# Estimating Companies and Sectoral Sustainability in Resource Consumption

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**ABSTRACT**
*The economic growth during the last decades has been associated with a continuously increasing intensive use of material resources, in spite of the technological progress. The historical data over a century reveals that the current economic system supports to a certain degree the inefficient use of resources by allowing large waste, low conversions factors, pricing below true costs. The paper intends to address some interesting points based on observations derived from statistical evidence on resource indicators. The resource efficiency indicators relate to the following broad categories - overall (national) resource consumption/ efficiency and industry resource consumption/efficiency. In the paper, the first category is addressed by involving the resource productivity - measured as the volume of Gross Domestic Product in market prices (GDP) over Domestic Material Consumption (DMC), it is studied for the period 2000-2009 based on the Eurostat database. The indicator has increased by 16 %, with a slightly larger rhythm as compared to the growth in GDP (around 12 %) over the same period, indicating that in the EU27 there was placed in a separate and decoupled growth pattern from that one of domestic resource consumption. Yet the evolution was very specific at the member states' level depending on domestic context – the economic structure, the competitiveness level, the impact of financial crisis etc. Even if the most frequently used to estimate the efficiency of the resource consumption is resource productivity, the link with other time series or structure indicators bring to light new perspectives in revealing the patterns of consumption and policy actions to improve the resource efficient use.*

**KEYWORDS:** *domestic material consumption, efficiency, productivity, resource consumption*

**JEL CLASSIFICATION:** *Q01*

## INTRODUCTION

In the contemporary economy, much attention is given to the resource efficient use mainly considering the capacity constraints and the costs of generated waste; adding into discussion the environmental impacts of the manufacturing activity (mainly) the interest in monitoring the resource efficiency increases. The importance of resource productivity has been acknowledged by many voices in the modern society, from economists to environmental policy-makers (Bleischwitz, 2010); the waves of energy crisis started with the beginning of the '70 have grown and fuelled a large number of studies about the resource consumption patterns of the industrial society and about imminent limits of growth.

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New accents were lately put on the policy plans for actions in the economic activity – towards sustainable competitiveness following the general and recently articulated concern about „*green economy*" and the urgent need for meeting the challenge of stimulating the further economic growth preserving the nature and the current environment and human health. In the OECD report (2011), green growth means "*fostering economic growth and development while ensuring that the natural assets continue to provide the resources and environmental services on which our well-being relies*". Nowadays, one of the socioeconomic themes of sustainable development relates to innovation, competitiveness and eco-efficiency – meaning resource efficiency: using and reusing resources more efficiently throughout our economy (Feindt, 2012). ***Eco-efficiency*** is the more efficient use of materials and energy in order to reduce economic costs and environmental impacts (Manzini, 1993). This is widely considered a pragmatic approach, particularly among business, but it has been noted that improved unit efficiency does not necessarily lead to lower consumption levels. Economic output may rise with constant or reduced resource inputs.

It also implies eco-innovation, meaning developing and using products, processes and other solutions that contribute to environmental protection or efficient use of resources. Eco-efficiency helps to enhance resource productivity and generate more value from the use of resources. It means not wasting valuable materials, but rather recognizing the value of resources like energy, water, land and raw materials as the basis of well-being and economic growth in Europe.

There is also, a Eurostat document (2009) reporting on the "Environmental Impact of the use of Natural Resources and Products". The UNEP/International Panel for Sustainable Resource Management's report (2011) assessed the environmental impacts of consumption and production. Also, linked to the resources being used in the production purposes and generated waste, there is another point of interest concerning this end-process stage of the resource consumption. The EU's sustainable development strategy and its sixth environment action program, which identifies waste prevention and management as one of seven thematic strategies 'Taking sustainable use of resources forward – A thematic strategy on the prevention and recycling of waste', underline the relationship between the efficient use of resources and waste generation and management.

Incorporate sustainable management of natural resources, including biodiversity, in development cooperation programs, and strengthen the focus on environmental and natural resources management issues in poverty reduction strategy papers' are priorities of millennium development goal "ensuring environmental sustainability" (OECD, 2007).

In the context of actual EU's policy approach, *sustainability* is concerned with the contribution made by the manufacturing to economic growth, to ensure advances towards social cohesion and employment and with those capabilities within the sector (or the enterprises therein) that enable it to compete in markets that are open to international competition (United Nations, 2008). It also implies that the sector's economic performance needs to be set against its performance in terms of conducting processes and using resources in an efficient and sustainable way while minimizing negative environmental impacts (i.e. enhancing environmental welfare).

The European policy relates to the resource efficiency as one of the crucial dimension in the Europe 2020 strategy of achieving throughout European areas a smart, sustainable and

inclusive growth; it also aims to claim an adjusting process towards a resource-efficient, low-carbon economy to achieve sustainable growth (European Commission, 2011). The *Europe 2020 strategy* focuses on the three major priorities to undertake to a growth which should be:

- *smart*: developing an economy based on knowledge and innovation;
- *sustainable*: promoting a more efficient, greener and more competitive economy;
- *inclusive*: fostering a high-employment economy delivering social and territorial cohesion.

