

Article

Fuzzy Front-End Vertical External Involvement, Corporate Social Responsibility and Firms' New Product Development Performance in the VUCA Age: From an Organizational Learning Perspective

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Abstract: Fuzzy front-end (FFE) innovation is the important initial phase of manufacturing companies' new product development (NPD) process, which can be a factor that determines manufacturers' NPD performance and sustainable growth. This study seeks to investigate the role of FFE vertical external involvement (FFE customer involvement and FFE supplier involvement) in advancing firms' corporate social responsibility (CSR) and NPD performance in the COVID-19-influenced age of volatility, uncertainty, complexity and ambiguity (VUCA). This study adopts an organizational learning (OL) perspective as its theoretical foundation in constructing a comprehensive framework by developing a series of hypotheses. In addition, we test the mediating effect of CSR on the relationship between FFE vertical external involvement and firm NPD performance. We use the structural equation modeling method to examine our hypotheses empirically based on data collected from 548 Chinese manufacturing companies. The findings illustrate that FFE customer involvement and FFE supplier involvement are vital drivers of a firm's CSR engagement. Furthermore, we find that FFE supplier involvement plays a more significant role than FFE customer involvement in contributing to NPD performance. Finally, we find that a firm's CSR engagement positively mediates the relationship between FFE vertical external involvement and NPD performance.

Keywords: fuzzy front-end; vertical external involvement; corporate social responsibility; new product development performance; organizational learning; VUCA age



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1. Introduction

Innovation is the fundamental basis for firms' sustainable development. However, under the influence of the cloud of volatility, uncertainty, complexity and ambiguity (VUCA) brought by the COVID-19 pandemic, supply chain disruptions, international trade crises, poor sales and new policies have been threatening the survival of enterprises around the world, thus negatively impacting enterprises' innovation ability. Through an analysis of Chinese listed companies, Jin et al. [1] found that the COVID-19 pandemic has restricted the innovation quality of both large companies and SMEs. Therefore, to understand how firms' innovation ability is evolving during this VUCA period, we should give fuzzy front-end (FFE) innovation intense research attention because FFE innovation represents the starting phase of a manufacturing company's innovation process and plays an important role in determining a firm's product innovation success [2,3].

Khurana and Rosenthal [4] defined FFE innovation as the early phase of the new product development (NPD) process through which firms explore, evaluate and form innovation ideas to determine whether a product should ultimately receive commercial investment and be integrated into the production line. The execution quality of FFE innovation activities significantly impacts a firm's NPD performance [5]; hence, FFE activities must be closely

managed for firms to stay competitive in the long run [6]. However, researchers have not reached a conclusion on FFE best practices related to innovative activities. Koen et al. [2] were the first to propose that FFE innovation success consists of internal activities with positive external influencing factors. However, some studies have focused on only internal FFE innovation activities, overlooking external influences [3,7]; therefore, the extent to which external players can be involved in FFE has tremendous potential for study. Christiansen and Gasparin [8] further added that a firm's FFE is an off-boundary innovation process where both human and nonhuman actors from organizational, social and technical areas work together to finalize product prototypes. Hence, organizational learning (OL) is a way of involving different external stakeholders in FFE to acquire and absorb knowledge in an open innovation environment, create innovative concepts and thus realize innovation outcomes and commercial success [9–11]. Moreover, involving external groups deeply at the FFE stage provides valuable and innovative information and ideas in addition to internal FFE activities that decrease FFE fuzziness and uncertainty [12–14]. Moreover, regarding the current VUCA age, studies have shown that a high level of collaborative innovation activities with external stakeholders during the COVID-19 pandemic positively influences a firm's overall performance and even guides firms through the crisis [15,16].

According to previous research findings, the common external collaborators at a firm's FFE stage are customers, suppliers, competitors, universities and governments [12,17]. However, competitors, universities and other external stakeholders do not share the same economic and sustainable development interests for achieving a common goal with focal firms in the NPD process, whereas customers and suppliers are the most important players in the vertical value chain of a firm's economic returns and social responsibilities [13,14,18,19]. On the other hand, the participation of the customers and suppliers affecting a firm's innovation process has been suggested both academically and practically to be effective in terms of improving manufacturing firms' NPD performance [20–22]. Therefore, we view customers and suppliers as vertical external groups involved in the FFE phase of firms' NPD processes in this study of Chinese manufacturing companies.

The essence of a firm's FFE innovative activities is to learn, share and evaluate market and technology knowledge with the ultimate goal of creating a final product prototype [8,23]. By applying Chesborough et al.'s [11] open innovation theory, we propose that the whole FFE innovation phase is an open-type OL process through which firms decrease uncertainties while taking in external knowledge that helps them succeed [10]. Therefore, in this study, we use OL theory as a theoretical basis for this FFE vertical external involvement process of developing new products through the construction of a learning organization. We further explore the mediating role of corporate social responsibility (CSR) in balancing the relationship between manufacturing firms' vertical external stakeholder involvement in FFE innovation and firms' NPD performance. After observing 383 SMEs in Uganda's emerging market, Turyakira et al. [24] found that CSR engagement is positively related to a firm's long-term competitiveness, revealing that sustainable CSR engagement input generates more benefits for firms in the long run. Therefore, the initial external FFE involvement of external stakeholders (customers and suppliers) will help firms to reinforce CSR engagement for greater NPD results [8,24]. As a result, a high quality of FFE external vertical involvement will help companies to build CSR engagements as a long-term learning process for increasing innovation levels and producing sustainable new products.

This study has three objectives. First, we examine how the FFE external involvement of vertical stakeholders in Chinese manufacturers' vertical value chain affects their NPD performance based on OL theory; second, we test how CSR mediates the relationship between FFE vertical external involvement and manufacturing firms' NPD performance as well as the contribution of CSR to firms' OL and NPD performance; third, we examine how Chinese manufacturing firms react to VUCA by establishing FFE vertical external involvement through CSR engagement to realize more sustainable outcomes in an open innovation environment. The whole study is based on evidence from both scholarly

literature and field research on Chinese manufacturing companies. We hope to add Chinese experiences to the global FFE research.

The paper is organized as follows. We present the theoretical framework of this study in the next section. We then analyze the scholarly literature and provide hypotheses according to our research model. In the fourth section, we report the empirical analysis and results. In the final section, we highlight our research contributions by discussing the results, outlining theoretical and practical implications and finally providing possible directions for future research.

