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Eco-innovation and Economic Growth in the European Union

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Abstract: *Eco-innovation, as a new concept, and green technologies are central to the Europe's future and at the core of the European Union policies to boost competitiveness, create jobs, and generate sustainable growth for years to come. In this context, eco-innovation is a significant tool that combines decreased environmental impact with a positive socioeconomic impact. This paper highlights the prominent role of eco-innovation and investigates still scarcely explored impact assessment of GDP growth, quality of institutions, and recycling rates on the eco-innovation index in the 28 European Union member states. Specifically, the set of regression analyses that use panel estimation models was undertaken and the system GMM estimator with robust standard errors was used. Econometric analysis indicates that GDP growth rate, quality of institutions, and recycling rate of municipal waste had a statistically significant and positive effect on eco-innovation in the period 2010-2016.*

Keywords: circular economy; decoupling; eco-innovation; European Union; panel data analysis

JEL Classification: C33, O11, O30

Introduction

According to the Global Material Flows and Resource Productivity report (UNEP, 2016: 5), during the past four decades material use has tripled at the global level, with annual extraction of materials growing from 22 billion tonnes in 1970 to 70 billion tonnes in 2010. If current trends continue, by 2050, the global population is expected to grow by 30% to around 9 billion and people in developing and emerging coun-

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tries will strive for the levels of prosperity and consumption of developed economies (EC, 2011a: 2) requiring 180 billion tonnes of materials, nearly three times today's amounts (UNEP, 2016: 17). The rising use of natural resources puts pressure on our planet resulting in both environmental degradation (caused by climate change, higher levels of acidification and eutrophication of soils and water bodies, increased biodiversity loss, more soil erosion and rising amounts of waste and air contamination) and negative effects on quality of life (EC, 2011a; UNEP, 2016). In order to change our current trends of rising material use, countries need to enhance productivity of resources and decouple economic growth from resource use and its influence on the environment (EC, 2011a: 11). European Union (EU) has embarked on a strategy to significantly increase the material efficiency and reduce the level of resource use through high-level policy frameworks and laws which underpin efficiency of resources and guide investment in the green economy sectors (UNEP, 2016: 18).

The term "eco-innovation" is commonly used to refer to innovative products and processes that reduce environmental impacts (Sarkar, 2013). European Commission (EC) approaches eco-innovation as a significant tool that connects reduced negative impact on the environment with a positive socioeconomic impact. Eco-innovations with the potential to enable the transition to resource-efficient circular economy model span effort to change dominant business models (from novel product and service design to reconfigured value chains), transform the way citizens interact with products and services (owning is replaced by sharing or leasing) and develop improved systems for delivering value (sustainable cities, green mobility, smart energy systems, etc.) (EC, 2014a: 9).

According to Global Eco-Innovation Scoreboard, the European countries were among top-performers within the group of 126 countries in 2015. Although the need to eco-innovate is widely recognised within the EU, eco-innovation performance indicates high variations across EU Member States. European Eco-Innovation scoreboard groups countries into eco-innovation leaders, average eco-innovation performers and countries catching up in eco-innovation. According to the 2016 Eco-Innovation Index and Scoreboard, countries catching up in eco-innovations are mostly new Member States with the exception of Belgium. Top six performing countries are significantly above the EU average, led by Germany, Luxembourg and Finland. Following three top-performing countries, Denmark, Sweden and the UK have also been grouped into the eco-innovation leading countries. Leading countries have generally well developed framework conditions that include both supply and demand-side instruments. As compared to the results shown by the 2015 Eco-Innovation Index, only minor changes in performance occurred among the top six countries. Germany moved from second place in 2015 to first place in 2016, while Finland dropped from first place in 2015 to third place in 2016. Also, minor changes in positions took place in groups of average and catching up countries. Surprisingly, Greece climbed up to the second group, while Belgium dropped from the average performer to the group of countries catching up in eco-innovation (Eco-innovation, 2018).

The analysis of the relationship between economic growth, quality of EU institutions, recycling behaviour and the eco-innovation performance across the EU was based on panel estimation models. Hence, the paper contributes to the literature in several ways. Firstly, this paper highlights the prominent role of eco-innovation and investigates still scarcely explored selected variables on the eco-innovation index in 28 European Union member states. Secondly, it analyses economic, social and institutional aspect of eco-innovation performance in the EU from a macro-level perspective. As such, it provides an insight into important drivers of eco-innovation across the EU.

