

The findings do not offer evidence for synchronization hypothesis, but reinforce all literature assumptions regarding the tax-spending nexus, for different sub-periods and frequencies. Thus, we do not confirm the outputs of Campeanu and Catarama (2007), and Hye and Jalil (2010). The results partially are in accord with the findings of Stoian (2008), Dima et al. (2009), and Tiwari and Mutascu (2012), but only for specific time-periods and different frequencies. These new results, obtained based on the wavelet analysis, unravel the time and frequency dependencies between tax and spending, in the case of Romania, which could not be detectable through classical econometric tools.

5. Conclusions

The analysis investigates the causality between the government revenues and government expenditures, in the case of Romania, for the period 1991m1-2015m5, by following the wavelet approach. The study offers detailed information of this connection, for different sub-periods and frequencies, emphasizing the lead-lag nexus between variables under cyclical and anti-cyclical shocks.

For a country with structural reforms, the findings reveal that the introduction of global individual tax techniques (i.e. separate income taxation vs. global income taxation) reacts very well on short term. Similar elasticity can be obtained by controlling the spending but under shocks of economic crisis and flat tax. The government expenditure is the main instrument of fiscal policy in this context. In the medium term, the changes in taxation techniques (i.e. from separate income taxation to global one) offer a good elasticity related to the expenditures. Fiscal policy expectations during the crisis seems to be better connected with the type of taxation system and structure of government expenditures. Thus, quick effects can be obtained through the control of productive expenditures followed by adjustments in the taxation system of individuals (i.e. progressive vs. flat taxation system). However, the main important aspect is evidenced in the long term, with the taxation system of individuals being crucial for the fiscal policy under structural reform and economic crisis.

Regarding the policy implications, it is recommended for the Romanian government to adjust the budgetary disequilibrium taking into account the time horizon, the type of tax system, and its corresponding techniques. Under structural changes, in order to deal with the treasury goals, the Romanian government must focus on individual taxation techniques. Moreover, the expenditure adjustments seem to be the most effective choice during the economic crisis. In the medium term, during the crisis, the budgetary deficits should be firstly controlled through productive expenditures, and only after by adjustments of taxation system of individuals. Finally, Romanian budgetary strategy in the long term is strongly related to the taxation system of individuals. Such instrument is recommended especially when the structural reform and economic crisis shocks arise.

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Appendix

Table A1: Summary statistics of variables

	x	y
Mean	1082.123	1359.963
Median	684.217	784.7214
Maximum	3017.68	4347.318
Minimum	56.65797	205.3365
Std. Dev.	736.4083	990.278
Skewness	0.743767	0.794468
Kurtosis	2.067963	2.222776
Jarque-Bera	37.61936	38.19734
Probability	0	0
Sum	317062	398469
Sum Sq. Dev.	1.58E+08	2.86E+08
Observations	293	293

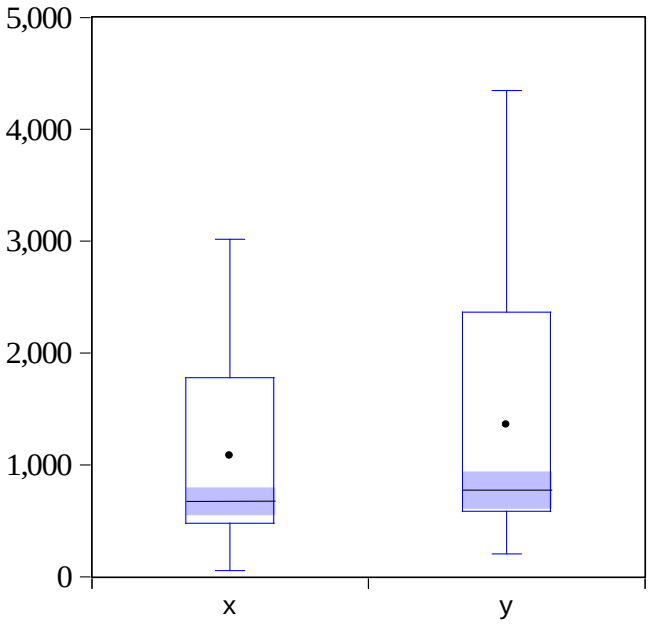

Figure A1: Time-series plot of variables