Available online at www.sciencedirect.com

ScienceDirect

Materials Today: Proceedings XX (2016) XXX–XXX

www.materialstoday.com/proceedings

PMME 2016

Moving towards a circular economy: economic impacts of higher material recycling targets☆

Massimo Beccarello[a], Giacomo Di Foggia[b]*

[a] *Dep. of Business Administration, Finance, Management and Law. University of Milano-Bicocca. Milan (IT). massimo.beccarello@unimib.it*
[b] *Dep. of Business Administration, Finance, Management and Law. University of Milano-Bicocca. Milan (IT). giacomo.difoggia@unimib.it*

Abstract

The environment contribution paid by producers of packaging is the key financial mechanism of the Italian packaging management system in operation that bases on a private not for profit consortium. This paper covers the technical and economic aspects and draws up potential socio-economic implications arising from new recycling targets in the medium-term. We estimate two scenarios: the baseline, which simulates the environmental contribution according to the current recycling rate along with the reference that reflects higher goals. Results suggest that higher recycling targets are associated with positive effects on job creation, production and value added, thus, by virtue of both direct and indirect effects. The application of the model has demonstrated significant positive socio-economic impacts achievable when defining new policies and regulations for the sector. Although limited to Italy, this paper serves as a reference for policy makers since environmental legislation and especially waste management policy deserve careful consideration in the light of the polluter pays principle and shared responsibility.

Selection and Peer-review under responsibility of International Conference on Processing of Materials, Minerals and Energy (July 29th – 30th) 2016, Ongole, Andhra Pradesh, India.

Keywords: Material recycling, Circular economy, waste management, Sustainability, Environment policy assessment

* Corresponding author. Tel.: +390264483178.
E-mail address: Giacomo.difoggia@unimib.it

Selection and Peer-review under responsibility of International Conference on Processing of Materials, Minerals and Energy (July 29th – 30th) 2016, Ongole, Andhra Pradesh, India.

1. Introduction

Recovery and recycling have become a prominent vehicle for maintaining production capacity and for investments in new economic activities and technology within the recycling industry. However, such processes also pose particularly thorny challenges related to the waste management systems. Thanks to the improved quality and quantity of available waste along with the development of the treatment plants, the secondary raw materials have become vital to the medium and long-term sustainability since the market for recycled materials is now able to create wealth under the circular economy framework. Recycling targets concur at driving the transition to a circular economy with well-known beneficial effects. Mamnaging this transformational effort presents major challenges. In fact recycling is a costly waste management strategy, particularly when compared to conventional land filling and disposal options [1]. This situation presents stakeholders with multiple new challenges, for which they need to develop new expertise. Although Europe is engaged in a thorough reflection on how the objective of circular economy can be reached in an efficient way that is fully compatible with the jobs and growth agenda, the establishment of a common policy across European countries appears not to be achieved yet. Truthfully whereas at an European level recycling and recovery targets are the same, member states still enjoy a considerable degree of freedom with respect to the practical organization and management strategies adopted [2]. Prior research suggests that economies will benefit from substantial net material savings and secondary materials use [3], nevertheless, the economic effects of recycling-related activities, as well as appraisals of economic policies promoting recycling has been only partially documented so far [4]. It is in this context that the Italian legislative framework set up a non-profit private entity financed primarily through a contribution applied to packaging sold by producers to users [5]. This paper sheds some light on the issue serving both policy-makers and the industry that shall organize operations accordingly. Accordingly, the research purpose is twofold. In fact, from a macro perspective we assess the impact based on national accounts representing supply and use of goods and services by the industry sector. In addition to this, we discuss the cost-efficiency of the Italian model that bases on a private consortium between companies producing packaging. This paper is organized as follows: first, the current issues in packaging waste economic assessment are discussed, as well as ways to overcome some of the obstacles that deter the field's development. The following paragraphs define the field of our manuscript as well as the data collection and analysis methodologies. Next, main results from the study are presented and added to those of previous literature. This is followed by a comprehensive discussion. Our empirical analysis concludes with a discussion of implications, limitations, and potential extensions of the research.

2. Previous literature

The conceptualization of the link between economies and ecologies traces back to the sixties, see for example [6] or [7]. Both similarities and differences between the traditional and the circular economy model – which traces back to different schools of thought – have been well documented [8]. From an economic point of view, the environmental economists primarily introduced this concept Pearce & Turner (1989) building, in turn, on previous studies of ecological economics [10]. Over the years, some prominent principles have emerged as identifiers: reduction, reuse and recycle [11]. Admittedly, waste management, due to the many tasks involved, the several origins of waste and the vast array of stakeholders is a fairly complex issue [12]. Many authors describe the characteristics of waste recycling systems or compare institutional frameworks, recycling rates, green dot fees and, whenever possible, recycling costs and benefits [13], [14]. Again, the packaging waste management arguably represents one of the most thought-provoking topic [15] of which a recent work analyzes similarities, trends and differences in eleven European systems with particular focus on the role of local authorities thus making a noticeable step towards international comparison [16]. Nevertheless, national systems vary considerably in design, in terms of influence of pre-existing policy and systems, methods of achieving producer compliance, fee structures, targets, waste stream prioritization and local authority involvement. Therefore it may be argued that the financial costs and benefits of collecting and sorting packaging waste, although fundamental, is not enough if one wants to carry out an assessment from a general welfare perspective [17]. Hence, the economic impacts in terms of the effects of recycling-related activities, has been only partially documented so far [4]. In this paper we put emphasis on the implications for the economy as a response of higher recycling targets set by the EU in the Italian framework regarding the packaging waste management system that mostly relies on a private non-profit consortium which funds itself through an environmental contribution for each material applied to packaging sold by producers [5]. The national consortium is supported by activities carried out by material consortia and is oriented towards cooperation with the public administration. The general principles ruling the system are the polluter pays i.e. the polluter pays for environmental damage in the form of a clean-up or taxation [18] and the shared responsibility i.e. other players in the system hold part of the responsibility, and they should share the costs proportionally [19].

