How to drive corporate responsible innovation? A dual perspective from internal and external drivers of environmental protection enterprises

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Responsible innovation has been widely concerned by the public sector and actively explored by scholars for its great role in supporting eco-innovation and sustainable development. However, as the main body of innovation, enterprises have not been fully recognized. Moreover, the research on the driving factors of responsible innovation is mostly the direct influence of a single factor, lacking the overall consideration of the internal and external environment. To bridge this research gap, this study, by deeply interviewing 13 entrepreneurs in environmental protection enterprises, clarified the concept of corporate responsible innovation and its four-dimensional framework (inclusion, anticipation, reflexivity, responsiveness), and then proposed the MPN-MSE driving factor model of corporate responsible innovation from the internal and external perspectives. The external factors include market pressure (M), policy pressure (P), and normative pressure (N), while the internal factors include responsible innovation motivation (M), responsible innovation system (S), and responsible innovation elements (E). The research findings provide an important theoretical contribution to the research of corporate responsible innovation.

KEYWORDS

corporate responsible innovation, environmental protection enterprises, drivers, dual perspective, construct

1 Introduction

Responsible Innovation (RI), which was first proposed in the EU (Horizon, 2020) framework program, emphasizes the establishment of an open, interactive and transparent innovation process in which innovation actors share responsibility with social actors, attempting to rationally embed scientific and technological progress in the evolution of social development and to guide innovation processes and products towards ethical acceptability, development sustainability and social satisfaction to address the social impacts of innovation and the latest technological advances (Owen et al., 2012; Schomberg, 2012; Christofi et al., 2022). Corporate social responsibility has become an

important factor for enterprises to achieve sustainable management (Lee and Jeong, 2022). As the main body of innovation, enterprises are also the main body of implementing responsible innovation, which plays important role in promoting the research and practice of responsible innovation. This is particularly representative of environmental protection enterprises because sustainable development can be achieved by deepening into more effective and eco-friendly products and technologies (Moldes et al., 2013). Environmental protection has always been the focus of social concern, which will affect the sustainable development of the social economy (Wang et al., 2022).

However, due to the huge uncertainties and lag effects of innovation as well as the lack of awareness of innovation responsibility in some enterprises (Gauttier et al., 2017; Jakobsen et al., 2019; Magni et al., 2022), entrepreneurs or Top Management Teams (TMT) tend to have a short-sighted view about corporate innovation behaviors. Thus, it is of great importance to study the issue, which is how to drive environmental protection enterprises implementing corporate responsible innovation (CRI) or under which circumstances do the enterprise will carry out responsible innovation behaviors.

Existing research has explored to some extent the target characteristics, ethics of responsibility, and implementation methods of responsible innovation (Saille, 2013; Burget et al., 2017), defining the basic elements of responsible innovation (including a broad interactive process of subjects, forward-looking forecasting, and the highlighting of moral factors), but findings on responsible industry projects suggest that firms lack the understanding of responsible innovation concepts (Gauttier et al., 2017; Stahl et al., 2019). At the same time, the behavioral logic of companies has shifted from a single point of departure of economic rationality to a focus on institutional rationality, and with it a shift in management perspective from a focus on efficiency only to a focus on organizational legitimacy (He et al., 2012). In other words, the behavioral logic (economic rationality, institutional rationality, social rationality, etc.) and management perspective (efficiency, effectiveness, legitimacy, etc.) of companies have become more diverse. Therefore, a comprehensive understanding of the factors influencing innovation behavior from the perspective of internal and external drivers is necessary to achieve a win-win situation in terms of both internal and external benefits. However, existing studies have started from a single perspective (internal or external) of what drives responsible innovation, focusing on the external (major social challenges (Chatfield et al., 2017a; Čeičytė, 2019; Schönherr et al., 2020), stakeholder (Auer and Jarmai, 2018; Tian and Tian, 2021) and internal [profit-seeking and risk reduction (Chatfield et al., 2017a), cultural values and institutional structures (Chatfield et al., 2017b; Ranabahu, 2020)] perspectives to explore the drivers of firms' implementation of responsible innovation, but there is a lack of research that

examines the role of corporate responsible innovation from an integrated internal and external perspective.

Some companies may not be sufficiently aware of their responsibility to innovate, which is likely to lead to a certain degree of short-sightedness in the innovative behavior of companies (Gauttier et al., 2017; Ranabahu, 2020), and thus there may be some real potential crises. From an external corporate perspective, companies may face increasing development pressure from competitors, pressure from social third-party agencies to evaluate, and pressure from consumers for high comfort and environmental protection (Power, 2008). Internally, companies need to maintain relationships with key stakeholders (e.g., high-end customers, government), comply with ethical regulations for energy efficiency and environmental protection, as well as follow their own strategic guidelines for product development, and avoid possible leakage of customer privacy information due to intellectual technology (Eden et al., 2013). These compounding realities, both internal and external, are partly driving companies to seek new management paradigms and concepts. In addition, the social consequences of technological innovation often lag behind, taking more than a decade to become apparent (Owen and Goldberg, 2010; Chatterjee et al., 2021). Therefore, the existing strategic thinking and governance paradigm of companies may not be able to address the negative externalities (e.g., data leakage) and lags of technology innovation, and there is an urgent need for innovative management models in the early stages of research and development, such as implementing corporate responsibility innovation to more effectively meet social needs and ethical constraints (Van den Hoven, 2013), so that companies can better deal with the potential crisis of ethics, environmental protection and sustainable development brought by technological innovation.

To sum up, we put forward the practical problems of implementing responsible innovation in companies and make contributions to the gradually expanding research literature on responsible innovation through the following analysis: (a) Clarifying the concept of corporate responsible innovation; (b) Exploring the internal and external mechanisms driving corporate responsible innovation in environmental protection enterprises.

The contribution of this study is mainly reflected in the following three aspects. Firstly, environmental protection enterprises are selected as the research objects, which expands the existing research scope of corporate responsible innovation. At present, research on corporate responsible innovation is concentrated in the fields of artificial intelligence, gene editing, nanomaterials, and biomedical ethics (Alexander and Katharina, 2017; Shelley et al., 2018; Bruce and Bruce, 2019; Buhmann and Fieseler, 2021). However, researches on industries closely related to the ecological environment such as environmental protection enterprises are scarce. Secondly, this study clarifies the concept

and structural system of responsible innovation at the firm level and enriches the scope of responsible innovation research. Previous research on responsible innovation has mainly focused on the macro level such as public governance, but less research has been conducted on the micro firm level. Thirdly, this study advances the study of the antecedents of corporate responsible innovation by exploring the drivers of corporate responsible innovation from both internal and external perspectives. By analyzing the internal and external environmental factors as a whole, the study facilitates a comprehensive understanding of the drivers of corporate responsible innovation.

The subsequent sections of this paper are organized as follows: the next section will review the literature on responsible innovation and corporate responsible innovation, as well as CRI's drive factors. This is followed by the description of the research methodology in Section 3. Section 4 will present the results, while the research findings will be discussed in Section 5, including the theoretical and practical contributions of this paper as well as an explanation of future research directions. This is followed in the sixth section by a summary.

2 Literature review

2.1 Responsible innovation

Starting from the research focus, the conceptual content of responsible innovation can be divided into three aspects: intrinsic attributes, process and management, and evaluation of results. Firstly, based on the internal attribute perspective of responsible innovation. Dreyer et al. (2020) emphasize that responsible innovation needs to be rooted in an innovation ecosystem of stakeholders, including government, business, and consumers, where each stakeholder has a role and responsibility, and where stakeholders are able to make forward-looking collaborative decisions based on existing knowledge to guide innovation in the direction of social needs satisfaction and ethical requirements (Stilgoe et al., 2013; Mei and Chen, 2015). Wilford (2016) focuses on the central role of the responsibility attribute of actors in the research and innovation process, arguing that responsible innovation creates a change whereby actors need to be concerned with the potential impact of their own practice of innovation and take responsibility for it.

Secondly, based on the process and management perspective. Schomberg (2012) proposes that responsible innovation is a transparent and interactive process in which social actors and innovators give feedback to each other, taking full account of the ethical acceptability, sustainability, and social desirability of the innovation process and its market products so that scientific and technological developments are properly embedded in social development. Stilgoe et al. (2013) then propose a broader definition of responsible innovation than the above, namely

that responsible innovation means exploring the future of innovation through the collective management of current science and innovation. Mei and Chen (2015) believe that responsible innovation is a dynamic process involving collaborative decision-making involving multiple stakeholders, which prospectively evaluates innovation objectives and results based on existing knowledge and builds an adaptive institutional system of science and technology governance to guide innovation toward the direction of social demands and moral and ethical requirements.

