Impact of GDP, gross capital formation and employment on waste generation - The case of EU regions

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Abstract

The impact of economic growth on environment (including waste generation) has remained a bone of contention and continuously debated in both public as well as political platforms. Studies on waste generation into the economic system have also attracted increased attention nowadays with a significant focus on its negative effect on our environment. Similar to economic growth and waste generation, the contribution of waste into the economic system can also be attributed to increasing both gross capital formation and employment rate. In previous literature, these relationships have been studied at the national level which may lead to biased results due to the spatial scale mismatch. Therefore, here we study the data for 217 EU regions for the years 2000-2013. Using panel cointegration tests, we find that cointegration is present between total waste per capita, GDP per capita, employment rate and gross fixed capital per capita formation. We further investigate both short and long run Granger causal relationships between waste generation and GDP, employment rate likewise gross fixed capital formation. Specifically, a panel vector error correction model (VECM) is estimated to perform Granger causality tests. The results indicate that there is a unidirectional short run effect from GDP, gross fixed capital formation and employment rate. In addition, there is a unidirectional long run Granger causality running from GDP, employment rate and gross fixed capital formation to waste generation into the economic system.

Key words: economic growth, waste generation, causality model, EU regions, employment.

JEL Classification: Q53, O13, C23

1 Introduction

Economic growth and waste emission into the economy have been a major problem facing the globe. Experts and environmental economists are showing much concern about the devastating effect of the emission of waste into the economic system. Traditionally, waste has been there for a considerable amount of time in small quantity and it was decomposed in natural cycle. The development of cities, regions, population, industries and consumption has created a large quantity of waste on the globe. However, the adverse effect of waste emission into the economic system and the environmental concern have attracted much public attention only since a 1999 World Bank report (Hoornweg and Thomas, 1999). Previously, it was difficult to obtain sufficient data on this effect. Later, accurate and comprehensive data have been made available for some regions in the world. Currently, global estimate portrays an annual world waste generation to be around 17 billion tonnes and expected to increase to 27 billion by 2050 (Karak et al., 2012). The urban centres in the world generate yearly about 1.3 billion tonnes of solid waste. This quantity is apt to increase 2.2

billion tonnes by the year 2025. Managing the solid waste costs an amount of 205 billion dollars probably increase to 375.5 billion dollars by the year 2025 (Hoornweg and Bbiada-Tata, 2012).

The EU, as an important part of regions on the globe, has not liberated from this waste emission problem as the region keeps on growing economically. The waste generation and its environmental implications have been main social and economic problems in the region. The adverse impact of the waste generation causes pollution and greenhouse emission. The link between waste generation and economic growth is another issue because financial and environmental costs are necessary to deal with waste. Expert reports on the implementation of waste legislation indicated that about 3 billion tonnes of waste and 100 million tonnes of hazardous waste is dumped in the region yearly (Biointelligence service, 2012). The waste is mainly generated by activities such as manufacturing, construction, water supply and energy. Waste (especially, hazardous waste) and its management has a lot of implications in the region. It is a cause of serious health issues such as neurological disorders (Chatham-Stephens et al., 2014) or cancer (Martuzzi et al., 2009; Gensburg et al., 2009; Garcia-Perez et al., 2013). There is also an emergence of new waste (hi-tech products) which contains a complex blend of materials such as plastic metals likewise hazardous material that is difficult to deal with safely. Moreover, recent research about waste generation, as well as the technical aspect of its management such as recycling, site filling, re-use and incinerators have been effective (Laurent et al., 2014), but much needs to be done since the amount of waste generation keeps on increasing in the regions. It is also necessary to ensure that the planet resources (air, land, water, etc.) are utilised in a prudent way so that they will be sustained for future generations.