3. Research objective and methodology

The research process can be divided into two consequential phases each composed by sub-steps. The first phase corresponded to the estimation and forecasting of the environmental contribution. At the beginnings, we defined the variables to be included in the regression analyses; variables selection resulted combining a rigorous literature review and the cooperation for validation from a consortium officer. Official data were used to create our models: reports on budgetary and financial management, general packaging and packaging waste prevention and management program (PGP), specific packaging and packaging waste prevention and management program (PSP) as well as proprietary database used with permission. After that, we built and fine-tuned the models in an effort to predict the environmental contribution for each of the six materials up to 2020. Once model fitted the data well, i.e. the differences between the observed values and the model's predicted values were small and unbiased we summed the results in such a way to obtain the aggregate environmental contribution. In the second phase we made use of our obtained results to show how the highly EU targets will affect the Italian economy. Our estimates were generated using the well-known input-output analysis approach through which we assessed the change in overall economic activity as the result of the corresponding change in the recycling sector. The study bases on a mixed methods research relying on both theoretical assumptions and statistical techniques and methodologies including procedures of case study analysis i.e. an empirical inquiry that investigates a phenomenon within its real life context [20] using more than one set of research methods [21]. This study offers two scenarios: the first one (Baseline Scenario) predicts the environmental contribution up to 2020 according to current trends/policies, while the second one (Reference Scenario) incorporates the effects of higher recycling targets i.e. 45% in the case of plastic and 85% for paper respectively.

4. Institutional framework

Since a long ago as the VI Environmental Action Program, the European Union (EU) defines the priorities and objectives of European environment policy [22]. In the context of the initiative raw material [23] and in the following communication the recycling of waste is set as a key pillar. The circular economy package consists of an EU action plan for the circular economy that establishes a concrete and ambitious program, with measures covering the whole cycle: from production and consumption to waste management and the market for secondary raw materials [24]. No wonder that collection – and, particularly, separate urban waste collection – continues to grow [14]. ith the aim of achieving the recovery and recycling targets, the Italian legislative framework set up CONAI, the national packaging consortium that constitutes a unique case in Europe in terms of regulations, structure and financial mechanism. The national consortium encompasses and coordinates six material consortia CIAL (aluminum), COMIECO (cellular-base, paper), CORIEVE (glass), RICREA (steel), COREPLA (plastic), and RILEGNO (wooden packaging) and its relation within main actors is represented in Figure 1.

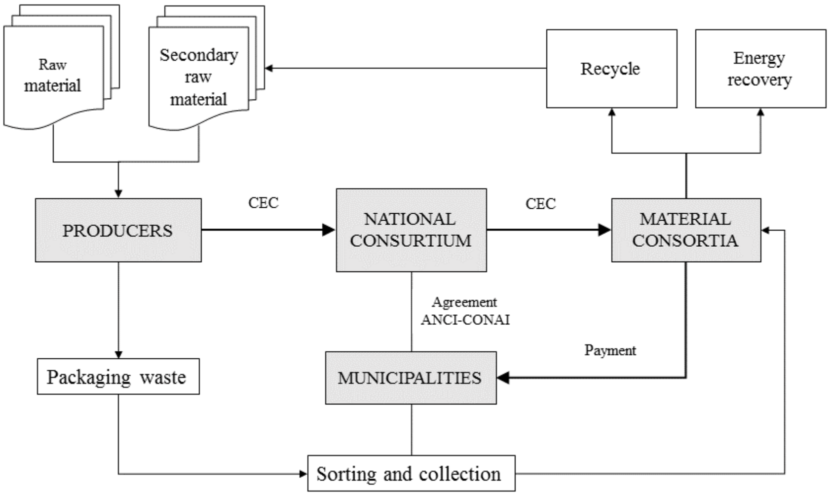


Figure 1: The system: material and money flows
Source: own elaboration based on [25]

The consortium is a non-profit private entity funded through the Environmental contribution (CEC) applied to packaging sold by producers to users [5]. To place our study in a clearer context Table 1 presents a digest of operating results of the consortium.

Table 1: Packaging released for consumption, processed for recycling and recovery in 2014

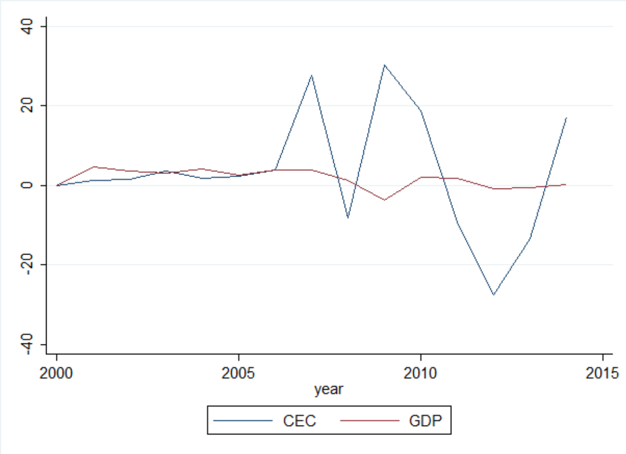
Material	Packaging released for consumption (kton)	Packaging waste processed for recycling (kton)	Percentage of recycled on released for consumption	Packaging waste overall recovery (kton)	Percentage of overall recovery
Steel	452	336	74.30	336	74.30
Aluminum	63,4	47,1	74.30	50.2	70.30
Paper	4 378	3 482	79.50	3 859	88.20
Wood	2 578	1 539	59.70	1 626	63.10
Plastic	2 082	790	37.90	1 717	82.50
Glass	2 298	1 615	70.30	1 615	70.30
Total	11 851	7 808	65.90	9 203	77.70