Thirdly, based on the evaluation of the results perspective. Hellström (2003) was the first to propose a framework for responsible innovation from a technology assessment and risk management perspective by analyzing forms of systemic innovation and their associated risks, through which the complex technical and risk issues of systemic innovation can be assessed and managed. Spruit et al. (2016) propose that responsible innovation is a collective collaborative and inclusive process to realize the transfer from the expected goal evaluation of the innovation process to the quality evaluation of the innovation process.

To sum up, the research on concept of responsible innovation are summarized in Table 1.

In the latest research on responsible innovation, the study of Kuzma (2022) shows that the main forces that hinder the implementation of responsible innovation in the governance system of emerging technologies are concentrated in the mesolevel and macro level, and uses the policy process theory to analyze the possible ways to bring responsible innovation into the national policy agenda. Ambos and Tatarinov, (2022) point out that responsible innovation wants a wide range of stakeholders to participate in scientific decision-making by expressing their needs and concerns, whereas individuals who believe in scientific conspiracies pose a challenge. Therefore, Popa and Blok, (2022) use the ideal experimental method to explore the relationship between responsible innovation and scientific conspiracy theories, and test four possible exclusion criteria for scientific conspiracy theories.

2.2 Corporate responsible innovation

Existing research on responsible innovation has focused on exploring the sources of ideas and the policy orientation of science and technology, in the public sector (Van den Hoven et al., 2012; Stilgoe et al., 2013; Pelle and Reber, 2015) and academic research (Van der Burg and Swierstra, 2013) predominantly, but there is little research on responsible innovation in business contexts (Pavie et al., 2014; Scholten and Blok, 2015; Foley et al., 2016), lacking exploration of the theoretical and practical implications of their management (Ribeiro et al., 2017). However, as the main body of innovation, the theoretical research on responsible innovation

TABLE 1 The research on concept of responsible innovation.

Research perspectives	Main research contents
The internal attribute perspective	• Responsible innovation needs to be rooted in an innovation ecosystem of stakeholders, including government, businesses, and consumers Dreyer et al. (2020)
	• Responsible innovation creates a change whereby actors need to be concerned with the potential impact of their own practice of innovation and take responsibility for it Wilford, (2016)
	• Responsible innovation requires stakeholders are able to make forward-looking collaborative decisions based on existing knowledge to guide innovation in the direction of social needs satisfaction and ethical requirements Stilgoe et al. (2013); Mei and Chen, (2015)
The process and management perspective	• Responsible innovation is a transparent and interactive process Schomberg, (2012)
	• Responsible innovation means exploring the future of innovation through the collective management of current science and innovation Stilgoe et al. (2013)
	• Responsible innovation is a dynamic process involving collaborative decision-making involving multiple stakeholders Mei and Chen, (2015)
The evaluation of the results perspective	• Hellström, (2003) was the first to propose a framework for responsible innovation from a technology assessment and risk management perspective
	• Responsible innovation is a collective collaborative and inclusive process to realize the transfer from the expected goal evaluation of the innovation process to the quality evaluation of the innovation process Spruit et al. (2016)

of enterprises is of great significance. Since 2017, the research on responsible innovation has entered the exploration stage of theoretical construction, and the implementation and research of corporate responsible innovation have been paid more attention.

2.2.1 Implementation status: Exploration of responsible innovation in the business context

The exploration of responsible innovation in the business environment is in its infancy, and studies have been conducted to investigate successful practices related to responsible innovation in firms and to develop elements of evaluation indicators.

Findings regarding responsible industry projects suggest that firms lack an understanding of the concept of responsible innovation. However, this does not necessarily mean that they innovate in an irresponsible way (Gurzawska et al., 2015). For example, Stahl et al. (2019) through a qualitative survey of a number of companies in the ICT industry conducting 'responsible' activities, suggest that although they do not fully understand the meaning of responsible innovation, they are aware of some ethical and social issues related to their activities and have adopted some of the ideas of responsible innovation (Stahl et al., 2019). The results indicated that these companies, although not fully understanding the meaning of responsible innovation, were aware of some ethical and social issues related to their activities and had adopted some of the ideas of responsible innovation. However, in practice, the implementation methods to promote responsible innovation are often fragmented and not systematically integrated and effectively explored (van de Poel, 2020). Through business network resilience, Xie et al. (2022) found that responsible innovation has a positive impact on the sustainable

performance of enterprises, and the resilience of business networks plays a mediating role in this relationship.

Further, Stahl et al. (2017) constructed a maturity model for responsible research and innovation. Firms can assess their maturity level of responsible research and innovation in terms of purpose, process and product, and locate the stage of maturity they are at. Jin et al. (2016) constructed an index system for evaluating responsible innovation based on the need to evaluate responsible innovation in three aspects: the enterprise product design concept, the product production process and the evaluation and supervision mechanism in Dalian High-tech Zone, China. Coffay et al. (2022) put forward the comprehensive concept of responsible innovation laboratory, developed responsible innovation tools and impact tools, and developed environment-specific methods to predict and evaluate the potential of new enterprises to improve sustainability.

2.2.2 The conceptual content of corporate responsible innovation

At present, an academic exploration of responsible innovation concept in business focuses on managers' willingness to act and stakeholders' influence in the business environment. Ramadhan (2017) studied the individual behavior of responsible innovation in the business environment and argued that responsible innovation behavior refers to embedding the concept of responsibility into the beliefs, attitudes and intentions of individual innovators, i.e. adding responsibility to the whole process of innovation thinking, and eight questions were designed to measure four aspects of responsible idea generation, responsible fluency, responsible flexibility and responsible innovation realization (Ramadhan, 2017). Čeičytė (2019) identifies the main characteristics and

concepts of responsible innovation in business contexts based on literature analysis, arguing that responsible innovation is a democratic, inclusive and transparent innovation process that is used by organizations in solving major challenges related to related problems, seeking innovations with stakeholders that have positive added value for society and the environment, and using 11 items to measure responsible innovation behavior in companies (Čeičytė, 2019). Adomako and Tran (2022) studied environmental cooperation, responsible innovation and enterprise performance, and found that stakeholder pressure positively regulates the impact of environmental cooperation on responsible innovation, and responsible innovation further regulates the relationship between environmental cooperation and enterprise performance (Adomako and Tran, 2022).

However, the current definition of corporate responsible innovation is not tailored to enterprises. For business-oriented enterprises, their responsible innovation should be rooted in the ecological environment they rely on (Long et al., 2020; Wiarda et al., 2021) and based on what enterprises are already doing (Katharina et al., 2020). Therefore, we believe that corporate responsible innovation is inevitably embedded in the network of social development. Through openness, transparency and interaction, entrepreneurs or managers and other stakeholders urge enterprises to determine the current innovation behavior in order to prevent possible adverse results in the future, so as to take responsibility for innovation, that is, corporate responsible innovation is the responsible innovation behavior of enterprises facing social expectations, Such behavior should fully consider the external environment represented by ethics, public values, technical characteristics, industrial chain, industrial culture, etc. And the internal elements represented by entrepreneurs.

2.3 Influence factors for CRI

### 2.3.1 Motivations for implementing corporate responsible innovation

Firstly, from an organizational change perspective, the fact that organizations face major challenges is an important driver for firms to implement responsible innovation. The level of environmental cooperation of enterprises will affect corporate responsible innovation (Adomako and Tran, 2022). The networked nature of the environment in which firms operate facilitates the implementation of their responsible innovation, i.e., the integration of internal and external stakeholders in the firm contributes to the emergence of responsible innovation ideas and their implementation in the firm to address and solve major societal challenges (Chatfield et al., 2017a; Schönherr et al., 2020). In turn, major social challenges (e.g., poverty, health and safety) are important drivers of technological innovation (Pandza and Ellwood, 2013).