The next question that comes to mind is "what are the causalities between GDP, gross capital formation and employment on one side and waste generation on the other side?". The early works on economic growth and waste generation have failed to recognise the important role of gross capital formation and employment in the economic system. It is generally agreed that economic growth generates waste into the economics system (Chiemchaisri et al., 2007; Saeed et al., 2009; Liu and Wu, 2011). Generally, gross capital formation and employment increase economic output (GDP). In other words, they form the central part of economic growth theory and consequently contribute to waste generation. Another contribution from investment in capital formation is the creation of jobs. This increases consumption as the result of additional income. Hence waste is generated into the economic system as the consumption rises. In addition, the relationship between economic growth and waste generation have been studied at the national level in previous studies which may lead to biased results due to the spatial scale mismatch. Therefore, this study intends to fill this gap and examines the data for 217 EU NUTS 2 regions in 28 countries for the period of 2000-2013. Here we investigate both short and long run Granger causal relationships between waste generation and GDP, employment rate likewise gross fixed capital formation. Specifically, a panel vector error correction model (VECM) is estimated to perform Granger causality tests. Based on the results, we offer suggestions and recommendations to households and policy makers in order to enhance the effectiveness of waste management policies.

The paper is organised as follows. Section 2 introduces the used data and econometric methodology. Section 3 shows the empirical results and the last section summarizes the findings and policy implications.

2 Data and Research Methodology

The specific objective of this study is to find the direction of causal relationship between waste generation, GDP, employment and gross capital formation. As empirical data, we used annual time series data from the Eurostat regional database from 2000 to 2013. The variables used are represented by waste generation (measured in tonnes per capita, annual average 0.487), GDP (in EUR per capita, annual average 22649), employment rate (in %, annual average 64.9) and gross fixed capital formation (thousands EUR per capita, annual average 4.92). We used the indicators of GDP per capita, employment rate and gross fixed capital formation because these have been employed in previous economic literature (Azam et al., 2015; Ozturk and Acaravci, 2016; Inglesi-Lotz, 2016).

The sample of 217 NUTS 2 regions included the following EU countries: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Croatia, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, Netherland, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden, United Kingdom and Norway.

Based on the previous literature review and findings observed in energy economics, it is prudent to form a long-run relationship between GDP, gross capital formation (CAPIT), employment (EMPL) and waste generation (WASTE) in a linear quadratic form, with an aim of testing the validity between GDP, gross capital formation and employment as independent variables and waste generation as the dependent variable. Johansen multivariate cointegration technique was used to study the causal relationship between waste generation and the other variables (Johansen, 1988). The Johansen cointegration approach was carried out in four steps. First, we estimated the unit root test to determine the stationarity of individual variables using Breitung *t*-statistics (Breitung, 2001). Once the series were integrated in the same order as well as stationarity among linear combinations of their levels existed, this implied cointegration. In other words, there is an existence of long-run equilibrium relationship. We then estimated the VAR model by using the stationary series. We determined the lag length *p* by considering Akaike information criterion (AIC) in the next step. The test is based on error correction model defining the VAR model as presented below:

$$\mathrm{WASTE}_{i,t} = \alpha + \Sigma\beta_{t-j}\mathrm{GDP}_{i,t-j} + \Sigma\beta_{t-j}\mathrm{EMPL}_{i,t-j} + \Sigma\beta_{t-j}\mathrm{CAPIT}_{i,t-j} + u_{it} \qquad (1)$$

where i denotes the i-th region, $i = 1, 2, \dots, N$, N is the number of regions, t denotes time lag, α is intercept, β_{t-j} are parameters, $j = 1, 2, \dots, p$, and u_{it} is assumed to be serial uncorrelated error term (white noise residuals).

Johansen cointegration test is only employed to test whether the variables are integrated and does not show the trend or the direction of causality between or among the variables. If the variables are cointegrated, there may be a short run or long run causality. This might be verified through the estimation of VECM. This is stated in the following equations to determine the short and long run Granger causality test:

$$\Delta\mathrm{WASTE}_{i,t} = \alpha + \Sigma\beta_{t-j}\Delta\mathrm{GDP}_{i,t-j} + \Sigma\beta_{t-j}\Delta\mathrm{EMPL}_{i,t-j} + \Sigma\beta_{t-j}\Delta\mathrm{CAPIT}_{i,t-j} + u_{i,t} \qquad (2)$$