Source: [25]

5. Modelling the Environmental contribution

The contribution paid by producers of packaging is proportional to the quantity, to the weight and to the typology of the packaging material released for consumption, net of the amount of reused packaging in the previous year; it is calculated in terms of EUR/ton. The amount is irregular over time; in fact, there has been some volatility of such contribution as can be seen in graph 1 that shows the evolution in terms of yearly percentage change in comparison with gross domestic product. It is also possible to observe the instability of the contribution as from 2006; this is due to the weight of the plastic chain (roughly 75% of the total). In fact, the contribution referred to plastic changed dramatically to cope with financial shortcuts during the recent economic crisis reaching a peak in the two years period of 2009-2010.

Graph 1: CEC and GDP evolution (yearly percentage change)



Source: own elaboration

Firstly, we estimate the environmental contribution as per the material consortia end merge them into one in order to obtain the aggregate amount. Secondly, we use the results as an input in a general equilibrium macroeconomic model based on the input-output analysis; this is done to capture both economic and social impacts of recycling targets on the light of different scenarios: the baseline scenario that means in line with current targets and the reference i.e. recycling rates with more ambitious targets. The statistical methodology used to study model the evolution of the CEC is the multiple linear regression of time series data.

5.1. Variables and models

Our variables are defined as follows; first comes the dependent variable i.e. CEC that relates to Environmental Contribution (monetary). Second come the independent variables expressed both in thousands of tons and in euros accordingly. The Italian national packaging consortium annually compiles and provides the data and this guarantee data quality and integrity.

Dependent variable

- CEC: Environmental Contribution. The consortium system is self-financing through the application of the CEC. The Contribution levies upon the so-called first transfer, which takes place when the finished packaging is transferred from the last producer to the first user within the national boundaries.

Independent variables

- RFC (released for consumption): quantity of packaging released for consumption. This quantity corresponds with the quantity of waste produced in the same year, thus, ecyclable in order to reach the set targets. Actually, the mentioned targets are expressed as percentage of recovery on total packaging released for consumption;
- PFR (processed for recycling): quantity processed for recycling from the system. These quantities generate the costs of selective collection and sorting of packaging waste i.e. the main cost items for the chain consortia;
- rRC (ratio Revenues/total cost PFR): revenues from selling the recycled materials concur to bring down the economic need affecting the CEC amount. Quite the reverse, the cost for processing for recycling is the first CEC driver. Thus their ratio is a viable measure which contributes to the improvement of the model;
- CR (capital reserves). This variable appears only in the model related to plastic. The Environmental Contribution is closely linked to the amount of capital reserves of the consortia. When stocks tend to run out because of deficits, the CEC is set to increase and vice versa.

Model estimation

Provided the types of variables used in this paper, linear models provide adequate representation [26]. Consistently with common wisdom about the elements of this kind of forecasts, the information set corresponds to the described data, the projection date corresponds to 2015 and the forecast horizon is 2020. As anticipated, we first rely on a model with current (dependent) and one year lagged independents variables used as explanatory variables.

$$CEC_t = f(X_{t-1} + Y_{t-1} + \cdots + Z_{t-1} +). \quad \text{Eq. 1}$$

Eq. 1 is the generalized equation that is adapted to each material as indicated in eq. 2 in which *n* comprehends the six material consortia, *t* is the reference year while t_{-1} stands for the one-year lag.

$$m\_CEC_t^{1..n} = \propto + \beta_1(rfc_{t-1}^{1...n}) + \beta_2(pfr_{t-1}^{1...n}) + \beta_3(rrc_{t-1}^{1...n}) + \beta_4(cr_{t-1}^{1...n}) + \varepsilon \quad \text{Eq. 2}$$

Since Eq. 2 generates the environmental contribution per each material, by combining the results, we get the aggregate environmental contribution as Eq. 3 shows.

$$CEC = \sum_{1}^{n} m\_CEC \quad \text{Eq. 3}$$

It is worth noting that the independent variables fall into all the six generated sub models but CR i.e. the variable referred to capital reserve, which only appears in the plastic related model as duly explained in the variable description. Annex 7 contains data on key variables as from 2000.

