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Institutional pressures as drivers of circular economy in firms: A machine learning approach

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ABSTRACT

This paper investigates how institutional pressures affect the development of Circular Economy (CE) in firms. Using Institutional Entrepreneurship as a theoretical framework, this paper considers three different levels of institutional pressures (*coercive, normative, and mimetic*) to examine the effect of each pressure and their interactions on the development of CE. Seeking to clarify the debate on the effect of institutional pressures, this paper considers that the main limitation arises from the fact that previous research has analysed the relationship between institutional pressures without considering the interaction between them and the non-linearity of the processes. Deviating from previous papers, our analysis combines regression methods with Machine learning (i.e. Artificial Neural Networks), and employs data from the EU survey on *Public Consultation on the Circular Economy*. This research finds that while coercive pressures have a compulsory effect on the development of CE, mimetic and normative pressures do not have an effect by themselves, but only in interaction with coercive pressures. Moreover, this paper shows that the application of machine learning tools has an important contribution in solving interaction problems. From the perspective of environmental policy, this means that a comprehensive policy is required, which implies the coexistence or interaction of the three types of pressures.

1. Introduction

The Circular Economy (CE) is an economic model conceived from a cycle of development and transformation, whose main objective is to optimise the use of resources and promote the efficiency of production systems (Gedam et al., 2021; Salvador et al., 2021; Kanda et al., 2021). The CE model seeks to eliminate negative externalities of economic activity while ensuring economic growth, preserving natural capital, and promoting greater well-being of societies (Martins, 2018; Millar et al., 2019). The CE model strives to achieve production and consumption sustainability by implementing closed cycles (closed-loops), with activities that promote efficiency in the utilisation of resources and value chains based on more efficient uses of waste and by-products generated in the production processes (Bocken et al., 2014; Hazen et al., 2017; Kirchherr et al., 2018; Perey et al., 2018; van Capelleveen et al., 2020). The growing relevance of CE models is reflected in the increased attention being paid to the implementation of CE in businesses and organisations by institutions, policy-makers, and public administration (Bocken et al., 2016; Martins, 2018; Katz-Gerro and López Sintas, 2019; Millar et al., 2019). This interest is also reflected in the development of various policy initiatives to promote the CE models in organisations (Levänen et al., 2018; Haque and Ntim, 2018).

The research has not been alien to these initiatives and has analysed the impact of these policies on the adoption of CE strategies. Institutional theory has been used as a framework to explore the willingness of companies to engage in environmental activities (Berrone et al., 2013; Phan and Baird, 2015; Daddi et al., 2016; Wang et al., 2019). These studies rest on the assumption that institutional pressures may influence the environmental activities of firms (such as CE). The institutional perspective highlights the role of normative, mimetic and regulatory factors in influencing the decisions of companies to pursue a particular strategy, independently of the strategy's efficiency (Scott, 2005; DiMaggio and Powell, 1983; Delmas and Toffel, 2004). Despite the importance of the research examining the relationship between institutional pressures and the implementation of CE models in the firm, little is known about how institutional pressures operate (del Mar Alonso-Almeida et al., 2021). De Jesus and Mendonça (2018) point out that the difficulties to understand how these pressures act, arises from the need for interaction between institutions in the development of CE, and from the diversity of measures that stimulate CE at all levels (i.e.

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regulations, standards, guidelines, certifications, and educational frameworks). Moreover, different authors have concluded that the research is scarce, has focused more on qualitative research, and has generated contradictory results (Delmas and Toffel, 2004; Ahrens and Ferry, 2018; Zapata and Zapata Campos, 2019; Wang et al., 2019). Therefore, Ferasso et al. (2020) have highlighted the necessity for more academic research in this line, and Ahrens and Ferry (2018) and Zapata and Zapata Campos (2019) have emphasised the importance of empirically analysing how institutional actors drive these types of changes in firms and their effectiveness.

Thus, this paper empirically investigates the effect of institutional pressures on the development of CE in firms. First, in line with previous research on CE and environmental sustainability policy (Stål, 2015; del Mar Alonso-Almeida et al., 2021; Daddi et al., 2020), this study assumes the perspective of institutional theory, particularly institutional entrepreneurship, which indicates how organisations at all levels can act as 'institutional entrepreneurs' (Ahrens and Ferry, 2018). This study is framed in the context of the European Union (EU), a supranational institution, which, following Battilana et al. (2009) and Dorado (2005), acts as an institutional entrepreneur. Institutional entrepreneurs promote changes in the environment using different politics, strategies, activities and pressures (Greenwood and Suddaby, 2006). Using this framework, this paper assumes the conceptualisation of institutional pressures or power of DiMaggio and Powell (1983) and Scott (2005). Thus, this research considers three levels of institutional pressure (*coercive, normative, and mimetic*), and examine the effect of each individual type of institutional pressure on the CE in firms. Second, this paper analyses how institutional pressures affect the CE in firms, explaining the dynamics of how these pressures act. In line with Delmas and Toffel (2004) and Gao et al. (2019) that highlight the importance of studying the interactions between variables to explain the impact of institutional pressures, this paper argues that each type of institutional pressure is due, not only to itself, but rather it is conditioned by the rest of the institutional pressures. Based on this assumption, the research focus on the debate about the institutional effect on the development of CE in companies, which has yielded contradictory results (Wang et al., 2019). As mentioned before, this is problematic, especially because as noted by Boons and Lüdeke-Freund (2013) and del Mar Alonso-Almeida et al., 2021, an optimal combination of institutional pressures can influence the transformation of the CE, implying radical changes at all levels of an institutional environment. Hence, this paper postulates that the discrepancy in the results is due to a *methodological problem of the analysis*, since most of the prior quantitative research exclusively considers the direct effect of each type of institutional pressure on the organisation, without considering the possible interactions between institutional pressures, which might lead to indirect and even complementary effects. Thus, this paper examines the effect of the interaction between coercive, normative, and mimetic institutional pressures on the development of CE in firms.

To overcome these methodological concerns, this study combines conventional regression methods with Machine Learning (ML). ML consists of algorithms that automatically improve their performance with experience (Alloghani et al., 2020). Hence, ML with its good pattern recognition and modelling of multivariate non-linear relationships serve as a good tool to study CE models, given the great challenges these models pose for conventional regression methods due to their innate characteristics (Garbero et al., 2021; Gevrey et al., 2006). Particularly, for this research, Artificial Neural Networks (ANNs) are utilised, which are a type of ML method that allows analysing the interaction among variables (Ciurana et al., 2008; Somers and Casal, 2009) and has been extensively used in environmental analysis (see, for example, Olden et al., 2004). For this study, data from the European Union survey on *Public Consultation on the Circular Economy* database in the year 2015 is employed, which includes 870 organisations in different economic sectors (European Commission, 2015).

2. Conceptual background

2.1. Institutional pressures

The institutional theory (DiMaggio and Powell, 1983; North, 1991; Scott, 2005; Berrone et al., 2013) emphasises the social factors that affect organisations' actions. From this perspective, organisations seek approval from their environment and, therefore, are susceptible to social influence. Institutional theory has become a well-established theory with a large body of literature, rich with concepts and models to explain the influence of institutions on organisations (Greenwood et al., 2011; Stål, 2015; North, 1991). The literature ranges from institutional logics (see, for example, Thornton and Ocasio, 2008, or Stål, 2015), institutional complexity (Greenwood et al., 2011; Smets and Jarzabkowski, 2013) and institutional entrepreneurship (del Mar Alonso-Almeida et al., 2021; Battilana et al., 2009; Elliot, 2016; De Jesus and Mendonça, 2018). This research is contextualised within institutional entrepreneurship.

