

# The role of marketing strategies in achieving the environmental benefits of innovation

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## Disclaimer

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The anonymous data of the Community Innovation Survey 2014 (CIS 2014) used in the analysis of this paper was provided by EUROSTAT. All results and conclusions are given by the authors and represent their opinion and not those of EUROSTAT, the European Commission or any of the national authorities whose data have been used. The responsibility for all conclusions drawn from the data lies entirely with the authors.

**Abstract:**

Government agendas are increasingly focused on environmental issues, pressuring companies to reduce the environmental impact of their activities, and innovation plays a key role in this. Substantial evidence from academics and practitioners has revealed that technological innovation can reduce negative environmental impact, but the role of marketing innovation in driving environmental benefits has been overlooked by academic research. This study aims to shed light on the environmental contribution driven by marketing innovation by examining the different roles of four types of marketing innovation (product, promotion, placement and price) in achieving environmental benefits, through an empirical analysis of the latest available Community Innovation Survey in Germany and Portugal related to the period 2012-2014. In our models we consider a multinomial outcome, namely four clusters of companies with a different combination of environmental benefits, constructed using a Cluster Analysis conducted on Principal Component Analysis main factors. Then, the determinants of the cluster membership are analyzed through a Multinomial Logistic Regression model. Results show that the introduction of a marketing innovation yields environmental benefits both within the enterprise (internal) and during the consumption or use of services and products (external). When the four types of marketing innovation are analyzed separately, further results emerge: only two types of innovation, in pricing and placement, were found to be significantly related to both internal and external environmental benefits. Companies are challenged to carefully evaluate the types of marketing innovation that should be introduced to positively impact the environment.

## **1. Introduction and background**

In recent years, the over-exploitation of natural resources, the increase in the number of natural disasters and rising awareness of environmental issues and the growth of world population have all led consumers and companies to think more about how a balance between consumption requirements and sustainability can be achieved (García-Granero et al., 2018). The transition towards a clean and circular economy is stated as a key priority of the Horizon Europe programme. Mobilizing companies for a clean and circular economy is necessary for the abatement of greenhouse gasses. As established by the Paris Agreement signed in December 2015 by 189 nations (O'Brien, 2018a), it is also essential to limit the increase in global warming to well below 2°C before the end of the century. Moreover, the Covid-19 pandemic has the potential to transform how individuals and organizations view the world and the future, and the way they conduct their lives and daily activities (He and Harris, 2020). Indeed, it could be a good opportunity for companies to develop authentic Corporate Social Responsibility initiatives and address pressing environmental challenges (He and Harris, 2020).

Innovation is very important to orient companies' efforts toward the environment in introducing new products, new processes and new marketing and organizational activities. A growing body of literature has focused on the role of technological innovation in leading to environmental benefits (Mothe and Guyen, 2017). Technological innovations have been found to be pivotal in achieving greater efficiency and sustainability (e.g., Medrano et al., 2020; Wang et al., 2021). Less attention has been devoted to the role of non-technological innovations, such as organizational and marketing innovations, in contributing to the environment. For example, introducing recyclable packaging for new products or launching a new pricing system that incentivizes consumers to purchase and consume green products could lead to significant advantages for the environment. Recent research has highlighted that the role of marketing innovation (MI) in obtaining environmental benefits (EBs) has been largely overlooked and the extent to which MI can positively contribute to the environment is

unknown (de Jesus et al., 2018; Medrano et al., 2020). Several studies are calling for further investigation on the potential role of MIs in generating EBs (Mariadoss et al., 2011; García-Granero et al., 2018). Therefore, the present work addresses the aforementioned research gap and aims to understand whether MIs could support technological innovation to achieve different types of EBs, namely benefits internal to the company (e.g., the replacement of polluting materials with materials that are better for the environment) and external to the company (e.g., recycling of product after usage). To this aim, we employ data for Germany and Portugal collected via the Community Innovation Survey (CIS) carried out in 2014, as a special section on “Innovation with environmental benefits” was included in that wave. The present study analyses two countries, Germany and Portugal, to explore the relationships between MI and EBs. In line with several previous studies focusing on two or more countries (e.g., Horbach et al., 2013; Disoska et al., 2020), the consideration of two different settings was intended to increase the robustness of the results. Germany and Portugal were chosen for theoretical and empirical reasons. On the theoretical side, in addition to expanding the geographical scope of empirical research in eco-innovation in Europe, the consideration of the two countries allows us to figure out more clearly the relationship between marketing innovation and EBs net of their contextual differences, since the two countries substantially differ in terms of their sensitivity towards sustainability and eco-innovation and their economic and institutional background. Germany is one of the leading countries in both sustainable development and innovation, and has been consistently recognized as an eco-leader from 2012 to 2021 (Eco-innovation scoreboard), having a strong tradition of societal and political awareness of sustainability challenges (e.g., Mousavi et al., 2018). Portugal, on the other hand, has been identified as ‘a close to the EU average’ eco-performer from 2012 to 2021 (Eco-innovation scoreboard). Unlike Germany, Portugal still lacks a solid policy framework for eco-innovation and the circular economy (Costa and Lorena, 2016; Lorena, 2018). Germany also represents one of the most important trading partners for Portugal. Moreover, according to Flash Eurobarometer analytic report on ‘Sustainable Consumption and

Production' (Flash EB, 2009) in the two countries consumers share almost the same awareness about the environmental impact of products bought or used and it is in line with the EU average.

With reference to the economic and institutional background, Germany represents the largest manufacturing economy in Europe. According to 'Statistics on the production of manufacturing and goods' produced by EUROSTAT, in 2020 Germany recorded the highest value of sold production equivalent to 29% of the EU total. Moreover, in terms of eco-innovation it has developed advanced regulation, adopted several policy measures to address the circular economy and eco-innovations and possesses a state-of-the-art waste infrastructure, while exhibiting high recycling rates (Bahan-Walkowiak and Wilts, 2016; O'Brien, 2018b). Portugal, despite its increased role in some manufacturing sectors (e.g., automobile, biotechnologies and IT), is mainly a service-based economy. According to 'Statistics on the production of manufacturing and goods' produced by EUROSTAT, in 2020 it still belongs to the group of 21 EU member states that contributed with smaller shares (up to 3%) of the EU's value of sold production.

On the empirical side, among the EU countries for which CIS 2014 data were available along with the section devoted to 'innovation with environmental benefits', the CIS data related to Germany and Portugal did not have missing information as far as innovation and EBs. Moreover, they displayed a sufficient sample size.

The results of our study provide support for the importance of MI in delivering EBs within the firm and for consumers/users: findings appear to be consistent in Germany and Portugal. Moreover, empirical evidence points to the need to disentangle MIs, as they play a different role in contributing to the environment. Price and placement innovations rather than other types are found to provide EBs, with small differences between Germany and Portugal.

The original contribution of this work is threefold. First, it offers empirical evidence for a significant relationship between the introduction of a marketing innovation and the achievement of EBs, both internal and external to the innovative company. Second, to the best of the authors' knowledge, this

is the first study disentangling the role of each MI strategy in providing EBs, showing that MIs differ in their contribution to the environment. This finding might prompt scholars to rethink how MIs should be investigated in further research. Third, by analysing data from two countries, the present study is able to show which type of MI has a consistent environmental role in two different contexts. The remainder of this paper is structured as follows. First, we review previous research on EBs and MI. Next, we present our research framework and our research questions. Then, we explain the data collection and the analytic strategy, followed by the presentations of the results stemming from the analysis. The paper concludes with a discussion of the results, implications for research and practice, limitations and future research directions.

## **2. Literature review and conceptual development**

### *Innovation strategies and EBs*

Innovation plays a key role in reducing possible negative impacts on the environment and society (Mariadoss et al., 2011). The Oslo Manual (OECD, 2005) conceptualizes innovation as the implementation of a new or significantly improved product (good or service) or process, a new marketing method, or a new organizational method in the business. Innovation is widely regarded as a complex multi-disciplinary concept (e.g., Baregheh et al., 2009; Motjoloane, 2021) and it can usually be classified into two major categories: technological and non-technological. Technological innovation includes process and product innovations, and non-technological innovation entails marketing and organisational innovations. Innovation can directly or indirectly contribute to developing and offering products and services that minimize the negative effects on the environment of business activities, and reduce the resource consumption in product lifecycles (Pacheco et al., 2018). Innovations of this type prevent, reduce, and allow recovery from environmental damage and are usually regarded as Eco-Innovations (de Jesus et al., 2018). They have been defined as “the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization (developing or adopting it) and which results,

throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives” (Kemp and Pearson, 2007:7). EBs of innovation may stem directly from the production of a good or service, or they may be related to after-sale consumption or use of a good or service by the consumer (Horbach et al., 2016). The following taxonomy can be used to identify the major EBs. EBs within the firm are identified as: reduced use of material (ECOMAT), reduced energy consumption for production (ECOENO), reduction in water soil pollution (ECOPOL), replacement of polluting materials with materials that are better for the environment (ECOSUB), replacement of fossil energy with renewable energy (ECOREP) and recycling of waste and material that is related to the production (ECOREC). On the other hand, EBs that are achieved, due to innovations, during the consumption or use of goods and services from the end user are identified as follows: reduction of energy consumption from the end user (ECOENU), reduction of water, soil or air pollution (ECOPOS), recycling of product after usage (ECOREA) and increase of product life (ECOEXT). Innovations may have EBs as their primary objectives or as outcomes of other established goals (Horbach et al., 2016). A rich body of literature has already highlighted the key role of technological innovations in providing EBs. Technological innovations have been found to significantly improve the utilization efficiency of resources and to achieve energy savings and emission reduction for companies (e.g., Miao et al., 2018; Ghisetti and Rennings, 2014). The introduction of technological innovations has been widely recognized as a key element in leveraging ecological and social responsibility strategies in multiple sectors (Floričić, 2020).

Non-technological innovations in organization and marketing may also influence producers in developing services and products that provide EBs in terms of the end user consumption process, such as longer-lasting products (de Jesus et al., 2018). MIs are increasingly having an environmental impact (García-Granero et al., 2018). Moreover, the EBs of innovation can be strengthened by firms' marketing efforts (Choi and Yi, 2018). Some companies regard environmental management as a tool for taking advantage of the market opportunities generated by environmental issues (Choi and Yi,

2018), and the decision-making process relating to EBs is often based on customer demand (Liao and Tsai, 2019).

### *MI and EBs*

Resource-based theory (Barney, 1991) states that it is resources which enable companies to successfully perform business activities and gain competitive advantage. Capabilities, part of the firm's resources, aim at supporting companies to better leverage their other resources, by increasing related efficiency and productivity (Makadok, 2001). Capabilities are distinctive competencies which competitors are unable to imitate in the short term. It is difficult for current and new competitors to substitute them, and thus they have an intrinsic value in the market (Barney, 1991). Firm capabilities play a critical role in the development of innovation-based sustainability strategies (Mariadoss et al., 2011), and these include marketing capabilities which can drive commercial success of the firm's products and services (O'Cass and Weerawardena, 2009). Marketing capabilities have the potential to influence all types of innovation pursued by the firm (Medase and Barasa, 2019) and they can exert a positive effect on innovation-based sustainable strategies (Yu and Ramanathan, 2016). Pacheco et al. (2018) posit that marketing capabilities are higher order capabilities which enable firms to benefit from their green strategies: the EBs stemming from innovations can in fact be strengthened by marketing (Choi and Yi, 2018). MIs are key marketing capabilities (Mariadoss et al., 2011) that can positively influence firm performance (D'Attoma and Ieva, 2020) and corporate environmental orientation (Medrano et al., 2020).