5.2. Economic impact assessment

In this section, we assess the economic impact of higher targets in the Italian economy, in terms of gross value added, employments and demand. Along with the baseline, we assess the socio-economic impact of the reference scenario with new targets. Literature suggests that input-output tables constitute the appropriate basis for many different types of economic analysis in this sense [27]. Precisely, input-output analysis is an economic sub-discipline, that is especially conducive to the integration of technical information, because of the explicit way in which physical relationships are captured in the IO tables [28]. No wonder that the related literature has often analyzed relationships between multipliers and specific economic sectors, frequently to calculate the impacts of such sectors on the economy. The main reason is that these calculations allow a very appropriate application of the Leontief demand model, thereby giving reasonable estimations about economic impacts under different conditions [29]. Nevertheless, from an international point of view there are few studies available that quantify the economic impact of specific waste management systems, this is due to the fact that historically there has been an inadequate number of homogeneous Input-Output tables within the same time frame. Indeed this approach satisfactorily fits with our objectives. In fact, there is an acceptable number of homogeneous input-Output Tables, provided by the Italian national institute for statistics (ISTAT). These tables describe the domestic production processes and the transactions in products of the national economy in detail. The output of one sector can in turn become an input for another sector, which results in an interlinked economic system. In matrix form, an input-output table can be expressed as a sum of rows or columns: $x = aX + D$ and $x = xB = v$, with x being the total output, A the matrix of technical coefficients, B the matrix of allocation coefficients, D the final demand and v the primary inputs. Analytically the table can be read by rows as a system of *n* equations: the sum of the columns of the matrix of technical coefficients as a measurement of the backward linkages a_{ij}, while the sum of the rows of matrix of allocation coefficients as a measurement of the forward linkages b_{ij}. Straightforward manipulations lead to $A = Z\dot{x}^{-1}$ (The point sign is used to convert a vector into a diagonal matrix). In the previous formulation Z corresponds to a matrix (n x n) of intermediate inputs and in in the same way A defines a matrix (*n x n*) of technical coefficients A=[a_{ij}] where $a_{ij} = z_{ij}/x_j$ being z_{ij} the intermediate output of sector *i* to sector *j*. As a consequence, a_{ij} outlines the amount of output of industry *i* needed to produce an output unit of industry *j* and b_{ij} are the allocation coefficients that represent the share of the output of industry *i* sold to industry *j* over the total production of industry *i*. Moreover $B = \dot{x}^{-1}Z$ that is the matrix (*n x n*) of allocation coefficients corresponding to B=[b_{ij}]. Following this $b_{ij} = Zij/xi = a_{ij}(X_j/X_i)$. Starting from these bases the Leontief matrix can be drawn: $L = (I - A)^{-1}$ from which our assessment stems. As anticipated consistent empirical data are provided by the Italian statistical institute.

6. Results

A broadly positive assessment can be reached from Table 2. Even though some coefficients are not statistically significant the overall results are consistent with our purposes and seamlessly reflect the evolution of the actual CEC data.

Table 2: Regression output per material consortia

(1 year lag) Variable	(1) Plastic	(2) Paper	(3) Aluminum	(4) Iron	(5) Glass	(6) Wood
rfc_{pl}	-101	72.9**	98.841*	-43.990**	-30.108	-1.640
	(202.88)	(35.66)	(51.581)	(13.368)	(29.491)	(3.591)
pfr_{pl}	1303***	156.32**	192.916**	-4.406	63.861***	5.062
	(315.6)	(58.40)	(37.688)	(13.729)	(13.302)	(4.134)
rrc_{pl}	-1263	-598***	-61.351***	-82.253	-775.863	-219.980**
	(1856.6)	(169.47)	(14.934)	(98.323)	(605.494)	(84.661)
(cr_{pl})	-.77***					
	(.198)					
R^2		0.814	0.889	0.665	0.883	0.882
Adj. R^2		0.735	0.855	0.565	0.796	0.824

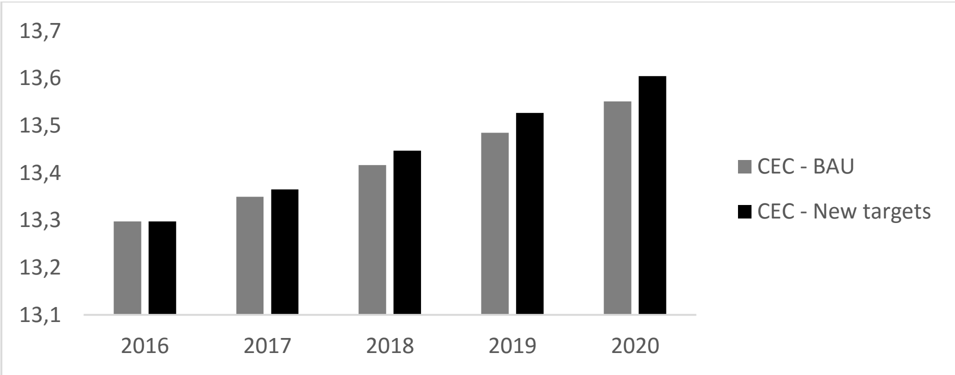
Source: own elaboration

6.1. The material consortia

Among the analyzed, plastic materials are the more complex with regard to the operations of selection and process to recycling and such difficulties reflect on the contribution. For this reason, a correct estimate of plastic-related contribution is essential to achieve a satisfactory goodness of fit of the overall model. Annex 1 contains the series of data used to calculate the model aimed at estimating the CEC up to 2020 as per the plastic. Differently from the other five materials, the model related to plastic, contains an additional variable (capital reserves) that is essential to capture the volatility during the recent economic crisis. The new targets will impact significantly the plastic chain. In order to achieve these targets the chain consortia will start recycling a remarkable quantity of additional material in next years and this will reflect on the environmental contribution. Turning to the paper chain, it is characterized by a high recycling rate and volatility of the variables related to revenues and expenses. Although the sale of materials covers a large part of operating costs, in recent years we are seeing a decline in the ratio revenue/costs; this is likely to lead to a new increase in the contribution over the coming years. The environmental contribution for the paper industry is expected to grow. On a hand this trend may be partially mitigated, at first, by the use of the capital reserves that are not considered in the model, on the other hand the introduction of new recycling targets will boost the environmental contribution. Annex 2 contains the data used to calculate the paper-related model. The portion of the aluminum environmental contribution is marginal, about 1% of the total. The characteristics of the material, together with it usage in the industry are particularly suited for high recycling percentage and in the meantime negligible burdens for the consortium because of the aluminum sales. Annex 3 contains the data used to calculate the aluminum-related model. Steel chain shares some common characteristics with the aluminum as per the utilization; nevertheless, the quantity released for consumption are higher and represents 3% of total environmental contribution. According to the model the steel contribution will fall considerably, in fact since 2015 the unit contribution (EUR/ton) tumbled from 26 to 21 euros per tons. Annex 4 contains the data used to calculate the model aimed at estimating the CEC up to 2020 as per the iron. Moving on glass, looking at the historical data one may note that the glass chain has always played an important role within the system; the glass-related environmental contribution has constantly grown reaching 13% over the last three years. The glass is, to date, the second chain for environmental contribution after plastic. Annex 5 contains the data used to calculate the glass-related model. As concerns the wood chain, it is worth noting that it characterizes for a massive implementation of preventing measures such as reuse and regeneration. Annex 6 contains the data used to calculate the wood-related model.