All these documents refer, in one way of another, the impetus of taking care of the resource consumption's regimes, regardless their nature of, as actions driven to raise resource productivity are determined by the need to conserve 'scarce' energy and materials resources and to preserve the natural environments which act as the receiving 'sinks' for resources when they are converted to wastes (Moll et al., 2012). Besides these, there are motivations based on businesses' profitability (especially, when the costs of improving resource productivity are not greater than the cost savings), to increase the net disposable income of households (the costs of improving households' use of resources does not exceed the cost savings households will be better off (even if they convert some of the savings to other goods) (Pearce, 2001).

The means of making natural resource use more efficient are: reducing the wasteful use of resources, adopting technological change which raises the efficiency of a given unit of resource, substituting other inputs, such as labor, for natural resources, so that output stays the same but resource use is reduced, recycling materials (note that energy cannot be recycled) so that the 'same' unit of resource is used several times, substituting one resource for another. If the focus is on environmental pollution, one tone of one material may be less polluting than one tone of another (Pearce, 2001).

## 1. THE INDICATORS FOR RESOURCE EFFICIENCY AND SUSTAINABLE CONSUMPTION

Recent rediscoveries of the importance of resource productivity include Hawken (1994), von Weiszäcker et al. (1997) and those in favor of using the term of 'material input per unit of service' (MIPS) (Hinterberger et al., 1997).

In the most general manner, the resource productivity means raising the ratio of 'output' to natural resource 'inputs'. **MIPS** is an indicator based on the material flow and the number of services or utilizations provided. Reducing the MIPS of a product is equivalent to increasing resource productivity.

The leading indicator assigned to the EU's policy initiative to foster sustainable development is the r*esource productivity, built as* the ratio of the volume of gross domestic product (GDP) over domestic material consumption (DMC) and is regularly produced and published by Eurostat (BIO Intelligence Service, Institute for Social Ecology and Sustainable Europe Research Institute, 2012).

- *Gross domestic product (GDP)* is a measure of the economic activity, defined as the value of all goods and services produced less the value of any goods or services used in their creation. For measuring the growth rate of GDP in terms of volumes, the GDP at current prices are valued in the prices of the previous

year and the thus computed volume changes are imposed on the level of a reference year; this is called a chain-linked series. Accordingly, price movements will not inflate the growth rate.

- *Domestic material consumption (DMC)* measures the total amount of materials directly used by an economy; it is defined as the annual quantity of raw materials extracted from the domestic territory of the focal economy, plus all physical imports minus all physical exports. The DMC indicator provides an assessment of the absolute level of the use of material resources, and allows distinguishing consumption driven by domestic demand from consumption driven by the export market. The DMC indicator is derived from Economy-wide Material Flow Accounts, which is a Eurostat methodology closely following the concepts of National Accounts.

The available data from the Eurostat database will refer the member states for the 2000-2009 period of time. For comparisons across countries, resource productivity is measured as Gross Domestic Product (GDP) expressed in purchasing power standard (PPS) over Domestic Material Consumption (DMC).

In 2009, the resource productivity amounted to 1.57 PPS/kg for the aggregated EU-27 economy. The ratio varies considerably across member states from 0.21 PPS/kg in Romania up to 3.43 PPS/kg in the Luxembourg (figure 1).

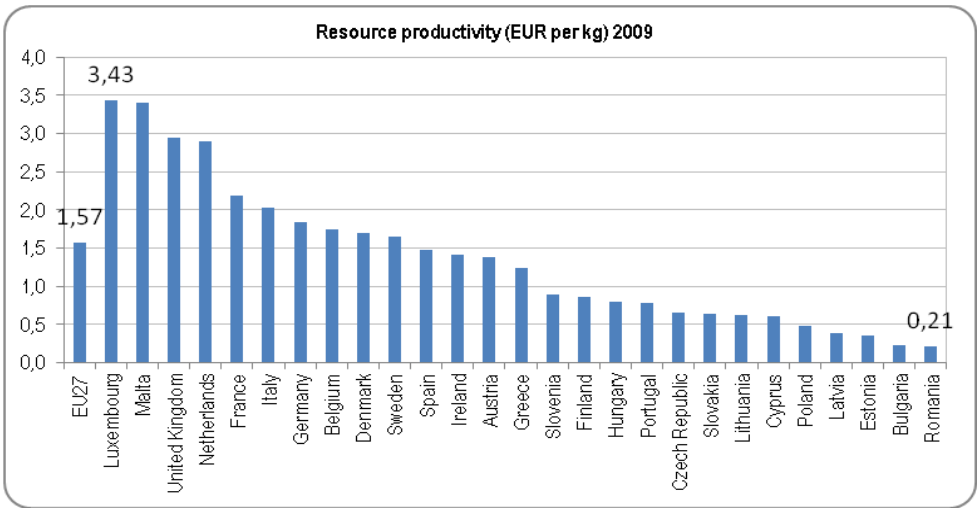


**Figure 1. Large differences across EU state members in Resource productivity (EUR per kg) 2009**

*Source:* Eurostat (tsdpc100)