De Jesus et al. (2018) call attention to the importance of MIs in enabling new distribution channels and forms of usage of products and services that can benefit for the environment - e.g., monthly rental of refrigerators, washing machines, concrete mixers, and other tools such as drills, saws, and hammers. MIs can also set up incentives for EBs in technological innovation, such as new longer-lasting products or more efficient models (Mont, 2008). Marcòn et al. (2017) identified several best practices in MIs that could lead to EBs. Arranz et al. (2020) found that the introduction of a MI

increases the likelihood that the company will introduce an eco-innovation in the same period. Choi and Yi (2018) found that adopting new marketing strategies and introducing employee training for marketing practices increase the likelihood of introducing environmental process innovations and environmental product innovations. Medrano et al. (2020) found that introducing a MI is positively related to the environmental orientation of innovation activity carried out in the company. These studies touch on the role of MI and related practices in increasing sensitivity to environmental issues among companies bringing in innovation, but the link between MI and EBs remains underexplored (de Jesus et al., 2018; García-Granero et al., 2018). As noted above, there are multiple potential EBs of each innovation. Although MIs are more closely related to the consumption or the end use of a given product or service, they could also be used to encourage companies introducing technological innovation to achieve EBs related to, for example, the production process.

We therefore formulate the following research question:

RQ1: What is the role of MI in contributing to EBs?

Recent research has found that MIs should not be considered equal, as they play different roles and differ in their contribution to the success or failure of innovation (D'Attoma and Ieva, 2020). The marketing mix model is a key framework for academics and practitioners in identifying and classifying MI strategies (Adams et al., 2019; Coviello et al., 2000). MIs have been usually classified into four types: innovations in product, promotion, placement and price.

Innovations in product are related to changes in product design and packaging so that the aesthetics of a product or its packaging is significantly improved (OECD, 2005). Such innovation can also lead to EB. Mariadoss et al. (2011) highlight that innovation in packaging is the starting point for many companies to shift marketing toward EBs, probably because packaging innovations are often safe and cost effective but make no significant changes to products or production processes. Marcon et al. (2017) take refill or concentrated versions of a product as an example of a type of MI in product design and packaging that can lead to EBs, such as lower water use for detergents, or fuel savings

when transporting a high volume of products. The introduction of recyclable packaging could also entail significant EBs (García-Granero et al., 2018).

Innovations in promotion involve initiatives to raise consumer knowledge and awareness of products and to enhance communications, through the use of new media or loyalty programs (OECD, 2005). Innovation in promotion could also be used to achieve EBs, for example by shifting investment from print to digital media, as print involves greater consumption of ink, paper, and other resources (Medrano et al., 2020). Companies could also develop new loyalty programs or corporate social responsibility programs offering monetary or non-monetary incentives to consumers to purchase green products and to behave in an environmentally friendly manner (Kumar, 2020). Such promotional activities could feasibly increase green purchasing behaviour or reduce resource consumption, thus leading to EBs.

Innovations in placement involve those channels through which the products or services are distributed and sold such as franchising and direct sales (OECD, 2005). Companies could introduce new channels, new logistic solutions or re-design existing channels. Innovations in placement could also deliver EBs if companies introduce new applications to optimize product delivery routes, potentially lowering CO<sub>2</sub> emissions (Marcon et al., 2017). Reverse logistics and recyclable collection are another type of MI that could yield EBs, such as product re-use (Marcon et al., 2017). Decentralized production can also reduce the impact of transportation on the environment, and e-commerce can decrease the number of consumers driving to outlets, thus reducing pollution stemming from multiple cars travelling to different stores (Medrano et al., 2020).

Innovation in price is related to the use of new pricing methods, for example discount systems (OECD, 2005), which could also be used to leverage EBs. Companies could price products differently depending on the extent to which they impact the environment, giving products with a low impact on the environment a lower price (Medrano et al., 2020). Innovations in this area might also involve new terms and conditions for the use of green products or services, such as rental or leasing plans.

Consumers could pay a monthly or annual fee to rent appliances which could then be recycled or resold, which would lead to a lower impact on the environment once they are replaced (de Jesus et al., 2018). Sharing or pooling initiatives at a special price could also be promoted for this purpose.

Hence, all four type of MI could lead to EBs, both within and outside the company. The present study hypothesizes that companies might increase the EBs of technological innovation by introducing an MI. However, given the variety and the different role that MIs have been found to play in innovation success and failure (D'Attoma and Ieva, 2020), we expect to find differences in how the different types of MIs deliver EBs. It is important to distinguish between MIs in order to identify those which deliver most EBs. We thus formulate the following research question:

RQ2: What is the role of the four MI strategies in contributing to EBs?

To answer the two research questions, the study analyses the relationship between MIs, at aggregate and at single level, and EBs among innovative companies.

### **3. Methods**

#### *3.1 Data*

The study used data from the latest available wave of the CIS survey which contains information about firm-level innovations and innovation activities for the period 2012-2014. Our empirical analysis was made on a sample of respectively 6282 and 7083 German and Portuguese manufacturing and service firms with more than 10 employees. This harmonized survey is run every two years in each EU member state, as well as some EFTA countries and EU candidate countries, and data are usually released two and half years after the end of the survey reference period. The survey is administered by the statistics bureau of each country under the coordination of EUROSTAT and aims to provide information on the degree of innovativeness of each sector. Questions are related to the different types of innovation (product, process, organizational and marketing) and to various aspects

of development of innovation. Company-specific information is also retained, including economic sector, geographic location, number of employees, and turnover.

In CIS 2014, most questions and thus most indicators cover the reference period 2012-2014. Unlike previous waves, CIS 2014 includes an ad-hoc module on innovations with EBs. This consists of a set of questions focusing specifically on ten different types of innovation with EB made within the enterprise (internal) or by the end user (external). The CIS has a focus on EBs stemming from innovation (technological or non-technological), which allows us to outline an environmental profile of the companies in terms of innovation. In this respect, the CIS survey is similar to the Flash Eurobarometer-433 on “EU business innovation trends” released in 2016. But although this is a rich source of data, it would not allow investigation of the important nuances between the roles of different strategies MI of product, package, promotion and price, which is possible using CIS data. The CIS survey is useful for several other reasons. To the authors’ knowledge, no other survey has combined and accumulated so much information at the company level, which means that is widely applied empirically (see Mairesse and Mohnen, 2010 for a review). Indeed, the CIS survey allows data to be collected not only on the input and output of the innovation process, but also on important structural characteristics of all the firms included in the survey. The CIS survey has also been used as a reference framework for innovation studies in extra-European countries, such as South Korea (e.g. Lee et al., 2019) and Chile (e.g. Geldes et al., 2017), where there is no well-established approach to measuring and analysing innovation. The CIS survey is moreover bi-annual and large-scale, covering Europe and providing harmonized data that allow for a comparative approach.

### *3.2 Variables and measures*

The analysis was restricted to companies which engaged in technological innovation, including ongoing innovations and those innovations which were abandoned or suspended before completion. Restricting the sample to largely technologically innovative firms enables us to focus on the degree of eco-innovativeness in innovation. Following the structure of the CIS data, we defined our *dependent variable* as firm membership of one of the clusters obtained on the basis of EBs.

*Independent variables* were constructed in the light of extant empirical analysis of drivers of eco-innovation which are taken to be regulatory push-pull factors, demand, technology conditions and firm-specific factors (Rennings, 2000).

Three variables describe the effect of *regulatory push-pull* factors. The first dummy variable, [REGULATIONS], captures the effect of existing or expected in the future environmental regulations in driving the decision to introduce innovations with EBs. It includes existing ‘environmental regulations, existing environmental taxes, charges or fees, environmental regulation or taxes expected in the future’. Second, a dummy variable [INCENTIVES] captures the importance of ‘Government grants, subsidies or other financial incentives for environmental innovation’. The dummy variable [FUNDING] shows whether the company has received public support for innovation.

As the *demand-pull* factor, we consider the ‘current or expected market demand for environmental innovations’ proxied in the variable [DEMAND]. Demand from environmentally conscious customers is expected to drive (Caravella and Crespi, 2020; Triguero et al., 2013) and increase (e.g., Triguero et al., 2013; Liao and Tsai, 2019) the introduction of eco-innovation, especially in markets close to end consumers (Doran and Ryan, 2012).

*Technology-push* factors are related to the development of technological and organizational capabilities, and we proxy the firm technological capabilities necessary for eco-innovation in different variables. The level of cooperation [COOP\_SCALED] is defined as the number of partners with which the company undertakes active cooperation on innovation (see D’Attoma and Pacei, 2020). R&D status is captured by innovation intensity [RALLX\_RAT] which represents the ratio of total expenditure on innovation. We also consider organizational innovation [ORG\_INN] as an alternative type of non-technological innovation, as highlighted in previous studies (Arranz et al., 2020). Finally, we proxy technological capabilities with the percentage of employees holding a tertiary degree [EMPUD]. It has been shown that highly qualified employees contribute to developing new products and processes (Cainelli et al., 2015; Horbach, 2008), making eco-innovation (Horbach, 2016;

Bitencourt et al., 2019) and solving potential problems in compliance with new environmental regulations (Canon de Francia et al., 2007).

*Firm-specific* factors complete the set of explanatory variables. They consist of size, group membership [GP], degree of internationalization [FM], proxied by the foreign market focus in the sale of goods and/or services, export behaviour, the employee growth rate [EMP\_GROWTH] and the turnover growth rate [TURN\_GROWTH]. The economic sector, manufacturing vs service, is proxied by [MANUFACTURING].

Besides the four main clusters of drivers, we also consider the appropriability regime, proxied by a scaled variable [APPROPRIABILITY], which captures the form of protection adopted (D'Attoma and Pacci, 2020). Finally, with reference to our research questions, we test the role of MI and its four different strategies, design and packaging, promotion, placement, and pricing. Each strategy was represented by a dummy that assumed the value 1 if it was introduced during the reference period.