6.2. The total Environmental Contribution

For the assessment of the economic impact of the Environmental Contribution on the Italian economy, we aggregate all of the estimates and forecasts set out for the individual sectors. The model, shows good accuracy in the complex. Annex 8 contains comprehensive data for the historic CEC up to 2014 together with the model prediction up to 2014, the forecast as the baseline scenario and the forecast as per the introduction of new targets. Graph 2 summarizes the models outcomes up to 2020 highlighting, among the differences between the two scenarios: altogether the models suggest an additional expenditure of EUR 104.2mn. The impact of these two scenarios on the Italian economy, in terms of value added, employment, and total production are worth noting.



Graph 2: Breakdown of CEC, baseline vs reference (values expressed in log)
Source: own elaboration

The graph put emphasis on additional CEC corresponding to the reference scenario; these additional resources are used to cover the additional costs of achieving socially efficient use of environmental resources by shifting the cost of negative externalities associated with resource use [30].

6.3. Impact assessment: production, employment and value added

According to the statistical classification of economic activities in the European Community (NACE, Rev. 2), the Italian consortium falls into the division 38 “Waste collection, treatment and disposal activities; materials recovery”. Provided that he consortium turnover is well approximated by the CEC and although it covers a relatively low percentage of the division (8%), one should note that the effects on the economy are thought provoking. Data presented in Table 3 are useful to compare the estimated values coming from the two scenarios and sheds some light on the total change, using 2015. Specifically Table 3 presents information regarding the effects on the demand, the impact on the job market and finally the estimation regarding the value added. This is done according to the current goals i.e. the baseline scenario and in view of the new recycling targets, i.e. the reference scenario; the horizon is 2020.

Table 3: total output estimates up to 2020

	Baseline			Reference			Delta		
	Total	Direct	Indirect	Total	Direct	Indirect	Total	Direct	Indirect
P*	952,2	540,5	411,7	1148,6	651,7	496,87	196,5	111,3	85,0
E	3797,0	1776,0	2021,0	4381,0	2049,0	2331,0	584,0	273,0	310,0
V*	207,9	103,3	104,6	239,9	119,2	120,67	32	15,9	16,1

Source: own elaboration. P=production. E = employees, V = value added; * = million EUR. See Annex 9 for

Table 3 presents a digest of main economic and social implications of the analyzed policy i.e. recycling targets. Regardless of the point of views, it must be remembered that conceptually, social benefits arise for example income diversification opportunities for households and new economic opportunities, nevertheless social costs can arise by imposing costs on pollution activities of businesses which cannot be off-set or passed on to customers.

7. Discussion

Widely speaking, over the last two decades literature has investigated the relation between environment regulation and competitiveness from different perspectives. The main goal of this paper was to attempt to predict the socio-economic impact on the Italian economy of new recycling target set by the circular economy road map. In specific terms the paper aimed at modelling main financial and social results of recycling industry in a broad context which in turn deliver environmental benefits. An aggregative model combining results from six sub-models was defined to explain the evolution of the CEC under different scenarios. Results were used to develop our economic assessment using a consolidated approach. A comparison of the estimated model and the historic data indicates that the estimated model well describes real data. Overall, the examination shows that remarkable benefits in terms of job creation, value added and demand can arise in the mid-term as in Table 3. While results inspire a reflection in favor of adopting a model based on private consortium between companies producing packaging, as a precaution such statement requires very thorough analysis and additional research. As regards the forecasted effects we would like to recall the fact that this paper has involved the study and estimate of the socio-economic impacts caused by two different recycling scenarios. The results of this study will contribute to the discussion on the future of waste management and recycling programs and policies helping to better assess the implications in the mid-term. As a consequence important efforts are needed to develop policies that allow progress to be made towards the EU targets, again, in view of the fact that environmental policy and especially waste management policy deserve careful consideration for both the composite nature of the problems to be dealt with and the technical solutions that are available [19]. In concrete terms from our analyses, we can define some recommendations to take into consideration when it comes to go from a general prospects to precise acts. To increase the system efficiency it necessary to improve the quality of recovered secondary materials also by supporting the development of a more competitive market for secondary raw materials in such a way as to facilitate economies of scope and scale and create a more competitive business environment that allowed the development of a benchmarking framework. Policy makers shall support the investments in those companies and technologies capable of increasing the above mentioned efficiency. In addition, it must be remembered that poor comparisons across countries in prior research does not permit a straightforward extension of the results.

8. Conclusions

Recycling industry plays an important part in moving from a linear to a circular economy and higher recycling targets will prompt new challenges to waste management systems. We simulated the evolution of the CEC up to 2020 comparing two scenarios, namely the baseline scenario in with current trends were supposed to last in the next years and new targets scenario as in the Circular economy Directive. It was found that higher recycling targets are associated with positive effects on job creation, production and value added. The results show a clear upward trend in the CEC, mainly driven by the plastic. In particular, the difference in production value between the new targets scenario and the baseline amounts to EUR 195,5 million of which 56% are directly imputed to the recycling industry. Also additional 584th jobs would be created of which 46% within the industry. Similarly, the reference scenario value added outdo the baseline estimation by EUR 32 millions, 50% produced by the recycling sector. Although reported differences, especially in job creation may appear negligible it should be stressed that this is because the outperforming current trends that are already over the established targets. Accordingly, we take a positive view of the Directive, particularly because of both direct and indirect effects on the economy as a whole. Although some limitations especially in terms of generalizability our results can contribute to a wider economic impact analysis in particular within European countries which share the same targets. Some improvements could be added such as an integration with purely environmental benefits in an effort to provide a more comprehensive reference. Further research moreover shall focus on complementary equally important topics, to name but a few (i) the technological implications coming from improving green companies and related technologies that with operate in this industry (ii) implications for industrial policy analyzing, for example, the substitutional effects of secondary materials with regard on import of raw material and (iii) how higher recycling rates can contribute to reducing a country's dependence on imported raw materials and test (iv) whether and to what extent economies of scope exist..

