A Threefold Assessment of the Romanian Economy's Eco-efficiency

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Abstract: *The present paper assesses the ecological sustainability of the Romanian economy from three different angles. The first two applications use the economy's energy and material consumption as proxy for its overall environmental impact. The third assessment approach is a qualitative and context-based one: the main obstacles to and opportunities for incorporating sustainability-competitiveness synergies into the Romanian industrial firms' management are identified. In the period 2000-2007, GDP growth was an important contributor to the Romanian economy's eco-efficiency levels, while the material and energy consumption remained constant or even increased. The predominance of competitive advantages based on low labour costs, high potential of increasing labour productivity, deficient environmental and industrial policies, and lack of awareness in both business and policy environment as to the beneficial role of resource productivity increase constitute significant obstacles to adopting competitive sustainability strategies. Fortunately, the relatively low levels of eco-efficiency and eco-innovation in industry offer in fact a wide scope of still unexploited win-win solutions. On the basis of the results, further research directions are sketched and several desirable public policy actions for enhancing the ecological sustainability of the Romanian economy are put forward.*

Keywords: *sustainability, eco-efficiency, energy efficiency, material flow analysis, competitiveness*

JEL Classification: *M20; Q01; Q32; Q49; Q56*

Setting the scene

The thinking on the relationship between economy and environment has evolved from a strictly functional treatment of the latter[1] and a purportedly infinite substitutability[2] of it in

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[1] In this conventional perspective, environment is regarded as being external to economic system and performing the following *economic functions*: i) providing natural resources, subsequently used as factors of production within the economic system; ii) recipient of pollution and waste generated by the economic processes; and iii) amenities provider (e.g. Hussen 2004).

[2] For example, according to Solow (1974), the technological progress and infinite possibilities of substitution between man-made and natural capital make depletion of natural resources a simple „event", capable of postponing and even avoiding the bio-physical limitations.

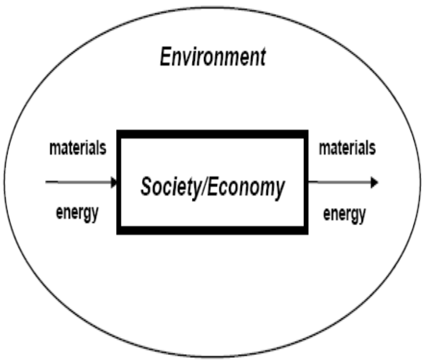
the economic processes to a progressive recognition of its intrinsic value and of the complex interplay between it and the socio-economic system[3]. Thereby a bio-centric and processual paradigm is replacing the anthropocentric and utilitarian one.

The recently emerged transdisciplinary schools - i.e. environmental economics, ecological economics and economics of natural resources – have been focusing on i) the causes of the ecological non-sustainability of socio-economic development process and ii) the best ways of assessing its negative impact on the environment. Their main contributions to economic theory resides in: i) the extension of neoclassic economy's scope beyond the economic growth preoccupation and ii) in challenging the neoclassical assumption of the automatic socio-environmental spillovers of the economic growth (e.g. Kuznets Environmental Curve hypothesis; Beckerman 1992).

Especially in the ecological economics perspective, economic processes mean in fact extracting, using and transforming natural resources (in essence matter and energy) according to the first two laws of thermodynamics[4]. As Boulding (1966) points out, the economic processes are included in an enclosed (and not open) thermodynamic system (Figure 1). Thus, the ecosystem's capacity of supplying energy and matter and assimilating waste proves to be rather limited. As an economic application of the laws of thermodynamics, the "material balance principle" has become an implicit assumption of ecological economics (e.g. Kneese *et al*. 1972; Ayres 1978; Giljum 2006).

These bio-physical limits of economic system would consequently demand: i) a more eco-efficient exploitation of natural resources, ii) identification of their substitution opportunities and iii) even setting up economy dematerialization thresholds. On macro level, that brings about minimizing the socio-economic pressure on ecosystem's carrying capacity and preserving its essential functions by (a relative or even absolute) decoupling the environmental impact from economic growth.

Figure 1: *The economy-environment interdependencies*



Source: *Eurostat (2001)*

[3] As stated in the recent *The State of the Planet Declaration*, emerging form the *Planet Under Pressure* conference proceedings, "the Earth system is a complex, interconnected system that includes the global economy and society, which are themselves highly interconnected and interdependent".

[4] More specifically, based on the law of the conservation of mass, economic system's inputs are equal outputs to the natural system plus net physical stock change (e.g. Hinterberger *et al*., 2003).

This explains why a good understanding of an economy's material and energy flows provides the ground for a proper formulation of natural resource and environmental policies.

More specifically, **eco-efficiency** represents an indicator of nature use productivity, in which "nature" is considered as a factor of production. From the perspective of "weak" sustainability approach, it is the rightest response to the more pressing need of reducing the environmental impact of economic processes. In addition, eco-efficiency, a common indicator used for assessing macro-sustainability and quantifying the degree of decoupling economic development from environmental impact, is computed as a ratio between the economic performance (in terms of turnover, value added, GDP at constant prices, etc.) and the environmental impact (e.g. use of natural resources, emissions or waste generated, etc.) induced by it. For quantifying the macro-sustainability degree of an economy, i) the overall energy consumption and ii) material consumption can be used as proxy for the environmental impact.