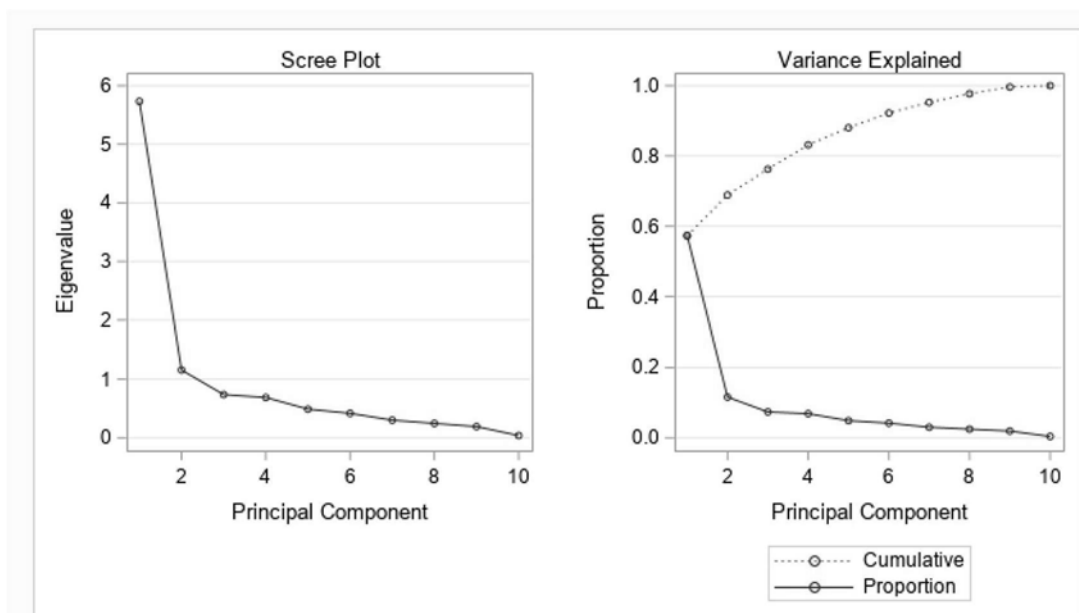
### *3.3 The construction of the dependent variable*

#### *3.3.1 Germany*

The dependent variable is constructed using Cluster Analysis (CA) (Everitt, 1993) conducted on factors retained after a Principal Component Analysis (PCA), which puts companies into homogenous groups with respect to the EBs of their innovation activity. The CIS survey collects information on EBs that are related to each other. Therefore, this results in a complex set of data that is difficult to interpret. Hence, we reduce the number of variables while maintaining the information content through a PCA. PCA (see Jolliffe and Cadima, 2016 for a review) is usually conducted on a set of correlated variables in order to reduce these variables to a smaller set of factors, which are by definition orthogonal. The number of significant principal components ( $j=1, \dots, m$ ) is then chosen according to certain criteria. PCA appears particularly appropriate for our empirical analysis as, with

reference to Germany, EBs were found to be highly and positively correlated<sup>2</sup> in that some types of EBs tend to be adopted together. For instance, German innovating firms achieving more than one EB are in the majority (about 68%). Operationally, PCA consists of replacing the original set of variables with the Principal Components (PCs) summarizing the original variability. All EBs were measured on the same scale, so normalization was not necessary for the variables used in the PCA. Following i) the Kaiser criterion (Braeken and van Assen, 2017; Kaiser, 1960) whereby the component with corresponding eigenvalue ( $\lambda$ ) >1 is retained; and ii) the cumulative percentage of the total variance criterion (Jolliffe, 2005), which consists of selecting the number of components that explains an established variance threshold level included around the range 70-90%, we selected the first two PCs with  $\lambda > 1$  ( $\lambda_1=5.7317$  and  $\lambda_2=1.1572$ ). This explains around 69% of the original variability (Figure 1).

Figure 1. PCA results (Germany)

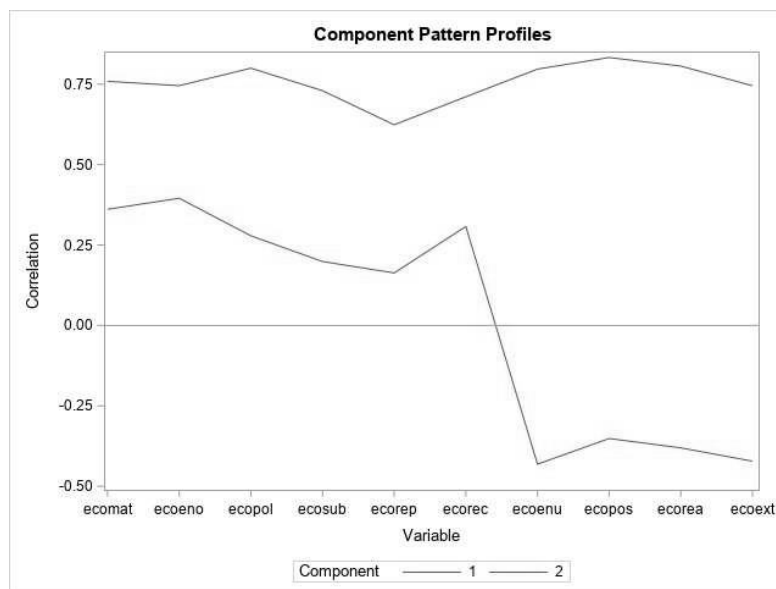


The profile plot (Figure 2) shows the correlations between each PC retained and the ten EBs. The first PC (solid blue line) is strongly positively correlated with all EBs. This correlation indicates that this PC represents an overall positive general attitude toward EBs. The first PC was thus labelled

<sup>2</sup> The tetrachoric correlation matrix is available upon request.

‘General attitude towards EBs’. The second PC (red line) is moderately positively correlated with all internal EBs and negatively correlated with all external EBs, thus highlighting the contrast between internal and external benefits. The second PC was thus labelled ‘Internal vs External EBs’: innovative firms that obtain internal EBs tend not to obtain external EBs, and vice versa. On the one hand, there is general interdependence between EBs, which probably reflects knowledge spillovers. On the other hand, this interdependence moves in opposite directions when internal and external EBs are compared separately, which implies that different knowledge spillovers may underly the two types of benefit.

Figure 2. Profile plot (Germany).



Following a tandem approach (Markos et al., 2019), a CA was then conducted applying the k-means algorithm first proposed by MacQueen (1967) and using as cluster variates the two PCs retained. The k-means algorithm is a partitional clustering algorithm where first the number of clusters is specified in advance, then each cluster is associated with a centroid, and then each unit is assigned to the cluster with the closest centroid. At each step of the iterative algorithm, the sum of the distance of each element from the centroid of its cluster is evaluated and minimized. The re-allocation of each unit to the closest centroid is repeated until a suitable stabilisation of the groups is reached (i.e., centroids do not change). To evaluate the quality of the clustering process, the error of each data point is calculated

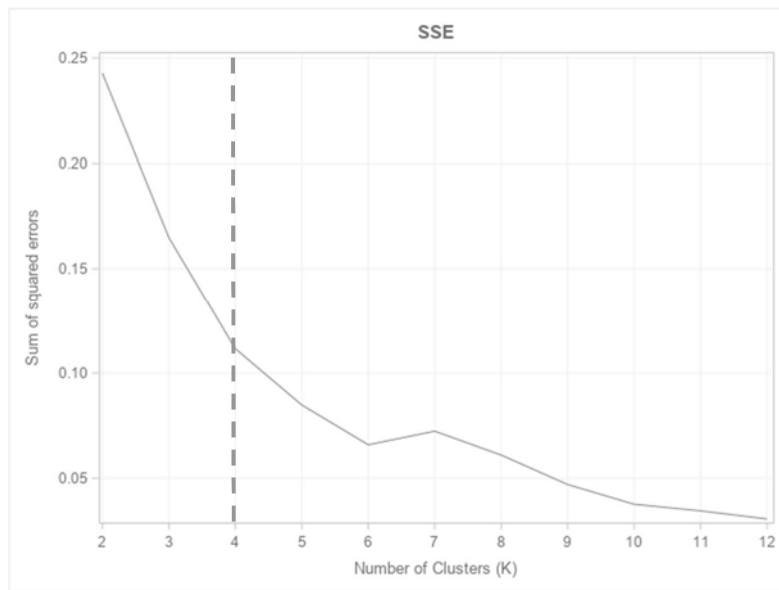
by computing the squared Euclidean distance to the closest centroid, and then the total sum of the squared errors (SSE) is computed as in (1):

$$SSE = \sum_{l=1}^k \sum_{i \in l} d^2(x_i, \bar{x}_l) \quad (1)$$

where  $\bar{x}_l = [\bar{x}_{1l}, \dots, \bar{x}_{pl}]'$  is the centroid (namely the vector of means) of group  $l$  and  $x_i = [x_{i1}, \dots, x_{ip}]'$  is the vector of coordinates of company  $i$  and  $p$  is the number of cluster variates.

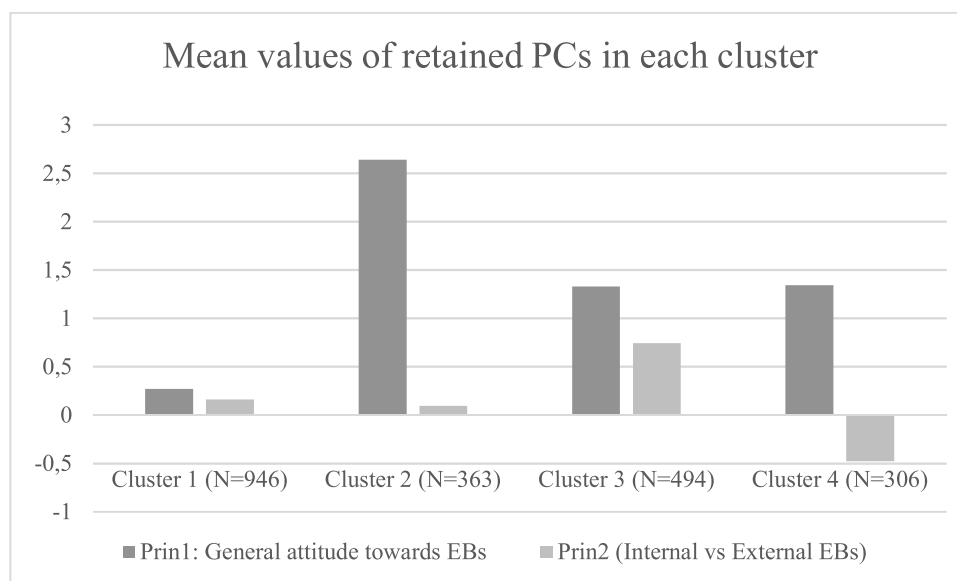
Because the number of clusters is not known beforehand, different numbers of clusters were tested and the resulting SSE evaluated using the heuristic elbow method (Ng, 2012), i.e. plotting the SSE as a function of the number of clusters, and picking the elbow of the curve as the number of clusters to use. This method suggests  $K=4$  as the initial number of clusters (Figure 3). At  $K=4$  an increase in  $K$  will cause a very small decrease in the SSE, while a decrease in  $K$  will sharply increase the SSE.