Second, from an institutional theory perspective, gaining legitimacy is an important factor that drives firms to implement responsible innovation. Trittin-Ulbrich and Böckel (2022) took corporate digital responsibility as an example to study how entrepreneurs in different fields construct corporate digital responsibility, so as to legalize the commitment of enterprises to responsible digital innovation. Responsible behavior is seen as necessary for organizational success and survival, and firms implementing responsible innovation can both improve their corporate image and potentially enhance their competitive advantage and thus increase profits (Stahl et al., 2019). Furthermore, corporate responsible innovation behavior is a strategic response to external institutional pressures (both formal and informal) and reflects an organization's ability to adapt and choose its external environment (Mei and Chen, 2015). And soft law mechanisms can help overcome the limitations of hard law in the global governance of responsible innovation in multinational organizations (Voegtlin and Scherer, 2017). Third, the demands of stakeholders such as consumers and public forces (Auer and Jarmai, 2018) also drive the implementation of responsible innovation in firms, with customer satisfaction being a strong and attractive incentive for firms. Mainstreaming responsible innovation into existing funding schemes is therefore an important incentive for firms (Zwart et al., 2014), as is the perceived legitimacy of responsible innovation to attract investment.

Fourth, in terms of organizational development, the pursuit of profit and risk reduction are the primary factors for firms to engage in responsible innovation. The potential for greater economic benefits from effective stakeholder involvement in innovation is widely accepted and, as a result, some firms may engage in activities related to responsible innovation for purely pragmatic reasons to reduce economic risk and improve the acceptability of their products and services (Zwart et al., 2014).

Fifth, in terms of corporate culture, cultural values and institutional structures have a profound impact on the development of responsible innovation. Corporate culture, awareness of responsible innovation, and ethical codes of conduct are important influences on the development of responsible innovation in firms (Chatfield et al., 2017b), such as implicit and explicit ethical commitments (Stahl et al., 2019), the intrinsic motivations of key individuals in the firm such as founders and executives, their attitudes towards responsible performance and their past experiences. In addition, the management and organizational structure of a company can promote responsible innovation by explicitly considering ethical, social or other responsibilities for action, and by supporting employees' commitment to implementing responsible innovation, which in turn facilitates its implementation.

In addition, some scholars have researched and proposed a more comprehensive set of drivers for responsible corporate innovation. On the one hand, instrumental motives (e.g.,

FIGURE 1
Motivations for implementing corporate responsible innovation.
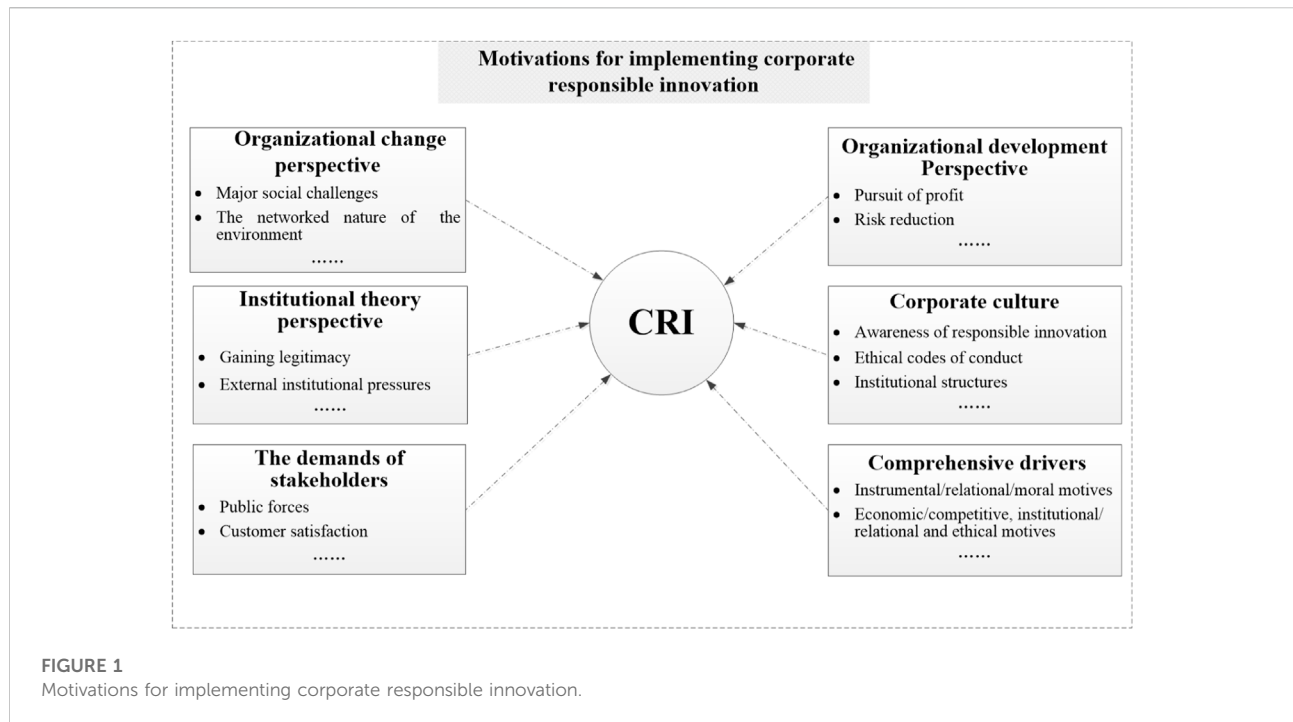
profit-seeking), relational motives (e.g., voluntary compliance with laws and regulations under regulatory pressure, legitimacy craving) and moral motives (originating from companies and employee groups with high demands for moral and ethical norms) (Yaghmaei and Poel, 2021), or economic/competitive, institutional/relational and ethical motives (Chatfield et al., 2017b) are three important motivators that lead organizations to implement responsible innovation. On the other hand, the six factors, including regulatory framework, availability of financial resources, market orientation, customer knowledge, organizational structure and knowledge among innovation partners, will affect the degree of responsible innovation (Auer and Jarmai, 2018).

To sum up, the existing research about the motivations for implementing corporate responsible innovation are summarized in Figure 1.

2.3.2 Barriers for implementing corporate responsible innovation

Firstly, profitability is the primary consideration in business decisions, and this conflicts with the notion that responsible innovation goes beyond a financial profit-only orientation (Brand and Blok, 2019). Secondly, the prevailing notion of innovation, that it stems from information asymmetries in the marketplace and that firms have a clear incentive not to engage with stakeholders, is inconsistent with the openness and inclusiveness required by responsible innovation and may also lead to resistance from firms

(Garst et al., 2017). In addition, insufficient resources can limit the implementation of responsible innovation in firms, such as internal factors like budgetary constraints and funding issues, lack of human resources, and external factors like lack of financial support and investor understanding for responsible innovation in the market. Further, insufficient ethical considerations in organizations and systems are also important reasons why some people and institutions engage in irresponsible innovation behavior (Liu et al., 2016). Figure 2 presents the study of barriers factors for implementing corporate responsible innovation.

2.3.3 Situational factors for implementing corporate responsible innovation

Corporate responsible innovation may be associated with specific industries (Stahl et al., 2017), and therefore the industry in which a firm operates may be an important moderating variable. For example, in the context of ICTs for health, population change and wellbeing, many innovation processes are highly regulated and require close alignment with the values of responsible innovation (Chatfield et al., 2017a). Furthermore, Auer and Jarmai (2018) note that all factors can be drivers or barriers for firms to undertake responsible innovation, in the process of driving or hindering enterprises to carry out responsible innovation, many environmental or situational factors from inside (e.g., corporate culture) or outside (e.g., public policy) will have different degrees of influence in this process.

FIGURE 2
Barriers for implementing corporate responsible innovation.
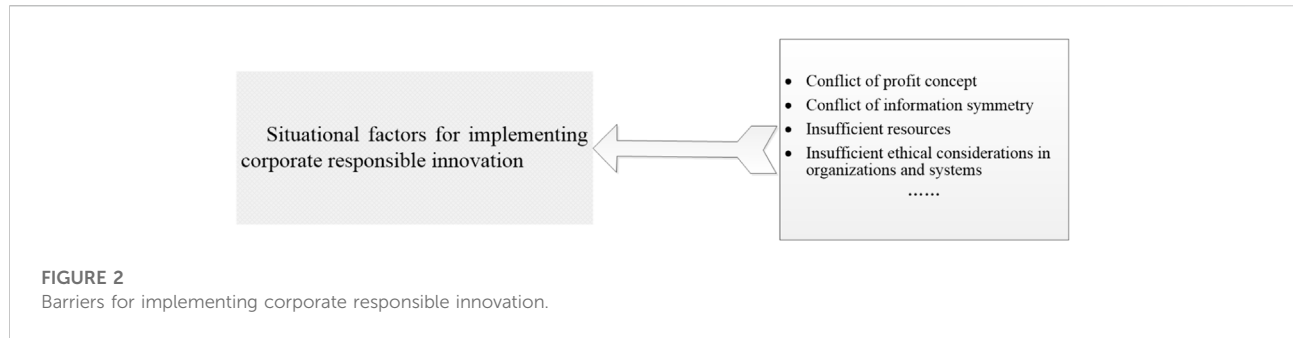
2.4 Research on CRI based on internal and external perspectives of the organization