References

[1] C. Lakhan, “Resources , Conservation and Recycling The relationship between municipal waste diversion incentivization and recycling system performance,” *"Resources, Conserv. Recycl.*, vol. 106, pp. 68–77, 2016.

[2] R. C. Marques, N. F. Da Cruz, P. Simões, S. Faria Ferreira, M. C. Pereira, and S. De Jaeger, “Economic viability of packaging waste recycling systems: A comparison between Belgium and Portugal,” *Resour. Conserv. Recycl.*, vol. 85, pp. 22–33, 2014.

[3] WEF, “Towards the Circular Economy : Accelerating the scale-up across global supply chains,” World Economic Finance, Geneva, 2014.

[4] P. van Beukering, O. Kuik, and F. Oosterhuis, “The Economics of Recycling,” in *Handbook of Recycling. State-of-the-art for Practitioners, Analysts, and Scientists*, E. Worrell and M. Reuter, Eds. Elsevier Inc, 2014, pp. 479–489.

[5] CONAI, “Packaging recovery in Italy : THE CONAI SYSTEM.” CONAI, Milan (IT), pp. 1–12, 2013.

[6] H. Daly, “On economics as a life science,” *J. Polit. Econ.*, vol. 76, no. 3, pp. 392–406, 1968.

[7] W. Isard, K. Bassett, C. Choguill, J. Furtado, R. Izumita, J. Kissin, E. Romanoff, R. Seyfarth, and R. Tatlock, “On the linkage of socio-economic and ecologic systems,” *Pap. Reg. Sci.*, vol. 21, no. 1, pp. 79–99, 1968.

[8] S. Sauvé, S. Bernard, and P. Sloan, “Environmental sciences, sustainable development and circular economy: Alternative concepts for trans-disciplinary research,” *Environ. Dev.*, pp. 1–9, 2015.

[9] D. W. Pearce and R. R. Turner, *Economics of Natural Resources and the Environment*. London: Hemel Hempstead, 1989.

[10] K. Boulding, “The economy of the coming spaceship earth,” in *Economics, Ecology, Ethics: Essay towards a Steady State Economy*, H. Daly and W. H. Freeman, Eds. San Francisco, 1966.

[11] P. Ghisellini, C. Cialani, and S. Ulgiati, “A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems,” *J. Clean. Prod.*, pp. 1–22, 2015.

[12] M. Walls, “How local governments structure contracts with private firms: economic theory and evidence on solid waste and recycling contracts,” *Public Work. Manag. Policy*, vol. 9, no. 3, pp. 206–222, 2005.

[13] M. Rouw and E. Worrell, “Evaluating the impacts of packaging policy in The Netherlands,” *Resour. Conserv. Recycl.*, vol. 55, no. 4, pp. 483–492, 2011.

[14] D. Bianchi, “Eco-efficient recycling. The Italian recycling industry between globalization and the crisis challenges,” Edizioni Ambiente, Milano, 2012.

[15] M. Molinos-Senante, F. Hernández-Sancho, and R. Sala-Garrido, “Cost-benefit analysis of water-reuse projects for environmental purposes: a case study for Spanish wastewater treatment plants.,” *J. Environ. Manage.*, vol. 92, no. 12, pp. 3091–7, Dec. 2011.

[16] R. Cahill, S. M. Grimes, and D. C. Wilson, “Review Article: Extended producer responsibility for packaging wastes and WEEE - a comparison of implementation and the role of local authorities across Europe,” *Waste Manag. Res.*, vol. 29, no. 5, pp. 455–479, 2011.

[17] N. F. Da Cruz, P. Simões, and R. C. Marques, “Costs and benefits of packaging waste recycling systems,” *Resour. Conserv. Recycl.*, vol. 85, pp. 1–4, 2014.

[18] P. Glavič and R. Lukman, “Review of sustainability terms and their definitions,” *J. Clean. Prod.*, vol. 15, no. 18, pp. 1875–1885, 2007.

[19] G. Citroni and A. Lippi, “Pubblico e privato nella governance dei rifiuti in Italia [Public and private in the governance of waste management in Italy],” *Riv. Ital. di Polit. Pubbliche*, vol. 1, pp. 71–108, 2009.

[20] R. K. Yin, *Case Study Research, Design and Methods*, Fourth. Thousand Oaks: Sage Publications, Inc, 2009.

[21] A. G. Woodside, *Case Study Research: Theory, Methods, Practice*. Bingley, UK: Emerald Group Publisher Limited, 2010.

[22] G. Di Foggia, “Steering the implementation of urban sustainability projects: Implications for policy,” J. Environ. Manag. Tour., vol. 7, no. 1, 2016.

[23] European Commission, *The raw materials initiative - meeting our critical needs for growth and jobs in Europe. Communication from the Commission to the Council and the European Parliament*. Brussels, 2008.

[24] European Commission, “Circular Economy Strategy Roadmap,” Brussels, 2015.