*Figure 3: SSE trend (Germany)*



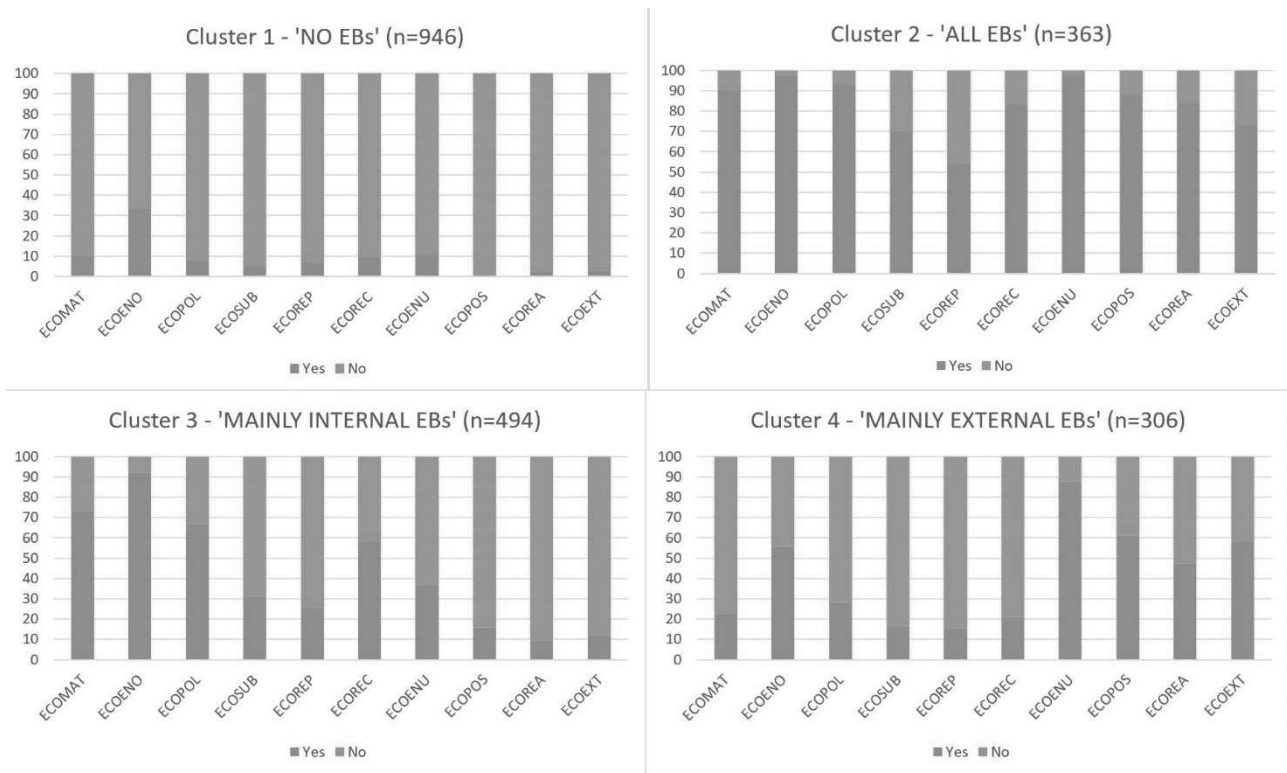
Moreover, we used the segment interpretability (Bertsimas et al., 2021; Horel et al., 2020; De Keyser et al., 2015) as a supplementary selection criterion and the identification of 4 meaningful clusters was confirmed. The interpretation of clusters was conducted using the mean scores for each retained component (Figure 4).

Figure 4. Results of CA (Germany)



As shown in Figure 4, the first cluster displays a very low mean in both retained components and identifies the biggest group of companies (N=946) with very low overall attitude toward EBs. Consequently, the contrast between internal vs external EBs (*'NO EBs'*) is not so clear. The second cluster scores very high on the first PC, identifying 363 companies that carry out generally all types of eco-innovations (*'ALL EBs'*). The third cluster has above-average values on both the first and second components, giving a group of 494 companies which have a medium general attitude towards EB innovations along the trajectory of internal EBs (*'INTERNAL EBs'*). Finally, the fourth cluster has above-average values on the first PC and below-average values on the second, thus identifying a group of 306 companies which have a medium attitude towards EB innovations along the external EBs trajectory (*'EXTERNAL EBs'*). Figure 5 reports percentages of each EB achieved by different clusters and confirms the interpretation of clusters reported above.

Figure 5. Frequencies of EBs achieved by clusters (Germany)



### 3.3.2 Portugal

The dependent variable was constructed following the same methodology as in Germany. First, PCA was conducted on the set of correlated indicators of innovations with EBs. Also for Portugal, innovations with EBs were found to be correlated, as some types of EBs tend to be obtained jointly<sup>3</sup>. The correlation coefficients<sup>4</sup> indicate a high and strong positive interdependence among EB innovations, as certain types of EB also tend to be generated together. About 67% of innovating companies present more than one EB.

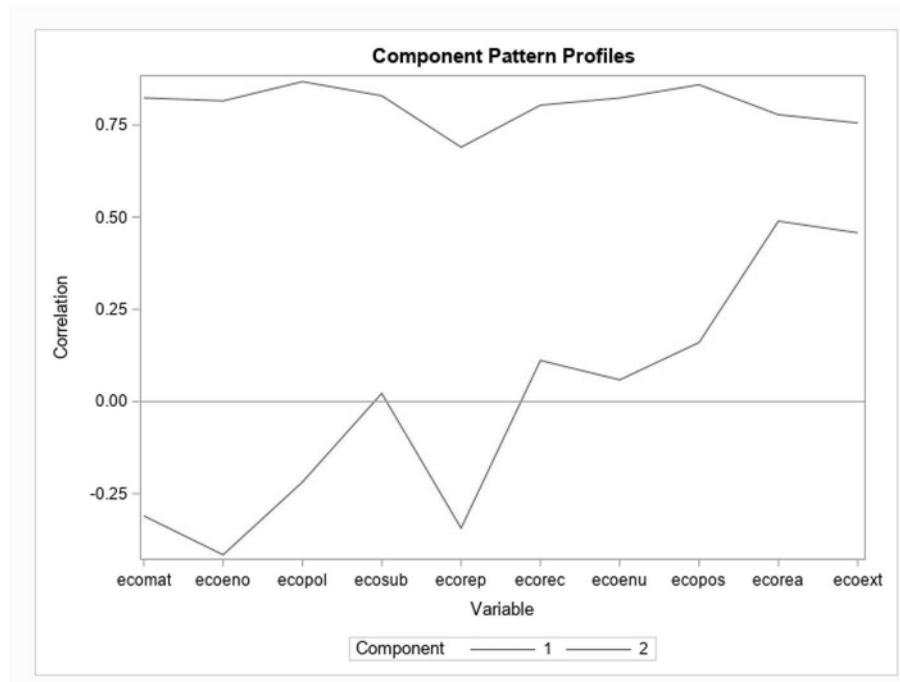
PCA on the 10 EBs was implemented and the first two components retained; these explained around 74% of the original variability. As showed by the profile plot (Figure 6), the first PC represents a general eco-innovation attitude as it shows positive coefficients on all 10 EBs. The second PC

<sup>3</sup> As for Germany, normalization of these indicators was not required; all were measured on the same scale.

<sup>4</sup> Correlation results are available upon request

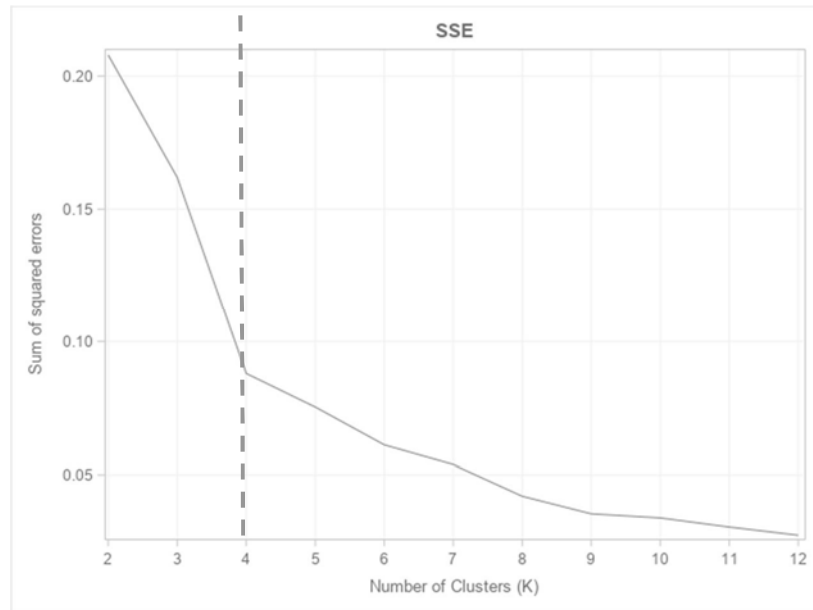
represents a polarization of internal EBs (negative coefficients) vs external EBs (positive coefficients). Therefore, as for Germany, the first PC was labelled ‘General attitude toward EBs’ and the second was labelled ‘Internal vs External EBs’.

Figure 6. Profile plot (Portugal).



CA was then conducted by applying the k-means algorithm and using as cluster variates the two retained PCs. Using the elbow method (Figure 7) we again selected k=4 and obtained the convergence of the algorithm.

Figure 7: SSE trend (Portugal)



As shown in Figure 8, the first cluster has above-average values on the first PC and below-average values on the second PC, thus identifying a group of 621 companies which have a medium attitude towards innovation EBs, especially along the trajectory of internal EBs (*INTERNAL EBs*). The second cluster has above-average values on both the first and the second components, establishing a group of 601 companies showing a medium general attitude towards innovation EBs along the trajectory of external EBs (*EXTERNAL EBs*). The third cluster displays a mean close to zero in both retained PCs, and identifies the biggest group of companies (N=1770) with no general attitude towards EBs and consequent null contrast between internal vs external EBs (*NO EBs*). The fourth cluster scores very high on the first PC, identifying 547 companies which generally achieve all types of EBs (*ALL EBs*).

Figure 8. Results of CA (Portugal)