Institutional entrepreneurship is a process that contributes to radical changes in the institutional environment where this process takes place, including new organisational structures, new business models, new operating systems and procedures, among other types of innovations (del Mar Alonso-Almeida et al., 2021; Elliot, 2016; Covaleski et al., 2013; Battilana et al., 2009; DiMaggio and Powell, 1983). Battilana et al. (2009) consider that an organisation must meet the following characteristics to be considered an institutional entrepreneur: first, support the initiative of a divergent change, and second, actively engage in the transformation. Therefore, an institutional entrepreneur is an actor who leverages resources to create or transform an existing institutional context by introducing new ideas (Elliot, 2016), favouring change (Covaleski et al., 2013), and introducing new concepts and innovations to change a certain situation (del Mar Alonso-Almeida et al., 2021). Thus, Dorado (2005) asserted that institutional entrepreneurs could be powerful actors with sufficient resources, such as governments, supranational organisations, corporations and other similar agencies, to promote change. This is the case of the EU, where this research is contextualised.

From an operational point of view, and following De Jesus and Mendonça (2018), Dorado (2005), and del Mar Alonso-Almeida et al., 2021 institutional entrepreneurship exerts pressure or power to achieve a greater degree of acceptance and contribution to change. This type of power refers to the ability to promote change through technical and economic means, modifying values and practices, shaping attitudes and preferences. Thus, del Mar Alonso-Almeida et al., 2021 point out that the institutional entrepreneur takes advantage of the resources to transform the institutional context, initiating and actively participating in the change and using his position to involve different actors to promote the desired change. This paper assumes the definition of DiMaggio and Powell (1983) and Scott (2005), which describe the forces pressing institutions to adopt shared routines and notions. These authors propose three mechanisms by which institutional change takes place: *coercive, normative,* and *mimetic pressures.* Coercive pressures result from political influence and originate from pressures exerted on organisations, both formal and informal (DiMaggio and Powell, 1983; Teo et al., 2003). Concerning the protection of the environment, coercive pressures are a direct response to government regulations and incentives. Mimetic pressures derive from uncertainty and are a powerful force that encourages imitation (Liang et al., 2007). If companies face an unclear or ambiguous problem, organisations can model themselves on other organisations that can provide a viable solution with little expense (DiMaggio and Powell, 1983; Scott, 2005). The third source, normative pressures, stems from professionalisation, understood as the conditions and methods of work defined by the members of a specific organisational framework (DiMaggio and Powell, 1983; Scott, 2005). The growth of professional networks encompassing organisations through which new models diffuse rapidly, and formal education, generate normative

pressures that drive companies to implement predominant practices and behaviours (Teo et al., 2003).

2.2. Circular economy and the challenges in the development of CE models

The CE is conceptualised as a business model for closed-loop production and consumption systems, where the management of waste (that is, the final phase in the economic cycle) constitutes a valuable resource (Bocken et al., 2017; Jabbour et al., 2019). Compared to the traditional linear economic model, whose production model consists of "*take, make, discard*", the circular economy model builds an economic system that is more resilient and adaptable to the shortage of raw materials and energy resources (Zucchella and Previtali, 2019; Ferasso et al., 2020). Hence, the economic system proposed by CE models is one based on recycling and reusing resources, which reduces the demand for new raw materials and contributes to the reduction of the ecological deficit.

The development of circular economy models implies several important challenges (Linder and Williander, 2017; Kirchherr et al., 2018; Bressanelli et al., 2019; Figge et al., 2021). The first group of challenges refers to the complexity of the design and creation of CE models. CE can be viewed as an eco-innovation (Scarpellini et al., 2020; Marzucchi and Montresor, 2017), which implies an associated cost (Boggia et al., 2018; Choi et al., 2016; Dangelico, 2016; Bönte and Dienes, 2013), and managerial complexity for firms. Bönte and Dienes (2013), and De Marchi (2012), suggest that when there are no incentives to invest in eco-innovation, the social cost of pollution is reduced but the firms' private costs increase. Additionally, the literature on innovation identifies a set of challenges and barriers that firms must confront, i.e., market complexity, the uncertainty of the process, and the management of organisational resources for innovation (Dangelico, 2016; Evans et al., 2017; Demirel and Kesidou, 2019). Furthermore, because environmental knowledge is a public good, first innovators are easily imitable. Thus, followers do not incur the high cost and risks that this involves. Moreover, the literature on CE highlights other challenges such as the organisational culture, lack of technologies and information, waste management, and consumer resistance (Hopkinson et al., 2018; Hina et al., 2022).

Another group of challenges stems from the closed supply chains, which are a pillar of the CE model (Lüdeke-Freund et al., 2018; Kirchherr et al., 2018; Perey et al., 2018; van Capelleveen et al., 2020). The CE model encompasses not only all tasks involved in the production, distribution, and usage of products, but also the maintenance, reuse, recovery, and recycling. In other words, it embraces producer organisations, as well as users, intending to facilitate the development of CE. Lewandowski (2016) noted the importance of collaboration and cooperation among organisations for the application of closed-loop systems. However, partnership building is not without difficulties (Arranz et al., 2016, 2019). Finding the right partner, coordinating tasks, preventing and resolving conflicts may inhibit organisations' interest in implementing CE models through cooperation.

2.3. Institutional pressures and the circular economy

In this context, institutional pressures are drivers of the CE in firms. The literature has analysed the effect of institutional pressures on various environmental practices: for example, Ren et al. (2019), Liao (2018), or Aragon-Correa and Leyva-de la Hiz (2016) examine the adoption of *green innovation* in firms under the effect of institutional pressures. Usually, to adjust to the external and institutional environment, and to gain legitimacy, companies are prone to modify their organisational configurations and behaviours by adopting the leading strategy (Berrone et al., 2013; Daddi et al., 2016; Liao, 2018; Wang et al., 2019; Wei et al., 2020). De Jesus et al. (2019), Domenech and Bahn-Walkowiak (2019), and del Mar Alonso-Almeida et al., 2021 highlight the importance of resources for the implementation of CE. Boons and Lüdeke-Freund (2013) and Brown et al. (2019) indicate that incentives can help partner engagement for the development of CE models. Wang et al. (2019) show that if companies refuse the external and institutional environment, they can be isolated. Thus, it could be concluded that it is more likely that firms develop CE under various types of institutional pressures. Despite the importance of institutional entrepreneurship in the development of CE, little is known about how institutional entrepreneurs operate (del Mar Alonso-Almeida et al., 2021). This could be due to different reasons. On the one hand, this could be because of the need for interaction between institutions in the development of CE. This is the case of the European Union, a supranational institution, where interaction with various national governments is necessary to promote CE (Bocken et al., 2017; Brown et al., 2019; De Jesus et al., 2019). On the other hand, the diversity of measures and policies such as rules, guides, standards, certifications, and educational structures that promote CE at all levels, could be at fault (De Jesus and Mendonça, 2018). While regulatory efforts, such as directives and policies, have a positive effect (coercive nature, in the case of CE (Rodriguez-Antón et al., 2019; De Jesus and Mendonça, 2018), however, it is not clear how other types of measures, such as normative or mimetic, affect companies to implement CE. In this sense, this is problematic, because as noted by Boons and Lüdeke-Freund (2013) and del Mar Alonso-Almeida et al., 2021 an optimal combination of institutional pressures can influence the transformation of the CE, implying radical changes at all levels of an institutional environment. Table 1 classifies the main authors and themes of the literature review.

3. Hypotheses

3.1. The effect of institutional pressures in the development of CE

3.1.1. Coercive pressure for CE development

Coercive pressure, employed by institutions and governments, offers a push for organisations to adopt environmental practices and strategies (Berrone et al., 2013; Levänen et al., 2018; Ariti et al., 2019; Wang et al., 2019). Using various environmental standards and regulations, firms react to this regulatory pressure, which might enforce mandatory and disciplinary measures on company behaviours that are deemed illegal or immoral (Li and Yu, 2011).