Due to the lack of a comprehensive and universally accepted methodology for identifying the potential firm-level sustainability-competitiveness synergies, a qualitative approach[5] appears to be more appropriate and it is consequently used in the third sustainability assessment application.

1. First application: Romanian economy's eco-efficiency in terms of energy consumption

Even though the traditional statistical energy indicator of energy intensity was continuously decreasing in the period 2000-2010, the Romanian economy still remains the most energy-intensive economy in EU-27 (with the exception of Bulgaria), and it is still pretty far from reaching the average energy intensity level of EU-27 (Table 1).

Table 1: ***Romanian economy's energy intensity in the period 2001-2010 (kgoe per 1000E of GDP)***

	2001	2002	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Romania	869.231	857.738	847.432	766.696	732.991	704.783	659.089	612.759	575.070	588.039
EU-27	187.817	184.979	186.842	184.389	181.283	175.726	169.147	167.639	165.715	167.99

Source: *Eurostat, Energy Indicators*

In addition to the good news of substantial decreasing energy intensity, the share of renewable energy in gross final energy consumption is well above the EU-27 average and very close to the 2020 target[6] (Table 2).

[5] Complementary to the "theorist's approach", the English economist Ely Devons names this qualitative approach "the historian's technique". It is "the approach of the reality which tries to understand what is going on by 'soaking oneself in the facts of the situation'. In this approach one has no precise model clearly formulated in advance which one is testing again reality. One may, however, have general considerations in mind of what are important elements in the situation, and one approaches the facts within this kind of vague framework" (Devons, 1959).

[6] The EU targets set in the Directive 2009/28/EC on renewable energy are: i) EU will reach a 20% share of energy from renewable sources by 2020 and ii) a 10% share of renewable energy specifically in the transport sector - http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=Oj:L:2009:140:0016:0062:en:PDF .

Table 2: ***Share of renewable energy in Romanian's gross final energy consumption in the period 2006-2009 (%)***

	2006	2007	2008	2009	2020 target
Romania	17.2	18.4	20.5	22.4	**24**
EU-27	9	9.9	10.5	11.7	**20**

Source: *Eurostat, Energy Indicators*

According to Leca *et al*. (2009), the causes of the relatively low level of Romanian economy's energy efficiency (Table 3) are: i) the general lack of concern over the high energy final consumption levels; ii) inactivity of responsible institutions; iii) defective implementation of the energy efficiency strategies and programmes; iv) lack of properly designed penalties and stimuli to energy efficiency increase; v) ineffectual management; and vi) difficult access to the financing programmes.

Table 3: ***Evolution of Romanian economy's energy efficiency in the period 2003-2008***

Indicator	2003	2004	2005	2006	2007	2008
Energy final consumption (1000 toe), out of which:	24201	25497	24664	24771	24022	24887
Industry	10355	10165	9974	9565	9129	9210
Energy efficiency (%) (Energy final consumption / Gross domestic energy consumption)	60.2	64.4	62.9	60.8	59.4	61.3

Source: *Eurostat*

Fortunately, there is a significant energy-saving potential in the Romanian economy that could be exploited (Table 4).

Table 4: ***Romanian economy's energy-saving potential***

Sector	Average energy-saving potential (% of consumption)
Industry	20-25
Buildings	40-50
Transport	35-40
Overall national potential	**30-35**

Source: *Leca et al. (2009)*

In spite of being a raw proxy for the overall economy's environmental impact, gross inland energy consumption can be used in getting the big picture of the economy's eco-efficiency - i.e. as a denominator of the ratio of *GDP* to *Gross inland energy consumption*. In the period 2003-2008, although gross inland energy consumption remained more or less constant in the Romanian economy, the positive evolution of eco-efficiency is explained through a slight energy efficiency increase and mostly to the GDP growth. After 2008, the contracted economic activity led to sharp decrease in both GDP and gross domestic energy consumption (Table 5), hereby leading to higher eco-efficiency levels.

Table 5: ***Evolution of Romanian economy's eco-efficiency in terms of energy consumption in the period 2003-2010***

Indicator	2003	2004	2005	2006	2007	2008	2009	2010
GDP (mil. RON constant prices)	94638	102673	106938	115359	122646	131659	122340	120790
Gross domestic energy consumption (1000 toe)	40234	39597	39236	40730	40467	40616	35506	35708
Eco-efficiency (GDP/Gross inland energy consumption; 1000 RON / kgoe)	**2.35**	**2.59**	**2.72**	**2.83**	**3.03**	**3.24**	**3.44**	**3.38**

Source: *Own calculations based on IMF Database and Eurostat data*

It is worth noting that, despite its accelerating output growth in the period 2002-2010, Romanian industry's final energy consumption decreased, hereby leading to a significant increase of eco-efficiency in terms of energy consumption (Table 6).