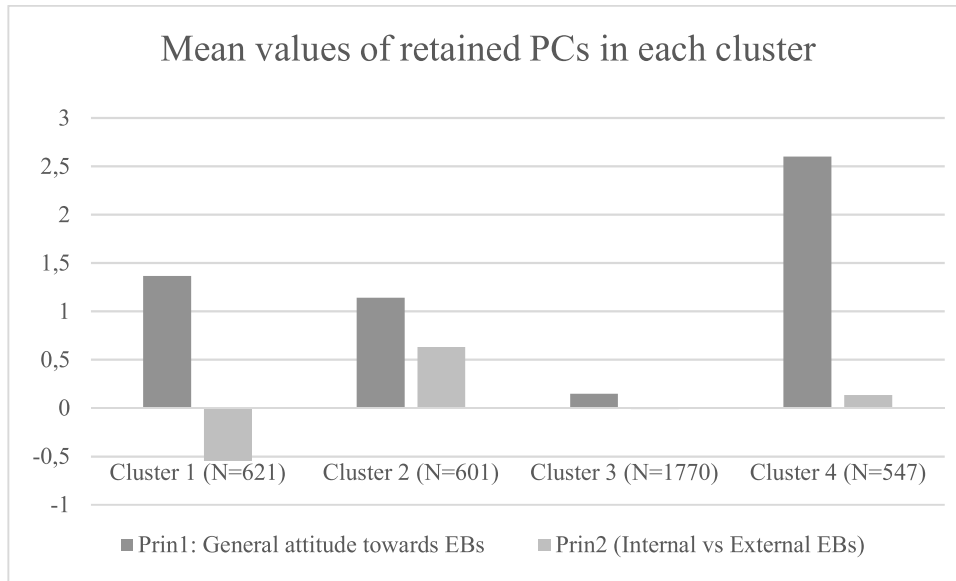
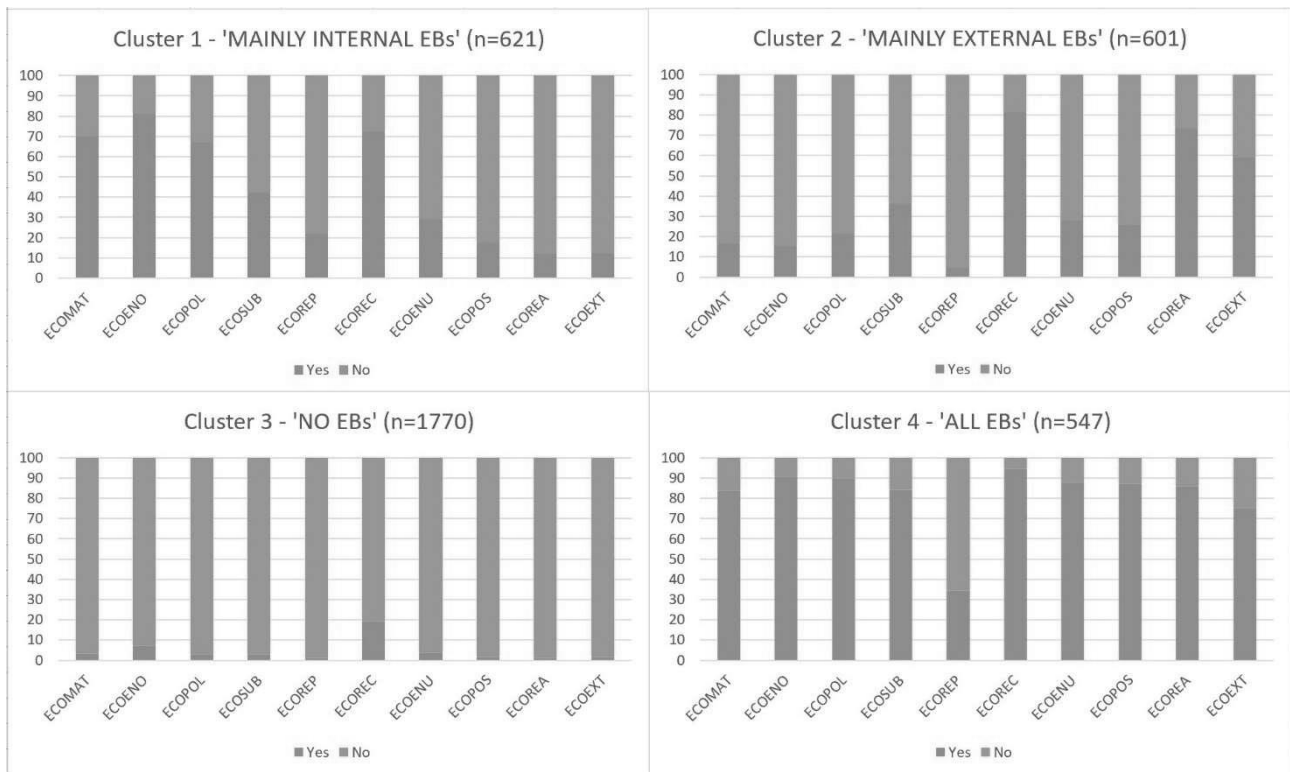


Figure 9 reports percentages of each EB achieved by different clusters and confirms the interpretation of clusters reported above.

Figure 9. Frequencies of EBs achieved by clusters (Portugal)



### 3.4 The estimated model

Having constructed the dependent variable, we evaluate the role of MI in shaping firm membership of the four clusters. We are interested in a multinomial outcome, in other words, clusters of companies with different levels of EBs: ‘no EBs’, ‘all EBs’, ‘internal EBs’ and ‘external EBs’. The characteristics of the four groups are analysed through a multinomial logistic regression model which estimates the probability of belonging to cluster  $j$  given a set of company characteristics. Cluster membership is represented by the vector  $y = [y_1, y_2, y_3, y_4]$  which has the following binary (mutually exclusive) elements:

$$y_1 = \begin{cases} 1 & \text{if the company belongs to cluster 'NO EBs'} \\ 0 & \text{otherwise} \end{cases}$$

$$y_2 = \begin{cases} 1 & \text{if the company belongs to cluster 'ALL EBs'} \\ 0 & \text{otherwise} \end{cases}$$

$$y_3 = \begin{cases} 1 & \text{if the company belongs to cluster 'INTERNAL EBs'} \\ 0 & \text{otherwise} \end{cases}$$

$$y_4 = \begin{cases} 1 & \text{if the company belongs to cluster 'EXTERNAL EBs'} \\ 0 & \text{otherwise} \end{cases}$$

The multinomial logit model (MNL) (McFadden,1973) is then estimated, as described in Greene (2018). The basic probability model for choice between  $J+1$  alternatives is based on a random utility model:

$$U_{ij} = \beta_j' X_i + \varepsilon_{ij} \tag{2}$$

where  $\varepsilon_{ij}$ , with  $j=0, \dots, J$ , have independent type 1 extreme value distributions, and:

$$\text{observed } y_i = j \text{ if } U_{ij} > U_{ik}, \forall k \neq j \tag{3}$$

The disturbances in this framework are assumed to be independently and identically distributed with identical extreme value distribution; the cumulative distribution function is  $F(\varepsilon_j) = \exp(-\exp(-\varepsilon_j))$ . Based on this specification, choice probabilities are defined as in (4):

$$Prob(y_i = j | \mathbf{X}_i) = \frac{\exp(\beta'_j \mathbf{X}_i)}{\sum_{j=1}^J \exp(\beta'_j \mathbf{X}_i)} \quad (4)$$

In our analysis  $y_i = j$  denotes the unordered category representing the cluster belonging ( $j=1, \dots, J$ ) of company 'i',  $\beta'_j$  is the coefficient vector for the outcome  $y_j$ <sup>5</sup> and  $\mathbf{X}_i$  is the row vector of observed values of the explanatory variables for the company  $i$ .

#### 4. Results

Table 1 displays the results of the two multinomial models with reference to Germany: Model 1 includes an aggregate measure of MI and Model 2 includes the four MIs. Where MI is considered as an aggregate measure, introducing it increased the likelihood of belonging to Cluster 2 (companies that achieve both internal and external EBs) and Cluster 4 (companies that achieve external EBs) rather than Cluster 1 (companies that achieve low or no EBs) which is used as a reference category. Therefore, introducing MI was found to be significantly related to EBs which are both internal and external and to EBs which are only external to the company. Focusing on the type of MI, innovations in price and in placement both increased the likelihood of being in Cluster 2 rather than Cluster 1. Innovation in placement also increased the likelihood of being in Cluster 4 rather than Cluster 1. Finally, innovation in placement was also found to be weakly related with the likelihood of being in Cluster 3 (companies that achieve mostly internal EBs) rather than Cluster 1. Innovations in product design and packaging and innovation in promotion did not play any role. Table 2 displays the results of the two multinomial models (Model 3 and 4) for Portugal, which show MI respectively as an

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<sup>5</sup> The model is unidentified in the sense that there is more than one solution to  $\beta'_j$  which leads to the same probabilities  $Prob(y_i = j | \mathbf{X}_i)$ . Therefore, to identify the model one of  $\beta'_j$  is arbitrarily set to zero (say  $\beta'_1$ ). As a consequence, the remaining coefficients will measure the change relative to the  $y_i = 1$  group.

aggregate measure and as the four separate types. Model 3 shows that MI increases the likelihood of being in the cluster of companies achieving both internal and external EBs (in the case of Portugal, Cluster 4) and the likelihood of being in the cluster of companies obtaining only external EBs (in the case of Portugal, Cluster 4), rather than in the cluster of companies that achieve low or no EBs (in the case of Portugal, Cluster 3). Results from Model 3 were thus consistent with results from Model 1 (Germany). Model 4 revealed which of the MIs explain the above patterns. Specifically, innovation in price was found to be related to a higher likelihood of being in Cluster 4 (companies that achieve both internal and external EBs), rather than in Cluster 3. Weak support was found for the relationship between innovation in product design and packaging and the probability of being in Cluster 4 rather than Cluster 3. Price innovation increased the likelihood of being in Cluster 2, rather than Cluster 3, in other words price innovation increased the likelihood of obtaining external EBs. No other types of MI were found to be significant. Empirical evidence related to price innovation was consistent across Germany and Portugal, while innovation in placement was significant in Germany but did not play any role in Portugal. Portugal also revealed a weak role of product packaging and design innovation in explaining EBs. Table 3 and Figure 10 and 11 summarize results for RQ1 and RQ2 with reference to both Germany and Portugal.

Table 1: Parameter estimates in the multinomial logit model for Germany (reference alternative: CLUSTER 1-NO EBs)

Covariate	Germany: Model 1 (MI)				Germany: Model 2 (MI types)					
	'Cluster 2' <i>ALLEB</i>		'Cluster 3' <i>INTERNAL EB</i>		'Cluster 2' <i>ALLEB</i>		'Cluster 3' <i>INTERNAL EB</i>		'Cluster 4' <i>EXTERNAL EB</i>	
	Coeff. (SE)	z	Coeff. (SE)	z	Coeff. (SE)	z	Coeff. (SE)	z	Coeff. (SE)	z
MKTG_INN	.5142 (.1594)	3.23***	.1602 (.1279)	1.25	.2957 (.3617)	1.96**	-	-	-	-
PROMOTION	-	-	-	-	-	-	-2.572 (.1596)	-1.61	-1.190 (.18124)	-0.66
PLACEMENT	-	-	-	-	-	-	2.589 (.1760)	1.85*	3.914 (.1724)	2.27**
PACKAGING	-	-	-	-	-	-	.0225 (.1794)	0.13	.1133 (.1526)	0.74
PRICE	-	-	-	-	-	-	.6034 (.1847)	3.27***	.2380 (.1662)	1.43
ORG_INN	.6568 (.1629)	4.03***	.4033 (.1284)	3.14***	.2576 (.1504)	1.71*	.6094 (.1650)	3.69***	.3938 (.1294)	3.04***
COOP_SCALED	1.3729 (.4603)	2.98***	.6959 (.4298)	1.62	1.0778 (.4589)	2.35**	1.3309 (.4641)	2.87***	.7244 (.4321)	1.68*
RALLX_RAT	.7300 (.4188)	1.74*	.0364 (.4851)	0.08	.1385 (.4176)	0.33	.6879 (.4247)	1.62	.0117 (.4882)	0.02
EMPUD	-0.155 (.0038)	4.09***	-0.138 (.0030)	4.61***	-0.009 (.0030)	0.30	-0.154 (.0038)	-4.03***	-0.138 (.0030)	-4.58***
DEMAND	1.8779 (.1961)	9.57***	1.0192 (.1916)	5.32***	1.5350 (.2017)	7.61***	1.8818 (.1971)	9.55***	1.006 (.1921)	5.24***
FUNDING	-1.562 (.1949)	0.80	-1.748 (.1655)	1.06	-1.585 (.1893)	0.84	-1.721 (.1958)	-0.88	-1.801 (.1655)	-1.09
INCENTIVES	2.203 (.2121)	1.04	.2187 (.1985)	1.10	-0.766 (.2313)	0.33	2.399 (.2135)	1.12	2.544 (.1991)	1.28
REGULATIONS	1.4959 (.1632)	9.17***	.9203 (.1345)	6.84***	.8538 (.1588)	5.38***	1.489 (.1638)	9.09***	.9179 (.1347)	6.81***
EXPORT	.0829 (.1814)	0.46	.2820 (.1444)	1.95*	-0.405 (.1662)	0.24	.0812 (.1823)	0.45	2.667 (.1450)	1.84*
GP	-1.201 (.3080)	0.39	-0.959 (.2651)	0.36	.0266 (.3130)	0.08	-1.317 (.3097)	-0.43	-0.932 (.2660)	-0.35
FM	-0.181 (.3060)	0.06	-1.644 (.2653)	0.62	-1.634 (.3153)	0.52	-0.261 (.3078)	-0.08	-1.529 (.2663)	-0.57
50-249 EMP.	.3169 (.1730)	1.83*	.3029 (.1399)	2.17**	-1.443 (.1640)	0.88	.3414 (.1738)	1.96**	.3129 (.1402)	2.23**
250-499 EMP.	.5353 (.2844)	1.88*	.4697 (.2404)	1.95*	-6.474 (.3273)	1.98**	.5638 (.2862)	1.97**	.4762 (.2412)	1.97**
> 500 EMP.	.6405	2.26**	.4467	1.81*	-4.699	1.53	.6960	2.44**	.4744	1.91*
										1.83*
										2.28**
										0.31
										-0.29
										7.56***
										-0.91
										-0.27
										5.44***
										-0.33
										0.04
										-0.55
										-0.89
										-1.92*
										-1.44