In the study of the drivers of corporate implementation of responsible innovation, scholars have generally adopted a perspective based on both external and internal organizational perspectives to explore. Because corporate responsible innovation requires the collaborative participation of multiple actors, the introduction of influencing factors from internal and external the organization and the refinement of the roles, functions and division of labour of different actors are more conducive to a comprehensive understanding of corporate responsible innovation. For example, Chatfield et al. (2017a) et al. explored the drivers of implementing responsible innovation in ICT firms from the perspective of both external to the organization (significant social challenges) and internal to the organization (pursuit of profit and risk reduction) (Chatfield et al., 2017a). Cao and Chen, (2017) et al. explored the driving effects of external policy pressure, market pressure, internal innovation resources, and innovation capabilities on green innovation strategies from an internal and external environmental perspective, using 216 firms as a research sample (Cao and Chen, 2017). In addition, van de Poel (2020) discusses how companies can integrate responsible research and innovation into their socially responsible policies and business strategies (van de Poel, 2020). The impact of the internal and external environment on a firm's responsible research and innovation strategy is explored at both the strategic and operational levels, and Key Performance Indicators (KPIs) for corporate responsible research and innovation are developed to help firms measure the extent of implementation and outcomes of responsible innovation. Therefore, it is feasible and important to study corporate responsible innovation from a dual perspective of internal and external organization.

2.5 Environmental protection enterprises and CRI

The environmental protection enterprises in our study include those engaged in water pollution control, air pollution control, noise control, and solid waste treatment et al. The innovation-driven development of environmental protection enterprises is characterized by the allocation of relevant human resources, financial resources and capital, as well as the conversion efficiency of resource value and patent output (Bărbulescu et al., 2021). The prospect of responsible innovation is to achieve sustainable economic and social development. The existing research results show the innovative companies are always sustainable, there is a positive correlation between innovation and enterprise sustainability (Sempereripoll et al., 2020). The environmental protection industry is one of the most complex industries. Due to various challenges in project planning and research, great efforts are required. In recent years, the construction of the environmental protection industry has been promoted to the top of national strategy in China (Feng et al., 2022). Therefore, it is of great significance to study the responsible innovation of environmental protection enterprises.

In summary, firstly, there is still a lack of sufficient integration between responsible innovation and business in terms of practical application (Schönherr et al., 2020). Although some scholars have investigated companies conducting 'responsible' activities and attempted to construct a system of indicators for evaluating responsible innovation in companies, a maturity model, and key performance indicators to measure the level of implementation of responsible innovation, the evaluation methods are mainly qualitative analysis and fragmented descriptions. The difficulty in effectively screening and objectively evaluating the level of implementation of corporate responsible innovation is an important reason for the slow promotion of the concept of responsible innovation at the enterprise level. As an innovation subject, enterprises run through the research and practice of responsible innovation from stakeholders to important participants, then to key implementation subjects, and from "behind the scenes" to "in front of the stage", playing a more and more obvious role. Therefore, it is urgent to focus on the research of corporate responsible innovation.

Second, previous studies have analyzed the influencing factors of corporate responsible innovation from the aspects of environmental networks and major challenges (Čeičytė, 2019), legitimacy acquisition (Stahl et al., 2019), institutional

pressures (Mei and Chen, 2015; Voegtlin and Scherer, 2017), stakeholder requirements (Ramadhan, 2017), and corporate culture (Chatfield et al., 2017b), but as they are developed separately and not systematically integrated, it is also difficult to comprehensively consider the joint influence of multiple internal and external factors and the interactions between different factors, making it difficult to carry out quantitative analysis and in-depth exploration of the driving mechanisms. The current study will explore the driving factors of responsible innovation from internal and external perspectives.

3 Methodology

Qualitative research can choose from a number of different forms of data collection, and we chose in-depth interviews as the most appropriate method for this study. Burgess, (1988) describes an interview as a type of "purposeful conversation", and interviews are probably the most commonly used method of qualitative data collection. Compared to other methods such as questionnaires (Opie, 2004; Montazeri et al., 2016), interviews allow researchers to gain a deeper understanding of participants' attitudes, beliefs and perceptions. In addition, the use of interviews is well suited to investigating topics for which data may not be available in other forms, those for which data may only be found among key informants or "key players in the field" (Denscombe, 1998). Interviews with these key figures can provide a direct route to in-depth information that is not available elsewhere.

The initial interview question was raised by the members of the research group in 2 months. The researchers asked 9 questions in an attempt to reveal respondents' experiences and perspectives on the topic of CRI. Respondents were asked questions about their level of knowledge of CRI, existing practices, and motivations for implementing CRI (see Appendix A for details).

In summary, to facilitate an understanding of what CRI means for enterprises, we began with the following two research questions:

- What is the concept of current CRI-related activity?
- What are the potential drivers for CRI in environmental protection enterprises?

3.1 Data collection

This study's consideration of Corporate Responsible Innovation arises under the influence of the negative externalities that exist in the development of science and technology innovation. Therefore, we conducted 13 in-depth interviews in some environmental protection enterprises in China. All interviewees are currently or have previously held

at least one key position in a large or small enterprise. To ensure anonymity, interviewees' individual names and their companies could not be identified, Table 2 provides an anonymized overview of interviewer characteristics.

Interviewees receive an invitation letter and an information sheet. Each interview lasts approximately 45–120 min and is conducted via face-to-face or online voice communication. All interviews were conducted in an ethical manner, such as informed consent, respect for privacy, and avoidance of harm and deception (Diener and Crandall, 1978; Frey and Fontana, 2005). In addition, each subject member followed the same interview guidelines, which were developed specifically for this study, and used the same interview schedule. This was necessary to promote consistency among the interviewers.

Although semi-structured interviews use pre-set questions, the actual topic varies between participants to allow respondents to describe their personal experiences, opinions and feelings about the subject matter. The interviewer's task is to ask for details or seek clarification if necessary, rather than to provide opinions or use leading questions. The interviews were conducted using recursive questioning so that they proceeded as a conversation rather than a question and answer session.

3.2 Data analysis

Following Chatfield et al. (2017b), the method we use is content theme analysis, as described by Burnard et al. (2008). This method is usually used for qualitative data analysis, including a detailed review of interview records to determine the themes and categories within the data. We invited three professional researchers to conduct manual step-by-step coding. By classifying and refining the contents of the interview manuscript, we improved the level of abstraction and interpretation and formed clear themes and categories.

First, all interview descriptions are screened according to the following two criteria: On the one hand, the description must have a clear meaning. On the other hand, the description must be related to CRI. Secondly, the purpose of data analysis is to extract themes from a large number of qualitative data. After further merging similar items, merging semantically similar descriptions, eliminating semantically ambiguous descriptions, and eliminating descriptions that do not match the reality of the company, a total of 20 items about corporate responsible innovation were obtained. Furthermore, after repeated deliberation by three professional researchers and further induction of all interview descriptions, 4 dimensions were obtained about the concept and behavior of corporate responsible innovation. Similarly, 6 dimensions about the driving factors of corporate responsible innovation in environmental protection enterprises were extracted.

TABLE 2 Anonymized overview of the interview participant details.

Code	Type of business	Size	Position held	Interview duration
1	Environmental technology services	Small	CEO	1 h
2	Sewage treatment	Small	CEO	0.8 h
3	Urban solid waste comprehensive services	Small	CEO	1 h
4	Solution for the urban waste treatment	Small	CEO	2 h
5	New energy technology	Small	CEO	1 h
6	Water pollution control	Large	Minister of government affairs	1.5 h
7	Air pollution control	Large	Head of R&D Department	1.5 h
8	Energy recovery system development	Large	Head of Business Department	1.5 h
9	Water conservancy project quality inspection	Small	CEO	1 h
10	Photovoltaic power	Large	CEO	1.5 h
11	Environmental protection monitoring	Small	Head of R&D Department	1 h
12	Noise control	Small	CEO	1.2 h
13	Environmental monitoring	Small	CEO	1.5 h

TABLE 3 Research questions and associated dimensions.