Table 6: ***Evolution of Romanian industry's eco-efficiency in terms of energy consumption in the period 2003-2007***

Indicator	2005	2006	2007	2008	2009	2010
Industrial output (mil. RON)	211081.9	247373.1	276110.4	352702.4	308709.5	339392.3
Industry's energy final consumption (1000 toe)	10092	9379	9076	8543	6202	6613
Industry eco-efficiency (RON/toe)	**20915**	**26375**	**30422**	**41285**	**49775**	**51321**

Data source: *Own calculations based on data from TEMPO-online of the Romanian National Institute of Statistics*

Efforts of reducing Romanian manufacturing industry's energy intensity were significant, taking into account the fact that only 1% of the energy intensity decrease was due to the structural change, while 69% was brought about the energy efficiency increase (and possibly technological change)[7]. In the period 2001-2010, the final energy consumption of manufacturing sectors followed different pathways (Table 7).

[7] According to the results of the structural decomposition conducted by UNIDO (2012).

Table 7: *Final energy consumption in several Romanian manufacturing industry sectors in the period 2001-2010 (1000 toe)*

Sector	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total industry, out of which:	**9880**	**10656**	**10363**	**10357**	**10228**	**9734**	**9318**	**9017**	**6521**	**6884**
Iron and steel	2836	2893	3039	3482	3632	3629	3373	2862	1789	2000
Chemical and petrochemical	2619	2906	3121	2419	2508	2240	2150	2519	2029	2033
Food and tobacco	784	746	704	887	981	567	697	687	523	557
Textile and leather	320	422	350	338	192	267	297	251	183	181
Paper, pulp and print	295	356	477	286	266	251	251	121	90	165
Transport equipment	170	127	148	123	84	165	185	153	150	114
Machinery	773	812	637	597	519	506	474	465	325	365
Wood and wood products	184	200	121	229	202	243	317	248	194	263

Source: *Eurostat*

2. The second application: Romanian economy's eco-efficiency computed on the basis of material flow accounts

Developed during the '90s, standardized by Eurostat (Eurostat, 2001) and promoted by the most important international organizations (e.g. OECD), material flow analysis (MFA) is increasingly applied worldwide. Within environmental sustainability assessment context, material flows are regarded as aggregate proxy for the overall environmental pressure induced by an economy, i.e. an economy's environmental performance is dependent on its physical basis, i.e. the volume and structure of material flows induced by the economic activities. The amount of pollutants and waste generated is dependent on the volume of material inputs used in economy. Thus, an economy's dematerialisation through increasing eco-efficiency becomes a solution for reducing its overall environmental impact.

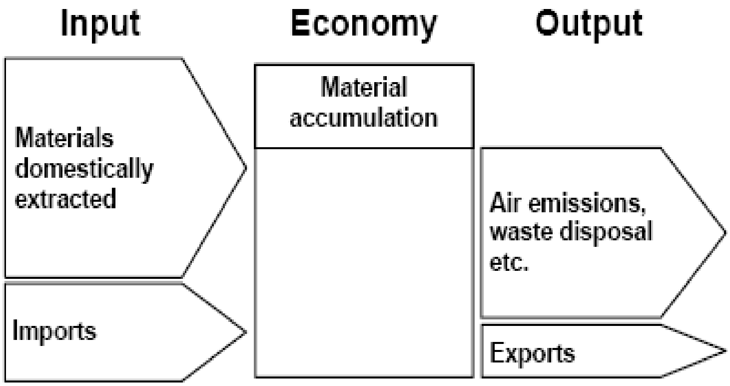
MFA's analytical framework has succeeded in revealing in a satisfactory way the interdependencies between the material flows and overall economic activities. It hereby proves to be a quite sound methodology for capturing an economy metabolism and assessing the sustainability of its development pathway (Figure 2). Based on the theoretical framework of "socio-economic metabolism", the methodology of material flow analysis (MFA) aims mainly to: i) measure the material basis sustaining an economy's production and exports; and ii) compute indicators for macro-level monitoring the management of natural resources, resource use efficiency (i.e. by relating economy-wide material flow indicators such as DMC to GDP)[8]

[8] That is made possible by MFA methodology's compatibility with the System of National Accounts.

and environmental relevance of an economy's foreign trade flows and structure (e.g. OECD, 2008; Kovanda et al., 2012).

In the European Union, since Eurostat's publication of the methodological guide for the compilation of material flow accounts and the derived indicators (Eurostat, 2001), many EU national institutes of statistics (including Romania's) compile them. In Eurostat (2001), the economy-wide material flow indicators are divided into input, output, consumption and balance indicators (i.e. physical trade). They can be further disaggregated by industries or main material categories, i.e. biomass (from agriculture, forestry and fishery); fossil fuels (coal, oil and gas); non-metallic minerals and metal ores (Hinterberger *et al.,* 2003; Giljum, 2006; OECD, 2008; Kovanda *et al.,* 2012).