EMP_GROWTH	(.2834) .0976 (.1969)	0.50 .0988 (.1923)	(.2471) -1.697 (.2363)	(.3079) -1.697 (.2363)	0.51 -1.120 (.1251)	0.72 0.02 1.56	(.2847) .1035 (.1967)	0.53 0.19 3.24***	(.2478) .1015 (.1947)	(.3085) -1.401 (.2337)	-0.60 -0.01 1.61
TURN_GROWTH	(.0191) .5849 (.1928)	0.19 3.03*** (.1518)	(.1251) .3678 (.1518)	(.0244) 2.747 (.1765)	0.90 2.42** 1.10	0.02 1.56 3.46***	0.040 (.0213) (.1942)	0.19 3.24*** 3.29***	-1.139 (.1236) (.1527)	-0.003 (.0263) (.1773)	-0.01 1.61 3.81***
MANUFACTURING	1.3013 (.3922)	3.32*** -9.04***	.3974 (.3599)	1.3677 (.3955)	1.10 -5.25***	3.46*** -5.72***	1.3319 (.4045)	3.29*** -8.99***	.4193 (.3680)	1.5363 (.4037)	3.81*** -5.59***
APPROPRIABILITY	-3.399 (.376)	-9.04*** (.307)	-1.617 (.307)	-2.068 (.362)	-5.25*** (.307)	-5.72*** (.307)	-3.361 (.374)	-8.99*** (.307)	-1.615 (.307)	-2.008 (.359)	-5.59*** (.359)
_CONS											

**Notes:** \*\*\*1% significance, \*\*5% significance and \*10% significance. Reference category is Cluster 1, "No EBs"

Source: Own elaboration of the CIS 2014 data

Table 2: Parameter estimates in the multinomial logit model for Portugal (reference alternative: CLUSTER 1-NO EBs)

Covariate	Portugal: Model 3 (MI)				Portugal: Model 4 (MI types)					
	'Cluster 1' <i>INTERNAL EB</i>		'Cluster 2' <i>EXTERNAL EB</i>		'Cluster 1' <i>INTERNAL EB</i>		'Cluster 2' <i>EXTERNAL EB</i>		'Cluster 4' <i>ALL EB</i>	
	Coeff. (SE)	z	Coeff. (SE)	z	Coeff. (SE)	z	Coeff. (SE)	z	Coeff. (SE)	z
MKTG_INN	-0.0880 (.1199)	-0.73	.2653 (.1167)	2.27**	.3481 (.1316)	2.65***	-	-	-	-
PROMOTION	-	-	-	-	-	-	.0876 (.1371)	0.64	-0.0079 (.1541)	-0.05
PLACEMENT	-	-	-	-	-	-	.0630 (.1746)	0.36	-0.0671 (.1672)	1.31
PACKAGING	-	-	-	-	-	-	.0154 (.1408)	0.11	.1831 (.1329)	1.38
PRICE	-	-	-	-	-	-	.1331 (.1631)	0.82	.3422 (.1508)	2.27**
ORG_INN	.5401 (.1201)	4.50***	.5047 (.1167)	4.32***	.9001 (.1317)	6.83***	.4755 (.1181)	4.02***	.7783 (.1344)	5.79***
COOP_SCALED	1.2169 (.3305)	3.68***	1.1120 (.3526)	3.15***	1.5674 (.3614)	4.34***	1.2106 (.3316)	3.11***	1.4751 (.3641)	4.05***
RALLX_RAT	.0093 (.0524)	0.18	.0277 (.0419)	0.66	.0499 (.0467)	1.07	.0100 (.0523)	0.72	.0296 (.0411)	1.05
EMPUD	-0.0066 (.0028)	-2.38**	-0.0085 (.0027)	-3.15***	-0.133 (.0032)	-4.07***	-0.0065 (.0028)	-2.33**	-0.0086 (.0027)	-3.17***
DEMAND	.9726 (.1415)	6.87***	.9636 (.1410)	6.84***	1.6193 (.1494)	10.84***	.9748 (.1419)	6.88***	1.6384 (.1503)	10.90***
FUNDING	.0514 (.1319)	0.39	-0.2998 (.1351)	-2.22**	-0.2050 (.1452)	-1.41	.0649 (.1323)	0.49	-0.2822 (.1354)	-1.09
INCENTIVES	-0.1523 (.1612)	-0.94	-0.3059 (.1657)	-1.85**	-0.0439 (.1645)	-0.27	-0.1519 (.1616)	-0.94	-0.3108 (.1659)	-0.40
REGULATIONS	2.4323 (.1383)	17.58***	2.1470 (.1273)	16.86***	2.7200 (.1751)	15.54***	2.4260 (.1385)	17.52***	2.1429 (.1275)	15.42***
EXPORT	.1763 (.1451)	1.21	.0418 (.1346)	0.31	.0936 (.1572)	0.60	.1863 (.1455)	1.28	.0503 (.1350)	0.37
GP	.0841 (.1814)	0.46	-0.0227 (.1862)	-0.12	-0.0157 (.2039)	-0.08	0.0828 (.1815)	0.46	-0.0153 (.1862)	-0.08
FM	-0.3917 (.1928)	-2.03**	-0.0262 (.2097)	-0.13	-0.2896 (.2198)	-1.32	-0.4072 (.1931)	-2.11**	-0.0313 (.2098)	-0.15
50-249 EMP.	.4469 (.1281)	3.49***	-0.2256 (.1275)	-1.77*	-0.0088 (.1425)	-0.06	.4498 (.1284)	3.50***	-0.2187 (.1433)	-1.71*

> 250 EMP.	1.0405 .2033 .0926 .0876	5.12*** 1.06	-2.14** 0.80	.7482 .1741 (.1002)	3.32*** 1.74*	1.029 (.2033) .0979 (.0892)	5.06*** 1.10	-2.17** 0.84	.7498 (-.2261) .1833 (.1021)	3.32*** 1.80*
EMP_GROWTH										
TURN_GROWTH	-.0055 .0138	-0.40	-0.59	-.0752 (.0684)	-1.10	-.0060 (.0139)	-0.43	-0.63	-.0777 (.0695)	-1.12
MANUFACTURING	.3259 .1358	2.40**	2.58***	.5741 (.1492)	3.85***	.3262 (.1366)	2.39**	2.67***	.6178 (.1509)	4.10***
APPROPRIABILITY	-.0211 .0867	-0.24	2.12**	-.0049 (.0934)	-0.05	-.0221 (.0876)	-0.25	1.99**	-.0343 (.0946)	-0.36
_CONS	-3.12 (.26)	-11.81***	-10.03***	-4.11 (.31)	-13.10***	-3.13 (.26)	11.93***	10.11***	-4.19 (.31)	- 13.35***

**Notes:** \*\*\*1% significance, \*\*5% significance and \*10% significance. Reference category is Cluster 3, "No EBs"

Source: Own elaboration of the CIS 2014 data

Table 3: Summary of findings with reference to each research question

Research question	Germany	Portugal
<b>RQ1:</b> role of MI with respect to EBs	Introducing a MI increases the likelihood to achieve both internal and external EBs or external EBs only	Introducing a MI increases the likelihood to achieve both internal and external EBs or external EBs only
<b>RQ2:</b> role of MI strategies with respect to EBs	<b>MI in price:</b> it increases the likelihood to achieve both internal and external EBs	<b>MI in price:</b> it increases the likelihood to achieve both internal and external EBs and external EBs only
	<b>MI in placement:</b> it increases the likelihood to achieve both internal and external EBs, external EBs only and internal EBs only (weak support for the latter)	<b>MI in placement:</b> no role
	<b>MI in design and packaging:</b> no role	<b>MI in design and packaging:</b> it increases the likelihood to achieve both internal and external EBs (weak support)
	<b>MI in promotion:</b> no role	<b>MI in promotion:</b> no role

Figure 10. Role of MI and MI strategies with respect to EBs (Germany)