2. Theoretical Background and Hypothesis Development

2.1. Theoretical Foundation

OL theory is one of the most important theoretical frameworks for dynamic organization studies around the globe. Dodgson [25] claimed that OL is a collective way for firms to develop organizational efficiency by absorbing and integrating knowledge from individuals and organizations. Moreover, Chesbrough et al. [11] stated that it is important to have “purposeful inflows and outflows of knowledge to accelerate innovation internally while also expanding the markets for the external use of innovation” based on open innovation theory. Therefore, we adopt an OL perspective to examine the way in which manufacturing firms execute FFE activities to create an open innovation environment in which to build a learning organization that increases NPD performance. With the effects of the COVID-19 pandemic and other VUCA events, involving vertical external stakeholders in FFE is not only a learning tool for gaining extra useful knowledge but also a way to reinforce manufacturing firms’ organizational strength so that all players on the value chain can create an OL network to firmly resist this era of turbulence.

Nevertheless, previous studies have shown that during the FFE phase of NPD, FFE activities are usually performed within the firm; these activities include opportunity recognition, idea generation, product assessment, concept definition, idea evaluation, concept screening, concept development, product strategy formulation and communication, product definition, project planning and executive reviews [3–5,7]. However, firms also should exploit all their resources by adopting an OL mindset not only within the firm but also and more importantly outside the firm to gain competitive advantage. During the COVID-19 pandemic, it has become more urgent to open up firm boundaries to external stakeholders to prevent technological and market isolation since FFE is a process through which firms address uncertainties from the outside world: these stem from both the market and rapidly developing technologies [26,27]. Using the OL method to acquire useful resources from external stakeholders is advantageous in terms of quickly and accurately processing information inflows, as information processing is fundamental to firms’ ability to perform FFE activities, decrease uncertainties and make decisions that satisfy different stakeholders [4,8,13,14,28–30]. Moreover, scholarly evidence has shown that overall FFE performance improves if firms can reduce as many uncertainties as possible through interactions with external stakeholders [28,31,32]. Customers and suppliers are positioned at a firm’s back end and front end, respectively. Therefore, they ought to directly share products’ radical function and value. We propose that customers and suppliers from a firm’s vertical value chain intensify the FFE OL process to decrease uncertainties, as the involvement of customers and suppliers increases NPD and innovation performance [2,33,34]. Thus, we believe that a vertical OL process involving customers and suppliers is vital for FFE innovation.

An OL FFE process involving customers and suppliers strengthens the market-centered goals of manufacturing firms by using a more efficient management method to reduce unnecessary costs as companies face supply and demand changes, raw material shortages, overstock and a decrease in consumption under the negative effects of the COVID-19 pandemic. Customer involvement has an incentivizing influence on customers’ perceptions of firms’ new products, which fosters their trust and loyalty [35–37], whereas supplier involvement provides a communication pathway between firms and their suppliers that allows the organizations to share a timely mutual understanding and allows the suppliers

to provide the right raw materials on time [38]. This off-boundary OL environment between a firm and vertical external players nurtures an open innovative process that contributes to the firm's sustainable development and builds a cocreation mechanism that stimulates NPD creativity. Hence, FFE vertical external involvement is a dynamic OL FFE activity that assists firms in more effectively executing internal FFE activities that eventually bring better NPD outcomes.

Drucker [39] noted that the science of management can be classified as a liberal arts subject because it should deal with the complexity of humanity and universal values in addition to corporate governance. Therefore, we propose that firm management should not only focus on profits, efficiency and growth but also consider social benefits so that firms can engage in corporate social responsibility initiatives for the social good. The United Nations Industrial Development Organization (UNIDO) [40] defined CSR as "a management concept whereby companies integrate social and environmental concerns in their business operations and interactions with their stakeholders". Sen and Bhattacharya [41] adopted a societal perspective, defining CSR engagement as a company's activities and stating that they should be related to the company's perceived societal or stakeholder obligations. According to stakeholder theory, in the context of taking on social responsibility and remaining sustainable, the external involvement of vertical stakeholders directly pushes firms to implement CSR activities because they share the same central business values [18,19,42,43]. On the other hand, unifying the moral values of vertical external stakeholders with those of firms can facilitate cooperation, thus increasing mutual identity and corporate social capital. Moreover, Hassi and Wever [44] stated that engaging in environmentally friendly green innovation during the FFE stage is more effective than doing so later.

Therefore, in this study, we propose that manufacturing firms' CSR engagements are embedded in the FFE OL process such that a firm's vertical stakeholders can help improve a product's market legitimacy and technology and thus reduce FFE uncertainties stemming from the market and technology [26,27]. By involving customers and suppliers during the FFE stage, a firm can create a stable mutual learning environment where all the participants in the vertical value chain can reach a consensus on social and environmental values to simultaneously more effectively produce market-approved products and decrease VUCA-related uncertainties, thus increasing corporate social capital. After conducting research on Chinese manufacturing firms, Qi et al. [45] found that the demands of customer involvement cause firms to be positively exposed to CSR activities that involve green innovation, as environmentally friendly actions need to be seriously considered by firms for the sake of undertaking more environmental and social responsibilities. Supplier involvement in a firm's product design responsibility positively stimulates the use of contrasting learning styles [46]. In addition, engaging vertical external stakeholders in CSR measurements is an OL process that can help firms meet various precise CSR requirements imposed by vertical external stakeholders [9–11,25,39]. Furthermore, engaging in CSR is a useful learning process by which firms can identify new opportunities and realize environmental, philanthropic and product responsibility awareness [47,48]. Finally, firms that fail to implement CSR approaches have a negative impact on social and economic outcomes [49].

2.2. FFE Vertical External Involvement and NPD Performance

Successful NPD output requires a detailed and formal FFE process that comprises many available resources and much interdisciplinary work input [6]. Many influential studies have emphasized the importance of involving external stakeholders during firms' FFE stage [2,12–14,50–52]; hence, it is clear that firms should combine different external resources, knowledge sources and stakeholders in a boundaryless system to co-innovate during the FFE stage and improve organizational performance, as FFE openness and competence brings both financial and nonfinancial success to innovations [28,30]. Moreover, Menguc et al. [33] suggested that knowledge and resources from inside an organization do not facilitate open-boundary innovation but that the utilization of external customers and suppliers for fusion innovation helps firms improve NPD performance. The vertical

involvement of customers and suppliers helps firms understand the market in advance to accurately plan and design products during the FFE stage, decrease the time and cost needed for the FFE process and reduce FFE uncertainty [2,12–14,52]. Real-world business practice has also shown that some internationally known firms, such as Chaparral, Dell, HP and GE, have realized corporate-level benefits by allowing vertical stakeholder involvement [53–55]. On the other hand, FFE vertical external involvement can also benefit customers and suppliers in an inverse way during vertical FFE co-innovation, helping them appreciate their own stakes in sustainable considerations. Especially under the shock of the COVID-19 pandemic, it is urgent for firms to rebuild a more sustainable stakeholder ecosystem that cocreates with both suppliers and customers instead of focusing solely on the influence of firms' internal activities on NPD efficiency [56,57]. Accordingly, we believe that the FFE vertical external involvement of customers and suppliers is not only the factor that can help firms better execute internal FFE activities but also a feedback OL mechanism for FFE internal activities that corrects unilateralism mistakes by polishing market-oriented products. As the previous discussions have shown, in this study, we focus on the impact of FFE vertical involvement on firms' NPD performance in the context of sustainable transformation from an OL perspective.