Eco-Innovation: conceptual definition

The challenges of environmental mainstreaming on the one hand, and resource constraints on the other hand, have led to a demand for new technologies, solutions and products. Eco-innovation or green innovation is the type of innovation that addresses current and future environmental problems in a new way, and decreases energy and resource consumption, while promoting sustainable economic activity (OECD, 2012: 3). The EU's Eco-Innovation Observatory (EIO, 2010: 7) defines eco-innovation in a similar way as "the introduction of any new or significantly improved product (good or service), process, organisational change or marketing solution that reduces the use of natural resources (including materials, energy, water and land) and decreases the release of harmful substances across the whole life-cycle." Eco-innovation takes the full life-cycle perspective into account, rather than just focusing on environmental aspects of individual life-cycle stages. It does not just mean inventing new products and delivering new services, but it also encompasses reducing environmental impacts in the way products are designed, produced, used, reused, and recycled (EIO & CfSD, 2016). According to recommendations for entrepreneurs, Eco-innovation can be an idea for a new start-up or product as well as for improving existing operations. Focus of eco-innovation extends from new technologies to creating new services and introducing organisational changes. At its core, eco-innovation is about creating business models that are both competitive and respect the environment by reducing resource intensity of products and services. Incremental eco-innovation focuses on improving existing business models, products or services whereas disruptive eco-innovation focuses on developing new eco-innovative and circular processes, products and services (EIO & CfSD, 2016).

According to European Commission (2012), Eco-innovation refers to all forms of innovation including technological and non-technological, new products and services, and new business practices that create business opportunities and benefit the environment by preventing or reducing their impact, or by optimising the use of resources. Eco-innovation is closely related to the way of using, producing and consuming natural resources, and also to the concepts of resource-efficiency and circular economy. In order to boost competitiveness and environmental protection, it encourages approaches that minimise material and energy flows by changing products and production methods. Clean and healthy environment is recognised as a precondition for maintaining wellbeing and high quality of life. Considering the above mentioned eco-innovation leads to resource efficient growth enabling the path or transition to circular economy.

The European Commission's Eco-innovation Action Plan (EcoAp) (2011b) built under the Europe 2020 strategy for smart, sustainable and inclusive growth (2010), supports three mutually reinforced priorities and focuses on boosting resource productivity, efficiency and competitiveness in order to protect environment and accelerate the path of innovative products toward markets. Current key priorities related to achieving environmental objectives through innovation include mobilising finance and other actions promoting market opportunities for businesses involved in environmental technologies. These actions include establishing credible verification of environmental performance to increase confidence in eco-technologies. In order to evaluate the eco-innovation performance across all EU Member States, building on the experiences of the "Eco-Innovation Scoreboard", the Commission is monitoring and reviewing measures taken by EU Member States. The Eco-innovation Action Plan also complements other Europe 2020 Flagship Initiatives, especially "A Resource Efficient Europe" Flagship and its roadmap.

Eco-Innovation in the context of circular economy

In recent years, many of the Eco-innovation Action Plan's goals have come together in the concept of the circular economy that aims to maintain the value of products, materials and resources for as long as possible by returning them into the product cycle at the end of their use, while minimising the generation of waste (Eurostat, 2018). The European Commission argued that Eco-innovation is essential to delivering many aspects of the circular economy such as industrial symbiosis or ecologies, cradle-to-cradle design and new, innovative business models. In 2015, the European Commission adopted an Action Plan for the Circular Economy and Circular Economy Package, which included measures to stimulate Europe's transition towards a circular economy, boost global competitiveness, foster sustainable economic growth and generate new jobs. All these strategies aim to transform Europe into a more competitive resource-efficient economy and acknowledge the key role of eco-innovation in the context of job creation, growth and competitiveness, as well as environmental protection.

The increased pressure on the use of limited natural resources and negative environmental impact of production processes urged the need to rethink the way that products are manufactured and used. The need to integrate circular activities into the production and consumption patterns is essential to achieving sustainable development goals. According to Ellen McArthur Foundation (2014: 14), circular economy is “an industrial system that is restorative or regenerative by intention and design. It replaces the end-of-life concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse and return to the biosphere, and aims for the elimination of waste through the superior design of materials, products, systems and business models.” In order to overcome the limits of linear economy model that uses a “take-make-use-dispose” approach, a circular economy follows a “take-make-use-take-make…” pattern based on six functional pillars. Besides recycling, these pillars include remanufacturing, reuse, repair, sharing and design (EIO & CfSD, 2016). Every single functional pillar can be perceived as a part of eco-innovation process that contributes to the transition from linear to circular economy. Eco-innovation lies in the very heart of circular economy and presents an integral part of government growth strategy in many countries as a way to reconcile economic and environmental priorities (OECD, 2012). The EIO’s eco-innovation definition indicates there are different types of eco-innovation that take into account the product’s full lifecycle perspective i.e. product, process, organisational, marketing, social, and system eco-innovation (EIO, 2016).