Research question	Dimensions/factors
What is the concept of current CRI-related activity?	Inclusion
	Anticipation
	Reflexivity
	Responsiveness
What are the potential drivers for CRI in environmental protection enterprises?	Market pressure
	Policy pressure
	Normative pressure
	Motivation of responsible innovation
	System of responsible innovation
	Elements of responsible innovation

4 Results

Table 3 details the two questions and their respective dimensions and factors that emerged from the subsequent analysis, showing the relationship between the research questions and the categories.

In the following content, these two research questions and their dimension classification will be explained in more detail, and each dimension is provided with explanatory quotes from respondents to help summarize its meaning. The interviews were coded (1–13), representing the serial number of the respondents respectively.

4.1 The concept of corporate responsible innovation

In the interviews, we asked respondents about their level of knowledge of CRI and four categories were extracted from the deep descriptions of the participants including "inclusion," "anticipation," "reflexivity," and "responsiveness".

4.1.1 Dimension 1: Inclusion

Corporate responsibility innovation is oriented towards inclusion, it is to induce more stakeholders to participate in innovation activities, which can be done through various ways

such as dialogue and debate for collective deliberation of innovation activities and listening to the demands of different subjects on innovation activities. All respondents, without exception, agreed on the need and benefits of stakeholder involvement in innovation activities, which is typical of the responses:

> "When undertaking an innovative activity, the interests of all parties need to be weighed and considered." (1: Consider the interests of stakeholders)

> "Balancing the interests of all parties: the customer is at the core, because he has to use your stuff and consume it through him. Second is all the employees of the company. The third is the company's shareholders." (4: Consider the interests of the stakeholders)

Integrating the interests of stakeholders in the innovation process is ultimately a win-win situation in order to achieve economic and social benefits, as the interviewees talked about in their interviews:

> "People who come and refer business to me get a commission, and the commission from referring you by sharing the referral counts towards your earnings." (4: Win-Win with Stakeholders)

In addition to considering the interests of stakeholders and achieving a win-win situation with them, two other dimensions of inclusions were included in the interview themes: observing social and business ethics in the innovation process and considering the responsibility of innovation for ethical, ecological, economic and social development. As the interviewee said in the interview:

> "We take the culture of mutual trust as the support of supply chain management, build and share the business atmosphere of integrity with the upstream and downstream supply chain nodal enterprises, and form a very competitive strategic alliance." (2: Observe social and business ethics)

> "In terms of adopting green technologies, we focus on selecting recyclable, renewable, degradable and easy to treat green materials and cleaning equipment to achieve green supply chain management." (5: Consider the responsibility of ethical, ecological, economic and social development)

4.1.2 Dimension 2: Anticipation

Adverse impacts of new technologies are often not foreseen and risk-based hazard estimates often do not provide early warning of future impacts (Hoffmann-Riem and Wynne, 2002). Anticipation is to anticipate the potential impacts and risks directly related to the science and technology innovation

activities themselves and to effectively deal with the unintended consequences that may arise from research and innovation through technology assessment, scenario planning, and other methods (Bozeman et al., 2015; Kuzma and Cummings, 2021), taking into account social, environmental, and ethical influences, so as to "prospectively govern" the innovation activities and realize the controllable risks of innovation activities. The majority of interviewees indicated that they anticipate the ethical, ecological, economic, and social risks that innovation may pose:

> "The environmental protection piece, we have brought in some advanced talents from the country and internationally. Before doing each project to start construction, our environmental protection department will assess environmental safety, which also includes part of social responsibility." (6: Forecasting risks)

> "We ask for a lot of early warning before we do each project." (6: Predicting risk)

Forecasting is forward-looking systems thinking that situates innovation within the study of socially robust crisis management, thus placing the possibility of negative externalities, innovation uncertainty and other factors arising from scientific liberalism in the context of manageable social crisis management and social development orientation. For example, some interviewees mentioned that they consider the possible outcomes of innovation from a long-term perspective of social and environmental benefits:

> "Any design we do is not only for the present but also for the future. We have to sink what remains the same to deal with what changes in the future, to respond quickly to what changes, to create productivity that can be replicated quickly." (7: Considering long-term outcomes)

> "From a forecasting perspective, in the midst of the innovation process, predicting the future, the impact of this thing years down the line." (7: Considering long-term outcomes)

4.1.3 Dimension 3: Reflexivity

Responsibility requires reflection by actors on the known or unknown purposes, motivations and potential impacts of innovation (Stilgoe et al., 2013), which implies self-reflection on the assumed premises, requirements, goals, processes of implementation, and outcomes of innovative activities, and the realization that a particular framework for an issue may not be universally held. Social theorists consider reflection as a condition of contemporary modernity (Beck et al., 1994).

> "When companies innovate, they must adhere to the relevant requirements of the overall regulatory policy, which is the red

line, what can and cannot be done, what is done by licensed institutions and what is done by non-licensed institutions, clearly delineated." (10: Reflection and Legitimacy)

Depending on the level of knowledge of CRI, respondents generally agreed that there is a need for reflection in the innovation process, particularly on the legality of innovation activities, i.e. thinking about whether innovation activities comply with laws and regulations. Respondents also talked about reflecting on other aspects, such as the importance of involving stakeholders in the evaluation of innovation activities and whether potential threats to innovation are regularly and openly discussed within the organization.

"We don't let people monitor the innovation process, but of course visiting sometimes does. When something goes wrong it will be adjusted in time, for example if I find out that the thing has had a negative effect, then I will also correct it in time." (1: Formal evaluation)

"Every month we have a full staff meeting with the leadership and CEO and then listen to what the staff thinks." (6: Open discussion of threats and limitations)

4.1.4 Dimension 4: Responsiveness

Responsiveness is about responding to new knowledge, perspectives, views, and normative norms. Specifically, responsiveness involves the establishment of an interactive, continuous, and flexible adaptive learning process through institutionalized interrogation mechanisms when knowledge and control over innovation are felt to be insufficient, the framework and direction of innovation activities are moderately adjusted, the human value system is incorporated into the research framework of responsible innovation in the technological design process, and the institutional coupling of the innovation evolution process responsive to social values is realized. Responsible innovation requires the ability to change form or direction in order to respond to stakeholders and public values as well as to changing circumstances. During the interviews, we learned that it is important to integrate key stakeholders into the innovation process:

"So-called responsible innovation actually starts by allowing the company to build up the kernel first, and then it naturally attracts wider public participation." (5: Integrating stakeholders into the innovation process)

"We got a big expert in the industry to collaborate, the technology he developed, and I provided the funding, the space, and the conditions for the facilities." (1: Integrating stakeholders into the innovation process)

In addition, maintaining close communication with stakeholders, such as the public and the organization's employees, regarding the content of the innovation and adapting it to the important information provided by stakeholders are also important behavioral manifestations of responsible innovation:

"There will be public participation instructions on environmental protection, which is based on the public participation approach to environmental impact assessment, and online newspapers to collect public opinion; employees will also be informed at meetings and all-employee emails. There are too many people with too much information and one-to-one communication may not be possible, but the company will use all-employee emails or CEO meetings and departmental meetings to inform employees." (6: Transparency to stakeholders)

"For example, if I make this one good, but it has a negative impact on the next one, this is something we cannot allow to happen and go for a revision." (1: Adapting innovations to reflections)

We argue that the role of enterprises in responsible innovation research and practice gradually changes from combining corporate social responsibility with technological innovation to combining corporate open innovation with responsible ethics to combining corporate innovation governance with specific industries, and that corporate responsible innovation is embedded in a certain industrial environment and ethical social environment. Furthermore, the overall situation of the industry has a significant impact on corporate responsible innovation. By combining the specific characteristics of the industry in which the company is located, such as industrial technology and industrial chain, and by studying and judging the trends of technology risk, intellectual property rights, industrial layout, industrial agglomeration, industrial transformation and upgrading, corporate responsible innovation can be better implemented in the industrial innovation ecosystem in which the company is located (Stahl, 2022). As an important part of the national innovation system, enterprises need to comply with the requirements of morality, ethics, public values and social culture of the country they are located in to carry out innovation activities, and to build up responsible thinking, awareness and responsibility for innovation development from the bottom. On this basis, the connotation of corporate responsibility innovation can be elaborated through "one subject, one factor and four goals". In summary, the core connotations and structural dimensions of CRI are distilled through content analysis, and the preliminary connotation analysis is shown in Figure 3, and the complete 20 items and 4 dimensions are shown in Table 4.