In 2009, countries performing significantly above EU average include the Netherlands (223.87% as compared to the 100% the bases for the EU27), Luxembourg (220%) and the United Kingdom (187%) – figure 2. Countries where resource productivity is very low as compared to the EU27 average are Romania (only 13.55%), Estonia (22.58), Latvia (25,16%), Poland (30.325).

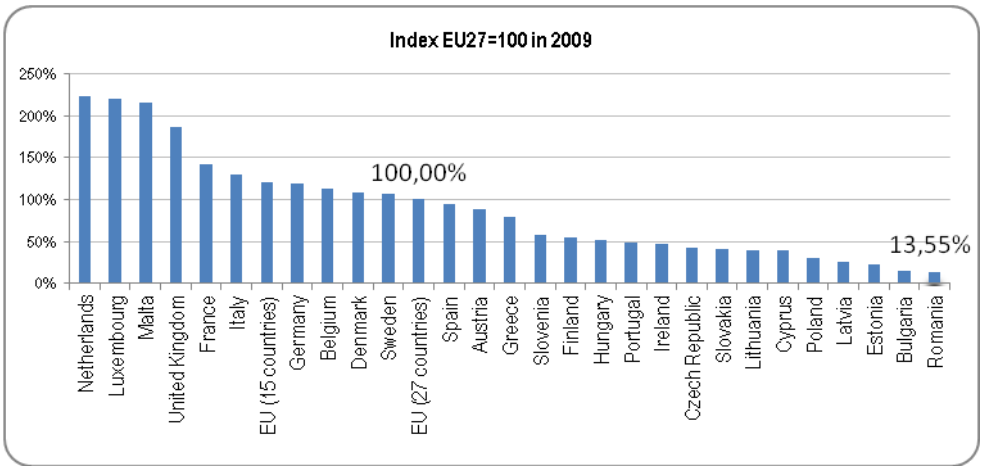


**Figure 2. Resource productivity EU-27, GDP/DMC, 2000-2009 (EUR per kg)**
*Source:* Eurostat (tsdpc100)

The current situation is the results of the evolution trend in the last decade – table 1.

**Table 1. Resource productivity EU27 and Romania (2000-2009)**

| Unit | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|
| EU27 (euro per kg) | 1.36 | 1.39 | 1.42 | 1.38 | 1.39 | 1.41 | 1.42 | 1.43 | 1.55 |
| EU27 Index 2000=100% | 102.26% | 104.51% | 106.77% | 103.76% | 104.51% | 106.02% | 106.77% | 107.52% | 116.54% |
| Romania (euro per kg) | 0.23 | 0.26 | 0.25 | 0.25 | 0.24 | 0.24 | 0.21 | 0.18 | 0.21 |
| Romania Index 2000=100% | 65.71% | 74.29% | 71.43% | 71.43% | 68.57% | 68.57% | 60.00% | 51.43% | 60.00% |

*Source:* Eurostat (tsdpc100)

The resource productivity of the EU-27 economy (as reported by the Eurostat) increased from 1.33 EUR per kilogram of DMC in 2000 to 1.55 EUR/kg in the year 2009 (table 1). In Romania, the resource productivity has fluctuated starting from 1.23 EUR per kilogram of DMC in 2000 and reaching the value of 0.21 EUR/kg in 2009.

In terms of dynamics, the aggregated EU-27 economy increased resource productivity by around 16.5 % in the period 2000-2009 (table 1).

In the EU-27 economy increased from 1.33 EUR per kilogram of DMC in 2000 to 1.55 EUR/kg in the year 2009 which relates to an average annual increase of 16.5% – figure 3. For Romania, the level of resource productivity was placed at 60% from the 2000 value, with a diminished performance of 40% – figure 4 or table 2.