Product design eco-innovation minimizes overall impact on the environment and material input over the whole product’s life cycle by enabling the recovery options like repairing, maintenance, remanufacturing, recycling and cascading use of components and materials (EIO, 2016: 12). The European Commission stresses the importance of ecodesign of products to ensure their durability and reparability. Extending the lifetime of the products not only reduces waste, but also contributes to the EU’s job creation efforts due to labour-intensive nature of reuse and repair sectors (EC, 2015). In practice, the ecodesign concept is mainly applied to energy performance which has become a standard element of a wide range of products, while the application of life-cycle thinking has been rather limited (EC, 2014a). Although the focus of Ecodesign was on energy efficiency improvements, in the future it should tackle material efficiency issues in areas such as durability, reparability, upgradeability, design for disassembly, information and ease of reuse and recycling, greenhouse gas and other emissions (EC, 2016). Repair, maintenance and remanufacturing are important activities for prolonging the lifespan of products and preventing purchasing new products for replacement, thus avoiding pollution, unnecessary material use and waste arising (EIO, 2016: 19). Remanufacturing is a process of returning a used product to like-new condition by recapturing the value added to the material when a product was first manufactured (Charter & Gray, 2007: 5). Remanufacturing has been called a “hidden giant” because it presents a huge industry operating at a low level of visibility while restoring used and discarded durable products to like-new condition (Lund, 1996). Although it has been particularly prominent in the US, where the estimated price of a remanufactured product is normally between 45% and 65% of the price of a comparable new product, the significant potential for boosting both economic growth and job creation while saving materials was also recognised within the EU (EC, 2014a: 5). Recycling is s process of returning a product to a raw material form while destroying the value added to the raw material when a product was first manufactured (Charter & Gray, 2007: 10). In that way, the secondary raw materials are created for future manufacturing needs, and by returning the valuable materials back to the economy the demand for virgin raw materials may be reduced. Offsetting the input of virgin materials can also be achieved through cascading components and material by diversifying their reuse across different industries (Ellen McArthur Foundation, 2014).

The development of process eco-innovations involves integration of materials that do not harm human health, reduce environmental impacts and also comply with government regulations (de Oliviera Brasil et al., 2016). Process eco-innovation includes implementation of new processes that reduce material use, emissions and hazardous substances, lower the risks and save costs in production processes by recycling and reuse of raw materials (EIO, 2016). Functional recycling is a process of recovering materials for the original purpose or for other purposes, excluding energy recovery (Ellen McArthur Foundation, 2013: 25), but the quality of secondary resources gained through the recycling process can differ substantially.

Organisational eco-innovation is presented by methods and management systems reorganization pushing for closing the loops and increasing resource efficiency (EIO, 2016: 12). Industrial symbiosis is an innovative industrial process allowing waste or by-products of one company or industry to be used as an energy or material input for another (EC, 2015: 5). A widely used environmental policy is Extended producer responsibility (EPR) implying that producers take over the responsibility, organisational or financial as well, for collecting or taking back used goods and for sorting and treating for their eventual recycling in order to design products that last longer and are more easily treated after use (EC, 2014b). Replacing ownership of products with functional services is reflected in the development of product-service systems as a business model in the business to consumer context (EEA, 2017: 18).

The role of marketing is especially important in raising public awareness of sustainable consumption and production patterns. Marketing eco-innovation involves changes in product and service design, placement, promotion, and pricing with the aim of driving consumers to buy, use or implement eco-innovations (EIO, 2010: 27). The EU introduced official voluntary eco-label of the European Union (EU Ecolabel) for labelling products with a lower environmental impact during their entire life cycle, as compared to similar or identical products within the same product group, to direct consumers and retailers towards selecting a greener product, and to confirm that companies' products and services meet high environmental protection standards (EIO & CfSD, 2016).