Sandmier et al. [50] highlighted the significance of involving customers early in the FFE process, as this allows the FFE team to create an actual market scenario for firms to better comprehend the market to decrease uncertainties later during the product commercialization phase. Murphy and Kumar [51] found that the FFE involvement of customers can help with FFE product idea generation. Due to the fuzzy nature of the FFE process, Stevens [10] suggested that firms should collect and share knowledge and information with different team members and departments to reduce uncertainties. Furthermore, Tran et al. [58] creatively extended the opinion that customers are a part of the FFE team as a learning source of creativity in NPD just as audiences are an important component of an orchestra's delivery of a successful symphony performance, comparing a global technology corporation and a city symphony orchestra. Alam [31] also showed that customer interaction reduces FFE uncertainties. It is also important to get customers involved in the process of FFE for the purpose of monitoring ever-changing uncertainties and identifying customers' demands and preferences at the same time to maintain a competitive advantage under the trend of product customization [38,59]; furthermore, customer involvement also helps firms increase their performance of marketing, product delivery and customer service [60–63] as new-generation products are produced for customers to experience. Moreover, scholars have studied how customers' experiences affect product performance. Feng et al. [38] also found that customer involvement enhances consumers' perceptions of products, thus having a positive impact on product quality, reliability and flexibility. By involving customers in the FFE phase of NPD, firms can increase their market share and knowledge transfer effectiveness, thus decreasing NPD time and contributing to increased NPD performance [14,63,64].

Aside from the involvement of customers, the involvement of suppliers during the FFE stage of NPD constructs a beneficial communication platform where suppliers and buying firms learn from each other through knowledge exchange [65,66], and suppliers' knowledge of technology, costs and design can contribute to accurate FFE product definition and project planning [23]. On such a learning platform, suppliers can not only advance their sharing of market needs, information regarding raw material supply and costs with buying firms but also increase their sharing of hidden knowledge in the interest of reducing FFE uncertainties sustainably; such information and knowledge sharing can improve a buying firm's product quality, cost efficiency and product flexibility [67–69]. Moreover, it is important to engage suppliers with pivotal resources because they can offer a differentiating advantage that could improve a product's design and functionality during the FFE phase [70]. Supplier involvement also contributes greatly to firm performance. After investigating 418 Australian manufacturing companies, Singh and Power [71] showed that supplier involvement can increase a firm's operational performance. In a study of 176 Chi-

nese manufacturing firms, Feng et al. [38] showed that supplier involvement enhances a firm's competitive advantage by decreasing factory costs. In pursuing their mutual goal of increased NPD performance, it is important for suppliers and buying firms to develop long-term cooperation during the FFE stage that is composed of interactive elements by rationally dividing the workload corresponding to the target of unifying standards regarding technology and design to simplify the NPD process [38,72]. The innovation practices of a supplier improve the corresponding buying firm's FFE performance [73], thus improving its NPD performance. Therefore, a buying firm's choices of suppliers at the FFE stage are pivotal because selecting the right suppliers can help buying firms repair, manage and strengthen the vertical value chain from the beginning to prevent unnecessary financial and time costs and to better serve downstream customers. Therefore, we propose the following:

Hypothesis 1a (H1a): *The higher the level of customer involvement in FFE innovation is, the higher NPD performance.*

Hypothesis 1b (H1b): *The higher the level of supplier involvement in FFE innovation is, the higher NPD performance.*

2.3. FFE Vertical External Involvement and CSR

Hassi and Wever [44] first opened up the discussion of how to bring sustainable considerations into FFE innovation. However, research on FFE vertical external stakeholders' involvement and firms' CSR is lacking. In our opinion, it is also essential for firms to consider not only NPD innovation activities but also the CSR actions that firms must undertake at the FFE stage since firms' CSR engagement is also an obligation of firms' stakeholders [74]. In the context of global VUCA conditions, firms need to assume responsibility for social goods and benefits to build a sustainable manufacturing ecosystem and thus raise social capital instead of focusing on only economic capital for sustainable development. Sarkis [56] suggested that firms should seek to build a more agile and localized supply chain to decrease the uncertainties brought by COVID-19 in a timely manner so that firms and other stakeholders can create a small range of sustainable business ecosystems. Stakeholders are often divided into internal and external stakeholders [75,76], and we propose that external stakeholders are more obligated to drive firms to pursue more green innovation and practices [45,77]. Therefore, external stakeholders are usually the main force promoting an organization's green procurement practices [43], and they should help the company find the right business ecological niche within the ecosystem. Among external stakeholders, unlike horizontal stakeholders such as competitors, governments and other alliances, customers and suppliers can prevent competition and bargaining through their vertical involvement in FFE innovation, allowing firms to apply OL for product innovation in a smooth and reliable manner [12]. Moreover, the external involvement of customers and suppliers not only promotes a firm's environmental responsibilities but also drives the firm forward based on CSR expectations regarding functional, emotional and social benefits [42].