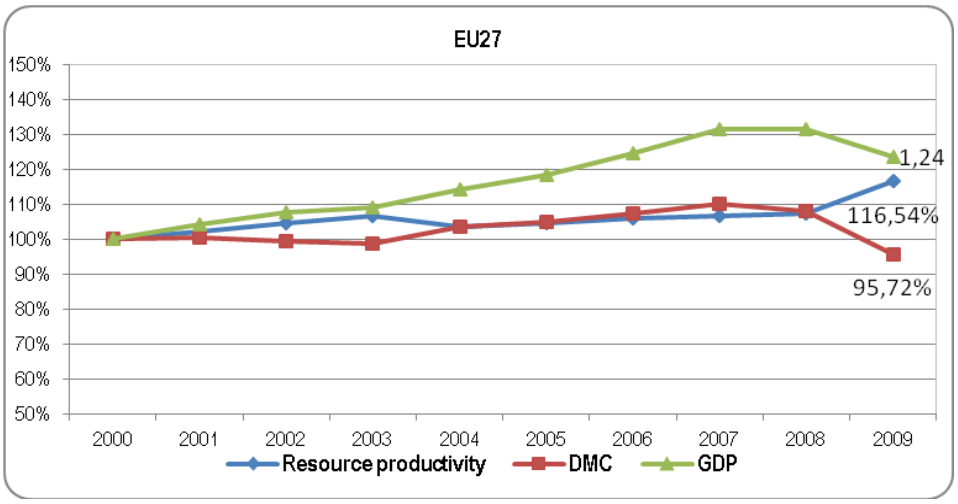


**Figure 3. Resource productivity in comparison to GDP and DMC, in EU-27, 2000-2009 (Index: 2000=100)**
*Source:* authors from Eurostat

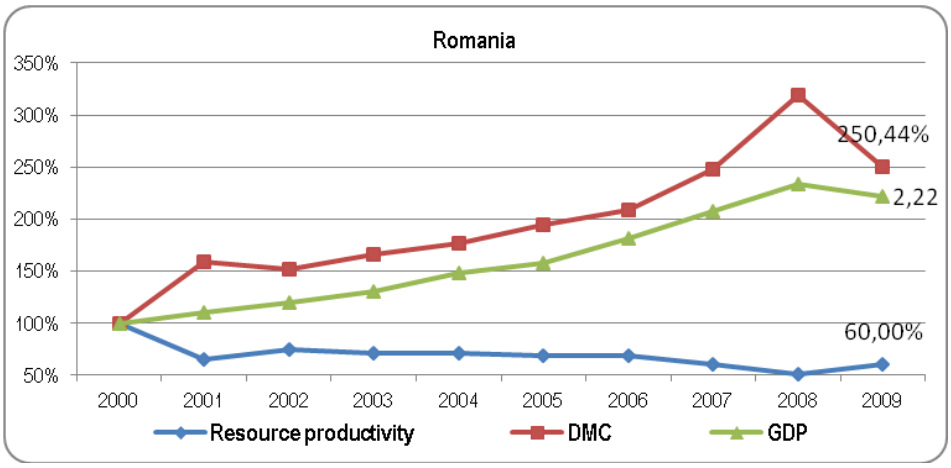


**Figure 4. Resource productivity in comparison to GDP and DMC, Romania in 2000-2009 (Index: 2000=100)**
*Source:* authors from Eurostat

The development of EU's resource productivity over time fluctuated in time. After a constant increase between 2000 and 2003, the resource productivity indicator dropped significantly in 2004; then, recovering the fall in 2005 it continued to go larger with a constant growth rate until 2008. From 2008 to 2009, in the case of EU27, it registered a leap from 1.43 to 1.55 EUR/kg (figure 5). One explanation of this sudden increase may be link to the fact that the economic crisis in 2009 affected the material-intensive industries of manufacturing and construction much more than the services industries. A clue is given by the decline in DMC by more than 11% between 2008 and 2009, i.e. dropping much more than GDP.

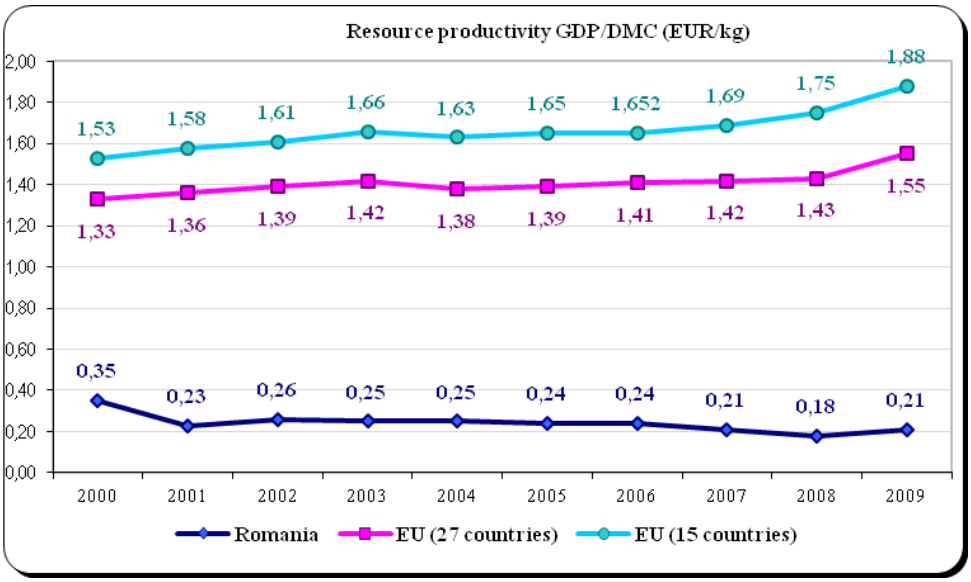


**Figure 5. The evolution in 2000-2009 period of the resource productivity GDP/DMC**
*Source:* authors from Eurostat

In the following various models will be tested in the attempt to identify a dynamic pattern for the recent development (corresponding to the period 2000-2009). The tested patterns were conducted on the time series in GDP/DMC (Euro/kg) (table 2), expressed in various types of models for estimating average resource productivity (each of them giving the equation and the coefficient of determination $R^2$) are:

- for **Romania**:

| | | |
|---|---|---|
| The linear equation: | $y = -0.0115x + 0.3053;$ | $R^2 = 0.6024$ |
| The polynomial of 2 degree equation: | $y = 0.0011x^2 - 0.0232x + 0.3287,$ | $R^2 = 0.6351$ |
| The logarithm model: | **$y = -0.051\ln(x) + 0.3196;$** | **$R^2 = 0.7032$** |
| The power equation: | $y = 0.3209x^{-0.196},$ | $R^2 = 0.6839$ |

- For **EU27**:

| | | |
|---|---|---|
| The linear equation: | $y = 0.0158x + 1.3213,$ | $R^2 = 0.666$ |
| The polynomial of 2 degree equation: | **$y = 0.0018x^2 - 0.0042x + 1.3613,$** | **$R^2 = 0.7227$** |
| The logarithm model: | $y = 0.0601\ln(x) + 1.3173,$ | $R^2 = 0.567$ |
| The power equation: | $y = 1.3196x^{0.0424},$ | $R^2 = 0.5888$ |
| The exponential equation: | $y = 1.324e^{0.011x},$ | $R^2 = 0.6796$ |

- For **EU15**:

| | | |
|---|---|---|
| The linear equation: | $y = 0.0287x + 1.5053;$ | $R^2 = 0.8076$ |
| The polynomial of 2 degree equation: | **$y = 0.0029x^2 - 0.0031x + 1.569,$** | **$R^2 = 0.8601$** |
| The logarithm model: | $y = 0.1088\ln(x) + 1.4988,$ | $R^2 = 0.6804$ |
| The power equation: | $y = 1.5049x^{0.0653},$ | $R^2 = 0.7098$ |
| The exponential equation: | $y = 1.5123e^{0.017x},$ | $R^2 = 0.8245$**.** |

It may be seen that in the case of EU27 and EU15, the dynamics is nonlinear and increasing (following a polynomial model) whereas for Romania, the most suitable model, In terms of the highest coefficient of determination, is the logarithm one, meaning the expected evolution tend to be steadier.

The dynamic growth corresponds to an average annual increase of about 1.4 % (table 3 – column 3). The specific growth rates varies heterogeneously across the different state members; from the smallest values in Bulgaria (0.18) and Romania (0.24) to the largest values – in the case of Malta (3.35) and Netherlands (2.81). For the EU27, the average annual resource productivity growth rate was slightly above the volume growth rate of GDP (around 1.2 %).

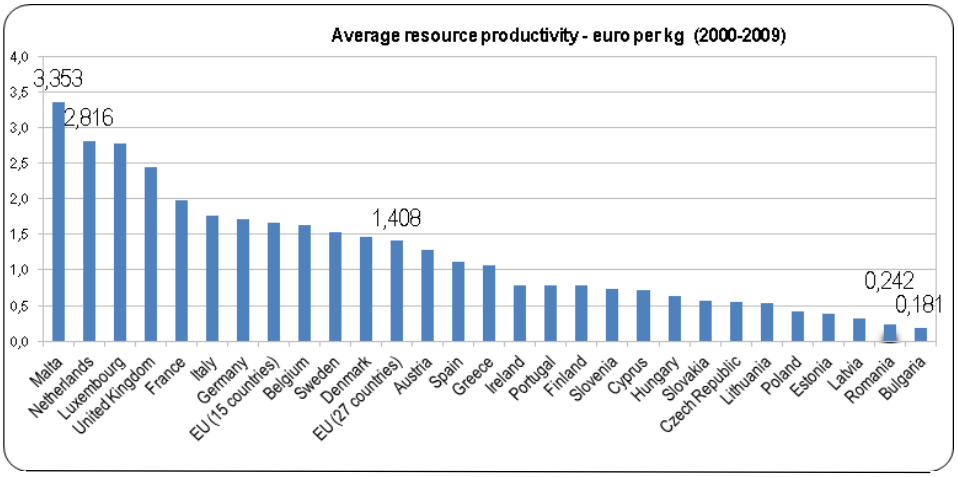


**Figure 6. Distribution of average resource productivity (**GDP/DMC ratio) **- euro per kg (2000-2009)**

*Source:* Eurostat (nama_gdp_c, demo_gind, env_ac_mfa)