[25] CONAI, “Programma generale di prevenzione e di gestione degli imballaggi e dei rifiuti di imballaggio (Relazione generale consuntiva 2014).” Milan (IT), 2015.

[26] S. Becketti, *Introduction to Time Series Using Stata*, 1st ed. College Station: Stata Press, 2013.

[27] S. Suh, Ed., *Handbook of Input-Output Economics in Industrial Ecology*. London and New York: Springer, 2009.
[28] R. Lifset, “Industrial Ecology in the Age of Input-Output Analysis,” in *Handbook of Input-Output Economics in Industrial Ecology*, S. Suh, Ed. London and New York: Springer, 2009, pp. 3–22.
[29] L. Robles Teigeiro and B. Díaz, “Estimation of multipliers for the activity of hotels and restaurants,” *Tour. Manag.*, vol. 40, pp. 27–34, Feb. 2014.
[30] G. Di Foggia, “Effectiveness of Energy Efficiency Certificates as Drivers for Industrial Energy Efficiency Projects,” Int. J. Energy Econ. Policy, vol. 6, no. 2, pp. 273–280, 2016.

Annexes

Annex 1: historic data used to calculate the model (plastic)

Year	Released (Kton)	Recycled (Kton)	Revenues/costs (%)	Reserves (K€)	CEC (K€)
1998	1 800.00	310.00			
1999	1 850.00	396.00			
2000	1 900.00	526.00			125 800.00
2001	1 950.00	209.00	10.00		130 740.00
2002	1 951.00	299.00	6.58		130 457.37
2003	2 000.00	343.00	5.53		136 728.64
2004	2 054.00	344.00	7.89	64 529.00	137 865.48
2005	2 100.00	358.00	16.27	51 155.00	139 855.30
2006	2 202.00	380.15	19.86	41 804.00	145 139.93
2007	2 270.00	451.00	22.81	31 904.00	149 986.04
2008	2 205.00	496.00	28.11	18 590.00	145 388.32
2009	2 092.00	561.00	10.90	(25 866.00)	279 849.70
2010	2 071.00	602.89	30.68	8 931.00	333 562.00
2011	2 075.00	615.33	40.35	137 552.00	280 363.00
2012	2 052.00	610.00	30.89	223 017.00	217 465.00
2013	2 043.00	751.69	28.11	203 728.00	202 790.00
2014	2 086.00	815.75	25.43	136 361.00	263 298.00

Source: own elaboration on Corepla

Annex 2: historic data used to calculate the model (paper)

Year	Released (Kton)	Recycled (Kton)	Revenues/costs (%)	CEC (K€)
1998	4 023.00	1 607.00		
1999	4 051.00	1 782.00		
2000	4 089.00	2 027.00		58 910.00
2001	4 160.00	445.00		59 872.00
2002	4 218.00	611.00		60 252.84
2003	4 208.00	720.00	0.96	61 166.22
2004	4 333.00	823.00	0.76	61 882.53
2005	4 315.00	924.70	0.01	61 513.78
2006	4 400.00	958.00	1.82	64 033.99
2007	4 619.00	978.00	28.03	125 508.87
2008	4 500.85	975.00	21.38	104 276.56
2009	4 092.00	1 018.00	0.08	81 866.35
2010	4 338.42	1 035.00	46.93	86 369.00
2011	4 436.20	905.00	80.15	86 858.00
2012	4 255.40	838.56	70.56	48 536.00
2013	4 107.00	819.71	62.72	24 039.00
2014	4 378.83	867.00	56.22	15 864.00

Annex 3: historic data used to calculate the model (Alumimium)

Year	Released (Kton)	Recycled (Kton)	Revenues/costs (%)	CEC (K€)
1998	57.00	7.00		
1999	58.30	15.10		
2000	59.20	17.90		3 950.00
2001	58.40	0.50		1 682.00
2002	59.80	1.10		2 415.29
2003	65.20	2.40	79.64	2 553.00
2004	67.30	4.30	93.17	2 607.00

Year	Released (Kton)	Recycled (Kton)	Revenues/costs (%)	CEC (K€)
2005	68.80	3.70	85.69	2 759.00
2006	71.50	5.00	98.16	2 821.00
2007	71.90	6.10	95.67	3 084.00
2008	66.50	6.30	87.95	2 960.00
2009	61.20	6.70	57.50	3 101.00
2010	64.20	8.19	87.74	4 760.00
2011	68.60	8.00	83.50	3 321.00
2012	68.50	10.08	83.65	4 473.00
2013	66.00	10.35	78.77	4 195.00
2014	63.40	11.20	86.97	4 267.00

Annex 4: historic data used to calculate the model (Iron)

Year	Released	Recycled (Kton)	Revenues/costs (%)	CEC (K€)
1998	600.00	27.00		
1999	618.00	44.00		
2000	600.00	97.00	8.63	8 920.00
2001	568.00	164.00	11.44	8 132.00
2002	566.00	232.00	6.99	8 553.23
2003	577.00	226.00	8.04	8 728.02
2004	606.00	224.00	12.63	9 135.28
2005	562.00	223.21	12.97	8 342.29
2006	561.38	226.47	9.12	8 333.89
2007	562.95	217.46	8.93	8 086.67
2008	536.98	209.00	13.91	7 527.63
2009	457.60	227.38	9.77	6 944.00
2010	504.32	211.75	14.27	13 689.00
2011	486.00	202.61	21.98	13 998.00
2012	439.99	200.00	29.87	12 864.00
2013	435.15	207.85	30.30	11 045.00
2014	450.49	223.36	52.51	13 394.00

Annex 5: historic data used to calculate the model (Glass)