Extended literature in the area of environmental policy and sustainability has highlighted coercive institutional pressure as a driver that encourages companies to develop both green products and processes compatible with the environment, either by creating a regulatory framework through standards, or by encouraging the development of these products or processes with financial support (see, for example, Arranz et al., 2019). In this regard, there are several initiatives that various governments and institutions are launching in the form of coercive pressures to promote the development of CE products. This is, for example, the Eco-design Directive 2009/125/EC from the European Union, which creates a framework for establishing eco-design requirements applicable to products that use energy, aimed at reducing energy consumption and other negative environmental impacts of products. While the primary goal of this Directive is to minimise energy use, it also aims to enforce other environmental concerns included in the CE product development framework, such as materials and water use, polluting emissions, waste issues and recyclability. Similarly, Spain has adopted the Zero Waste certification through the Spanish Standardisation Association (AENOR) and, in accordance with Directive 2009/125/EC, has created a set of eco-design requirements for ecological goods (European Commission, 2015). The AENOR Zero Waste certification recognises organisations that manage waste, reducing its generation, preparing it for reuse and/or transforming waste into raw materials and reintroducing them into the value chain. Therefore, in line with Wang et al. (2019) and Berrone et al. (2013), these rules and regulations, many of which are mandatory, must be followed by companies

Table 1
Authors and themes of the literature review.

Category	Theme		Description	References
Institutional Pressures	Institutional theory		Social factors that affect organisations' actions, behaviours and structures	DiMaggio and Powell (1983) North (1991) Teo et al. (2003) Scott (2005)
	Institutional Entrepreneurship		Create or transform an existing institutional context by introducing new ideas and favouring change	del Mar Alonso-Almeida et al. (2021)) Dorado (2005) De Jesus and Mendonça (2018) Elliot (2016) Covaleski et al. (2013) Battilana et al. (2009)
	Institutional logics and institutional complexity		Ideas underpinning practices prevailing in the industry Confronting incompatible prescriptions from multiple institutional logics	Stål (2015) Thornton and Ocasio (2008) Greenwood et al. (2011) Smets and Jarzabkowski (2013)
CE and the challenges in the development of CE models	CE concept		Definition of CE and applications of CE models	Bocken et al. (2017) Zucchella and Previtali (2019) Ren et al. (2019) Jabbour et al. (2019, 2020) Ferasso et al. (2020)
	Complexity in the design and creation of CE	Barriers for CE	Factors that hinder or impede CE models (such as managerial and market complexities, associated costs, organisational culture, lack of technologies, consumer resistance, etc.)	Linder and Williander (2017) Kirchherr et al. (2018) Hopkinson et al. (2018) Bressanelli et al. (2019) Figge et al. (2021) Hina et al. (2022)
		Eco-innovations vs CE	Description and characteristics of eco-innovation (to compare with the development of CE products)	Dangelico (2016) Boggia et al. (2018) Marzucchi and Montresor (2017) Scarpellini et al. (2020)
		Lack of incentives Public good quality	The absence of incentives suffered by companies to invest in ecological innovation	Bönte, and Dienes (2013) De Marchi (2012)
	Closed supply chains (Challenge)	Sustainable production models	Models for closed-loop production comprising the maintenance, reuse, recovery, and recycling; embracing producer organisations as well as users and third parties	Lüdeke-Freund et al. (2018) Perey et al. (2018) van Capelleveen et al. (2020)
		Collaboration and cooperation among organisations	Importance and difficulty of collaboration and cooperation for closed-loop systems	Lewandowski (2016) Arranz et al. (2016, 2019),
Institutional pressures and CE	Institutional pressures as drivers of CE		Effect of institutional pressures on shareholders, reporting policies, strategies, innovation, etc.	Liao (2018) Wei et al. (2020) Daddi et al. (2020)
	Institutional entrepreneurs and CE		Organisational practices are affected by values, norms, laws, cultures, social expectations, and common cognitions	Brown et al. (2019) De Jesus et al. (2019) del Mar Alonso-Almeida et al., 2021 Rodriguez-Anton et al. (2019) Boons and Lüdeke-Freund (2013)

to avoid being punished if they contravene them. Moreover, coercive institutional pressures can take the shape of incentive mechanisms, such as tax deductions, subsidies, and a low bank financing rate (Latan et al., 2018; Jabbour et al., 2020). Thus, creating direct incentives for the promotion and development of CE projects. For example, the EU has created the Circular Economy Action Plan (CEAP), which consists of a set of actions that establish the framework for the adoption of CE (European Commission, 2015, 2019). These actions are aimed at financing, informing, and enabling the CE products, which must be a key element that solves these drawbacks or encourages the development of CE products in the firm. Therefore, coercive pressures create rules and support that serve as a reference framework for developing 3Rs, 6Rs, or 9Rs[1] products, which must have a positive effect on their development. Hence, this paper proposes:

Hypothesis 1a. Coercive pressures on CE products impacts the

[1] Following Fonseca et al. (2018, p.3), "the CE model is framed on the principles of the 3Rs (reduce, reuse, recycle), the 6Rs (reuse, recycle, redesign, remanufacture, reduce, recover) and the 9Rs (refuse, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle, recover)".

development of CE.

As previously noted, the circular economy model is a closed-loop system. The development of the innovation process to implement CE models implies cooperation and collaboration with other organisations and institutions. Moreover, as extensively documented in the literature, the establishment of cooperation and collaboration agreements between companies entails a series of problems and barriers in their implementation (Bressanelli et al., 2019; Arranz et al., 2019). Thus, the primary challenges identified in the literature range from the search for the right partner, to communication problems between partners and coordination of tasks, as well as the existence of financial risks. In this sense, coercive pressures could promote support for the development of innovative business models between partners. First, this occurs through enabling the search for partners (via digital platforms and databases) and facilitating communication and negotiation among partners. For example, the French certification AFNOR's XP X30-901 for the development and implantation of CE, emphasises this management tool that permits the organisation, implementation, evaluation, and improvement of CE projects. Facilitating cross-organisational discussion and communication to represent both the mode of consumption and production via a single language and shared meanings. Second, the companies involved in the development of these collaborative projects allocate financial resources, withdrawn from other budget items. In this regard, a coercive impulse through financing can be an incentive for the development of CE processes that support the development of CE. Hence, this paper proposes:

Hypothesis 1b. Coercive pressures on CE processes impact the development of CE.

3.1.2. Normative pressure for CE development

Normative pressures originate from different social actors, such as customers and suppliers, as well as trade and industry associations (Scott, 2005). However, in the establishment of ground norms for the implementation of eco-innovations, trade and industry associations play crucial roles (Alda, 2019; Palmer and Truong, 2017; Chang et al., 2015), creating standard measures for voluntary use, or industry-led initiatives (self-regulation). For example, Wang et al. (2019) indicate that in the case of environmental management accounting implementation, behavioural norms will influence members in these associations. Companies can acquire better resources, knowledge and experience, as well as management skills by collaborating with organisations and industry associations (Liang et al., 2007). However, the normative pressure should not be an incentive to develop CE models in the organisation. As seen previously, the development of CE entails a double challenge. First, there is the creation of CE products, which involves substantial uncertainty for firms in terms of both, the technical solution, and the market acceptance of the new product, which adds to the costs of product development.[2] Second, it implies the development of closed-loop models, which entails collaboration and cooperation with other organisations. As indicated in previous hypotheses, this implies important obstacles and barriers in terms of cost and management that hinder implementation. Therefore, this research considers that the creation of sectoral standards of voluntary use or industrial self-regulation, as a normative impulse, does not provide sufficient incentive for companies to develop CE, given the important challenges that companies have in the development of CE models, involving associated costs and substantial managerial complexity for the firm, which leaves the company with a clear disadvantage, considering the public nature of environmental knowledge. Hence, this paper proposes:

Hypothesis 2. Normative pressures from sectors do not have an impact on the development of CE.

3.1.3. Mimetic pressure for CE development

Mimetic pressure arises when firms perceive the success of competitors' strategies and try to achieve equivalent benefits and advantages (DiMaggio and Powell, 1983; Scott, 2005), through voluntary imitation, particularly in the face of uncertain environments (Liang et al., 2007; Palmer and Truong, 2017). Wang et al. (2019) and John et al. (2001) point out that when faced with uncertainty problems, companies might research the behaviour of specific rivals and emulate those successful companies (John et al., 2001). Based on this, companies observe the development of CE business models, for example, in competitors, which propose a change from linear production to in-closed-loops production, assuming 3Rs, 6Rs, or 9Rs product development, and establishing partnerships with other organisations. Because of the *public good* nature of environmental knowledge (Tang et al., 2018), it is relatively simple to duplicate environmental products and services from first innovators. That is, without dealing with the high risks and research costs that these entail (Dangelico et al., 2017; Tang et al., 2018). However, if partnerships can be an option, the establishment of cooperation agreements is not without difficulties for the company (Arranz et al., 2019). Following these authors, from the search of partners, management of the agreement, to the resolution of conflicts, requires the company to possess the capabilities of prospective and negotiation, which are difficult to imitate. Therefore, it is expected that mimetic pressure does not have the power to influence the company to mimetically adopt CE development strategies from other companies, given the difficulties of establishing cooperation agreements with other companies in the CE process. Hence, this paper proposes:

Hypothesis 3. Mimetic pressures do not have an effect on the development of CE.