Figure 2: ***Material flows between an economy, environment and the rest of the world***



Source: *Eurostat (2001)*

The main MFA-based aggregate indicators are presented in the Table 8.

Table 8: Main MFA-based indicators

Indicator	**Description**
Domestic Extraction (DE)	DE includes all renewable and non-renewable raw materials extracted within the borders of a country
Direct Material Input (DMI)	DMI covers domestic extraction used in production and consumption plus material imports
Domestic Material Consumption (DMC)	In addition to DE, DMC includes imports minus exports directly used in an economy
Total Material Requirement (TMR)	TMR is equal to used and unused domestic extraction plus imports plus indirect flows associated to imports (usually calculated estimated by applying a set of coefficients)
Physical Trade Balance (PTB)	PTB is computed as material imports minus material exports
Domestic Processed Output (DPO)	DPO comprises emissions to air and water, wastes deposited in landfills and dissipative flows

Source: *Eurostat (2001)*

With Eurostat's technical support, the first data and MFA indicators covering the period 1994-2007 were published in Romania in 2008 (Eurostat and NIS, 2008).

Table 9: ***MFA-based indicators of the Romanian economy (mil. tones)***

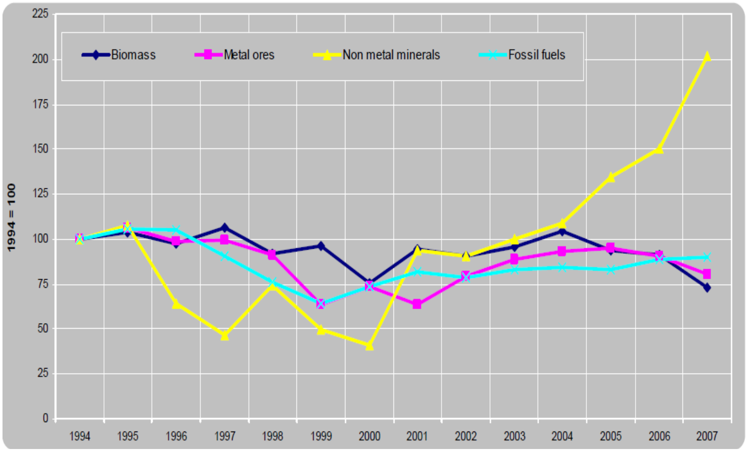
	Indicator	2000	2001	2002	2003	2004	2005	2006	2007
1	DMI	191.1	291.7	283.7	308.1	329.7	360.9	386.6	452.9
2	Domestic unused extraction	28.1	40.7	42.8	44.1	60.0	64.2	72.6	81.4
3	TMI (1+2)	219.3	332.4	326.5	352.3	389.7	425.2	459.3	534.3
4	Exports	19.1	18.6	21.5	22.3	24.6	26.5	26.3	24.5
5	DMC (1-4)	171.9	273.1	262.1	285.8	305.0	334.4	360.2	428.3
6	Imports	25.3	28.1	31.1	36.7	40.5	42.2	44.3	50.1
7	Physical trade balance (6-4)	6.2	9.5	9.6	14.4	15.9	15.7	18.0	25.6

Source: *Eurostat and NIS (2008)*

They are extremely useful in calculating the Romanian economy's eco-efficiency and resource productivity indicators and in assessing the ecological sustainability of Romania's economic development process. A first analysis of this kind was conducted by the Romanian Forecasting Commission (CNP, 2010).

In the period 2000–2007, DMI of the Romanian economy increased by 137%. In fact, the positive rates of economic growth induced an increasing material demand. DMI was made up mostly of domestic used extraction (89% in 2007). In 2007, following an ascendant evolution (Figure 3), non-metal minerals accounted for the high share of TIM (i.e. 68.9%), DMC (i.e. 71.7%) and TMI (i.e. 70.3%). This material category would thus need further sectorial (and even company-level) disaggregation and sustainability assessment of its extraction and use (Eurostat and NIS, 2008).

Figure 3: ***Evolution of the main components of DMI in the period 1994-2007***



Source: *Eurostat and NSI (2008)*

Both physical exports and imports constantly increased between 2000 and 2007. As imports exceeded exports, the physical trade balance was negative - a fact that shows a certain degree of environmental impact transferred abroad.

MFA-based indicators of eco-economic efficiency associated to the Romanian economy in the period 2000-2007 (i.e. one period characterized by positive economic growth rates) show clearly that its development was not ecologically sustainable (Table 10). Increasing resource consumption associated with economic growth indicate just a relative de-linkage of environmental impact from economic growth.

Table 10: ***MFA-based eco-economic efficiency indicators of the Romanian economy in the period 2000-2007***

Indicator	2000	2004	2007
Eco-efficiency (GDP/DMI, lei/tone)	0.38	0.28	0.24
Material intensity (tone/lei)	2.38	3.32	3.92

Source: *CNP (2010)*

According to the ecologically sustainable growth criterion put forward by Joachim H. Spangenberg, "economic growth can only be environmentally sustainable if it is accompanied by resource productivity increases at a higher rate than the economic growth rate". The criterion of socio-environmental sustainability is given by the following inequality:

$d(Y/L) < d(Y) < d(Y/R)$

where Y stands for output, L for active labour force, and R is resource consumption (Spangenberg, 2001). Using it as a sustainability condition, it is evident that Romanian economy was far away from meeting it (Table 11).