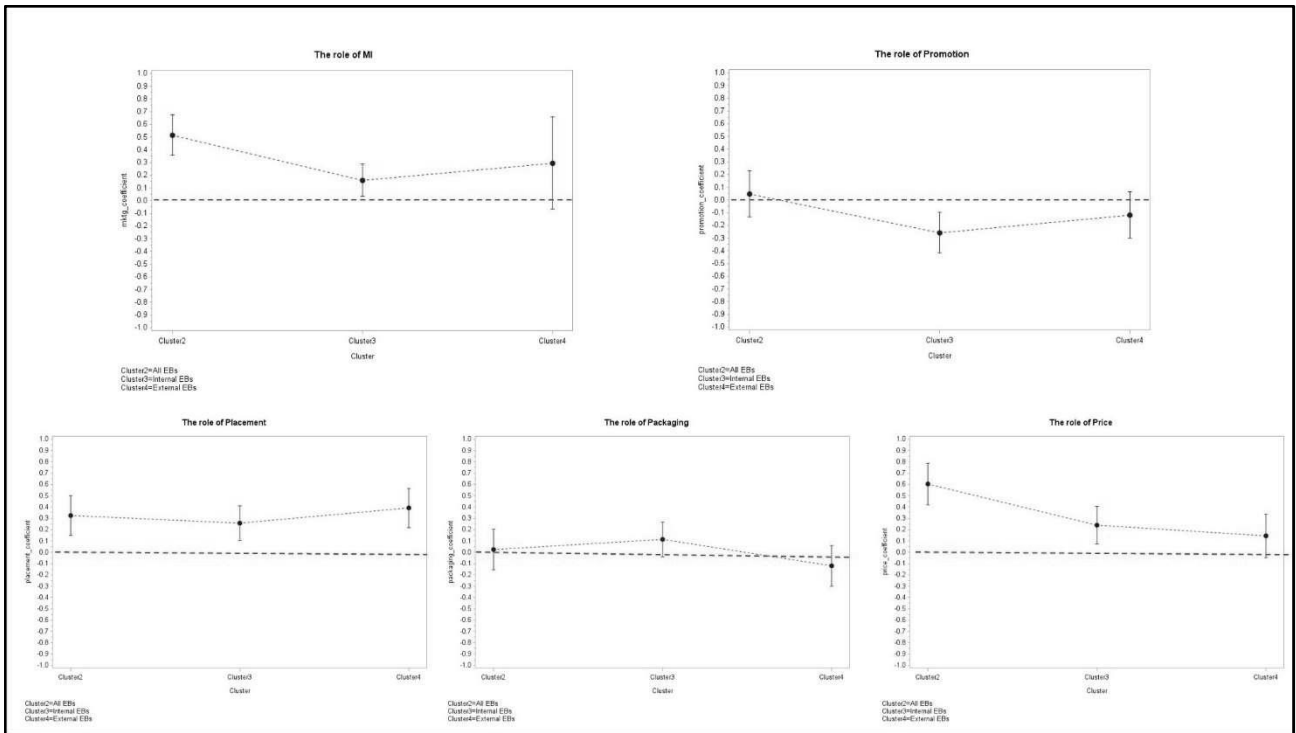
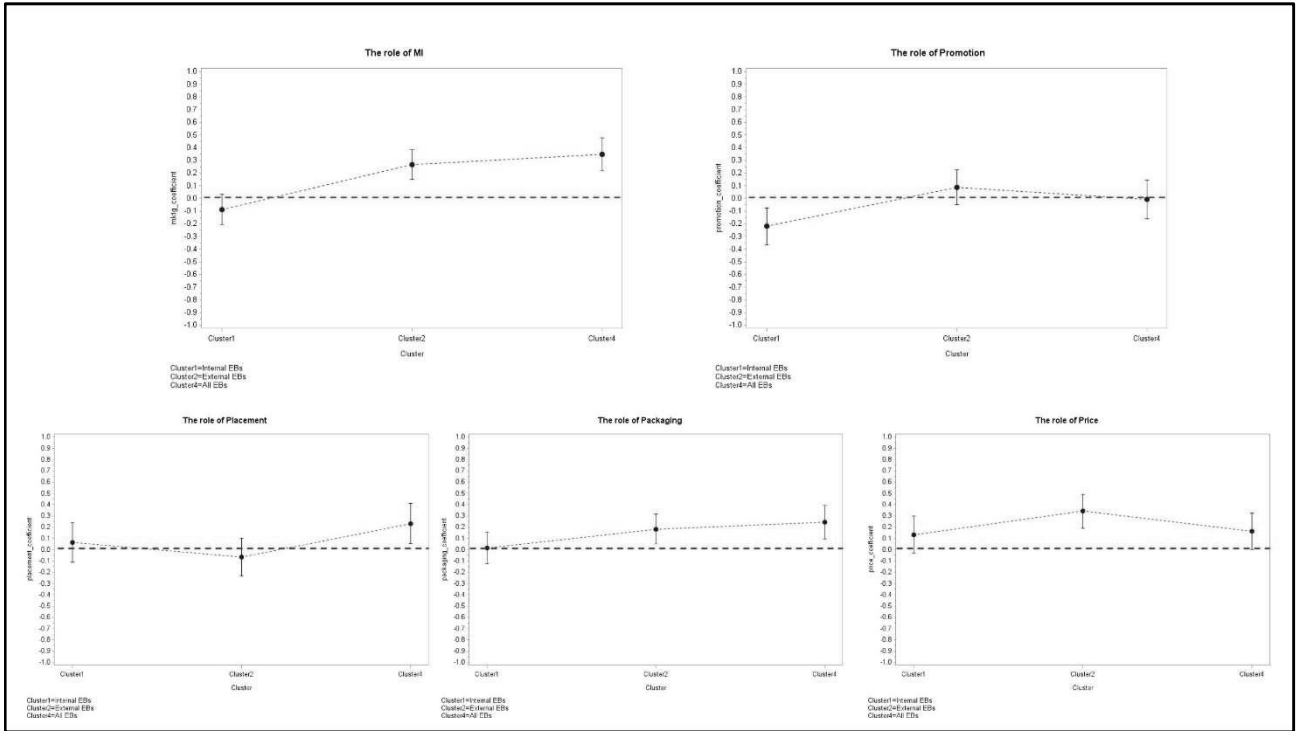


Figure 11. Role of MI and MI strategies with respect to EBs (Portugal)



## 5. Discussion and conclusions

### 5.1 Contributions to theory and practice

Our study attracts academic attention on the positive environmental contribution driven by marketing capabilities. Our findings contribute to the literature on environmental innovation: this is the first work offering empirical evidence highlighting the role of MI in leveraging EBs both at the aggregate level and at the level of each MI type, as we discuss below.

Results show that in both Germany and Portugal innovative companies introducing a MI were more likely to achieve EBs, and thus provide a reliable answer to RQ1. The environmental benefits obtained are mostly external, in other words for end users/consumers, or both external and within the company. This empirical evidence is in line with resource-based theory and points to the role of marketing capabilities in leveraging technological innovations to achieve EBs. As previously stated by Pacheco et al. (2018) and Yu and Ramanathan (2016), marketing capabilities appear to be enablers for

companies aiming to extract benefits from technological innovation. Our results expand findings from Medrano et al. (2020) which relate MI with environmental orientation by highlighting the relationship between MIs and EBs. Moreover, our findings offer empirical evidence supporting the identification of a link between best practices in MIs and EBs as hypothesized by Marcon et al. (2017). MI is thus important in obtaining external EBs, for example, by encouraging recycling of products after use, increasing product life, or replacing polluting with environmentally friendly materials.

RQ2 challenges the assumption that all MI strategies play the same role in leveraging EBs, and results from Germany and Portugal consistently reveal that not all MIs are equally important for the environment. First, the key role of innovation in price in obtaining both external and internal EBs emerges. New pricing systems based on the environmental friendliness of products and services, and rental or sharing plans, or innovations which extend the life of a product, are best practices in price innovation, contributing positively to environmental conservation. In Portugal, price innovation is found to contribute to external EBs only, but it contributes to both internal and external ones in Germany. Previous work has discussed at the theoretical level the role of price innovation in contributing to the environment (e.g. Medrano et al., 2020; de Jesus et al., 2018). To our knowledge, the present paper is the first study offering empirical evidence supporting the positive role of price innovation in achieving EBs.

Evidence from Germany and Portugal is somewhat inconsistent regarding innovation in placement. Placement innovation involves the delivery of products to shops or to end consumers: delivery can be optimized to reduce pollution, and thus generate EBs. Decentralized distribution of items and enabling local stores to manage recycled items are an additional possible way of obtaining EBs. Findings are in line with previous studies suggesting the potential positive role of placement innovation towards the environment (Marcon et al., 2017; Medrano et al., 2020). In Germany, placement innovation contributes to all types of EB, but it is not as significant in Portugal. Differences

between Germany and Portugal in terms of distribution networks, in sensitivity towards innovation and in levels of environmental awareness may explain this difference.

Only in Portugal weak support was found for the role of product and packaging design in leveraging EBs. Unlike previous studies (e.g., Mariadoss et al., 2011), our findings suggest that packaging need not necessarily be the first step in a company's journey towards an environmental orientation. Moreover, innovations in design and packaging could also be driven by aesthetic reasons and consumer preferences (Sundar et al., 2020), or by cost and functionality considerations (Glock et al., 2019), and may have a weak link with environmental goals.

No support has been found for the role of innovation in promotion. This appears consistent with the fact that few scholars have focused on innovation in promotion with respect to its environmental role (e.g., Marcon et al., 2017). Promotion innovation involves activities which can have either a positive or a negative impact on the environment. The shift from printed to digital advertising could contribute positively, as suggested by previous research on online versus print promotional flyers (e.g., Ieva et al., 2018). However, re-branding or the introduction of a new loyalty program could have a negative impact where, for example, outdated promotional material has to be physically replaced.

This study also has implications for management. In public discourse, companies today are often asked to focus on MI in order to make their technological innovations environmentally aware, but because MIs are not all equal, companies should carefully consider which ones to introduce. Innovation in pricing is found to be the most effective marketing strategy for the environment, as it leads to EBs in terms of both production and consumption/use. But innovation in placement could also deliver EBs. When planning MI, companies need to improve their understanding of the potential EBs, in addition to the obvious focus on the impact on economic performance.

## *5.2 Limitations and future research directions*

The present paper has certain limitations and also implications for future research. Because of the structure of the CIS data, it is not possible to provide details of MIs beyond the four types described here. Finer detail and information about costs of MI would enable further insights. Moreover, a weakness is represented by the inadequate timeliness of the CIS 2014 wave we used in our empirical application, namely the gap between the release date of the information and the reference period of the data collection. However, such a weakness is common to all empirical studies that make use of secondary harmonized data produced by Bureau of Statistics. Future research might use the latest released waves as soon as they will be available to evaluate the robustness of findings and might test if the described relationships hold in other countries, such as developing ones. Another weakness is that our data does not provide any measure of the environmental performance of innovations, in terms of, for example, quantifying carbon footprint reduction or the extent to which recycling or product sharing is performed. Measures such as these would provide useful insights. Finally, in the light of the recent pandemic, it would be important to assess how MIs address challenges from the Covid-19 pandemic and how they can help to achieve sustainability goals.

### **Disclaimer**

The anonymous data of the Community Innovation Survey 2014 (CIS 2014) used in the analysis of this paper was provided by EUROSTAT. All results and conclusions are given by the authors and represent their opinion and not those of EUROSTAT, the European Commission or any of the national authorities whose data have been used. The responsibility for all conclusions drawn from the data lies entirely with the authors.

## References

- Adams, P., Freitas, I. M. B., Fontana, R., 2019. Strategic orientation, innovation performance and the moderating influence of marketing management. *J.Bus.Res.* 97, 129-140.
- Arranz, N., Arroyabe, M., Li, J., Fernandez de Arroyabe, J. C., 2020. Innovation as a driver of eco-innovation in the firm: An approach from the dynamic capabilities theory. *Bus. Strateg. Environ.* 29(3), 1494-1503.
- Bahn-Walkowiak, B., Wilts, H., 2016. Eco-innovation in Germany, EIO Country Profile.
- Baregheh, A., Rowley, J., Sambrook, S., 2009. Towards a multidisciplinary definition of innovation. *Manage. Decis.*, 47(8), 1323-1339.
- Barney, J., 1991. Firm resources and sustained competitive advantage. *J. Manag.* 17(1), 99-120.
- Bertsimas, D., Orfanoudaki, A., Wiberg, H., 2021. Interpretable clustering: an optimization approach. *Mach. Learn.*, 110(1), 89-138.
- Bitencourt, C.C., De Oliviera Santini, F., Zanandrea, G., Ladeira, W.J., Frohlich, C., 2019. Empirical generalizations in eco-innovations: A meta-analytic approach. *J. Clean. Prod.*, 245, 1-14.
- Braeken, J., Van Assen, M. A., 2017. An empirical Kaiser criterion. *Psychol. Methods*, 22(3), 450.
- Cainelli, G., De Marchi, V., Grandinetti, R., 2015. Does the development of environmental innovation require different resources? Evidence from Spanish manufacturing firms. *J. Clean. Prod.*, 94, 211-220.
- Canon de Francia, J., Garcés-Ayerbe, C., Ramirez-Alesòn, M., 2007. Are more innovative firms less vulnerable to new environmental regulation? *Environ. Resour. Econ.*, 36, 295-311.
- Caravella, S., Crespi, F., 2020. Unfolding heterogeneity: the different policy drivers of different eco-innovation modes. *Environ. Sci. Policy*, 114, 182-193.