3.2. The effect of the interaction between coercive, normative, and mimetic institutional pressure on the development of CE

The interactions between variables in the fields of economics, management, and the environment, are an important and recurring topic. Interactions that produce synergistic and complementary effects between variables (see, for example, Hullova et al., 2016), or that moderate the effect of one variable on another are especially significant (Delmas and Toffel, 2004). In this paper, the interaction between an explanatory variable and an environmental variable is conceptualised as moderation. This means that the environmental variable moderates or modifies the effect of the explanatory variable (Delmas and Toffel, 2004). Therefore, to have an overview of the effect of institutional pressures on the development of CE, the case of interactions between the various types of institutional pressures has to be considered.

Unlike previous hypotheses, which postulated that there is no direct effect of normative and mimetic pressure on the development of CE, this paper proposes that if the existence of interrelationships between institutional pressures is introduced, both normative and mimetic pressures, together with coercive pressures, have an impact on the implementation of CE.

The interrelationship between coercive and normative pressures facilitates the development of CE. For example, every year, about 800,000 end-of-life vehicles are deregistered in Spain. In 2000, Directive 2000/53/EC was approved, which was transposed into Spanish legislation through RD 1383/2002. Thus, because of this coercive institutional

[2] The creation of green products requires a long development time, meaning significant costs of R&D investment, and extensive market research. The environmental literature refers to this effect as the double externality (Bönte, and Dienes, 2013; De Marchi, 2012; Porter and Van der Linde, 1995), which relates to the absence of incentives for firms to invest in environmental innovations. The minimisation of ecological damage by innovations lessens the burden on other polluting companies, as there is a societal benefit, without the latter needing to take any further measures. Furthermore, due to the public good feature of environmental knowledge, it is relatively simple to replicate the early innovations without suffering the substantial research costs and risks that this involves.

impulse, in 2007 one million vehicles were decommissioned, while in 2013 the figure did not reach 600,000 units. Compliance with said RD (Royal Decree) is done through the scrapping and recycling sector. End-of-life vehicles must be reused efficiently, especially with regards to the reuse of parts through the scrapping network. The lack of adequate financing by manufacturers, to cover the negative costs of managing these parts, means that they are practically not recycled. On the other hand, from the vehicle manufacturers' sector, initiatives have been carried out to advise on the dismantling of parts and even marking them, to facilitate their separation and subsequent recycling. This normative impulse developed by the manufacturing sector in combination and interrelation with the coercive impulse of RD 1383/2002, has meant that today there are about 950 authorised scrap yards and 28 fragmentation plants that recycle almost all the vehicles, creating an association that supports and advises on the management of end-of-life vehicles. Therefore, this example shows that the interrelation of coercive and normative pressures encourages companies to develop CE. While the action of the normative pressure had no effect on firms given the difficulties and costs of developing CE in firms, the combination with the coercive pressure makes firms assume the development of CE projects.

In this line, the need to implement CE in firms will be favoured if, in addition to following the rules and incentives of coercive pressure, through mimetic effect, the organisation assumes successful strategies from other companies. For example, during 2005 in Spain, RD 1619/2005 entered into force, which required tire manufacturers to provide a fund to finance the proper management of tires. In addition, this RD prohibited the dumping of tires. Since then, all the out-of-used tires or end-of-life tires (ELTs) have been recycled or recovered, having finished with the ELTs discharge. In response to RD 1619/2005, two Integrated Management Systems were created: (i) the "Sistema Integrado de Gestión de los Neumáticos Usados" (SIGNUS Ecovalor) – or Integrated Used Tire Management System. Created by five main tire manufacturers: Michelin, Goodyear, Dunlop, Firestone, and Pirelli, which manages 70% of the ELTs in Spain. In parallel, and mimetically adopting the strategies of the large companies in the tire sector, (ii) "Tratamiento de Neumáticos Usados" (TNU) - or Used Tire Treatment, was created. Fashioned by other importers and retreaders as an alternative and complementary system to that proposed by SIGNUS Ecovalor. This shows how importers and retreaders, which would have not been able to engage in the development of CE through mimetic pressures alone (due to a lack of managerial skills, know-how, or high cost), are able to do it by assuming and mimicking the organisational behaviours of the largest manufacturers in the sector (mimetic pressure), given coercive and normative pressures in place. Hence, creating their own management system to recycle or reuse around 30% of ELTs. Therefore, this example indicates that the interrelation of coercive, normative, and mimetic pressures promotes the development of CE in companies. While the action of the mimetic pressure had no effect by itself, the combination with the coercive and normative pressures, makes firms develop CE. Hence, this paper proposes:

Hypothesis 4. The interrelation of normative and mimetic pressures with coercive pressures has a positive effect on the development of CE.

4. Methodology

The methodology of this paper is based on a quantitative analysis, which combines traditional statistical methods (regression analysis) with machine learning (Artificial Neural Networks), and uses an EU database about the Circular economy.

4.1. Database

The empirical analysis is based on a cross-sectional database from the 2015 EU survey on the Implementation of the Circular Economy (European Commission, 2015). This database is used since it is the most recent one done at a European level regarding CE. The main purpose of the Survey is to comprehend the extent of the adoption of CE in firms, the motives, and organisations' knowledge and awareness on CE, and to explore ways of promoting CE business models. The survey focuses on three topics, in line with prior research by Ghisellini et al. (2016), Rizos et al. (2016), Fonseca and Domingues (2018), and Lakatos et al. (2016). The first set of questions is intended to describe the organisation. The second set of questions seeks to gather data on knowledge, motivation, and intensity in the organisation's adoption of CE models. Finally, the last series of questions concentrate on the actions aimed at facilitating the adoption of CE models in firms.

The survey has a similar structure to that of previous studies (Yuan et al., 2006; Fonseca and Domingues, 2018). The data was collected via an online database, over two weeks, following the methodology of "wave analysis" (Armstrong and Overton, 1977). Moreover, non-response bias has been verified, and no significant differences were found between early and late respondents. Previously, the survey was reviewed by a panel of CE model experts.

The sample consists of 870 organisations[3] in different economic sectors whose geographic distribution corresponds to the 27 countries of the EU. More in detail, approximately 60% of the companies belong to the industrial sector, the rest belong to the services sector. Regarding size, more than 50% of the companies have more than 250 workers; approximately 30% are companies with between 11 and 249 workers, and 15% correspond to large companies (more than 500 workers). Regarding the implementation of some certifications of Environmental Management (for example, ISO 14001; ISO 50001), about 30% of the respondents have held a certified EMS for more than 3 years.

4.2. Dependent variable

The dependent variable measures the implementation level of CE. As described by Pieroni et al. (2021) and Bocken et al. (2016), CE is measured as the rationale for creating, delivering, and capturing value while slowing, closing, or narrowing resource flows (i.e., energy or materials). This is in line with the question from the questionnaire that identifies several elements or characteristics of CE in firms that narrows or reduces the flow of natural resources: i) Durability; ii) Reparability: Design facilitating maintenance and repair activities; iii) Reparability: Availability of spare parts; iv) Reparability: Information for reparation; v) Upgradability and modularity; vi) Reusability. The importance of each item is rated based on a Likert scale, which ranges from 3 (very important) to 0 (not important). One variable was generated, *CE*, as a factor analysis of all seven previous items (Cronbach's Alpha: 0.948).

