GOVERNANCE OF NEW PRODUCT DESIGN: THE INFLUENCE OF NATIONAL INSTITUTIONS*

ISABEL MARIA BODAS FREITAS†
Grenoble Ecole de Management

RICARDO GONÇALVES‡
Católica Porto Business School and CEGE, Universidade Católica Portuguesa

RUI SOUSA§
Católica Porto Business School and CEGE, Universidade Católica Portuguesa

May 2023

* Financial support from Fundação para a Ciência e Tecnologia (through project PEst-OE/EGE/UI0731/2013) is gratefully acknowledged. We would like to thank Katherine Castellano, Celine Abecassis-Moedas, Steve Conway, Leonardo Corbo, Eylem Gevrek, Viacheslav Iurkov, Tarek Mostafa, Ricardo Ribeiro, André Trindade and Bozidar Vlacic for their helpful comments and suggestions. We also thank seminar participants at Católica Porto Business School (January 2018) and Universidad Autónoma de Madrid (June 2019), as well as participants in the 25th Innovation and Product Development Management Conference (IPDMC) (Porto, June 2018), and in the European Academy of Management (EURAM) 2018 Conference (Reykjavik, June 2018) for their feedback on earlier versions of the paper. Moreover, we thank the generous comments of Snehal Awate during the AIB PDW (June, 2021).

† E-mail: isabel-maria.bodasfreitas@grenoble-em.com.

‡ Corresponding author. Católica Porto Business School, Universidade Católica Portuguesa, Rua Diogo Botelho, 1327, 4169-005 Porto, Portugal. E-mail: rlgoncalves@ucp.pt.

§ E-mail: rsousa@ucp.pt.

ABSTRACT

This paper builds on institutional economics theory to analyze whether and how the institutional environment shapes the micro-level governance decisions related to innovation activities. Specifically, we suggest that the extent of co-creation with value-chain partners in new product design – a relational form of governance – is influenced by the institutional setting of the focal firm. Empirically, we rely on data on 636 manufacturers in 21 countries. Results from a hierarchical probit regression show that co-creation is more likely for firms that operate in countries with weak rule-of-law and/or atrophic technological infrastructures. We discuss the implications for theory and practice.

JEL Classification: O32, O57

Keywords: co-creation, collaboration, value-chain partners, institutional environment

GOVERNANCE OF NEW PRODUCT DESIGN: THE INFLUENCE OF NATIONAL INSTITUTIONS

1. INTRODUCTION

It is becoming increasingly frequent for firms' innovation activities to extend beyond firm boundaries and to involve especially external value-chain partners in the creation and design of new products and associated processes (Ambos et al., 2021; Chesbrough and Appleyard, 2007). This mode of product design activity, which is described also as 'co-creation' (Henkel, Baldwin and Shih, 2013; Vasudeva, Leiponen and Jones, 2020), involves joint governance of problem-solving and decision-making.

Co-creation involving value-chain partners provides several benefits. It allows closer control and monitoring of the exchanges among the firms than outsourcing contracts, which are likely to be incomplete given the numerous decisions involved in the innovation process (Baldwin and Von Hippel, 2011). It grants the focal firm access to 'sticky' knowledge about additional or improved product functionalities and the technological bottlenecks that need to be resolved to develop more technology efficient and higher-value products (Belderbos et al., 2018; Zobel and Hagedoorn, 2020). Co-creation also allows for Research and Development (R&D) costs and the uncertainty involved in innovation to be shared among the partners (Gulati, Wohlgezogen and Zhelyazkov, 2012; Hohberger, Kruger and Almeida, 2020).

However, co-creation with value-chain partners can increase the risk of dependence on less efficient or less reliable technologies, and of the development of products that might satisfy the needs of the collaborating customers but not those of other customers (Appiah, Bonsu and Sarpong, 2021; Fischer, Greven, Tornow and Brettel, 2021; Verhoef, Beckers and van Doorn, 2013). Managing collaboration partners with different expectations and objectives increases the risks and costs of communication and coordination, as well as the threats posed by knowledge leakages (Appiah, Bonsu and Sapong, 2021; Gulati et al., 2012b).