In an open innovation environment, external stakeholders usually want to continue collaborating with their partner firms after their NPD projects are finished, which fosters a long-term, stable relationship that reflects the core value of sustainable value chain management during a firm's FFE stage [78]. At the downstream end of a firm's value chain, customers are the receivers of commercialized products; hence, they are endowed with the obligation to become involved in the firm's CSR activities during the FFE stage. Lee and Yoon [79] revealed that when customers are deeply involved with a firm's corporate volunteering initiatives, they increasingly value the firm's social initiatives, and this reinforces their belief in the firm's CSR activities. As 2013 CSR Retrak results show, customers no longer care about only a product's price and quality; rather, they are also concerned about firms' CSR efforts because up to 50 percent of customers' eagerness to trust, recommend and endorse a firm is driven by their perceptions of the firm's CSR efforts; moreover,

only 17 percent of customers are willing to purchase products and recommend firms with poor CSR reputations [80]. Hence, manufacturing firms need to pay much attention to learning from customers at the beginning of the NPD process, which is the FFE stage in an open innovation setting, since such knowledge has a major CSR image effect on product commercialization. Consequently, Robinson et al. [81] stated that customer involvement in a firm's CSR campaign has a positive cause-related marketing effect on customers. On the other hand, the involvement of customers in establishing a firm's CSR initiatives boosts the firm's CSR image in the public market [79]. Prior research conveyed that a firm can usually realize greater philanthropy and social outcomes when customers consider themselves as part of the firm [82]. Simultaneously, unlike customers, suppliers usually have closer ties with buying firms since they share the same economic goals and at the upstream end of firms' value chains. Due to the COVID-19 pandemic, suppliers also need to reconstruct their methods of supply, shifting from a focus on long distances and accommodating large quantities of goods to local and lean supply to build long-term, sustainable relationships with firms and thus better execute CSR initiatives. In regard to CSR-related global supply chain research, Lund-Thomsen and Lindgreen [83] suggested that suppliers should build cooperative purchasing practices with buying firms to better engage in CSR development. To implement CSR initiatives well in the long run, firms also need to carefully select suppliers. Klassen and Vachon [84] suggest that supplier assessment not only helps firms improve CSR engagement but also increases suppliers' compliance with firms in terms of sustainability standards. Moreover, a trustworthy relationship with a firm helps suppliers increase their own sustainability knowledge [85]. When suppliers become involved in a company's sustainability practices, the firm realizes social-related benefits [86]. After researching 101 Swedish manufacturers, Chen et al. [85] found that supplier involvement in sustainability practices brings better sustainability performance that can be attributed to a firm's CSR engagement [87]. Therefore, we draw the following conclusions:

Hypothesis 2a (H2a): *A greater level of FFE customer involvement leads to higher CSR engagement.*

Hypothesis 2b (H2b): *A greater level of FFE supplier involvement leads to higher CSR engagement.*

2.4. CSR and NPD Performance

According to OL theory, an open innovation environment that attracts external stakeholders prospers during the FFE stage in terms of innovation intensity because external stakeholders represent an excellent way for firms to obtain previously undiscovered knowledge and resources to derive a competitive advantage from FFE innovation to product commercial performance [30,88]. More importantly, researchers have also emphasized the important role of CSR engagement in determining the general competitiveness of firms [89,90]. Manufacturers must focus on the long-term CSR interrelated sustainable development of a product to thrive in the long run, as products are eliminated quickly and VUCA conditions are impacting the real business world. Applying OL theory to customers and suppliers during the FFE stage prevents CSR-related product failures later on during a firm's NPD and product commercialization phases since CSR is an important measure of a firm's long-term competitive advantage [91]. Therefore, it is strategically important to include CSR engagement in a firm's FFE vertical external involvement to enhance the firm's NPD performance because CSR activities are important marketing strategies to communicate with external stakeholders; this increases a firm's performance through open-boundary FFE OL innovation with external dynamic communication [92–95].

Introducing social responsibility factors to NPD to create sustainable business practices is an industrial trend [96]. In the NPD process, it is critical for firms to take stakeholders' social concerns into account to achieve CSR goals with different stakeholders [88] because NPD performance is affiliated not only with a firm's economic interests, advanced technologies and market shares but also with customers' and suppliers' requests and environmental

concerns on a long-term basis. Aside from the reasons underlying a firm's responsibility toward society and stakeholders, Zhang et al. [91] found that a firm's CSR engagement aids employees in actively taking part in the establishment of company innovation activities and practices; moreover, it was affirmed that CSR engagement helps firms create a good reputation that provides them with future business benefits [97]. Hence, implementing CSR strategies early during the FFE stage is an important way to adapt to the future commercialized market for new products by learning from an uncertain market, as this approach can help cultivate a firm's reputation and increase trust [80]. Lee and Yoon [79] showed that a value chain's downstream end consumers are willing to recommend and purchase a firm's product if the firm has a strong CSR reputation or image, which attracts desired support from consumers and eventually improves the firm's NPD performance. Moreover, CSR engagement is viewed as a corporate action that surpasses a company's economic and legal duties and different stakeholders' interests [98]. As Hur et al. [99] suggested, customers usually consider a firm's CSR reputation to be equally important as its credibility, which reveals that CSR image is as important as firm business-related credibility. That is, a firm's NPD performance is increased by both its business abilities and its CSR initiatives. Accordingly, integrating CSR initiatives into a firm's NPD process is not a voluntary option but firmly an obligation. Therefore, manufacturing firms should install CSR engagement at the beginning of the FFE stage of a market-accepted product's design process to reduce FFE uncertainties, which could present an inescapable issue later during the NPD process, as the costs of changing increase exponentially over time due to stakeholders' CSR requirements [12,44]. In addition, Naseem et al. [100] found that CSR activities have a positive effect on a firm's financial performance; indeed, the competitiveness of a firm gradually decreases if it chooses to ignore CSR concerns [101,102]. Thus, we propose the following:

Hypothesis 3 (H3): *Greater CSR engagement leads to higher NPD performance.*

2.5. The Mediating Effect of CSR

CSR engagement is a way to unify a firm's social values with both internal and external stakeholders, adding a dimension to a manufacturer's business practices. Through the improvement of a manufacturing company's CSR engagement, the FFE vertical external involvement of its customers and suppliers leads the company to establish a more sustainable NPD process [44,103]. Nevertheless, NPD performance is vital to a firm's sustainable growth under the rapidly changing VUCA competitive industrial environment. Thus, a good CSR comprehension of sustainable NPD performance encourages firms to improve their CSR management and sustainable development [5,104] because NPD performance is enhanced if all the stakeholders on a manufacturing firm's value chain have reached a consensus about the firm's business value.

Although engaging in CSR activities imposes extra costs on a firm, the financial benefits a firm realizes by actualizing CSR engagement outweigh the costs [100]. Additionally, the FFE activities encompassed by CSR engagement, such as vertical external involvement, create wealth, value and satisfaction for different stakeholders [100]. On the other hand, firms suffer societal chaos instead of economic turbulence if they choose to neglect the CSR appeals of external stakeholders, as these appeals are associated with a firm's sustainable growth [49,88]. Therefore, a shared understanding of a sustainable CSR vision should be the key factor that ties firms and external stakeholders together. It is easier for customers and suppliers to participate in a firm's sustainable CSR engagement during the FFE phase than it is later in the process during product commercialization, and a firm's product innovation level is increased when the company's vertical external stakeholders are fully involved [19].