1) Enterprise subject: the enterprise is the subject of implementing responsible innovation. Guided by inclusion, by involving stakeholders in innovation collaborative governance, conducting anticipation, reflexivity and

FIGURE 3
The concept map of corporate responsible innovation.
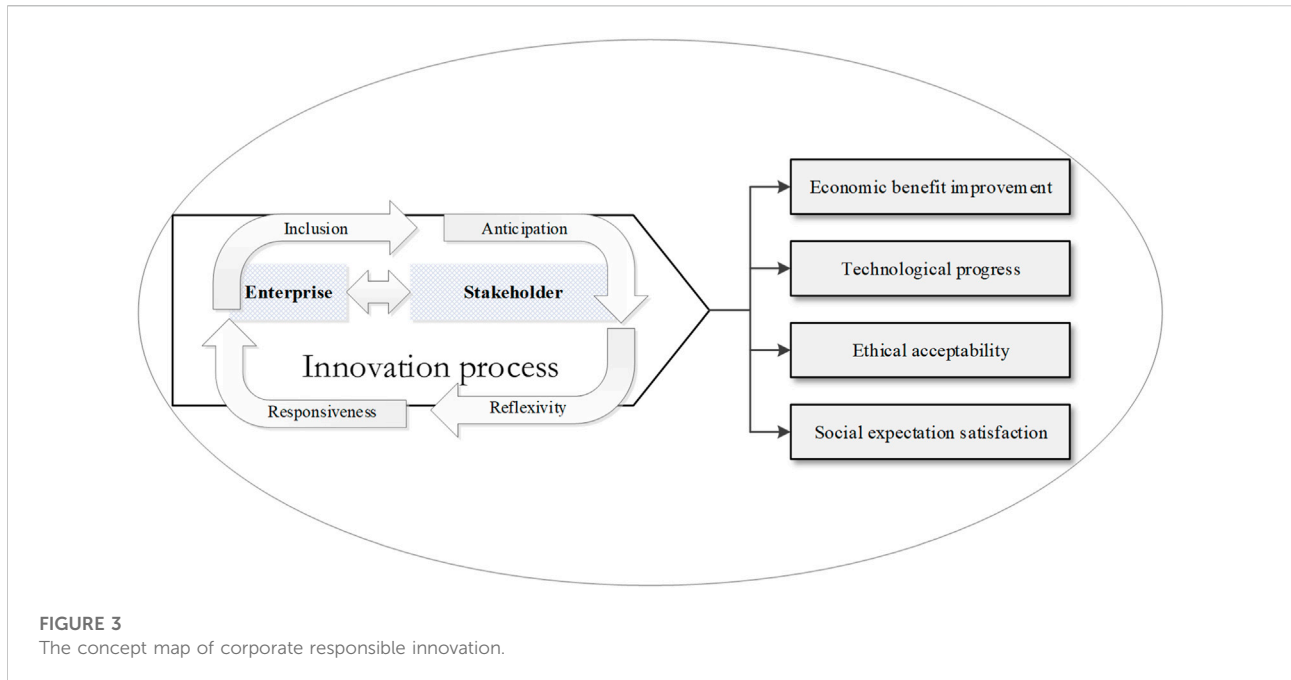
responsiveness in the process of idea formation, idea screening and idea verification implementation, and jointly seek innovation with stakeholders that have positive added value for society and the environment (Čeičytė, 2019).

2) Individual factor: whether and when enterprises implement responsible innovation, entrepreneurs play an irreplaceable role. Therefore, the concept of responsibility is embedded in the beliefs, attitudes and intentions of individual entrepreneurs, and responsible thinking is added to the realization of innovation (Ramadhan, 2017).

3) Four goals: on the basis of the existing technological innovation goals of "technological progress" and "economic benefit improvement", responsible innovation requires that the results of innovation activities must meet "ethical acceptability" and "social expectation satisfaction" (Van den Hoven, 2013; Owen et al., 2012). The fundamental goal of innovation evaluation is to achieve public value.

4.2 Drivers of corporate responsible innovation

Considering the extra effort and resources that CRI requires from companies, in the interviews we asked respondents why they bothered to do this. Combining the interviews, the following six factors that drive companies to engage in responsible innovation have been summarised.

4.2.1 Driver 1: Market pressure

Responsible corporate innovation behavior is a strategic response to external market pressures and reflects a firm's ability to adapt to the external environment, with firms engaging in responsible innovation-driven to some extent by the market. Respondents indicated that they engage in responsible innovation to a large extent from consumers, most of whom evaluate a company's reputation based on whether it is responsible in its innovation process, as they believe that responsible innovation by firms can benefit society.

> "Before making innovation decisions, we should put the needs of users in the first place. By meeting the growing healthy and positive needs of customers, we should combine innovation with social responsibility and give play to social value." (5: Consumer pressure)

In addition to consumers evaluating the reputation of companies, some professional third-party organizations also monitor companies as they implement responsible innovation, for example by issuing appropriate reports to evaluate the responsibility of companies' innovation, as interviewees said.

> "Third party institutions will investigate our innovation process from time to time, and the results of the industry responsible innovation report at the end of each year are the wind vane for us to continue to implement corporate responsible innovation." (9: Third party pressure)

TABLE 4 The items and dimensions of corporate responsibility innovation.

Items	Dimensions	Typical sentence from the interview
We will comprehensively consider the interests of stakeholders in the innovation process	Inclusion	"*When undertaking an innovative activity, the interests of all parties need to be weighed and considered.*" (1: Consider the interests of stakeholders)
We pursue win-win results for enterprises and stakeholders in the process of innovation		
In the process of innovation, we regard compliance with social ethics and business ethics as our due social responsibility		"*People who come and refer business to me get a commission, and the commission from referring you by sharing the referral counts towards your earnings.*" (4: Win-Win with Stakeholders)
We will consider the responsibility of innovation for ethical, ecological, economic and social development		
We consider the possible results of innovation from the long-term perspective of social and environmental benefits	Anticipation	"*We ask for a lot of early warning before we do each project.*" (6: Predicting risk)
We evaluate the entire life cycle of innovation from a social and environmental perspective		
We have preset some possible scenarios for innovative development		"*From a forecasting perspective, in the midst of the innovation process, predicting the future, the impact of this thing years down the line.*" (7: Considering long-term outcomes)
We predict the ethical, ecological, economic and social risks that innovation may bring		
Compared with our peers, we are more concerned about whether innovation complies with relevant regulations	Reflexivity	"*We don't let people monitor the innovation process, but of course visiting sometimes does. When something goes wrong it will be adjusted in time, for example if I find out that the thing has had a negative effect, then I will also correct it in time.*" (1: Formal evaluation)
We will reflect on the impact of innovation on ethics, ecology, economy and society		"*Every month we have a full staff meeting with the leadership and CEO and then listen to what the staff thinks.*" (6: Open discussion of threats and limitations)
Compared with our peers, we pay more attention to involving stakeholders in the evaluation of innovation activities		
We openly discuss the potential threats and limitations of innovation within the organization		
We are transparent in assessing the potential risks of innovation		
In order to achieve social and environmental benefits from innovation, we coordinate incompatible values among stakeholders		
Compared with our peers, we pay more attention to the introduction of third-party evaluation and certification in the innovation process		
We integrate key stakeholders into the innovation process	Responsiveness	"*We got a big expert in the industry to collaborate, the technology he developed, and I provided the funding, the space, and the conditions for the facilities.*" (1: Integrating stakeholders into the innovation process)
We maintain close communication with stakeholders in terms of innovative content		"*For example, if I make this one good, but it has a negative impact on the next one, this is something we cannot allow to happen and go for a revision.*" (1: Adapting innovations to reflections)
We adjust the innovation content according to the important information provided by stakeholders to obtain economic and social benefits		
In the process of innovation, we feed back the implementation of their suggestions to stakeholders		
In response to emergencies in innovation activities, we have paid more attention to safeguarding social benefits		

Pressure from suppliers is also an important driver of responsible innovation in companies. In their business dealings, suppliers make judgements about whether the innovation process is responsible for the enterprise and thus derive an assessment of the enterprise, particularly those suppliers who have launched socially and environmentally friendly products.

"Now the environmental protection requirements are getting higher and higher. We need to develop new materials to solve the original environmental pollution problem, and the threshold set by suppliers in environmental protection is also getting higher and higher." (1: Supplier pressure)

In addition, in a highly competitive market environment, modern firms operate with a strong focus on the ethics and morality of innovation, particularly as the high level of interest from peer competitors in undertaking responsible innovation can drive firms to implement responsible innovation.