**Table 2. The indicators for resource productivity across EU state members**

| Country | Average resource productivity (GDP/DMC ratio for 2000-2009) | Resource productivity growth rate in 2000-2009 | Index EU27=100 in 2009 |
|---|---|---|---|
| EU27 | 1.408 | 16.54% | 100.00% |
| Belgium | 1.634 | 14.38% | 112.90% |
| Bulgaria | 0.181 | 29.41% | 14.19% |
| Czech Republic | 0.556 | 40.43% | 42.58% |
| Denmark | 1.467 | 18.18% | 109.03% |
| Germany | 1.713 | 22.67% | 118.71% |
| Estonia | 0.388 | -16.67% | 22.58% |
| Ireland | 0.782 | -6.41% | 47.10% |
| Greece | 1.066 | 19.42% | 79.35% |
| Spain | 1.121 | 31.25% | 94.84% |
| France | 1.984 | 21.55% | 141.94% |
| Italy | 1.767 | 33.11% | 129.68% |
| Cyprus | 0.710 | -21.05% | 38.71% |
| Latvia | 0.312 | 56.00% | 25.16% |
| Lithuania | 0.536 | 17.31% | 39.35% |
| Luxembourg | 2.781 | 38.62% | 220.00% |

| Country | Average resource productivity (GDP/DMC ratio for 2000-2009) | Resource productivity growth rate in 2000-2009 | Index EU27=100 in 2009 |
|---|---|---|---|
| Hungary | 0.627 | 33.33% | 51.61% |
| Malta | 3.353 | 1.83% | 214.84% |
| Netherlands | 2.816 | 41.06% | 223.87% |
| Austria | 1.274 | 13.11% | 89.03% |
| Poland | 0.426 | 23.68% | 30.32% |
| Portugal | 0.779 | -2.56% | 49.03% |
| Romania | 0.242 | -40.00% | 13.55% |
| Slovenia | 0.742 | 27.14% | 57.42% |
| Slovakia | 0.566 | 12.50% | 40.65% |
| Finland | 0.779 | 10.26% | 55.48% |
| Sweden | 1.537 | 13.70% | 107.10% |
| United Kingdom | 2.450 | 36.79% | 187.10% |

*Source:* Eurostat (online codes: nama_gdp_c, demo_gind, env_ac_mfa)

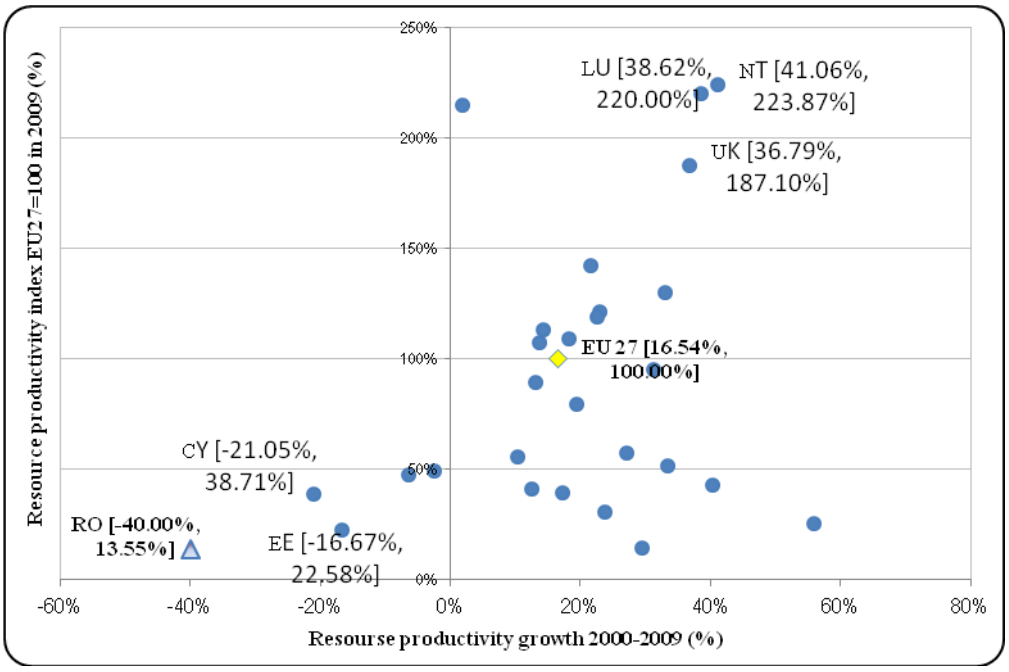


**Figure 6. The comparison among the EU member state – dynamics and level of resource productivity**

*Source:* authors from Eurostat (nama_gdp_c, demo_gind, env_ac_mfa)

The development trajectories for the period 2000- 2009 are more heterogeneous for those Member States who joined the EU after 2004 where the least preferred extremes are Romania (decrease by 40%) and Latvia (increase by 56%) and the positive ones are Netherlands (+41%) and Luxembourg (+38%), followed by United Kingdom with 36% (table 2, 3rd column or figure 8).