Under the global tendency to use science and technology for social good, carbon neutrality and COVID-19 prevention, it is even more urgent for manufacturers to consider an OL strategy when working with external stakeholders during FFE innovation to advance NPD performance based on CSR concerns. Studies have shown that as a firm increases its

investment in strategic CSR actions, its relationship with its stakeholders is increasingly sustained, and this enhances its product and process innovation [98,105]. By learning from customers, firms can engage in more CSR activities to attract more customers who perceive the firm's CSR actions as their positive social identities, decreasing the psychological distance between the firm and customers [99,106]; moreover, by engaging customers, firms foster CSR initiatives that eventually enhance customers' loyalty to the company and thus increase profits [107]. In response to customers, suppliers assist firms in more effectively addressing customers' CSR preferences by conducting market exploration, thus improving their buying firms' new product market acceptance based on potential market demand [108]. Researchers have also proposed that integrating suppliers' CSR codes of conduct into participating focal firms' NPD can help firms deliver final products [109]. As customers, suppliers and focal firms work together closely to develop CSR activities in order to build a sustainable supply chain during the FFE stage, the NPD process becomes more effective and less time and cost consuming; in this case, the implemented CSR operational standards are usually more matching with legal requirements [110–112]. Therefore, we believe that there is a sustainable pathway between FFE vertical external involvement and a firm's NPD performance through the mediating effect of CSR. The following hypothesis is thus proposed:

Hypothesis 4 (H4): *A firm's CSR engagement mediates the relationship between its FFE vertical external involvement and its NPD performance.*

In summary, on the basis of OL theory, we construct a new model to investigate the relationships between FFE vertical external involvement, firm CSR engagement and firm NPD performance (Figure 1). Specifically, this study examines the mediating effect of firm CSR engagement on the relationship between FFE vertical external involvement and NPD performance. In our research approach, we illustrate the relationship between FFE vertical external involvement and NPD performance in an open innovation context to determine how different vertical stakeholders along a firm's vertical value chain reach a common goal by incentivizing the focal manufacturer's OL during the current VUCA age. Our discovery provides empirical and theoretical evidence for future FFE research.

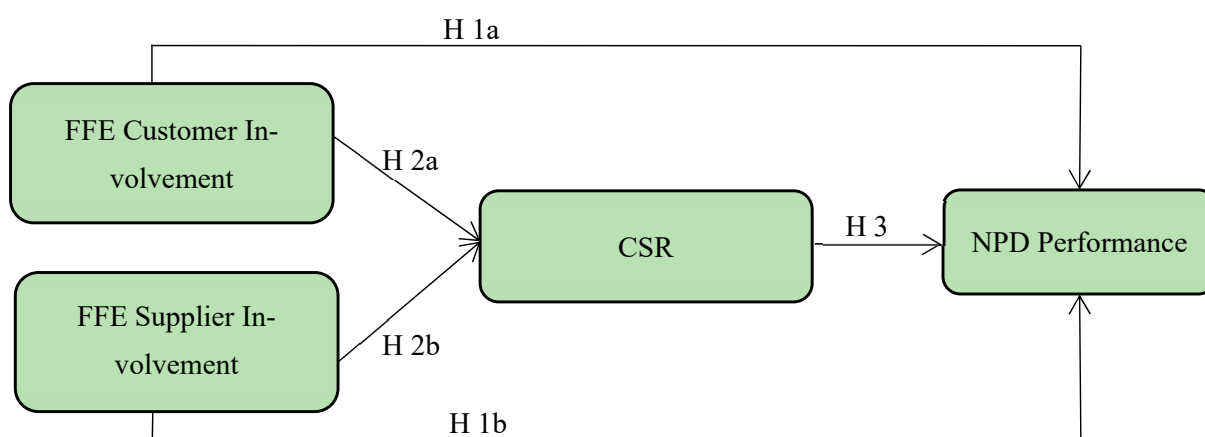


Figure 1. The hypothesized model.

3. Methodology

3.1. Sample and Data Collection

With the help of local government officials and industrial guild officials, we targeted Chinese manufacturing NPD team leaders who had adopted a formal FFE process [6] that involved customers and suppliers at the beginning of the NPD process in their companies for sample data collection. We define NPD team leaders as the ones who oversee the whole NPD process from FFE stage to new product commercialization stage [4,6]. The survey

was conducted for three main reasons. (1) The current COVID-19-pandemic-influenced age has imposed an environment characterized by VUCA on all business organizations, especially manufacturing firms, since COVID-19 quarantine policies, trade disputes and regional wars are impeding manufacturers' vertical supply chains and market shares. Hence, it is essential to undergo refined FFE innovation during the initial stage of a manufacturer's NPD process to be fully prepared for the global uncertain environment and to simultaneously satisfy different stakeholders. We hope to provide useful findings regarding international manufacturing companies' operations from our study of Chinese manufacturers. (2) With the increasing global trend involving technology use for the social good, carbon neutrality and other CSR measures, manufacturing firms must consider CSR initiatives during the FFE conceptual phase to deliver more technological and socially responsible products that contribute to the shift in the social innovation mindset that is introducing market dynamics [113] since manufacturing is one of the most important pillars of the global economy. (3) Under the theoretical framework of OL theory considered in this study, customers and suppliers are the two most important learning sources in a manufacturer's vertical value chain. A learning organization flourishes within an open innovative environment [11] by learning organizationally during FFE innovation to remain competent during the current VUCA era.

The questionnaires were distributed through a professional Chinese survey platform: Survey Star (<https://www.wjx.cn/>, accessed on 15 September 2022). The survey process started in April 2022 and ended in August 2022. We surveyed manufacturing companies in various industries to ensure that our results were comprehensive and refined since we aimed to cover comprehensive manufacturing industries in our exploration of the FFE process [114]. Local government officials in different high-technology industrial development zones assisted in the distribution of our questionnaires. A demographic map of the different included manufacturing companies' locations included the Shaanxi province, Sichuan province, Chongqing municipality, Henan province and Shandong province of China, covering most of Western China and the middle and lower reaches of the Yellow River, where sustainable and CSR measures are increasingly being taken seriously [115,116]. We conducted our questionnaire-based investigation in three steps. First, we surveyed 35 manufacturing team leaders using a pilot survey, after which we made minor improvements to increase the accuracy of our questionnaires to enhance the objectivity and precision of our research. Second, we interviewed 50 manufacturing CEOs to clarify our research questions and to ensure that they were sufficiently applicable and practical. Finally, we received 548 valid questionnaires out of all 596 questionnaires. Thus, the valid return rate was 92%. Table 1 demonstrates the basic characteristics of the sample firms. In general, the sample covered manufacturers of different ages, sizes, annual profits, types and industrial attributes.