Table 11: ***Indicators pertaining to the Spangenberg's environmental sustainability criterion (GDP/DMC; Euro per kg)***

	2002	2003	2004	2005	2006	2007	2008
Resource productivity - EU-27 average (GDP/DMC; Euro per kg)	1.27	1.29	1.26	1.27	1.28	1.3	1.31
Resource productivity – Romania	0.17	0.17	0.17	0.16	0.16	0.14	0.12
Real GDP growth rate – volume (%, percentage change on previous year)	5.1	5.2	8.5	4.2	7.9	6.3	7.3

Note: Resource productivity growth rates were not calculated since they were 0 or negative.

Source: *Eurostat*

3. Third application: Opportunities for sustainability-competitiveness synergies in the Romanian industrial firms[9]

Some theoretical clarification

Productivity, which is the essence of national competitiveness, is determined by several important factors (e.g. technological readiness, innovation, etc.), whose significance is highly dependent on an economy' stage of development (e.g. World Economic Forum, 2010). Despite being a major goal of economic policy, competitiveness is commonly set without taking into account its long-term convergence with social and environmental objectives, thereby overlooking the ultimate national goal of welfare[10].

At the micro level, there are two main theoretical approaches as to how firms can create competitive advantages. First, according to market positioning approach (e.g. Porter, 1996), the mechanisms of a firm's commercial success are "operational effectiveness" - i.e. superior efficiency - and market "differentiation". In fact, only the latter would represent a genuine competitiveness strategy. On the other hand, the resource-based approach (e.g. Hart, 1995) focuses on the optimization of firm's internal capabilities (e.g. physical, financial and human resources; technological and organizational capabilities), processes and activities. In practice, the two approaches are not completely independent[11], and a combination of the two seems to be more desirable. Furthermore, the success of any competitive strategy pursued is highly dependent on other particular circumstances embedding firms – e.g. location, access to factors of production, institutions, political and social context, etc.

Under the increasing stringency of environmental regulation and continuous rise in energy and raw material prices on world market, resource-intensive firms operating in high environmental impact industries see themselves forced to increase resource productivity by investing more in environmentally sound technology, material substitution, and process and product innovation. There are nowadays some favourable conditions for firms to consider balancing their economic performance and long-term social and environmental objectives such as: i) environmental regulation fosters firms to internalize environmental externalities; ii) the adoption of newly developed technologies may be conducive to eco-innovation; and iii) there is a considerable potential of increasing resource productivity through the optimization of material and energy flows (Hargroves and Smith, 2005; Wagner and Enzler, 2006). These two environment-oriented strategies represent in fact major opportunities for firms operating in "production-intensive sectors" (Pavitt, 1984 and 1991). Hence, any firm's attempt to create synergies between environment-oriented technological change and commercial performance has to be rooted in the specific operating context.

Taking an optimistic stance, stage development approaches (e.g. Hart, 1995; Bleischwitz and Hennicke, 2004; Keijzers, 2005) describe the process of firm's phasing in of sustainability

[9] This section is based on my paper *Drivers and constraints on the integration of sustainability into competitiveness strategy of Romanian Industrial firms*, presented at *the 7th International Conference on Management of Technological Changes – MTC2011*, *Sustainable Development through Technological Change* topic, Alexandroupolis, Greece, 1-3 September 2011 - http://www.cetex.tuiasi.ro/mtc2011/

[10] Notable exceptions are Aiginger (2006) and the *Sustainable Competitiveness Index* developed by the World Economic Forum (WEF, 2011).

[11] For example, a specific market positioning strategy could affect the way of using firm's internal capabilities.

objectives as a progressive evolution from an initially defensive approach (i.e. pollution reduction through end-of-pipe solutions) to a more and more holistic, proactive and interactive approach – i.e. eco-efficiency strategy implementation and finally an environmental management strategy integrated both vertically (e.g. life-cycle thinking) and horizontally (e.g. shared-responsibility). Whether this evolution is a necessary entrepreneurial pathway remains an open question.

Historically, compliance with environmental regulation was commonly considered as hindering firm's competitiveness. The "double dividend" hypothesis (Porter and Van der Linde, 1995) introduced a paradigm shift in the debate on environment-competitiveness relationship: by pursuing a dynamic efficiency strategy, firm's investments induced by stringent environmental regulation eventually become a source of both higher environmental performance and long-term competitive advantages. Environmental regulation would point in fact to the unexploited opportunities to increasing resource productivity, thereby stimulating technological investments, incremental changes and/or product and process innovation. Several empirical studies (e.g. OECD, 2007) confirmed empirically that hypothesis.