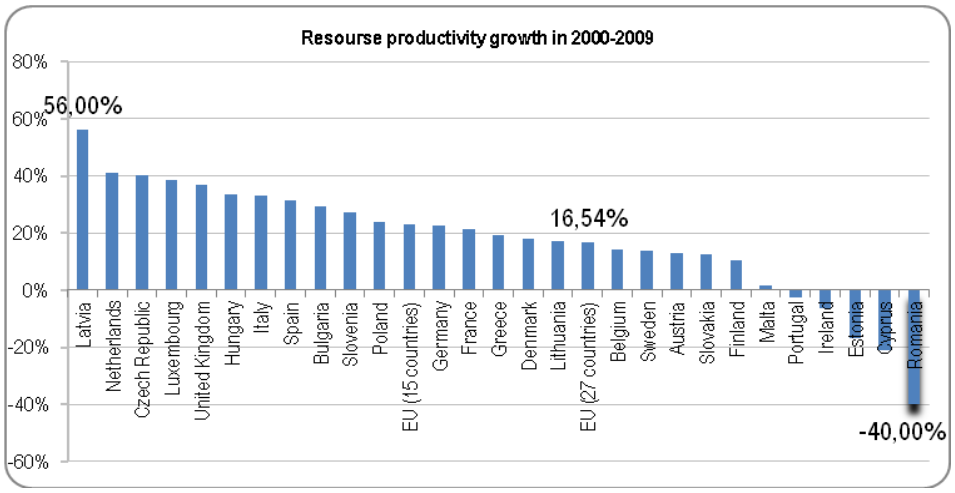


**Figure 7. The distribution among European countries - Resource productivity growth rate in 2000-2009**

*Source:* Eurostat (nama_gdp_c, demo_gind, env_ac_mfa)

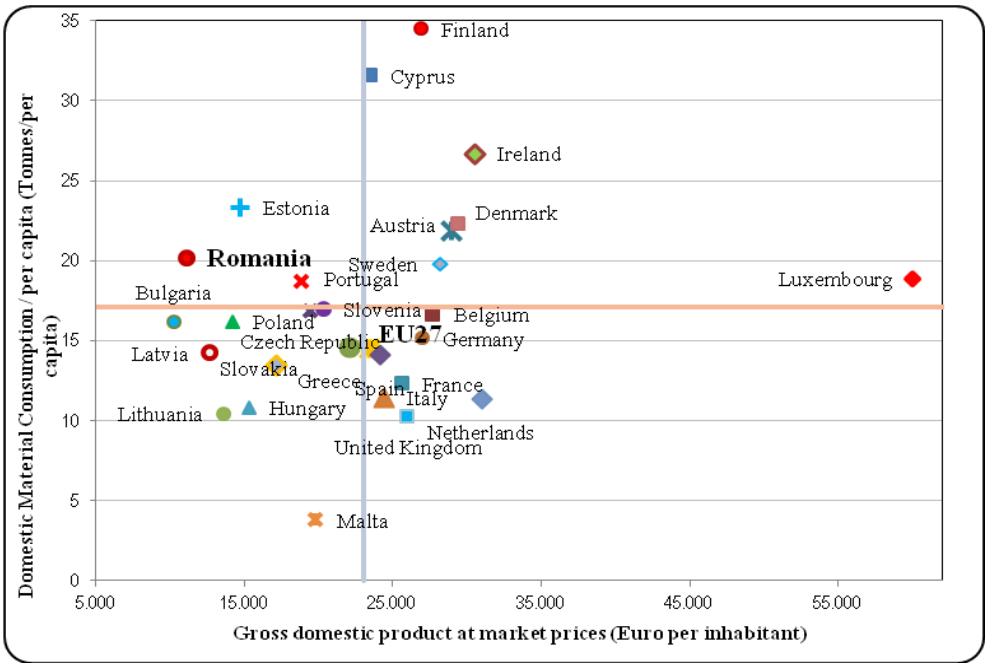


**Figure 8. DMC per capita chart and the GDP - cross country comparison, 2009**

*Source*: authors from Eurostat (online data codes: nama_gdp_c, demo_gind, env_ac_mfa)

The above graph in (Figure 9) is plotting DMC/capita (see table 2, first numerical column) against GDP (table 3, second numerical column) reveals that the variation in resource productivity is partly influenced by different GDP levels or stages of economic development.

The graph shows that countries can be roughly divided into two groups as regards GDP levels and resource productivity: the first country group (on the left side, horizontally) with GDP above 20000 PPS/capita also shows higher resource productivities. The second group with GDP levels below 20000 PPS/capita shows lower resource productivities. But for both country groups, one may find DMC more or less in the same range of about 10-23 tones/capita (excluding outliers such as Ireland, Luxembourg, and Malta).