4.3. Independent variables

The first variable measured in this paper is *coercive pressure*. Wang et al. (2019) and Ghisellini et al. (2016) highlight two types of direct actions from governments and institutions to promote CE. The first type of pressure tries to promote both the design and consumption of CE products. Following the questionnaire, four items were used to create the *Coercive1* variable: i) Establish binding rules on product design (e.g. minimum requirements on 'durability' under Ecodesign Directive, 2009/125/EC); ii) Promote and/or enable the use of economic incentives for eco-innovation and sustainable product design (e.g. via rules on Extended Producer Responsibility schemes); iii) Review rules on legal and commercial guarantees; iv) Review rules on legal and commercial guarantees (Cronbach's Alpha: 0.816). The second variable that measures coercive pressure is *Coercive2*. This variable measures the importance of promoting CE solutions in production processes. Five

[3] The total database consisted of 1280 organisations and companies. After filtering, eliminating incomplete responses, microenterprises and individuals, the final sample contains 870 organisations.

items from the questionnaire are used to create this variable: i) Support the development of innovative business models; ii) Improve the interface between chemicals and waste legislation; iii) Support the development of digital solutions; iv) Identify minimum standards for increasing resource-efficient processes; v) Provide access to finance for high-risk projects (Cronbach's Alpha, 0.724).

The next independent variable is *normative pressure* (*Normative*). Following Scott's (2005) description of the normative elements that shape the nature of organisations-oriented behaviour, the variable *Normative* is generated. The questionnaire identifies elements from professional networks and sectoral levels that promote the development and implementation of standards and frameworks in companies. Two items are used to create the variable: i) Encourage industry-led initiatives (i.e. self-regulation); ii) Develop standards for voluntary use (Cronbach's Alpha: 0.718).

Finally, the questionnaire includes a series of items to measure *mimetic pressure* (*Mimetic*). As mentioned before, and following Liang et al. (2007), mimetic pressures aim to develop actions inside the company, similar to those of other companies. That is, to implement sector best practices and for the development of collaboration between companies. In this context, the questionnaire frames the items as promoting knowledge exchange and spillovers through the collaboration for the transfer of best practices, as well as the direct exchange of these best practices. The questionnaire includes three items that conform the *Mimetic* variable: i) Identify and promote the exchange of best practice; ii) Identify and promote best practices for cooperation across value chains; iii) Identify and promote best practices for collaboration between and among private and public sector (Cronbach Alpha: 0.867).

The importance of all independent variables is measured through a Likert scale, which ranges from 3 (very important) to 0 (not important).

4.4. Control variables

Moreover, to properly measure the relationship of the dependent and independent variables of the model, the following two control variables are included in the analysis.

- *Sector.* The first control variable identifies the sector in which the organisation operates. This variable equals 1 if the organisation pertains to the industrial sector, and 0 for the service sector. This variable is used because effects on different sectors are to be expected (Rizos et al., 2017).
- *Environmental management.* The second control variable refers to the use of environmental management in the organisation, which following Marrucci et al. (2019), are useful tools for the promotion of CE. The questionnaire proposes the following items: i) EU eco-label[4]; ii) Eco-Management and Audit Scheme (EMAS)[5]; iii) Another environmental management scheme[6]; and iv) No environmental management scheme. A binary variable is created that is equal to 1 when organisations use any of the above-mentioned environmental management schemes, and 0 otherwise.

[4] Ecolabelling schemes are intended for consumers to obtain information regarding the environmental quality of particular products and companies at the time of purchase, allowing them to choose products that are environmentally friendly (Marrucci et al., 2019).

[5] The European Commission established the EMAS as a management tool for corporations and other organisations to review, report on, and improve their environmental performance. It applies to all industries globally and aims to improve performance, transparency, and credibility on an organisation's environmental performance (Marrucci et al., 2019).

[6] Such as ISO 14001 or ISO 50001.

4.5. Estimation models

To test Hypotheses 1a, 1b, 2 and 3 that explore the direct effect of institutional pressures on the development of CE (Table 4), this paper shows how the variability of each type of institutional pressure explains the variability of the dependent variable. To do this, an OLS regression model is utilised. Thus, *CE* (Y_1) is utilised as the dependent variable, and the institutional pressures (*Coercive1, Coercive2, Normative, and Mimetic)* as independent variables, including, also, the control variables. The direct effect of each variable is measured by the regression coefficient. Table 4 shows the regression analysis with the developed models. The equations below show the two main models.

Model 1 (Basic Model):

$$Y_1 = constant + \beta_1(Sector) + \beta_2(Environmental\ Management) + e \quad (1)$$

Model 6 (Full Model):

$$Y_1 = constant + \beta_1(Sector) + \beta_2(Environmental\ Management) + \beta_3(Coercive1) + \beta_4(Coercive2) + \beta_5(Normative) + \beta_6(Mimetic) + e \quad (2)$$

Hypothesis 4 studies the *interaction effects* of institutional pressures on the development of CE (Fig. 1). To do this, this research assumes that an interaction effect occurs because there is an interrelation between various types of institutional pressure. Thus, this paper considers that one type of institutional pressure affects the probability of developing CE, conditioned by the interrelation with the other institutional pressure. Fig. 1, shows this effect, in which variable x_1 is combined with variable x_2, being w_i the weight that each variable has in the combination; and the new variable arising from the combination of both affects the variable Y. To model the interaction effects, an ANN is used, which is a type of ML. The ANN architecture is based on the Multilayer Perceptron (MLP). This structure is considered feedforward since the connections of the network flow forward from the first layer or input layer (independent variables), to the last layer or output layer (dependent variables) (Minbashian et al., 2010). There may be several hidden layers between these two layers, whose role is essential in the MLP's generalisation capability. Fig. 2 below displays the structure of the ANN-MLP model.

Regarding the structure of the ANN-MLP network, this paper employed the *trial and error procedure* (Wang, 2007; Ciurana et al., 2008), since there are no well-established approaches in the literature for identifying these structures (see Table 2). First, this research has to consider that the inputs of the proposed network are determined by the number of independent variables, and the number of neurons in the output layer (i.e., one) by the dependent variable. Second, regarding the number and size of hidden layers, different combinations of the number of hidden layers and the number of neurons are tested to find the right fit (Hornik et al., 1989). Although, as proposed by Ciurana et al. (2008) and Mehrotra et al. (1997), a two-layer neural network is frequently enough to construct an accurate model. Finally, it is necessary to consider the activation functions. This paper assessed the same network architecture with three distinct configurations of activation functions (tangential, sigmoid logistic, and linear function) to analyse and determine the best ANN model, following Wang (2007) and Ciurana et al. (2008). The chosen configurations of architecture have been tested against different initial conditions to ensure that the proposed model is the best fit (Wang, 2007).

5. Analysis and results

The robustness of the questionnaire and results were tested, which this paper explains before presenting the results of the analysis. First, as proposed by Podsakoff et al. (2003), the common method bias (CMB) and the common method variance (CMV) were tested. These analyses show five latent constructs that represent 83.19% of the variance. As the first factor is below the recommended threshold of 50% (i.e., 26.04% of

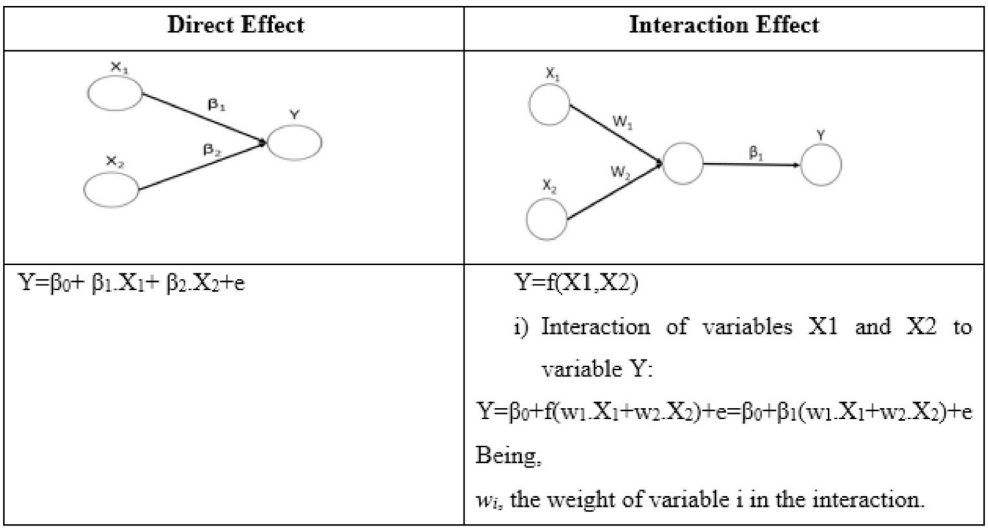


Fig. 1. Direct and Interaction effects among variables.