Yet, as Kemp (2000) and OECD (2007) point out, innovation seem to be more the result of adjusting firm's internal capabilities to suit particular market conditions than induced by public policy instruments. Second, double-dividend hypothesis cannot be translated into a one-size-fits-all solution and is not universally applicable. The scope and potential impact of both eco-efficiency and eco-innovation are highly industry-specific and even firm- or activity-specific. Furthermore, environment investments i) may not generate competitive advantage, ii) "innovation offsets" may prove to be insignificant or iii) as Orsato (2009) shows, the scope of win-win solutions might be rather narrow. A firm's incremental changes in response to regulation may really result in lower costs and resource productivity increase, but without outperforming its competitors. Despite being an essential part of environment-competitiveness strategy, resource productivity increase is *a necessary but not sufficient condition* for getting competitive advantages. This is much more in line with the traditional managerial preoccupation with economic efficiency than with the creation of market distinctiveness (e.g. Porter, 1996; Norberg-Bohm, 2000).

Towards integration of sustainability concerns into the Romanian companies' competitiveness strategy

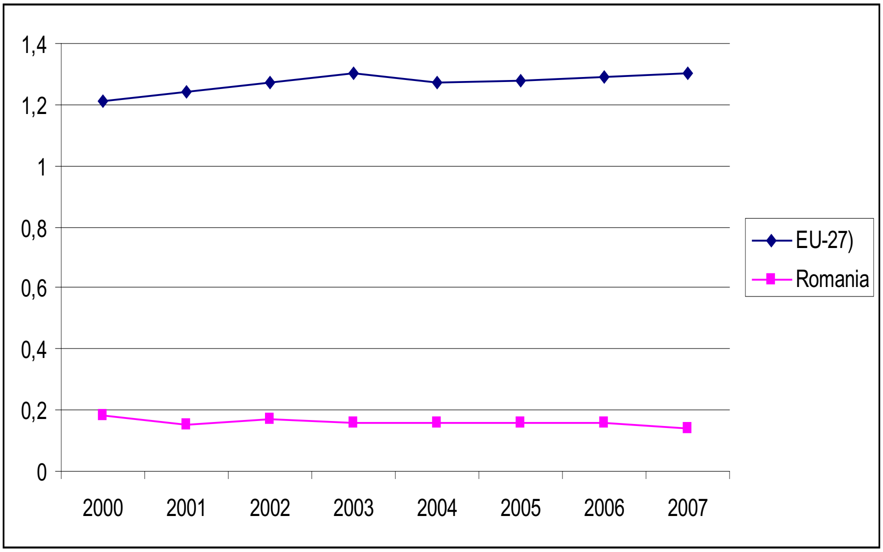
Against this background, it is timely to question whether and to what extent could Romanian industrial firms' pursuit of competitive advantages be matched with their (if any) sustainability objectives? To what extent could the integration of sustainable practices (e.g. eco-efficiency, eco-innovation etc.) into their strategic management become a source of competitive advantage? How extended is the scope of environmental-economic win-win solutions? In order to answer these questions I will try to identify which are the main obstacles and opportunities to incorporating sustainability concerns into Romanian industrial firms' competitiveness strategies by having a look at their embedding conditions and by analysing the most relevant indicators[12].

[12] Thus approach can provide just the big picture. Each economic sector's specific contribution to the overall environmental impact needs deeper examination. Since also the sectoral composition – i.e. in terms of the number and types of operating firms - is extremely relevant, for getting a much clearer picture the assessment must be also deepened at micro level. For example, though the environmental impact of each firm may be relatively low, the sector's total environmental impact may be high due to the large number of compounding firms (Constantinos *et al.*, 2010).

As far as Romanian economy's competitiveness is concerned, according to the European Commission's reports[13], there are still significant industrial competitiveness performance gaps between Romania and EU-27 average in terms of: i) labour productivity per hour worked; ii) labour productivity per person employed; iii) R&D performed by business sector; and iv) share of high-tech exports in total exports. According to the *Innovation Union Scoreboard 2011*, Romania is still a "modest innovator" with a relatively low share of innovating enterprises and decreasing business investments in R&D. Romania's R&D intensity is far below the EU average (the lowest R&D intensity in the EU - 0.47% of GDP in 2010), its sectoral R&D intensity declining relative to that of the EU. Thus one significant public policy challenge hereby emerges: supporting more and making operative the business support infrastructure (e.g. business incubators, technology transfer offices, science and technology parks and clusters).

The Romanian economy's resource productivity[14] was at the lowest level in EU-27 in the period 2000-2007, far below the EU-27 average (Figure 4). Currently, the predominant business foci are not resource efficiency or any other sustainability concern, but more the relatively low level of labour productivity and benefiting from the predominance of labour-intensive industrial sectors, with competitive advantages based on - even though increasing - the lowest labour costs in EU-27, excepting Bulgaria (Table 14).