Social eco-innovation includes market-based dimensions of behavioural and lifestyle changes of the consumers and the ensuing demand for green goods and services (EIO, 2010: 28). Innovative forms of consumption can accelerate the transition to the circular economy by infrastructure sharing or sharing of products (collaborative economy), selling performance instead of goods, using IT or digital platforms, etc. (EC, 2015: 7). The use of online sharing marketplaces enabled matching the demand for certain products, services or assets with their supply, and allowed for collaborative consumption to become widely spread (EEA, 2016: 16). Social innovation related to eco-design, reuse, recycling, sharing, and other developments is associated with more sustainable consumer behaviour, and expected to contribute to human health and safety (EEA, 2016: 13).

Finally, system eco-innovation creates an entirely new system (e.g. smart cities) with completely new organizational and functional structure reducing the overall environmental impact (EIO, 2016). It may include elements or combinations of all types of innovation leading to systemic changes in both social (values, regulations, attitudes, etc.) and technical (infrastructure, technology, tools, production processes, etc.) dimensions and the relations between them (EIO, 2010: 12). The systemic change of the entire economy that is obviously needed to allow fulfilling peoples' needs within the carrying capacity of the Earth must be supported by many actors (EIO, 2013). The new socio-economic model implies implementation of eco-innovations within new business models, consumer awareness of environmental impact and their active participation in achieving sustainable consumption as well as government regulatory measures and policy supporting the pathway towards a sustainable economy.

Econometric analysis

Data and the sources

The analysis included 28 EU member states and covers the period 2010–2016. In our analysis we use yearly frequencies. Hence, we empirically assess whether GDP growth, quality of institutions, and recycling rate of municipal waste are significant determinants of eco-innovation during this period. The dependent variable is the Eco-Innovation Index, which illustrates eco-innovation performance across the EU Member States. The values were taken from Eco Innovation Observatory 2017 (Eco Innovation Scoreboard). According to Eco Innovation Observatory the Eco-Innovation Scoreboard is the first tool to comprehensively assess and compare eco-innovation performance across the EU-27 and EU-28 Member States. Further, this specific index vis-à-vis Eco-Innovation (2018) captures the different aspects of eco-innovation by applying 16 indicators grouped into five dimensions: eco-innovation inputs, eco-innovation activities, eco-innovation outputs, resource efficiency and socio-economic outcomes. The Eco-IS and the Eco-Innovation Index complements other measures of innovativeness of EU countries and aims to promote a holistic approach to economic, environmental, and social performance (Eco-Innovation, 2018).

Next, real economic activity was captured by the real GDP growth rate, also from Eurostat. Hence, the impact on eco-innovation is expected to be positive. Further, in our analysis, we also evaluate the importance of recycling rate of municipal waste (as a circular economy indicator), expressed as the % of total waste generated, developed by the Eurostat. The indicator measures the tonnage recycled from municipal waste divided by the total municipal waste arising. Here we expect a positive relationship.

Finally, the last analysed variable is the quality of institutions proxied by the level of citizens' confidence in EU institutions (Council of the European Union, European Parliament and European Commission) and expressed as the share of positive opinions (people who declare that they tend to trust) about the institutions. Generally, the indicator is based on the Eurobarometer, a survey which has been conducted twice a year since 1973 to monitor the public opinion evolution in the EU countries. Here we expect a positive sign.

Model selection

For the purposes of the econometric analysis, a dynamic GMM estimator, known as the Arellano-Bover/Blundell Bond – system GMM is employed. Further, since there are no usable information for all years and countries covered by the analysis, an unbalanced panel model will be applied to estimate the corresponding models. The econometric specification that we estimate is as follows:

$$y_{it} = \beta_0 + \eta y_{it-1} + \sum_{k=1}^{K} \beta_k x_{kit} + u_{it}, \tag{1}$$

where y_{it} is the dependent variable (eco-innovation), $y_{it\text{-}1}$ is the lagged endogenous variable (lagged one period of time); $k=1,2,3,...,K$ is the number of different independent variables of interest, $i=1,2,3,\ldots,N$ is the number of different individuals or panels in the sample observed (28 EU countries) at $t=1,2,3,\ldots, T$ time points. Further, x_{kit} is any of the explanatory or exogenous variables whose lags are also included in the GDP growth rate, quality of institutions, and recycling rate of municipal waste, and finally, u_{it} is the error term in the model.