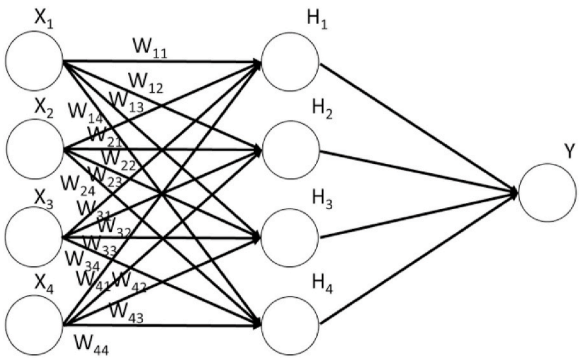


Fig. 2. The structure of the ANN-MLP model.

Table 2
The Procedure of ANN design: The main stages.

Stages	Choices
1. Choose the ANN typology	• MLP (Multilayer Perceptron).
2. Design of ANN-MLP architecture	• Input and output variables • Number and size of hidden layers • Activation Functions
3. The choice of the learning algorithm	• Backpropagation Algorithm
4. The learning stage	• Training phase (60%) • Testing phase (20%) • Holdout phase (10%)

the variance), both CMB and CMV are not a concern in the model. Second, to examine the statistical robustness of the regression analysis, this paper checked the collinearity test (VIF) and the autocorrelation test (Durbin-Watson). Table 4 displays the robustness of the results, showing adequate values for VIF and Durbin-Watson. Third, this paper has checked the robustness of the regression analysis adjustment by comparing the results of linear regression with other non-linear regression models (quadratic and cubic). Table 3 shows that the different regression models have similar results, both in the contribution to the variability of the model (R^2) and in the significance of the coefficients. The results do not reveal significant differences between these various types of analysis. Fig. 3 illustrates the fit of the various regression models proposed in Table 3 (linear, quadratic, and cubic regression).

Concerning the results, Hypotheses 1a and 1b indicate how coercive institutional pressure affects the development of CE (Table 4). In Model 6, the results show that coercive institutional pressure on product development ($\beta = 0.372$, $p < 0.001$), and process development ($\beta = 0.238$, $p < 0.001$), have a significant and positive effect, corroborating the two hypotheses. Regarding hypothesis 2 which explores the effect that normative institutional pressure, derived from sector associations and with voluntary basis, has on the development of CE. The hypothesis is not corroborated since it was argued that it had no effect (Table 4; Model 6). The results suggest that the effect is significant but negative ($\beta = -0.088$, $p < 0.05$). Finally, Hypothesis 3 is supported since the results do not show a significant effect of mimetic pressure (Table 4; Model 6).

Hypothesis 4 refers to both normative and mimetic institutional pressures in interaction with coercive institutional pressure. This hypothesis is analysed using an ANN. Following Cavalieri et al. (2004) and Ciurana et al. (2008), two types of tests were performed: the robustness of the ANN architecture and the robustness of the simulation. The robustness and reliability of the ANN are high, reflected by the level of error (training stage: 0.573, testing stage: 0.507) and the level of correlation between the ANN's predicted output and the observed output (correlation: 0.650). Moreover, Fig. 4 shows the response of the network to the variation of each input variable (institutional pressures) and its effect on the output of the real variables and the predicted output of the ANN. In the graphs, a similar response to the real variable output and predicted output can be seen. This enables us to confirm, in accordance

Table 3
Comparison of regression models.

Regression Model	Coercive1		Coercive2		Normative		Mimetic	
	R Square	β	R Square	β	R Square	β	R Square	β
Linear	.325	.501***	.194	.452***	.030	-.045***	.001	-.028
Quadratic	.327	.609***	.198	.470***	.044	-.242***	.005	-.065
Cubic	.356	.805***	.208	.542***	.068	-.412***	.005	-.070

*p < 0.05; **p < 0.01; ***p < 0.001.

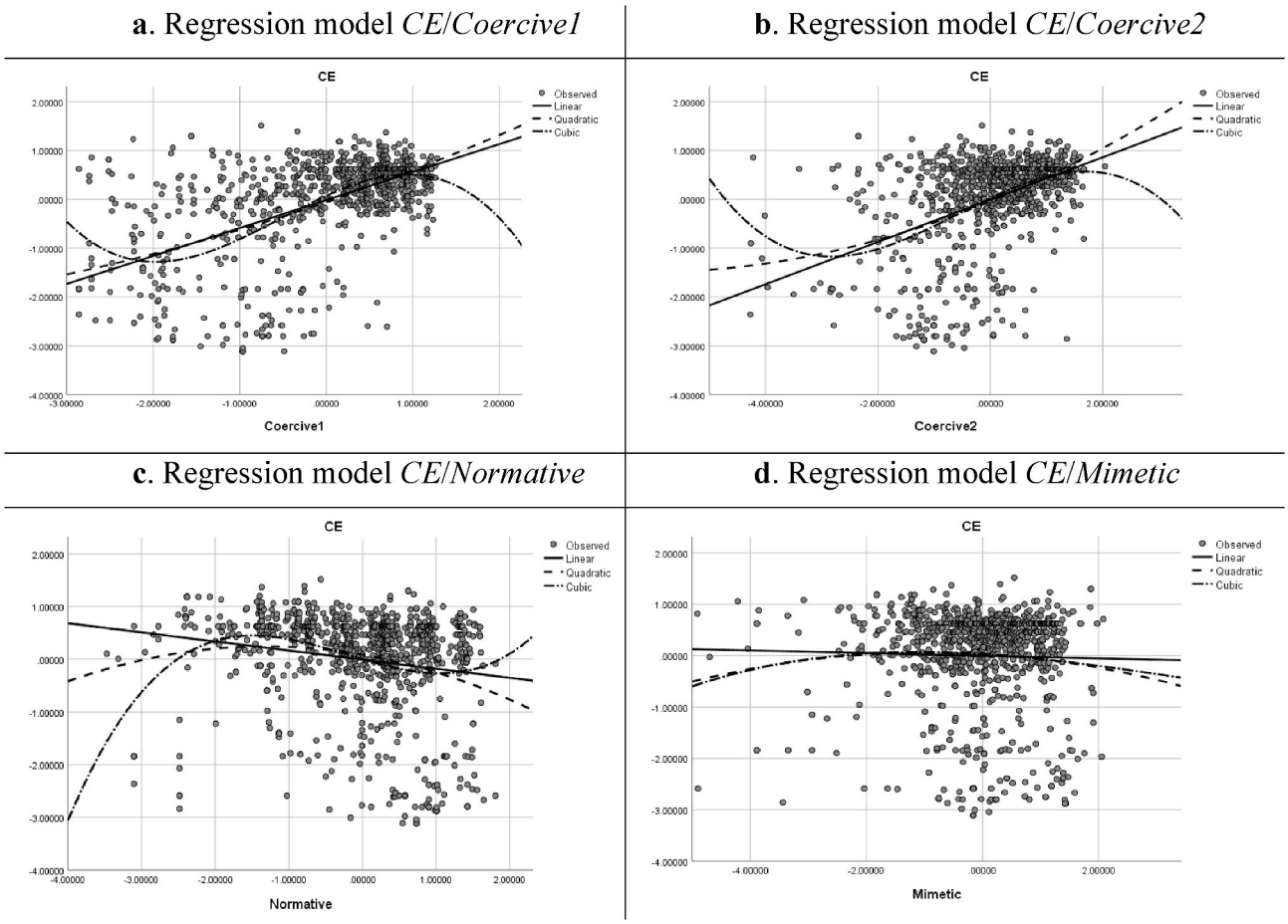


Fig. 3. The fit of regression models.