Figure 4: ***Evolution of Romanian economy's resource productivity between 2000 and 2007 (GDP/DMC;Euro per kg)***



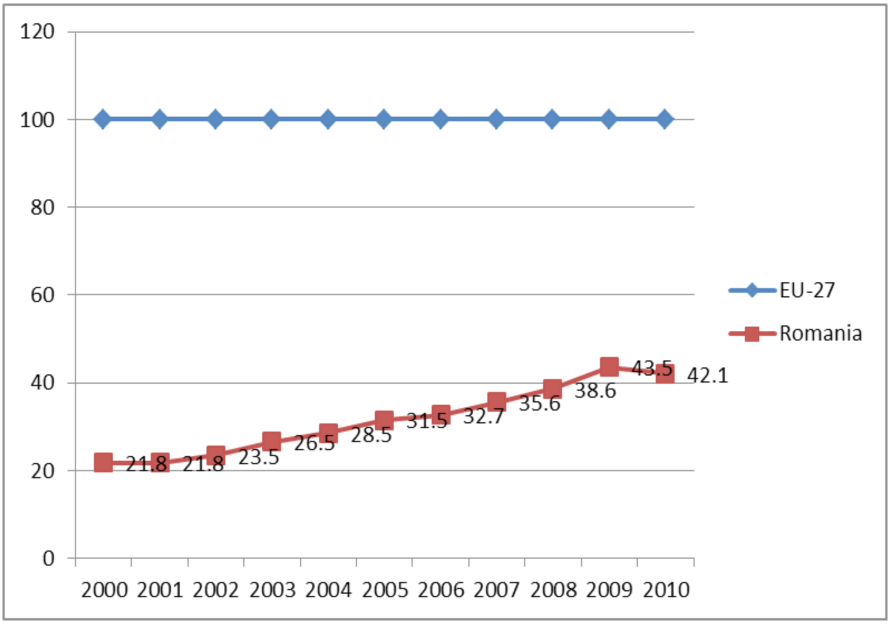
Source: *Eurostat*

[13] European Commission (2011a, 2011b and 2011c)

[14] Resource productivity is an indicator of both economic and ecological relevance. Besides being an important economic indicator pointing to the efficiency of an important factor of production, it is a relevant environmental indicator on macro level as well.

While labour productivity per hour worked (Figure 5) has progressively increased over the last years, it was about 58 percentage points below the EU-27 average in 2010. In addition, a cross-cutting challenge is the shortage of a medium and highly skilled labour force. Higher-education attainment still remains the lowest in the EU-27.

Figure 5: ***Labour productivity per hour worked in Romania (GDP in PPP; EU-27 = 100)***



Source: *Eurostat*

Table 14: ***Average gross annual earnings in the business economy (average gross annual earnings of full-time employees; NACE Rev.2, section B-N) in 2009***

	2009
Bulgaria	3.681
Czech Republic	10.663
Spain	23.714
Cyprus	24.775
Latvia	7.833
Lithuania	6.895
Netherlands	40.777
Poland	8.399
Romania	***4.964***

Slovenia	16.079
Slovakia	10.162
Sweden	33.613

Source: *Eurostat*

Due to the predominant cost-based competitiveness of most Romanian industrial firms, identifying material and energy consumption reduction possibilities to lower production process costs represents an enormous potential for both resource productivity increase and competitiveness gains through cost reduction. To this end, the specialized EU funding programmes for eco-efficiency, eco-innovation and competitiveness are opportunities to be fully exploited. In addition, phasing in competitive markets in energy sector will play an important role in stimulating overall economy's eco-efficiency.

Currently the lack of sector-tailored economic-environmental policies is the underlying obstacle to reaping resource productivity benefits. There are also other important obstacles to business firms' adoption of sustainable competitiveness strategy:

i) Almost exclusively political prioritisation of economic growth was conducive to overlooking the economy's ecological performance in the last two decades;

ii) Deficiencies in environmental policy design and implementation, as well as the lack of a coherent long-term industrial policy;

iii) Lack of awareness as to the beneficial role of resource productivity to competitiveness in both policy and business environment;

iv) Comparatively low level taxes on pollution and resource use (Table15).

Table 15: *Main environmental taxes in Romania, in 2007 (% of GDP)*

	Total environmental taxes	**Energy Taxes**	**Transport taxes**	**Taxes on pollution and resources**
EU-27	2.45	1.77	0.58	0.10
Romania	**2.07**	**1.71**	**0.35**	**0.01**

Source: *Eurostat*

v) Industry's out-of-date technological endowment;

vi) The high share of energy-intensive industries and foreign investments directed mostly towards the low-technology and energy-intensive sectors are resulting in low environmental performance.

Consequently, the need of meeting more and more stringent environmental standards will entail to: i) strengthen institutional effectiveness; and ii) direct more – both public and private - investments for upgrading productive capacities and for new eco-efficient technologies, in spite of the widely persistent effects of financial crisis (also EC, 2011a).

Fortunately Romanian economy's low environmental performance offers a wide spectrum of opportunity, especially in industry. Since industrial competitive advantages are based mostly on „operational efficiency" (i.e. cost-effectiveness) and less on „differentiation" (Porter, 1996), a higher level of resource efficiency, by reducing material and energetic costs, may lead to firms' significant increase of market shares.