"We are not willing to do the traditional model. We should solve the pain points of the industry and enter the blue ocean market through responsible innovation." (1: Competitor pressure)

4.2.2 Policy pressure

With the continuous improvement of various national laws, regulations and policy systems related to entrepreneurship, higher requirements are placed on the innovative activities of enterprises. In this context, the mandatory policy is reflected in the fact that if a company harms the interests of society and violates morality and ethics in its innovation activities, then it will be severely punished. As interviewees talk about:

"Actually, at the moment, doing responsible innovation is due to legal pressure, meaning that the state requires us to do it, and then we have to do it." (4: Legal red lines)

"A basic starting point is surely to comply with the law." (8: Legal red lines)

In fact, the implementation of responsible innovation by enterprises is not only due to the pressure of laws and regulations, but also due to the local government's efforts to improve the relevant laws and regulations, the formulation of tax incentives, the provision of special financial subsidies and preferential loans.

"Today we see the State Council's heavy innovation stuff, how about a registration system, how about companies filing for assets, a corporate bankruptcy system coming out, and personal bankruptcy laws coming out. We can then feel comfortable with responsible innovation and can let go of the need to contribute to society. The protection of the law actually breaks the stranglehold of innovation." (3: Policy: Positive)

4.2.3 Normative pressure

Corporate responsible innovation can be influenced by the overall national and sociocultural environment. As interviewees talked about:

"Innovation brought about by the general environment of social progress will affect the responsibility of the innovation process. When innovation improves the overall efficiency of society and loses the interests of a small number of people, we will also carry out responsible innovation." (3: Normative pressure)

"Through the advocacy of responsible innovation values, the public's level of innovation awareness has reached a higher level." (7: Normative pressure)

"For example, the COVID-19 epidemic has accelerated our digital transformation." (7: Normative pressure)

If the state promotes the idea of socially responsible innovation, strongly encourages responsible stakeholder behavior when innovating, and the company's leaders and employees are happy to be educated about the responsibility of innovation, then the company will to a large extent implement the behavior of responsible innovation. This is influenced by normative pressures, i.e. shared concepts and norms of meaning developed in national and regional cultures, values, normative beliefs and behavioral assumptions, which are agreed, assessable as well as obligatory dimensions of social life.

4.2.4 Motivation of responsible innovation

Innovative activities by companies help to continuously expand profitability channels and business scale and enhance the profitability of existing businesses. Clear economic benefits are therefore the main driver for corporate responsible innovation.

"Innovators think about whether I can win the market using this big data and are profit-oriented. When companies go to make decisions, they must be profit-oriented, I'll do it as long as I don't break the law and there's money to be made." (3: instrumental motivation)

In considering economic efficiency, companies also focus on and maintain relationships with core stakeholders, such as customers, peers and suppliers, and establish or maintain win-win relationships with them through innovation.

"The primary task of our innovation is to meet the market demand and solve the pain points of the industry, which is also a reflection of our responsibility. We have established long-term cooperative relations with some customers and suppliers." (1: Relationship motivation)

Interaction with society and the public will also drive enterprises to carry out responsible innovation. Corporate responsible innovation itself is guided by inclusion, as the interviewer said:

"*Products made through innovation respond to everyone's concerns, and the public continues to accept, participate and experience. It is not enough to rely on our own enterprise. To be exact, it is everyone who works together to develop the industry.*" (6: Moral motivation)

4.2.5 System of responsible innovation

A company undertaking responsible innovation will have its own innovation strategy, such as a dedicated person responsible for the socially responsible management of the innovation project, training to carry out the innovation project, or a clear reward or evaluation system for the company to carry out the innovation project responsibly, as in this typical interview dialogue.

"*Our company is very open in the internal management of employees. We encourage the implementation of the job rotation system, carry out regular training, and publicize responsibility innovation projects.*" (6: System of innovation)

These innovation systems underpin corporate responsible innovation and are an important driver of responsible corporate innovation.

4.2.6 Elements of responsible innovation

Another driver frequently mentioned in the interviews was the conditions for innovation in the firm. Among these, innovation resources are important for corporate responsible innovation, with higher investment in research and a high level of technological equipment compared to other companies in the same sector being important drivers of responsible innovation.

"*Increasing investment in science and technology is one of the prerequisites for responsible innovation.*" (6: Innovation resources)

In addition, companies with human resources of a high scientific quality are usually able to complete innovative projects with high quality, as this interviewer said.

"*We have introduced top talents from all over the world, established the top water pollution control team, and brought new technologies and new management concepts.*" (6: Innovation resources)

In addition to innovation resources, a firm's own ability to innovate is an important driver. For example, the originality of a product, the number of patents filed, and the speed and success of new product development can have an impact on whether a firm engages in responsible innovation.

"*Our next step is to strengthen the research and development speed of this batch of environmental protection materials,*

which will have a great impact on our responsible innovation." (1: Innovation ability)

Motivation is the cause and motivation that triggers behavior, and the transformation of organizational motivation into organizational behavior requires a weighted consideration of situational factors (Grewal et al., 2001; Liu et al., 2016). Therefore, based on the model of "moral factors affecting behavior" (Weber, 1990; Trevino et al., 2006), we propose a framework of drivers of corporate responsible innovation with the responsible innovation motivations as the core trigger variables, responsible innovation elements and responsible innovation system as the internal organizational factors, and market pressure, policy pressure and normative pressure as the external organizational factors in Figure 4.

5 Discussion

We clarified the concept of corporate responsibility innovation through interviews with 13 corporate executives and summarized a four-dimensional framework for corporate responsibility innovation: Inclusion, anticipation, reflexivity, and responsiveness. In addition, we propose an MPN-MSE model of the drivers of corporate responsibility innovation in environmental protection enterprises from the perspective of external organizations [including Market Pressure (M), Policy Pressure (P) and Normative Pressure (N)] and internal organizations [including Motivation of responsible Innovation (M), System of responsible innovation (S) and Elements of responsible innovation (E)]. The theoretical and practical significance of this study is discussed below.

5.1 Theoretical implications

Firstly, environmental protection enterprises are selected as the research objects, which expands the research scope of corporate responsible innovation. Under the impact of the tide of environmental protection in the world today, all countries attach great importance to the high-tech research of protecting the environment, saving resources and energy. For environmental protection enterprises, it is incumbent on them to carry out responsible innovation as they are closely related to people's livelihood. Our research explores the concept of corporate responsible innovation and the factors that drive technology environmental protection enterprises to carry out responsible innovation, which enriches the scope of research objects of corporate responsible innovation.

Secondly, this study further clarifies the concept and structural system of responsible innovation at the firm level and enriches the relevant research on responsible innovation. On the one hand, although scholars have explored the concept
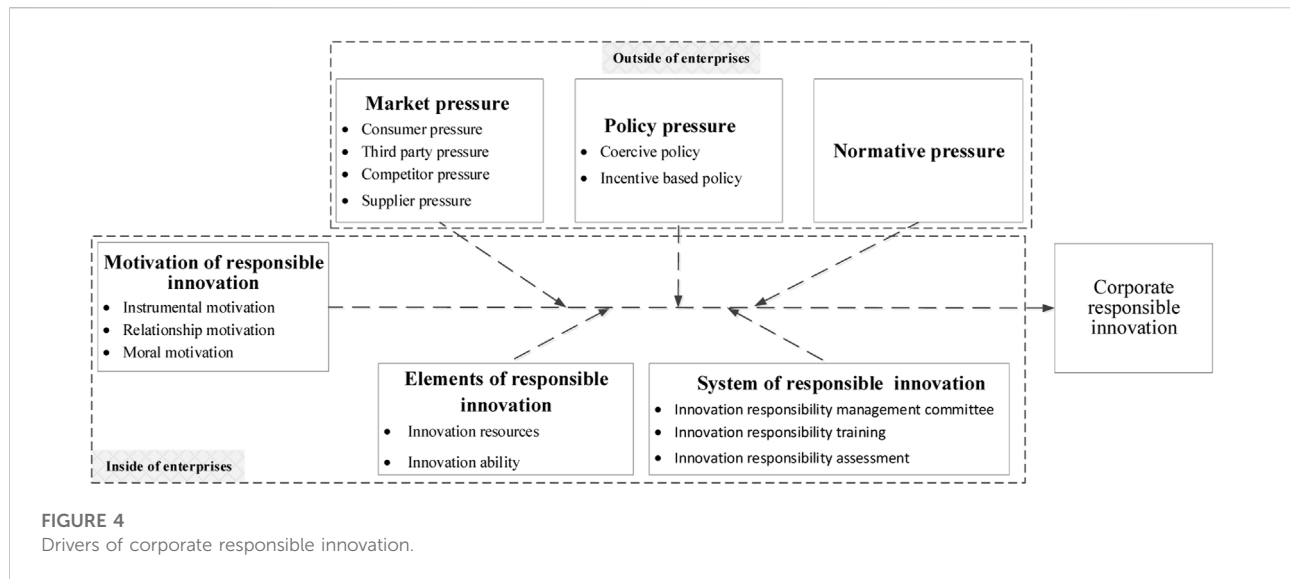
FIGURE 4
Drivers of corporate responsible innovation.