**Table 3. Resource productivity across European countries - 2000 and 2009**

| Country | Gross domestic product at market prices - Purchasing Power Standard per inhabitant (Euro per inhabitant) | | Gross domestic product per capita growth rate in 2000-2009 | Resource productivity (PPS per capita per kilogram) | | Resource productivity growth rate in 2000-2009 |
|---|---|---|---|---|---|---|
| | 2000 | 2009 | | 2000 | 2009 | |
| EU27 | 19,000 | 23,500 | 23.68% | 1.21 | 1.63 | 17.36% |
| Belgium | 24,000 | 27,700 | 15.42% | 1.34 | 1.66 | 21.67% |
| Bulgaria | 5,400 | 10,300 | 90.74% | 0.43 | 0.64 | 36.86% |
| Czech Republic | 13,500 | 19,400 | 43.70% | 0.76 | 1.15 | 59.75% |
| Denmark | 25,100 | 29,000 | 15.54% | 0.98 | 1.33 | 29.82% |
| Germany | 22,400 | 27,000 | 20.54% | 1.28 | 1.78 | 25.82% |
| Estonia | 8,600 | 14,700 | 70.93% | 0.63 | 0.63 | -16.54% |
| Ireland | 25,100 | 30,500 | 21.51% | 0.57 | 1.14 | 60.94% |
| Greece | 16,000 | 22,100 | 38.13% | 1.13 | 1.52 | 18.80% |
| Spain | 18,500 | 24,200 | 30.81% | 1.07 | 1.72 | 41.68% |
| France | 21,900 | 25,600 | 16.89% | 1.51 | 2.08 | 30.19% |
| Italy | 22,400 | 24,400 | 8.93% | 1.40 | 2.13 | 46.57% |
| Cyprus | 16,700 | 23,500 | 40.72% | 0.76 | 0.74 | -15.78% |
| Latvia | 7,000 | 12,700 | 81.43% | 0.48 | 0.89 | 74.81% |
| Lithuania | 7,500 | 13,600 | 81.33% | 0.96 | 1.30 | 12.52% |
| Luxembourg | 46,600 | 60,000 | 28.76% | 1.96 | 3.18 | 51.53% |
| Hungary | 10,300 | 15,300 | 48.54% | 0.87 | 1.41 | 22.56% |
| Malta | 16,500 | 19,800 | 20.00% | 4.45 | 5.23 | 22.96% |
| Netherlands | 25,600 | 31,000 | 21.09% | 2.06 | 2.74 | 25.98% |
| Austria | 25,100 | 29,400 | 17.13% | 1.08 | 1.32 | 19.87% |
| Poland | 9,200 | 14,200 | 54.35% | 0.65 | 0.88 | 32.97% |
| Portugal | 15,500 | 18,800 | 21.29% | 0.83 | 1.00 | 11.22% |
| Romania | 5,000 | 11,100 | 122.00% | 0.65 | 0.55 | -24.97% |
| Slovenia | 15,300 | 20,300 | 32.68% | 0.89 | 1.19 | 29.26% |
| Slovakia | 9,500 | 17,100 | 80.00% | 0.94 | 1.27 | 37.23% |
| Finland | 22,300 | 26,900 | 20.63% | 0.65 | 0.78 | 10.41% |
| Sweden | 24,300 | 28,200 | 16.05% | 1.20 | 1.42 | -0.39% |
| United Kingdom | 22,600 | 26,000 | 15.04% | 1.77 | 2.53 | 7.74% |

*Source:* Eurostat (nama_gdp_c)

## CONCLUSIONS

The paper brings into discussion statistical evidence necessary to explore the potential of eco-innovation and resource efficiency for Europe. It examined the existing barriers to realizing the benefits and identified what measures are needed to promote eco-efficiency in Europe. It found out that the benefits are significant: promoting and investing in eco-innovation and resource efficiency can help to create smart, sustainable and inclusive growth.

The evaluation of resource efficient use is crucial for a good conduct of doing business in the more increasing competitive business environment, concerned with the proper use of some constrained resources and preoccupied by the waste management and nature' alteration (WRI, 2002). There are several indicators that address the issue of resource consumption; among them the most frequently used is the resource productivity. This used the information on the GDP and the domestic material consumption.

A direction for new investigation deals with extracting information on both DMC as it is consumption oriented and Direct Material Input (DMI) which is input oriented. DMI measures the direct input of materials for the use in the economy. DMI equals Domestic Extraction (DE) plus imports.

The subject is linked to technological knowledge of existing and new technologies as transforming the economy onto a resource-efficient path will bring increased competitiveness and new sources of growth and jobs through cost savings from improved efficiency, commercialization of innovations and better management of resources over their whole life cycle. This requires policies that recognize the interdependencies between the economy, wellbeing and natural capital and seeks to remove barriers to improved resource efficiency, whilst providing a fair, flexible, predictable and coherent basis for business to operate.

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