$$\Delta\mathrm{GDP}_{i,t} = \alpha + \Sigma\beta_{t-j}\Delta\mathrm{WASTE}_{i,t-j} + \Sigma\beta_{t-j}\Delta\mathrm{EMPL}_{i,t-j} + \Sigma\beta_{t-j}\Delta\mathrm{CAPIT}_{i,t-j} + u_{i,t} \qquad (3)$$

$$\Delta\mathrm{EMPL}_{i,t} = \alpha + \Sigma\beta_{t-j}\Delta\mathrm{GDP}_{i,t-j} + \Sigma\beta_{t-j}\Delta\mathrm{WASTE}_{i,t-j} + \Sigma\beta_{t-j}\Delta\mathrm{CAPIT}_{i,t-j} + u_{i,t} \qquad (4)$$

$$\Delta\mathrm{CAPIT}_{i,t} = \alpha + \Sigma\beta_{t-j}\Delta\mathrm{GDP}_{i,t-j} + \Sigma\beta_{t-j}\Delta\mathrm{EMPL}_{i,t-j} + \Sigma\beta_{t-j}\Delta\mathrm{WASTE}_{i,t-j} + u_{i,t} \qquad (5)$$

We also determined the long run relationship by using error correction test (ECT). It operates on premises that if the variables are cointegrated, then it can also be anticipated that at least one or all the ECTs contain negative coefficient and ought to be significantly non-zero. In addition, the short run causality was estimated by using Wald test as well as using the lags of each explanatory variable in each VECM equation.

3 Empirical Results

We first tested for the unit root of the four variables The outcome of the unit root test is presented in Table 1. The results show that all the variables are non-stationary at a $p < 0.01$ level. In other words, they were cointegrated.

Table 1: Result of Breitung unit root test

	t-statistics	1st difference *t*-statistics	*p*-value	1st difference *p*-value
WASTE	5.708	38.013	1.000	0.000
GDP	5.029	-27.944	1.000	0.000
EMPL	1.713	-18.933	0.957	0.000
CAPIT	1.684	-18.049	0.954	0.000

source: own elaboration

To estimate cointegrations among the variables, we employed Johansen multivariate cointegration test. Before performing the test, we chose the optimum lag length which is necessary for cointegration test. Based on minimum AIC through the estimation of the unconstrained VAR model for the first difference of the variables under deliberation, we obtained the lag length $p = 3$. At this point, we assumed that the data contain deterministic trends but cointegration equations included intercepts. We selected this design because the unit root tests of the variables exhibited no common deterministic trend. Therefore, the cointegration rank of variables was estimated by means of the trace test statistics. The result of the cointegration test is presented in Table 2. After adjustments, 3034 observations were included. Linear deterministic trend was assumed and lags interval in first difference was from 1 to 3. The test was performed in Eviews software.

Table 2: Result of Johansen cointegration test

Hypothesized no. of CE(s)	Eigenvalue	Trace stat.	0.05 critical value	*p*-value
None	0.066	501.59	47.86	0.000
At most 1	0.052	295.98	1.000	0.000
At most 2	0.027	133.73	0.957	0.000
At most 3	0.017	51.90	0.954	0.000

source: own elaboration

The null hypothesis tested was no cointegration. The value of trace statistics were larger than critical values with p-value of 0.000 indicating the rejection of the null hypothesis. Hence it shows cointegration relationship between GDP, employment, gross capital formation and waste generation.

Naturally, cointegration refers to Granger causality, but it does not show the intensity of the direction of the relations. We found short and long run causality among the variables for the EU regions by using VECM. The VECM estimated equations (2) to (5) for a period of lag selection based on AIC. Before estimating Granger causality test, we also assessed the robustness of VECM using the normality distributions of the variables. The results of Granger causality test are shown in Table 3 and Table 4. Two tests were performed to determine the causality. The first one is testing for long run causality and it was estimated by the significance of the ECTs. The second was the short run causality term as week Granger causality. It was estimated by the joint significance of coefficient of lagged terms of individual independent variables (Wald statistics). The coefficient of error correction was negative and statistically significant at $p < 0.05$ for waste generation, equation (2). These results suggest that there is unidirectional long-run causality running from GDP, employment and gross fixed capital formation to waste generation.