and connotation of responsible innovation to some extent, such as the target characteristics of responsible innovation, ethics of responsibility, and implementation methods, and defined the basic elements of responsible innovation, including the extensive interactive process of subjects, forward-looking forecasting, and the highlighting of ethical and moral factors (Saille, 2013; Burget et al., 2017), the core characteristics, key aspects, defining criteria and assessment guidelines of responsible innovation are still not clear. On the other hand, responsible innovation has received widespread attention from the public sector, but companies, as innovation agents, do not have sufficient awareness and recognition of responsible innovation. Theoretical and practical exploration of responsible innovation in the business context is still in its infancy. We summarize the orientation, innovation process, results and essence of corporate responsible innovation through interviews, and propose four structural dimensions of corporate responsible innovation: inclusion, anticipation, reflexivity and responsiveness, promoting the conceptual study of corporate responsible innovation. Besides, previous scholars have proposed the AIRR framework (anticipation, inclusiveness, reflexivity, and responsiveness) for responsible innovation (Ranabahu, 2020). However, the AIRR framework has not yet indicated the specific subjects to which it can be applied. We further develop the framework by applying it to corporate responsible innovation and validating it through interviews.

Thirdly, this study explores the drivers of corporate responsible innovation from both internal and external organizational perspectives, enriching the antecedents of corporate responsible innovation. Although a few scholars have initially explored the organizational practice of responsible innovation and analyzed the factors influencing responsible innovation from different perspectives, they have

done so separately and not systematically, making it difficult to consider the joint influence of multiple factors and the interactions between different factors. Moreover, current research is limited to the conceptual integration of related theories and the construction of alternative management frameworks, such as debates on the concepts of corporate social innovation (Sliva, 2017), suggesting that the five-stage corporate citizenship theory in CSR can be used as a theoretical framework for responsible innovation (Hemphill, 2016), there is a lack of exploration of the foundations and motivations for the micro-implementation of responsible innovation. Firms engaging in responsible innovation are driven by external pressures on the one hand but also influenced by the internal environment of the firm on the other. This paper proposes the MPN-MSE model through a holistic analysis of internal and external organizational environmental factors, which is conducive to a comprehensive understanding of the drivers of corporate responsible innovation.

5.2 Practical implications

Firstly, for entrepreneurs, the results of a conceptual study of corporate responsible innovation help to increase the level of awareness and importance of responsible innovation among entrepreneurs and improve the effectiveness of corporate responsible corporate innovation practices. Although research suggests that firms may not necessarily innovate in an irresponsible manner, the current awareness and recognition of responsible innovation among firms is low (Hemphill, 2016; Jin et al., 2016; Stahl et al., 2019), resulting in a significant reduction in the effectiveness of responsible innovation practices. The results of this study clarify the core

connotations and structural dimensions of corporate responsible innovation, guide entrepreneurs to grasp the correct responsible entrepreneurial orientation and transfer the concept and awareness of responsible innovation to their employees, integrate core stakeholders into the whole innovation process, and achieve technological progress and economic benefits under the premise of being ethical and achieving social satisfaction.

Secondly, for environmental protection enterprises, this study shows that innovation motivation, innovation systems and innovation conditions are the internal drivers of responsible innovation. On the one hand, organizations often influence the behavior of employees and firms through the adjustment of their internal environmental protection systems, which are important for the operation of firms, and can gain competitive advantages for firms through the management and planning of their internal system structure. Therefore, enterprises should establish a sound internal environmental innovation system, i.e., make relevant regulations on the issue of responsibility in the management system of innovation, and coordinate the interests between the company and its stakeholders through a set of formal or informal systems or mechanisms to safeguard the interests of all aspects of the company. On the other hand, increase the investment in capital, technology, human resources and other resources for environmental innovation, improve the ability to effectively obtain information, integrate resources, absorb knowledge and apply it to innovation activities, and create conditions for responsible innovation.

Thirdly, for governments, the research shows that market pressure, policy pressure and normative pressure are external drivers of corporate responsible innovation. All three of these drivers are influenced by local government regulation, which provides practical guidance on how governments can drive firms to implement responsible innovation. In general, governments influence firms' strategic choices by setting and enforcing regulations. For governments, on the one hand, need to design a set of incentives/constraints to drive firms to implement responsible innovation. On the other hand, since customers are an important incentive for firms to innovate responsibly (Schönherr et al., 2020), and they influence corporate responsible innovation through product choice, governments also need to guide their customers to actively participate in responsible innovation.

5.3 Limitations and future direct

Despite the theoretical and practical implications of this paper, we acknowledge certain limitations in our research but believe these could pave the way for future research avenues.

Firstly, our qualitative study of 13 samples was limited and inevitably subjective. Although proactive measures were taken to minimize subjective bias on the part of the researcher and

respondents during the interview process, data collection and analysis, it must be acknowledged that in qualitative research, the findings are 'co-created' by the people involved, a degree of bias is inevitable (Denzin and Lincoln, 2011). In the future, the generality of the results need more examinations, a combination of qualitative and quantitative research can be used to develop a measurement scale for responsible corporate innovation by combining qualitative and quantitative research, summarising initial questions through a qualitative research process, using a large sample questionnaires for empirical analysis and testing for reliability and validity, and laying the foundation for further empirical research (Genus and Iskandarova, 2018) to more effectively support management decisions (Schönherr et al., 2020).

Secondly, the interviewees were essentially at the top of the company. Although each interviewee played an important role in the corporate responsible innovation practices, the company's middle management and employees may have a more in-depth description of this practice and their views may differ from those of top management. In future research, consideration could be given to adding a subset of company personnel other than top management as interviewees to gain a more comprehensive understanding of the corporate responsible innovation practices.

Thirdly, the current study has only studied enterprises in eastern China. However, as the level of economic and technological development varies greatly across different regions of China, the reasons for corporate responsible innovation and their understanding of CRI vary, more regions or other industries with high innovation intensity could be sampled and a larger sample of respondents could be identified in the future to improve the stability and reliability of the study. In addition, single or multiple case studies of typical companies can be conducted to further explore the performance of these companies in responsible innovation practices and to improve the reliability and dynamism of the study.

6 Conclusion

In this paper, based on literature analysis, we conducted 13 interviews with some enterprise representatives in environmental protection enterprises. After coding, summarizing and sorting out, we further clarify the concept and structural framework of corporate responsible innovation, and explored the factors driving environmental protection enterprises to engage in responsible innovation based on a dual perspective from within and outside the corporate. Our study not only expands the literature on responsible innovation, but also enriches the antecedent research on corporate responsible innovation. In addition, our research has practical implications for actual corporate responsible innovation activities and government governance. Finally, we present the research limitations and future research.

Data availability statement

The original contributions presented in the study are included in the article/supplementary materials, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

Author contributions

YL contributed to the derivation of ideas and wrote the Introduction of the paper. LJ contributed to the practical analysis and wrote the literature review and methodology of the thesis. PY wrote the results, discussion, and conclusion. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Appendix interview outline

1) When did you join the company? And what is your position in the company?

2) What is the number of R & D personnel in your company? What is the proportion of R & D personnel in the total number of employees?

3) What is the annual R & D investment of your company?

4) How about the launch of new products developed by your company every year? How did the market respond (social satisfaction)?

5) Which stakeholders internal and external the organization will be involved in the innovation process? To what extent will it communicate and negotiate with stakeholders? How to communicate with them?

6) As a leader of an innovative enterprise, will you weigh the needs of different stakeholders before making decisions about innovation activities? (For example)

7) In the process of innovation, will you let stakeholders monitor the possible negative effects? (For example)

8) When there are negative effects in the innovation process, will you let stakeholders jointly evaluate and take measures? (For example)

9) What influences your corporate's responsible innovation behavior the most (economic benefits, national policies, laws, industries, competition, personal characteristics, entrepreneurship, etc.)?