Table 1. Demographic characteristics of the sample.

Variables	Frequency	%
Firm age		
Under 10	126	23
10–20	147	26.8
Over 20	275	50.2
Firm size		
Under 500	213	38.9
500–1000	133	24.3
Over 1000	202	36.9
Average annual sales		
Less than 5 million	171	31.2
5 million–10 million	141	25.7
More than 10 million	236	43.1
Ownership type		

Table 1. *Cont.*

Variables	Frequency	%
Private enterprise	451	82.3
Foreign-owned enterprise	7	1.3
State-owned enterprise	75	13.7
Joint venture	15	2.7
Industrial category		
Mechanical equipment manufacturing	56	10.2
Pharmaceutical manufacturing	19	3.5
Electronic equipment manufacturing	50	9.1
Commodity manufacturing	376	68.6
Instrument manufacturing	4	0.7
Others	43	7.8

Note: n = 548.

3.2. Variables and Measurements

All the items on our questionnaire were measured using a 5-point Likert scale ranging from 1 (“strongly disagree”) to 5 (“strongly agree”).

FFE customer involvement and FFE supplier involvement. We drew on previous literature involving [33] scales of customer and supplier involvement during the FFE stage of NPD, creating three items for FFE customer involvement and three items for FFE supplier involvement. The three items for FFE customer involvement were FFE product reviews from customers, customer pilot runs and cross-functional FFE teams with customers; moreover, for FFE supplier involvement, we utilized FFE product concept reviews from suppliers, cross-functional FFE teams with suppliers and sharing FFE plans with suppliers.

CSR. We drew on CSR scale developed by previous researchers [117,118], who summarized three aspects of community environmental responsibility, employee responsibility and customer responsibility into the CSR scale. However, depending on the definition of CSR engagements [40,41], we believe that CSR engagements should be divided into two aspects: stakeholders’ benefit responsibility (including customer responsibility and employee responsibility) and environmental responsibilities. Moreover, as the Chinese business norms play out, firms usually contribute to external stakeholders’ welfare through the actions of philanthropic responsibility, according to our interviews of 50 manufacturing CEOs about the real practical CSR engagements in our pilot survey. We eventually set three items for our CSR scale, namely, environmental responsibility, employee responsibility and philanthropic responsibility.

NPD performance. Following previous scholars [6,14,32] whose research showed that market acceptance is prioritized in terms of NPD performance, we assessed NPD performance based on manufacturers’ measurements of their new products’ market performance over the past two years. Therefore, we included the examined firms’ actual profits and new product market share as two indicators of our NPD performance scale.

Control variables. Unlike other studies that use observable variables as control variables, we used environmental uncertainty as our control variable. Because uncertainty is a major research hot spot in the FFE scholarly literature and actual environmental uncertainties from both the market and the technology are looming over the international manufacturing industry in the real world [26,27], we created four items based on a firm’s sense of market and technology uncertainties [13,28,119].

4. Results and Analysis

We used structural equation modeling to examine our hypotheses empirically since we believed that it was the best approach to test our model’s analytical path because our research model included mediating relationships [120]. First, we checked the quality of our data sample by testing its reliability and validity. We then used the structural equation modeling method to examine our proposed hypotheses.

4.1. Reliability and Validity

We used IBM SPSS 23.0 to test the reliability and validity of our collected sample. Table 2 shows the results of the comparative factor analysis. The Cronbach's alpha values of all the constructs are greater than 0.70, and all the CR values of the constructs are greater than 0.70, denoting good internal consistency and reliability. All the items converge to five constructs according to our theoretical model. Each item's factor loading is greater than 0.6, and all the items are statistically significant, which indicates that the data sample is acceptable for subsequent analysis. The KMO measure and Bartlett's test of sphericity are both satisfactory. The KMO value is equal to 0.888, which is greater than 0.7. The approximate chi square of Bartlett's test of sphericity is 8339.422, and $p = 0.000$. The AVE value of each construct is greater than 0.5, denoting good validity. Our questionnaire scale was designed based on previous scholarly literature and other validated scholarly questionnaire scales. We also corrected the minor items by interviewing manufacturing FFE team leaders. Therefore, the content validity is decent. We also used Harman's single-factor test to evaluate the potential for common method bias. The first unrotated principal component load is 32.781%, showing that there is no significant common method bias. We further tested the correlation between the constructs and found that each pair of constructs is correlated; this provides statistical support for subsequent analysis (Table 3). Table 3 also shows that the square root of each construct's AVE value is greater than the correlation coefficients of the construct and the other constructs, indicating good discriminant validity.

Table 2. Report of reliability and validity.

Constructs	Indicating Items	Factor Loading	CR	AVE	Cronbach's α
FFE customer involvement	Firm always considers product reviews from customers during FFE innovation	0.833	0.879	0.707	0.891
	Firm always conducts pilot tryouts with select customers during FFE innovation	0.851			
	Firm's FFE team is cross functional with customers	0.839			
FFE supplier involvement	Firm always considers product reviews from suppliers during FFE innovation	0.967	0.977	0.934	0.988
	Firm's FFE team is cross functional with suppliers	0.968			
	Firm always shares FFE plans with suppliers	0.964			
CSR	Corporate environmental responsibility	0.810	0.852	0.658	0.901
	Corporate employee responsibility	0.818			
	Corporate philanthropic responsibility	0.805			
NPD performance	Firm's product profits have increased over the last two years	0.821	0.794	0.658	0.914
	Firm's product market share has increased over the last two years	0.801			
Environmental uncertainties	Competitor uncertainty	0.839	0.918	0.738	0.923
	Industrial policy uncertainty	0.868			
	Market demand uncertainty	0.866			
	Industrial technology uncertainty	0.862			

Table 3. Inter-construct correlations.