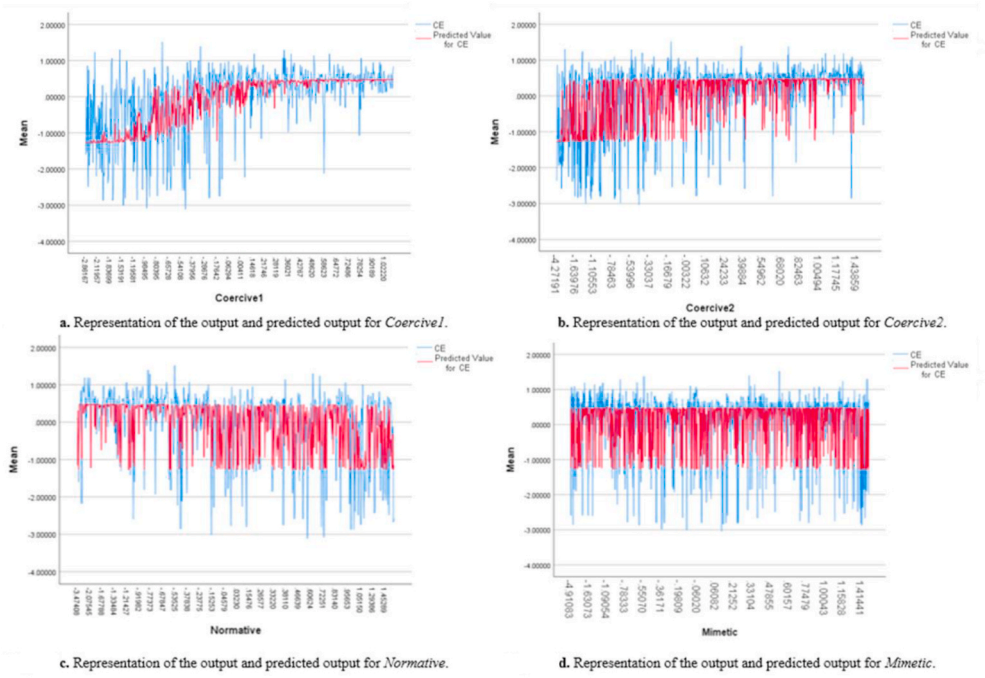
Table 4
Regression and multicollinearity analysis.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	VIF
	Estimated	Estimated	Estimated	Estimated	Estimated	Estimated	
Coercive 1		.501***				.372***	1.023
Coercive 2			.452***			.238**	1.049
Normative				-.045**		-.088*	1.520
Mimetic					-.028	-.016	1.558
Sector	.174**	.156**	.167**	.176**	.172**	.142*	1.333
Environmental Management	-.141*	-.127*	-.054	-.140*	-.137*	-.087	1.320
Adjusted R2	.045	.295	.238	.044	.039	.322	
R2	.053	.304	.247	.056	.052	.340	
Durbin-Watson	1.787	1.848	1.712	1.867	1.710	1.869	

*p < 0.05, **p < 0.01, ***p < 0.001.

with previous studies, that the ANNs' fit is better compared to that of regression models, explaining the effect between independent variables and the dependent variable more adequately (see Table 4). To construct the ANN model, a *trial and error* approach was followed. The data was adjusted to a 4-1-1 configuration (Fig. 5), which corresponds to 4 input variables, 1 node in the hidden layer, and 1 variable in the output. In this case, a hyperbolic activation function and an identity function are used for the hidden layer and the output layer, respectively. Fig. 6 shows the interaction of the three institutional pressures and the normalised importance of the effect of each institutional pressure on the output variable (*CE*).[7] It is observed that both *Coercive 1* (0.484; 100% normalised value) and *Coercive 2* (0.288; 59.5% normalised value) have a positive effect on the output variable, which is in accordance with the results of the regression analysis. However, the effect is more significant when the variable affects product development (*Coercive 1*). This can be explained either because the specific measures on the product (for example, designs of environmental products) are more concrete, or because the measures on the CE process are more ambiguous.

[7] For an explanation on obtaining the relative importance of input variables on output variables, see Ibrahim (2013). Specifically, we obtained the coefficients following Garson's (1991) work.



a. Representation of the output and predicted output for *Coercive1*.
b. Representation of the output and predicted output for *Coercive2*.
c. Representation of the output and predicted output for *Normative*.
d. Representation of the output and predicted output for *Mimetic*.

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Fig. 4. Representation of the output and predicted output for different institutional pressures.

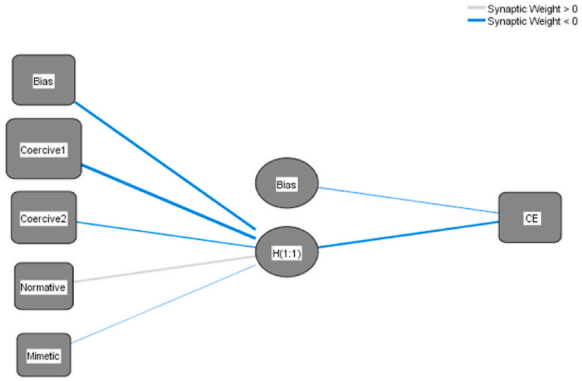

Fig. 5. ANN-MLP architecture.

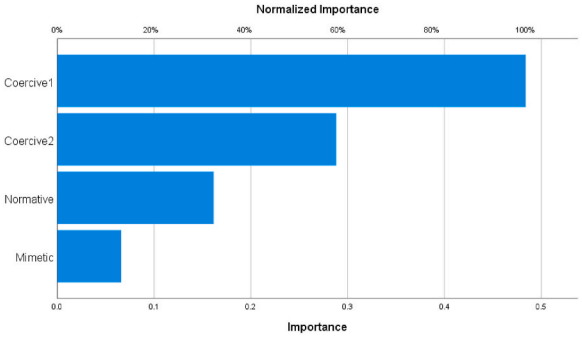

Fig. 6. Diagram of normalised importance of input variable to the output variable.

Additionally, as Lewandowski (2016) points out, the latter (CE process – *Coercive 2*) involves third parties for the establishment of cooperation agreements. On the other hand, both normative and mimetic pressure have a significant and positive effect on the development of CE, supporting Hypothesis 4. Likewise, normative (0.162; 33.4% normalised value) and mimetic pressures (0.066; 13.7% normalised value) have a positive impact on the adoption of CE in companies.

6. Discussion and conclusion

This paper studies the effect of institutional pressures on the development of CE in firms. This research distinguishes between various types and levels of institutional pressure (coercive, normative, and mimetic), examining how these institutional pressures affect the development of CE in companies, but also explaining how these pressures act.

This study is framed in the context of the EU, a supranational institution, which, following Battilana et al. (2009) and del Mar Alonso-Almeida et al., 2021, meets the conditions of being an institutional entrepreneur. Thus, first, the role of institutional entrepreneur that this institution exercises is confirmed, as it has the ability to influence companies. The results demonstrate that the pressures or power exerted by the EU makes it possible to achieve a greater degree of acceptance and contribution to the change towards the CE, corroborating previous studies (De Jesus and Mendonça, 2018; del Mar Alonso-Almeida et al., 2021). Thus, the results show that the EU uses both coercive, regulatory, and mimetic pressures, which allow promoting change through technical and economic means, modifying values and practices, shaping attitudes and preferences for the implementation of CE in firms (del Mar Alonso-Almeida et al., 2021; Elliot, 2016; Covaleski et al., 2013; Battilana et al., 2009; DiMaggio and Powell, 1983).