The estimator we use in our analysis is generalized and augmented by Arellano & Bover (1995) and Blundell & Bond (1998). Namely, according to Roodman, 2009, the Arellano & Bond (1991) and Arellano & Bover (1995) / Blundell & Bond (1998) dynamic panel estimators are a suitable choice in the following situations: 1) when we have small T (few time periods) and large N (many individuals); 2) a linear functional relationship; 3) a single variable on the left side that is dynamic (meaning it depends on its own past realizations); 4) independent variables that are not strictly exogenous; 5) fixed individual effects; and 6) autocorrelation and heteroskedasticity within individuals, but not across them. In the analysis, we employ the one-step estimator with robust standard errors. For one-step estimation, the robust estimator of the covariance matrix of the parameter estimates is calculated. Hence, the resulting standard error estimates are consistent in the presence of any form of both heteroskedasticity and autocorrelation within panels.

Empirical results

To investigate the impact of GDP growth, quality of institutions, and recycling rate of municipal waste on the eco-innovation, the set of regression analyses that use panel estimation models discussed in the previous section were undertaken under sample of 28 European Union member states. The model is estimated using one-step system GMM estimator with robust standard errors.

As can be seen in outputs (1) and (2) in Table 1, model diagnostics provides support to the analysed dynamic models. According to results, the test for AR (2) in first differences does not present evidence that the model is misspecified, i.e. there is no evidence for significant second order autocorrelation. Second, the results of the Sargan test, a test of overidentifying restrictions imply that the null hypothesis of instrument validity cannot be rejected (i.e. there is no correlation between the instrument and the error terms). The Wald chi-square test results indicate that the model as a whole (all of the coefficients jointly) is significant. Table 1 also shows the results of the impact assessment of the selected variables on the eco-innovation. More precisely, the model includes a persistence element (the lagged dependent variable), GDP growth rate and the quality of institutions. The results indicate a significant impact of all variables on the depended variable (Column 2). Specifically, the quality of institutions approximated by the level of citizens confidence in EU institutions, suggest that its increase would have a stimulating effect on the eco-innovation in EU countries. The empirical model also reveals that higher GDP growth rate has statistically significant and positive impact on eco-innovations.

Further, in order to check the robustness of our outcomes, we re-estimate and modify model (1) by adding the independent variable – recycling rate of municipal waste. Column 3 of Table 1 presents this robustness check. All the specification tests indicate a well-specified model. The evidence suggests that higher recycling rate of municipal waste, higher GDP growth rate and better quality of institution coincide with higher eco-innovation and that they are significant and positively correlated with them. As we can see, our results in Column 3 support the basic model and do not significantly differ from those in Column 2.

Table 1: The Results of the Dynamic Linear Panel Model – Dependent variable: eco-innovation

	Model 1	Model 2
Lagged dependent variable	0.706*** (0.007)	0.560** (0.039)
GDP growth rate	3.774*** (0.000)	2.855*** (0.002)
Quality of institutions	0.837* (0.071)	0.768* (0.072)
Recycling rate of municipal waste	-	0.656* (0.052)
Constant term	-14.461 (0.706)	-18.258 (0.607)
Wald chi2	15.45 (0.001)	22.33 (0.000)
Sargan test of overidentifying restrictions (p-value)	0.1279	0.1860
Arellano-Bond test for AR(1) in differences (p-value)	0.0856	0.1099
Arellano-Bond test for AR(2) in differences (p-value)	0.7781	0.6441
Number of observations	112	110
Number of groups	28	28

Note: ***, **, * denote 1%, 5% and 10% level of significance respectively; p-values in parentheses.

Source: authors' calculations (2018).

Conclusion

The EU's commitment to sustainable economic growth is reflected in the policy framework promoting resource efficiency and environmental protection while ensuring quality of life. Eco-innovation is a powerful instrument that underpins that commitment while taking into account the economic, environmental, and social dimensions of sustainable development.

The empirical analysis based on two models stressed the importance of economic growth, institutions, and recycling behaviour on eco-innovation performance across the EU. The first model confirmed that higher rates of economic growth and citizens' confidence in EU institutions have a positive impact on eco-innovation in the EU. The higher economic growth is usually associated with higher investments that provide an initiative for eco-innovation activities. Institutional support through EU policies, regulatory framework, and mechanisms for stimulating innovation and application of new technologies are particularly important driver of eco-innovation in catching-up countries. The results of the second model proved that higher recycling rates of municipal waste have a positive impact on eco-innovation as well. Recycling is crucial for feeding back materials into the economic system, and therefore a core element of eco-innovation processes. High recycling rates also indicate consumers' active participation in separate waste collection system.

Considering that eco-innovation paves the way towards a circular economy within the EU, providing institutional support to promote eco-innovation activities and consumers' commitment to sustainable consumption practices are important factors driving systemic change of current socio-economic model.

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