Variables	1	2	3	4	5
1. FFE customer involvement	1				
2. FFE supplier involvement	0.227 **	1			
3. CSR engagement	0.573 **	0.246 **	1		
4. NPD performance	0.508 **	0.314 **	0.743 **	1	
5. Environmental uncertainties	0.377 **	0.310 **	0.453 **	0.468 **	1
Mean	3.844	3.420	3.748	3.519	3.472
SD	0.733	1.647	0.692	0.803	0.831

** Correlation is significant at the 0.01 level. The diagonal values illustrate the square roots of the AVE of each construct.

4.2. Hypothesis Testing

According to our goodness-of-fit test conducted with IBM SPSS Amos 23, all the results lie within the range of recommended values (Table 4), which illustrates that our structural equation model is structurally valid and acceptable.

Table 4. Report of goodness-of-fit simulation.

Category	χ^2	χ^2/df	CFI	GFI	NFI	IFI	RMSEA
Values	63.401	1.668	0.996	0.980	0.990	0.996	0.035
Recommended values	>0	<3	>0.9	>0.9	>0.9	>0.9	<0.06

We then tested all of our hypotheses using structural equation modeling (Table 5). Our findings show that there is no statistically significant relationship between FFE customer involvement and NPD performance ($b = 0.003$, $p = 0.546$), rejecting H1a. This suggests that customers' preferences are changing rapidly during this era of VUCA, as society and the world are changing at a rapid pace; however, NPD is a time-consuming process. Taking customers' advice and preferences seriously during the FFE phase of the NPD process may lead to customer bias, resulting in market shortsightedness and thus harming innovation [121,122]. Our findings show that in the manufacturing industry, FFE customer involvement might not be an effective way to increase NPD performance. However, our findings support H1b ($b = 0.044$, $p < 0.01$), revealing that FFE supplier involvement positively influences NPD performance. Even though an environment characterized by VUCA brings ambiguity to a firm's business prospects, suppliers have strong support for the firm during the FFE process. Suppliers have very strong ties with their manufacturers, and they should be more focused on the long term than customers in providing market and technological knowledge.

Table 5. Report of hypothesis testing.

Hypotheses	Path Coefficient	C.R.	S.E.
Hypothesis 1a	0.033	0.604	0.054
Hypothesis 1b	0.044 **	2.947	0.15
Hypothesis 2a	0.605 ***	13.889	0.044
Hypothesis 2b	0.043 **	2.877	0.015
Hypothesis 3	0.852 ***	14.741	0.058

** Correlation is significant at the 0.01 level. *** Correlation is significant at the 0.001 level.

We also analyzed the relationship between FFE vertical external involvement and CSR engagement, supporting both hypothesis 2a ($b = 0.605$, $p < 0.001$) and hypothesis 2b ($b = 0.043$, $p < 0.01$). Hypothesis 3 was also shown to be sound ($b = 0.852$, $p < 0.001$), which indicates that CSR engagement positively affects NPD performance. We finally tested the mediating effect of CSR engagement, and the results are shown in Table 6. We constructed two mediating models to verify the mediating effect of CSR engagement since we have two split independent variables (FFE customer involvement and FFE supplier involvement). The previous test showed that although FFE customer involvement does not have a direct significant relationship with NPD performance and the 95% confidence interval contains 0, the tested mediating effect outcomes still illustrate that FFE customer involvement predicts NPD performance through the mediating effect of CSR engagement. As the previous testing of hypothesis 1a showed that FFE customer involvement does not significantly impact NPD performance, we claim that CSR engagement has a complete mediating effect on the relationship between FFE customer involvement and NPD performance; consequently, the results also show that FFE supplier involvement positively influences NPD performance via the mediating effect of CSR engagement in addition to having positive direct relationships with CSR engagement and NPD performance. This suggests

that CSR engagement has a partial mediating effect on the relationship between FFE supplier involvement and NPD performance. Therefore, we believe the mediating effect test results strongly support hypothesis 4.

Table 6. Results of intermediary variable report.

Variables	Point Estimate	Bias-Corrected 95% CI		Percentile 95% CI	
		Lower	Upper	Lower	Upper
Total Effects					
FFE customer involvement–CSR–NPD	0.600	0.463	0.730	0.464	0.735
FFE supplier involvement–CSR–NPD	0.096	0.053	0.153	0.051	0.142
Indirect Effects					
FFE customer involvement–CSR–NPD	0.539	0.425	0.678	0.421	0.673
FFE supplier involvement–CSR–NPD	0.040	0.009	0.079	0.010	0.081
Direct Effects					
FFE customer involvement–CSR–NPD	0.060	−0.057	0.185	−0.062	0.182
FFE supplier involvement–CSR–NPD	0.057	0.013	0.106	0.011	0.106

In order to check that only CSR has mediating effects according to our model, we also operated a robust check on the possible alternative moderating effects of CSR on the relationship between FFE customer involvement and a firm's NPD performance and the relationship between FFE supplier involvement and a firm's NPD performance (Table 7). The results show that CSR neither significantly moderates the relationship between FFE customer involvement and a firm's NPD performance ($b = 0.231$, $p = 0.076$) nor significantly moderates the relationship between FFE supplier involvement and a firm's NPD performance ($b = 0.127$, $p = 0.321$). Therefore, we are confident that only CSR has mediating effects on the relationship between FFE vertical external involvement and a firm's NPD performance, which suggests our theoretical model is adequate and complete.

Table 7. Results of alternative robust check on CSR's moderating effects.

Moderating Effects	Path Coefficient	C.R.	S.E.
CSR's moderating effect on hypothesis 1a	0.231	3.897	0.032
CSR's moderating effect on hypothesis 1b	0.127	1.982	0.074

5. Conclusions

5.1. Discussion

FFE activities represent an important initial factor that determines a firm's NPD performance, and FFE vertical external involvement is a key component of FFE activities that utilize external knowledge and resources to realize NPD success [12–14]. A consensus has been reached that firms should not only be growing economically but also paying attention to CSR engagement related to sustainable development to gain a long-term competitive advantage in this VUCA age [1]. Our study examined the relationship between FFE vertical external involvement and NPD performance in the context of CSR. We applied OL theory and open innovation theory to our research, further exploring how CSR engagement plays a role in this relationship. First, our study confirmed hypothesis 1b, showing that FFE supplier involvement has a positive effect on NPD performance. Under the influence of the COVID-19 pandemic and global supply chain shortages, manufacturers are more actively adopting an OL mindset to learn from existing suppliers during the FFE stage of NPD

to form an open innovative ecosystem. This approach can be seen as a way to combat the VUCA environment from the beginning of the NPD process, and it is consistent with previous studies [38,65,66].