Regarding Hypotheses 1a and 1b, which indicate that coercive institutional pressure affects the development of CE. The results of the analysis are in accordance with DiMaggio and Powell (1983), coercive pressure utilised by governments and institutions compels organisations to obey them. These results confirm previous literature, which suggested that compulsory institutional pressure or incentives for the promotion of CE have a significant impact on CE adoption in companies (del Mar Alonso-Almeida et al., 2021; Rodriguez-Anton et al., 2019). This is either because companies would be castigated if they infringe the rules

and regulations (Wang et al., 2019; Li and Yu, 2011; Roxas and Coetzer, 2012), or because the incentives (tax deductions, subsidies, and a low bank financing rate) encourage companies to solve the obstacles and difficulties in developing CE in the firm (Latan et al., 2018; Jabbour et al., 2020). More specifically, the results extend previous research (Haque and Ntim, 2018; Hazen et al., 2017), showing that coercive institutional pressures designed to develop the 3Rs, 6Rs, or 9Rs products, or the coercive pressure aimed at the development of CE processes (through financing for collaborative projects or facilitating the search for partners through digital platforms and databases) are an approach for the development of CE in firms.

Regarding Hypothesis 2, which explores the effect that normative institutional pressure, derived from sector associations and with a voluntary basis, has on the development of CE, the results contradict previous studies, which indicate that normative pressures either have a positive effect or have no effect on the development of environmental products (Wang et al., 2019; del Mar Alonso-Almeida et al., 2021). This paper argues that it does not have a positive effect, framing it in the so-called double externality effect, which relates to the lack of incentives faced by companies when investing in eco-innovation (De Marchi, 2012). Moreover, the results indicate that the development of CE by firms, unlike previous studies on eco-innovation, is a reactive attitude of companies to a voluntarily increase eco-innovation practices from sectoral associations, without the firm having a clear motivation for its development. This can be explained since the CE model not only involves developing new products, but also a change in the production system, involving other organisations, which is an addition to the complexity of tasks to be carried out in an eco-innovation context.

On the other hand, Hypothesis 3 is supported since the results do not show a significant effect of mimetic pressure, contradicting previous research that indicated information as key in the development of CE (see, for example, del Mar Alonso-Almeida et al., 2021). These findings highlight the lack of incentives for companies to invest in CE. As suggested by previous research, the voluntary acceptance of eco-innovation is seen by companies as an internal cost, although the social cost of polluting decreases (De Marchi, 2012). The development of CE products requires a prolonged time, which implies elevated costs of R&D investment, and a comprehensive market investigation (Dangelico, 2016; Evans et al., 2017; Tang et al., 2018). Moreover, rivals can copy CE products easily without dealing with these costs mentioned, due to the *public good* feature of environmental knowledge.

Concerning Hypothesis 4, the results note that the interaction of normative and mimetic with coercive pressures changes the effect on firms in the development of CE. Thus, this research concludes that normative and mimetic pressures have no effect by themselves, but change their effect in interaction with coercive pressure. These findings reinforce the conclusions of previous research, such as del Mar Alonso-Almeida et al., 2021, providing further evidence that a broad portfolio of actions and policies are critical for the implementation of the CE model. Moreover, a slight difference in the impact of *Normative* and *Mimetic* is observed, where normative pressures have greater normalised importance than mimetic, given interaction with coercive pressures. As a consequence, the results extend the literature, indicating that in interaction the pressures of sectoral associations are more effective for CE implementation than, for example, mimetic pressures, derived from the discretionary nature and experience of companies.

The paper makes two key contributions, firstly, it contributes theoretically to the field of institutional theory and environmental sustainability literature, and secondly, it contributes methodologically. Moreover, it provides some interesting implications for environmental policy and managers.

The *first contribution is theoretical*. Prior institutional theory research assumes there is a relationship between institutional pressures for the implementation of environmental activities and the organisation's strategies. In line with DiMaggio and Powell's (1983) and Scott's (2005) seminal work, which classifies institutional pressure both in its intensity and in its diversity (coercive, normative, and mimetic), the literature has analysed its effect on the environmental strategies of organisations. However, when the institutional pressure varies or decreases, as in the case of normative or mimetic, the results are not conclusive. These contradictory results have generated a debate about the effect of institutional pressures on environmental development in companies. The theoretical contribution is framed in this debate, clarifying the results. While coercive pressures have a compulsory effect or incentive for the development of CE in firms, mimetic and normative pressures do not have that effect by themselves. However, this research observes that the interaction of coercive, normative, and mimetic pressures changes the effect on companies for CE development. This can be argued due to the importance of norms and compulsory rules, or the existence of an incentive in environmental development, for the implantation of CE models in firms. Therefore, normative and mimetic pressures have no effect by themselves, but change their effect in interaction with coercive pressures. These results provide further evidence that a broad portfolio of actions and policies are critical for the implementation of the CE model.

The *second contribution is methodological*. Previous studies have used regression methods and considered exclusively the direct effect of each type of institutional pressure on the organisation, therefore, generating contradictory results. As shown in this study, both the low explanatory power of the regression models, in terms of explained variance, and the low significance of the explanatory variables, are a problem for the analysis with regression models, generating these conflicting results. In contrast, the empirical framework in this paper considers the possible interactions between different institutional pressures, which means, that each type of institutional pressure is due, not only to itself, but rather is conditioned by the rest of the institutional pressures. To overcome the methodological concerns, an ANN was used, which is a type of ML method that allows analysing the interaction among variables. The use of an ANN allows not only to analyse the interaction of variables, but also to consider the existence of non-linearities in this process, obtaining an explanatory power much higher than that obtained with regression analysis. Therefore, given the results, this research clarifies the debate about discrepancies in the effect of institutional pressures and conclude that it is a methodological problem.

Lastly, the study findings provide a range of *governmental and managerial implications* for the development of CE in firms. From the point of view of governments, this research provides an important contribution, especially from the perspective of environmental policy, since it suggests that a comprehensive policy is required for the development of CE, which implies the coexistence or interaction of the three types of pressures. This is also an interesting finding for policymakers, as in the face of a comprehensive policy, interaction is feasible and may lead to a decentralisation of institutional pressure, comprising either coercive, mimetic, or normative measures.

Regarding managers, despite the compulsory effect of coercive pressures, they should not underestimate the effectiveness of normative and mimetic measures for the promotion of CE in the company. Hence, based on the findings, this paper provides some guidelines for managers and decision-makers, when a circular environmental regulatory framework (i.e. coercive pressures) is in place:

First, managers and decision-makers should prioritise the adhesion to frameworks, standard measures for voluntary use, or industry-led initiatives, for example, at the sectoral level (normative pressures). This means that normative pressures are an effective measure in the company for the development of CE when there are established coercive pressures.

Second, if there are enough resources and capacity, then managers and decision-makers should also pursue strategies to obtain best practices by mimicking the behaviour of successful competitors (mimetic pressure) to facilitate the development of CE in the firm. That is, when coercive and normative pressures are in place, organisations can benefit from mimetic measures because they would lead to the successful

development of CE. The combination of the three types of pressures will help adopt CE in the firm most effectively.

As with any research, this study has some limitations, which could provide fruitful avenues for future research. This study utilises data from companies in the EU. Data from other territories and countries could be collected to further corroborate the hypotheses and conclusions of this research, thus allowing for a more holistic view. Future studies could examine the role of institutional pressures as drivers of CE in firms pertaining to other countries, such as the US, or developing countries, such as Latin America or Africa, where more research is needed. Moreover, this research employs a cross-sectional database, and therefore, is unable to examine how the effect of institutional pressures on the adoption of CE in firms changes over time. Such a line of inquiry could provide insights into the dynamic forces that shape the environmental responsiveness of firms in an institutional environment. Although, this does not diminish the validity of the results and their contribution to the literature. Finally, repeated surveys would help deliver more robust evidence and insights on the role of institutional pressures as drivers of CE in firms, however, official surveys often tend to change circular economy questions, or even take many years, undermining the possibility of observing the dynamic path.

CRediT authorship contribution statement

Carlos F.A. Arranz: Conceptualization, Methodology, Data curation, Formal analysis, Writing – original draft, preparation, Writing – review & editing. **Vania Sena:** Supervision, Conceptualization, Methodology, Data curation, Writing – original draft, preparation, Writing – review & editing. **Caleb Kwong:** Supervision, Conceptualization, Methodology, Data curation, Writing – original draft, preparation, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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