Year	Released (Kton)	Recycled (Kton)	Revenues/costs (%)	CEC (K€)
1998	1 905.00	740.00		
1999	1 934.00	800.00		
2000	1 963.00	920.00		11 680.00
2001	1 993.00	230.00		12 932.00
2002	1 970.00	254.00		13 148.87
2003	2 107.00	393.00		13 516.02
2004	2 141.00	500.00		13 813.37
2005	2 117.00	603.00		13 641.78
2006	2 133.00	776.00	2.66	13 492.01
2007	2 156.00	821.00	2.45	28 177.75
2008	2 139.00	870.00	2.68	26 942.27
2009	2 065.00	956.00	0.28	23 397.53
2010	2 153.00	1 100.81	1.69	39 510.00
2011	2 314.00	1 171.00	3.98	46 897.00
2012	2 275.00	1 196.00	6.24	43 539.00
2013	2 255.00	1 230.23	11.74	42 170.00
2014	2 298.00	1 292.00	19.31	43 148.00

Annex 6: historic data used to calculate the model (Wood)

Year	Released (Kton)	Recycled (Kton)	Revenues/costs (%)	CEC (K€)
1998	2 360.00	880.00		
1999	2 396.00	910.00		
2000	2 479.00	868.00		6 180.00
2001	2 532.00	106.00		5 602.00
2002	2 603.00	429.00		6 471.47
2003	2 663.00	691.00		6 602.87
2004	2 787.00	643.00	35.95	6 807.81
2005	2 788.00	708.00	49.35	10 468.63
2006	2 852.00	829.23	44.96	10 931.82
2007	2 860.00	960.21	44.22	11 426.76
2008	2 720.00	920.00	28.81	10 376.62
2009	2 094.00	789.00	14.65	16 555.70

Year	Released (Kton)	Recycled (Kton)	Revenues/costs (%)	CEC (K€)
2010	2 281.48	907.06	21.13	17 555.00
2011	2 305.93	839.00	25.26	18 021.00
2012	2 283.00	693.00	20.88	16 787.00
2013	2 505.00	676.33	20.86	16 860.00
2014	2 577.66	757.16	20.41	17 117.00

Annex 7: historic data processed to recycling, revenues/costs and CEC

Year	Released (Kton)	Recycled (Kton)	Revenues/costs (%)	CEC (K€)
2000	11 090.20	4 455.90		228 870.00
2001	11 261.40	1 154.50		232 080.00
2002	11 367.80	1 826.10		235 943.97
2003	11 620.20	2 375.40		244 458.63
2004	11 988.30	2 538.30	8.12	249 253.14
2005	11 950.80	2 820.61	12.92	255 094.40
2006	12 219.88	3 174.85	15.31	265 230.78
2007	12 539.85	3 433.76	24.30	350 250.87
2008	12 168.33	3 476.30	24.58	322 968.31
2009	10 861.80	3 558.08	7.84	437 782.73
2010	11 412.42	3 865.71	31.61	528 578.00
2011	11 685.73	3 740.94	44.49	482 840.00
2012	11 373.89	3 547.64	36.91	366 415.00
2013	11 411.15	3 696.15	33.47	320 316.00
2014	11 854.38	3 966.47	31.59	380 650.00

Annex 8: CEC, Model forecast, baseline scenario and reference scenario (EUR m)

Anno	CEC	Model	Baseline	New_targets
2005	255 094.40	267 105.38		
2006	265 230.78	294 197.49		
2007	350 250.87	319 240.97		
2008	322 968.31	362 091.54		
2009	437 782.73	403 773.47		
2010	528 578.00	512 856.42		
2011	482 840.00	495 575.87		
2012	366 415.00	368 171.17		
2013	320 316.00	304 652.02		
2014	380 650.00	369 426.78	369 426.78	369 426.78
2015			492 365.50	492 365.50
2016			595 730.40	595 654.30
2017			627 642.80	637 708.60
2018			671 065.70	691 817.20
2019			718 340.00	749 428.00
2020			767 638.80	809 936.40

Annex 9: Breakdown of effect from 2016 to 2020

		Baseline	Reference	Delta						
Year	Value	Total	Direct	Indirect	Total	Direct	Indirect	Total	Direct	Indirect
2016	P	74.0	41.9	32.1	97.6	55.3	42.3	23.5	13.3	10.2
2016	E	1 426.0	667.0	759.0	1 425.0	667.0	758.0	-1.0	0.0	-1.0
2016	VA	78.1	38.8	39.3	78.0	38.8	39.2	0.0	0.0	0.0
2017	P	100.7	57.1	43.7	125.5	71.1	54.4	24.8	14.0	10.7
2017	E	440.0	206.0	234.0	580.0	271.0	309.0	140.0	65.0	75.0
2017	VA	24.1	12.0	12.1	31.7	15.8	15.9	7.6	3.8	3.8
2018	P	109.7	62.1	47.5	133.6	75.7	57.9	24.0	13.6	10.4
2018	E	599.0	280.0	319.0	746.0	349.0	397.0	147.0	69.0	78.0
2018	VA	32.9	16.3	16.6	41.0	20.3	20.6	8.1	4.0	4.1
2019	P	114.4	64.8	49.6	140.4	79.5	60.8	26.0	14.7	11.3
2019	E	652.0	305.0	347.0	795.0	372.0	423.0	143.0	67.0	76.0
2019	VA	35.7	17.8	17.9	43.5	21.6	21.9	7.8	3.9	4.0
2020	P	553.5	314.6	238.9	651.6	370.2	281.4	98.2	55.6	42.4
2020	E	680.0	318.0	362.0	835.0	390.0	444.0	155.0	72.0	82.0
2020	VA	37.2	18.5	18.7	45.7	22.7	23.0	8.5	4.2	4.3

Source: ow elaboration, delta is the difference between the reference and the baseline