Excepting residential consumption, the Romanian industry was the main final energy consumer in 2010 (approximately 31%, Eurostat data). Manufacturing industry deserves special consideration since it is main domain of potential environment-competitiveness synergies in Romanian economy. In 2009 it accounted for 95% of the Romanian exports, 55% of the total energy consumption and 50% of the total hazardous waste generated in Romanian economy (data from Constantinos *et al*., 2010). It also plays a more important structural role in the Romanian economy than of EU's average (22.4 %, in comparison to 14.9 % of total value added). The share of manufacturing in GDP is one of the highest in EU Member States. In spite of its magnitude, Romanian manufacturing is mostly specialized in labour-intensive industries (e.g. textile) and low-level and medium-high knowledge sectors (European Commission, 2011a). While the rise of manufacturing output is accompanied by the increase of intermediate consumption in the period 2002-2006, the latter's share of the gross value added remained almost constant (Table 16).

Table 16: *Evolution of output, intermediate consumption and gross value added in the Romanian manufacturing industry between 2002 and 2006 (mil. lei current prices)*

Indicator	2002	2003	2004	2005	2006
Output	94984.7	117276.8	153778.8	171983.9	203400.8
Intermediate consumption	61559.9	76864.2	101717.1	110733.6	130984.5
Intermediate consumption (%)	64.8	65.5	66.1	64.3	64.4
Gross value added	33424.8	40412.6	52061.7	61250.3	72416.3
Gross value added (%)	35.2	34.5	33.9	35.7	35.6

Source: *NIS (2009)*

In the long term, one of the essential challenges for enhancing the future competitiveness of the Romanian industry will be to facilitate "a shift away from unskilled labour and energy intensive sectors towards more smart, low-carbon and resource-efficient activities" (EC, 2011a).

Given the major differences between SMEs and large firms pertaining to capability endowment, technological change potential and competitiveness-environment synergy scope, separate suitable public policy responses should be formulated. SMEs operating in the Romanian economy (99.6% of the total firms) account for 59% of the total turnover and 52% of the environmental impact, while, despite their small proportion, the large firms account for the remaining 41% of the total turnover (and 50% of the value added), and 48% of the overall environmental impact (Constantinos *et al*., 2010). Large firms' non-compliance or delays in compliance with the environmental regulation[15], distorting subsidies or preferential access to resources represent important barriers to their implementing of eco-efficiency-oriented strategies. As far as SMEs are concerned, they need to shift from simple compliance with environmental regulation towards more proactive competitiveness-sustainability strategies. However most of them lack financial resources for new technology adoption or for implementation of the costly environmental management systems.

[15] For example, the cases of Arpechim S.A. (http://www.wall-street.ro/articol/Companii/31846/Rafinaria-Arpechim-nu-se-mai-inchide.html) and Mittal Steel (http://www.gandul.info/news/mittal-steel-are-mari-intarzieri-la-investitiile-de-mediu-878192)

For overcoming these deficiencies and stimulating firm-level sustainability integration, state aid schemes and fiscal incentives directed towards the adoption of the best available technologies supplemented with technological standards could represent effective policy responses. They can stimulate industrial firms to shift the emphasis from simple end-of-pipe compliance to resource productivity increase concerns (e.g. Norberg-Bohm, 2000; Roome and Anastasiou, 2002; Constantinos et al., 2010).

Conclusions

In the period 2000-2007, GDP growth was an important contributor to the Romanian economy's eco-efficiency levels, while the material and energy consumption remained constant or even increased, especially due to several structural deficiencies – e.g. the high share of energy-intensive sectors. In spite of being an indirect and rough proxy for the economy's environmental impact, energy consumption may be used in calculating the eco-efficiency indicators. In Romania, the positive evolution of the energy consumption-based eco-efficiency indicators is due more to the GDP growth than to the energy efficiency rise. A notable exception is industry, where final energy consumption decreased in the period 2003-2007 in spite of the accelerating industrial output growth. Although the resource productivity improved in the period 2000-2007, DMC followed closely the GDP increase, a fact that points to a relative dematerialization if the Romanian economy.

Some framework-conditions of eco-efficiency increase (e.g. economic structure, innovation level and technological readiness) are, at the same time, determinants of competitiveness. Due to its i) significant share in the economy's total value added and exports and ii) high-level material and energy consumption, Romanian manufacturing industry is the sector with the highest sustainability-competitiveness synergy potential.

Further research is needed for: i) sectorial allocation of the economy's environmental impact, thereby identifying the main sectors, companies and socio-economic factors contributing to the relatively high levels of material and energy consumption; ii) determining the sector-specific potential of sustainability-competitiveness synergies; and iii) elaborating sustainable development scenarios based on Hardwick's sustainability criterion and possible future pathways of the national wealth stock and usage.

For resolving all sustainability-related deficiencies presented, a coherently integrated public policy response is needed, including environmental policy, industrial policy and RD&I.

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