Table 3: Result of long-run Granger causality test

	ΔWASTE	
	ECT coef.	*p*-value
ΔWASTE	-0.03	0.000
ΔGDP	-38.30	0.877
ΔEMPL	0.37	0.010
ΔCAPIT	0.56	0.000

source: own elaboration

The result of short-run Granger causality test, as presented in Table 4, show that there is an existence of unidirectional short-run Granger causality running from employment and gross fixed capital formation to waste generation. In the same scenario, there exists unidirectional Granger causality running from waste generation to GDP. In addition, there is bidirectional causality running among GDP, employment and gross capital formation. Similarly, there is also bidirectional causality running between employment and gross fixed capital formation.

Table 4: Result of short-run Granger causality test

	ΔWASTE	ΔGDP	ΔEMPL	ΔCAPIT
	F stat. (*p*-value)	*F* stat. (*p*-value)	*F* stat. (*p*-value)	*F* stat. (*p*-value)
ΔWASTE		13.23 (0.000)	1.07 (0.362)	0.70 (0.551)
ΔGDP	1.35 (0.257)			43.64 (0.000)
ΔEMPL	9.49 (0.000)	3.54 (0.014)		4.73 (0.003)
ΔCAPIT	6.52 (0.000)	69.58 (0.000)	11.98 (0.000)	

source: own elaboration

4 Conclusion

The study analysed the dynamic causal relations between waste generation and GDP, gross fixed capital formation as well as employment in 217 NUTS2 regions. The inclusion of employment and gross capital formation were of particular interest. Nevertheless, the two variables indicate the dynamic interactions of the system variables. The overall results show that there is at least long-run causality running from the gross fixed capital formation, employment and GDP to waste generation in the regions. The impact of GDP on waste generation was also confirmed by Khatib (2011). We found a unidirectional causality from employment and fixed capital formation to waste generation. The surprising result was that there was no short-run causality running from GDP to waste generation. Besides, we had an evidence of bidirectional causality among the GDP employment and gross capital formation. This result is not surprising as it has been confirmed by growth theory (Englander and Gurney, 1994) as these variables promote economic growth.

The overall result of an impact of economic growth, gross capital formation and employment on waste generation in the region were valid in both long and short run except GDP hypothesis in the short run which was not confirmed. Hence this indicates that policies regarding waste emissions and technical management of waste in the regions still need to be strengthened and enforced. This will curtail waste generation as the region keeps on growing economically. Although a strict control policy been has been applied in all the European regions, especially for hazardous waste. The use of market instruments such as tax or pay as you throw scheme was also effective in some countries but these economic instruments must not be used as punishment for undesirable waste management practices. It should rather serve as waste prevention. Also, the imposed tax should not be too high or increase else it will tend to create illegal dumping. Tax policy on landfill, mostly applied by western European countries, has been effective because it has stimulated reduction of waste, reuse and recycle and finally generated revenue. However, the challenge of this policy is that it does not provide price intended to stimulate citizens to embrace sustainable waste management scheme. What is also needed is that there should be a sustainable market which will recycle these waste products and materials for a long term. Adopting composting municipal waste will serve as a stepping stone for the creation of market opportunities.

Specific recommendations of our study are as follows: (1) There must be awareness of waste prevention especially from the household and other waste-generating sources; (2) Cleaner consumption should be promoted through incorporating, design, manufacture and use and disposal; (3) Recycling should be supported through sustainable market for recycling products and materials; (4) Policy makers should also blend the interest and concerns of the affected parties; and (5) Public awareness of the pernicious effect of waste should continuously be made public through campaign preventing techniques and research and development.

It should be noted that the main weakness of our study is related to data availability. In future, there should be examined a proper reliable annual data on waste. It would also be interesting to include additional sustainable development indicators into the model, such as transportation, energy consumption and carbon emission (Gardiner and Hajek, 2016).

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