Second, our study proved hypotheses 2a and 2b, demonstrating that both FFE customer involvement and FFE supplier involvement positively influence a firm's CSR engagement and stating that FFE vertical external involvement not only increases a firm's NPD performance but also promotes its CSR engagement to facilitate a compounded sustainable competitive advantage [44,103]. Furthermore, our study confirmed hypothesis 3, showing that a firm's CSR engagement has a positive impact on NPD performance. Once again, this result emphasizes the importance of the involvement of sustainable development in terms of a firm's growth prospects. Finally, we confirmed that CSR engagement has a mediating effect on the relationship between FFE vertical external involvement and firm NPD performance. Our findings suggest that both FFE customer involvement and FFE supplier involvement strengthen a firm's CSR engagement; thus, manufacturers should engage in such activities more often to create sustainable and diverse competitive advantages.

5.2. Theoretical Contributions

The new model we proposed in this study connects FFE vertical external involvement, CSR engagement and firm NPD performance. We creatively categorized FFE customer involvement and FFE supplier involvement as FFE vertical external involvement and further tested the mediating effect of CSR engagement on the relationship between FFE vertical external involvement and firm NPD performance. We made three main theoretical contributions through this study. First, we examined the relationship between FFE vertical external involvement (customers and suppliers) and firm NPD performance. We introduced vertical stakeholders to the scholarly discussion on FFE under the NPD framework and emphasized vertical stakeholders' important roles in FFE innovation in terms of OL and open innovation. Second, we introduced the effect of CSR engagement on a manufacturing firm's FFE innovation process by testing the mediating effect of CSR engagement. We found that CSR engagement is a stimulating tool enabling manufacturers to incentivize OL from vertical stakeholders. Third, we provided evidence that manufacturers can cope with the current VUCA age in a way that is both economical and sustainable by exploiting vertical external stakeholders in the formation of a co-innovation ecosystem designed to increase corporate social capital. We also found that CSR engagement has an important impact on firms' NPD performance in this VUCA era.

In summary, our research builds on previous FFE research by providing timely evidence from Chinese manufacturers regarding new FFE activity and a new effect of external FFE on a firm's NPD performance from a constant organizational learning perspective, further expanding the scope of FFE research to the global manufacturing industry in the context of the VUCA age [3,6]. Furthermore, we creatively introduced firm CSR engagement to the FFE research for the first time, providing important evidence of how a firm's sustainable measures can precisely affect FFE execution, thus improving firm NPD performance [44,103]. The theoretical contributions will assist manufacturing firms' FFE innovation research globally in the future.

5.3. Practical Implications

Generally, firms are focused only on embracing external stakeholders during the product commercialization phase through the use of marketing strategies. However, our research provided practical evidence showing that it is also fundamentally necessary to involve vertical external stakeholders in FFE innovation when product concepts are initially being constructed. Our research contributes to OL theory by testing the mediating role of CSR in encouraging manufacturers to learn from vertical external stakeholders during FFE innovation to increase profits and market share. We provided important proof showing that it is equally important to open up a firm's boundaries before a new product goes to market.

First, this study revealed that customers' and suppliers' in-depth intervention in manufacturers' FFE innovation helps them take on more corporate-level responsibilities for the social good. These CSR engagements in turn help manufacturing companies build greater competitive advantages. Firms need external inspections to affirm their social responsibilities for sustainable development. It is also an OL pathway from suppliers' experiences to a finished NPD project that ensures firm-level success from the beginning. Our theoretical results also support the famous practical advice of Steve Jobs, who stated that customers do not know what they truly want in the commercial market. As today's VUCA business environment has greatly impacted the world, customers' reviews of a product can become biased over time under changes in market capitalization, new technologies and other policy-related impacts. There are many products in a single category for customers to choose, and the speed of product iteration is extremely high. Therefore, it is important for firms to concentrate on product quality, serviceability, technology advancement and aesthetics rather than letting customers give judgmental advice early during FFE.

Second, the VUCA circumstances have given the manufacturing industry unforeseen indications about firms' futures. Trade disputes, COVID-19 lockdown requirements and regional conflicts have been threatening the global value chain. The manufacturing industry is undergoing a transformation from massive production to local and lean production. Therefore, firms' priorities should be centered on assuming corporate social responsibilities to build long-term sustainable relationships with different stakeholders instead of only seeking unrealistically rapid growth. The central goal of manufacturers is to survive this global economic decline while maintaining a sustainable status because manufacturing industrial pollution, energy waste and stakeholder dissatisfaction accelerate companies' failure. Our findings indicated that CSR engagements not only help achieve corporate-level long-term competitiveness but also activate firms' OL desire for constant change in the short term. As customers' consuming habits change over time under different VUCA circumstances, firms need to demonstrate a learning strategy during the FFE stage of NPD in the interest of fully understanding the market.

Finally, our theoretical results have practical implications about the importance of being an open, innovative, learning organization against the background of uncertainty under the VUCA condition. The second law of thermodynamics states that an isolated system accumulates more entropy and thus leads to chaos, which illustrates that any physical organization should be opened up to its external environment to reduce chaotic uncertainties. Therefore, organizations' open innovation environment will mitigate internal uncertainties, decreasing the probability of chaos and thus creating an OL environment. Vertical external stakeholders build trustworthy relationships with manufacturers to distribute risks. In addition, external uncertainties encourage FFE innovation with off-boundary organizations, thus increasing NPD performance.

5.4. Limitations and Future Research

Our study has limitations that can offer opportunities for further research. First, we narrowed down FFE external involvement to the vertical supply chain, which contains only customers and suppliers. However, there are other external stakeholders, such as domestic and foreign business partners, research institutions, domestic and foreign investment groups, financial institutions, NGOs and governments. The mechanism of how these important external roles impact a firm's FFE innovation and NPD performance is worthy of investigation. Furthermore, our study investigated the manufacturing industry's FFE vertical external involvement but neglected the service industry's FFE innovation. Third, our study on FFE innovation is based on an organizational point of view. However, human factors have proven to be an important factor determining FFE success [8]. Therefore, how to integrate human factors into FFE research is a topic that requires investigation. Finally, we believe that case studies based on grounded theory should be equally effective for FFE research. There should be a large number of distinctive cases related to executing FFE

activities involving the fuzzy nature of FFE innovation and the current uncertain VUCA business environment.

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Abbreviations

FFE	Fuzzy Front-end
CSR	Corporate Social Responsibility
NPD	New Product Development
OL	Organizational Learning
VUCA	Volatility, Uncertainty, Complexity and Ambiguity

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