Choi, H., Yi, D., 2018. Environmental innovation inertia: Analyzing the business circumstances for environmental process and product innovations. *Bus. Strateg. Environ.*, 27(8), 1623-1634.

Costa, I., Lorena, A., 2016. Eco-innovation in Portugal, EIO Country Profile 2014-2015.

Coviello, N. E., Brodie, R. J., Munro, H. J., 2000. An investigation of marketing practice by firm size. *J. Bus. Venturing*, 15(5-6), 523-545.

D'Attoma, I., Pacei, S., 2020. The determinants of eco-innovation strategies. An empirical investigation of two European countries., in: *Electronic Conference Proceedings of Sinergie - Sima Management Conference Grand challenges: companies and universities working for a better society*, Pisa, 2020, 247 – 254.

De Keyser, A., Schepers, J., Konuş, U., 2015. Multichannel customer segmentation: Does the after-sales channel matter? A replication and extension. *Int. J. Res. Mark.*, 32(4), 453-456.

de Jesus, A., Antunes, P., Santos, R., Mendonça, S., 2018. Eco-innovation in the transition to a circular economy: An analytical literature review. *J.Clean.Prod.*, 172, 2999-3018.

Disoska, E. M., Tevdovski, D., Toshevska-Trpchevska, K., Stojkoski, V., 2020. Evidence of innovation performance in the period of economic recovery in Europe. *Innovation: The European Journal of Social Science Research*, 33(3), 280-295.

Doran, J., Ryan, G., 2012. Regulation and Firm Perception, Eco-innovation and Firm Performance. *Eur. J. Innov. Manag.*, 15(4), 421-441.

Everitt, B.S. 1993. *Cluster Analysis*. London: UK: Arnold.

Flash EB #256 2009. European attitudes towards the issue of sustainable consumption and production, The GALLUP organization, accessed on January 10, 2022 at [https://ec.europa.eu/environment/eussd/pdf/FL256\\_analytical%20report\\_final.pdf](https://ec.europa.eu/environment/eussd/pdf/FL256_analytical%20report_final.pdf)

Floričić, T., 2020. Sustainable solutions in the hospitality industry and competitiveness context of “green hotels”. *Civil Eng. J.*, 6(6), 1104-1113.

García-Granero, E. M., Piedra-Muñoz, L., Galdeano-Gómez, E., 2018. Eco-innovation measurement: A review of firm performance indicators. *J. Clean. Prod.*, 191, 304-317.

Geldes, C., Felzensztein, C., Palacios-Fenech, J., 2017. Technological and non-technological innovations, performance and propensity to innovate across industries: The case of an emerging economy. *Ind. Market. Manag.*, 61, 55–66.

Ghisetti, C., Rennings, K., 2014. Environmental innovations and profitability: How does it pay to be green? An empirical analysis on the German innovation survey. *J. Clean. Prod.*, 75, 106-117.

Glock, C. H., Grosse, E. H., Kim, T., Neumann, W. P., Sobhani, A., 2019. An integrated cost and worker fatigue evaluation model of a packaging process. *Int. J. Prod. Econ.*, 207, 107-124.

Greene, W.H., 2018. *Econometric Analysis*. 8<sup>th</sup> ed. New York: Pearson.

He, H., Harris, L., 2020. The impact of Covid-19 pandemic on corporate social responsibility and marketing philosophy. *J. Bus. Res.*, 116, 176-182.

Horbach, J., Rammer, Rennings, C., K., 2012. Determinants of eco-innovations by type of environmental impact: the role of regulatory push/pull, technology push and market pull. *Ecol. Econ.*, 78, 112-122.

Horbach, J., 2008. Determinants of Environmental Innovation. New Evidence from German Panel Data Source. *Res. Policy*, 37(1), 163-173.

Horbach, J., Oltra, V., Belin, J., 2013. Determinants and specificities of eco-innovations compared to other innovations—an econometric analysis for the French and German industry based on the community innovation survey. *Ind. Inn.*, 20(6), 523-543.

Horbach, J., 2016. Empirical determinants of eco-innovation in European Countries using the Community Innovation Survey. *Environ. Innov. Soc. Transit.*, 19, 1-14.

- Horel, E., Giesecke, K., Storchan, V., Chittar, N., 2020. Explainable clustering and application to wealth management compliance. In *KDD Workshop on Machine Learning in Finance*, August 24, 2020, San Diego, CA. ACM, New York, NY, USA.
- Ieva, M., Ziliani, C., Gázquez-Abad, J. C., D'attoma, I., 2018. Online versus offline promotional communication: evaluating the effect of medium on customer response. *J. Advertising Res.*, 58(3), 338-348.
- Jolliffe, I., 2005. Principal Component Analysis. In: Everitt, B.S., Howell, D.C. (Eds). In *Encyclopedia of Statistics in Behavioral Science*.
- Jolliffe, I. T., Cadima, J., 2016. Principal component analysis: a review and recent developments. *Philos. Trans. Royal Soc. A*, 374:20150202.
- Kaiser, H.F., 1960. The application of electronic computers to factor analysis. *Educ. Psychol. Meas.*, 20, 141-151.
- Kemp, R., Pearson, P., 2007. Final report MEI project about measuring eco-innovation. UM Merit, Maastricht, 10 (2).
- Kumar, V., 2020. Global implications of cause-related loyalty marketing., *Int. Market. Rev.*, 37(4), 747-772.
- Lee, R., Lee, J. H., Garrett, T. C., 2019. Synergy effects of innovation on firm performance. *J. Bus. Res.*, 99, 507–515.
- Liao, Y.C.Tsai, K.H., 2019. Innovation intensity, creativity enhancement, and eco-innovation strategy: The roles of customer demand and environmental regulation. *Bus. Strateg. Environ.*, 28, 316-326.
- Lorena, A., 2018. Eco-innovation in Portugal, EIO Country Profile 2016-2017.

- MacQueen, J., 1967. Some methods for classification and analysis of multivariate observations. Proc. Fifth Berkeley Symp. Math. Stat. Probab. 1 (June 14), 281-297.
- Mairesse, J and Mohnen, P., 2010. Using Innovation Surveys for Econometric Analysis, In: Editor(s): Bronwyn H. Hall, Nathan Rosenberg, Handbook of the Economics of Innovation, North-Holland, 2, 1129-1155.
- Makadok, R., 2001. Toward a synthesis of the resource-based and dynamic-capability views of rent creation. *Strateg. Manage. J.*, 22 (5), 387-401.
- Marcon, A., de Medeiros, J. F., Ribeiro, J. L. D., 2017. Innovation and environmentally sustainable economy: Identifying the best practices developed by multinationals in Brazil. *J. Clean. Prod.*, 160, 83-97.
- Mariadoss, B. J., Tansuhaj, P. S., Mouri, N., 2011. Marketing capabilities and innovation-based strategies for environmental sustainability: An exploratory investigation of B2B firms. *Ind. Market. Manag.* 40(8), 1305-1318.
- Markos, A., Iodice D'Enza, A., van de Velden, M., 2019. Beyond Tandem Analysis: Joint Dimension Reduction and clustering in R. *J. Stat. Softw.* , 91(10), 1-24.
- McFadden, D., 1973. Conditional logit analysis of qualitative choice behaviour. In *Frontiers in Econometrics*, Zarembka P. (Ed.). Academic Press: New York, 105-142.
- Medase, K., Barasa, L., 2019. Absorptive capacity, marketing capabilities, and innovation commercialisation in Nigeria. *Eur. J. Innov. Manag.* 22(5), 790-820.
- Medrano, N., Cornejo-Cañamares, M., Olarte-Pascual, C., 2020. The impact of marketing innovation on companies' environmental orientation. *J. Bus. Ind. Mark.* 35(1), 1-12.
- Miao, C., Fang, D., Sun, L., Luo, Q., Yu, Q., 2018. Driving effect of technology innovation on energy utilization efficiency in strategic emerging industries. *J. Clean. Prod.*, 170, 1177-1184.

- Mothe, C., Nguyen-Thi, U. T., 2017. Persistent openness and environmental innovation: An empirical analysis of French manufacturing firms. *J. Clean. Prod.*, 162, S59-S69.
- Motjolopane, I., 2021. Pushing the Limits using Business Model Innovation a Three Pronged Approach and Lessons Learned. *J. Hum. Earth Fut.*, 2(1), 24-35.
- Mousavi, S, Bossink B., van Vliet M., 2018. Dynamic capabilities and organizational routines for managing innovation towards sustainability. *J. Clean. Prod.*, 224-239.
- Ng, A., 2012. Clustering with the k-means algorithm. *Mach. Learn.*.
- O'Brien, K., 2018a. Is the 1.5 C target possible? Exploring the three spheres of transformation. *Curr. Opin. Env. Sust.*, 31, 153-160.
- O'Brien, K., 2018b. Eco-Innovation in Germany. *EIO Country Profile 2016-2017*.
- O'Cass, A., Weerawardena, J., 2009. Examining the role of international entrepreneurship, innovation and international market performance in SME internationalisation. *Eur. J. Marketing*, 43(11/12), 1325-1348.
- OECD, 2005 Oslo manual: Guidelines for collecting and interpreting innovation data (3rd edition). OECD. Available at:  
<http://www.oecd.org/sti/inno/oslomanualguidelinesforcollectingandinterpretinginnovationdata3rdedition.htm>
- Pacheco, L. M., Alves, M. F. R., Liboni, L. B., 2018. Green absorptive capacity: A mediation-moderation model of knowledge for innovation. *Bus. Strateg. Environ.*, 27(8), 1502-1513.
- Rennings, K., 2000. Redefining Innovation-Eco-Innovation Research and the Contribution from Ecological Economics. *Ecol. Econ.*, 32(2), 319-332.
- Sundar, A., Cao, E. S., Machleit, K. A., 2020. How product aesthetics cues efficacy beliefs of product performance. *Psychol. Market.*, 37(9), 1246-1262.
- Triguero, A., Moremno-Mondéjar, L. Davia, M.A., 2013. Drivers of different types of eco-innovation in European SMEs. *Ecol. Econ.*, 92, 25-33.

Wang, K. H., Umar, M., Akram, R., Caglar, E., 2021. Is technological innovation making world "Greener"? An evidence from changing growth story of China. *Technol. Forecast. Soc.*, 165, 1-7 .

Yu, W., Ramanathan, R., 2016. Environmental management practices and environmental performance: The roles of operations and marketing capabilities. *Ind. Manage. Data. Syst.*, 111(6), 1201-1222.