The increased dependence on innovation as a source of competitive advantage is resulting in economic activities becoming more fragmented across different geographic locations (Ambos et al., 2021; WTO, 2017, 2019). This highlights the importance of understanding whether and in what national institutional settings product innovation based on co-creation with value-chain partners mitigates (rather than amplifies) the risks and costs of innovation.

Baldwin and Clark's (2000) study of product design inspired a stream of work suggesting that decisions about governance decisions in value-chains are led by both the characteristics of the product architecture (in particular, its degree of modularity) and the suppliers' capabilities (Gereffi, Humphrey and Sturgeon, 2005; Strange and Humphrey, 2019). This strand of work shows that lead firms employ different modes of governance to manage transactions with different suppliers (Buciuni and Pisano, 2021; Kano, 2018; Verbeke, Hutzschenreuter and Pyasi, 2021), and that suppliers' upgrading strategies can shape value-chain governance (Azmeh and Nadvi, 2014; Sako and Zylberberg, 2019). Use of specific governance modes to interact with value-chain partners allows for the development of specific firm capabilities and views, which lead to the pursuit of particular strategies to achieve resilience (Choksy et al., 2022). However, how firms govern their innovation activities is poorly understood (Ambos et al., 2021; Buciuni and Pisano, 2021) and we know little about whether and how the institutional environment shapes micro-level governance decisions (Munjal et al., 2022; Ponte and Sturgeon, 2014).

Different institutional environments lead to different perceptions of the risks and opportunities related to specific governance forms (Munjal, Varma and Bhatnagar, 2022; Ponte and Sturgeon, 2014; Thornton, Ocasio and Lounsbury, 2012). In addition to providing the context to which the firm must adapt its strategies, institutions create an environment which steers the actors towards the development of certain capabilities and certain ways of mobilizing and managing resources (Jackson and Deeg, 2008; Lundvall, 2016; Nelson and Sampat, 2001). The set of interdependent national institutions which impose "a stable (but not

necessarily efficient) structure to human interaction" (North, 1990, p. 6) determine the firm's transaction hazards and learning and appropriation opportunities (Dorobantu, Kaul and Zelner, 2017; Jacobides and Winter, 2012).

The present study aims to enhance our understanding of how product innovation activities within value-chains are governed. We address the following research question: Does heterogeneity in the firm's decision to co-create a new product design with value-chain partners reflect the transactional and learning issues imposed by the national institutional setting? We draw on the institutional economics understanding of institutions as "the rules of the game" which create incentives for specific low-cost forms of interaction and knowledge exchange (Nelson and Sampat, 2001; North, 1990). We propose that national institutions influence the firm's views about appropriate knowledge development and value generation practices (Nelson and Sampat, 2001; North, 1990), and the issues that require attention (Corsaro, 2022; Franczak, Lanivich and Adomako, 2023; Thornton et al., 2012). We focus on two interdependent aspects of the firm's institutional environment which determine the degree of uncertainty involved in coordinating and learning from exchanges with value-chain partners (Pietrobelli and Rabellotti, 2011): (i) level of enforcement of laws, property rights, and contracts (rule of law), and (ii) degree of development of the technological infrastructure in the firm's country of operation.

We build on this theoretical background to develop hypotheses about the relationship between the likelihood that firms engage in co-creation for product design with customers and/or suppliers, and the national rule of law and national technological infrastructure. We test our predictions using data from the 6th International Manufacturing Strategy Survey (IMSS-VI) for 636 manufacturing firms operating in 6 industries in 21 countries. We employ a hierarchical probit model and account for the characteristics of the product architecture and the extent of the exchanges with foreign value-chain partners. Results show that the form of

governance chosen by the firm to manage new product design activities with value-chain partners is associated with the characteristics of the national institutional setting.

Our study provides three main theoretical contributions.

First, it adds to the governance literature that focuses on the importance of product architecture on governance decisions related to innovation and production activities (mirroring hypothesis) (Baldwin, 2022; Burton and Galvin, 2022; Colfer and Baldwin, 2016; Gereffi et al., 2005). Work that tests this hypothesis uses samples of firms that share the same institutional and industrial setting (Burton and Galvin, 2022; Cabigiosu and Camuffo, 2012; MacCormack et al., 2012). Our study contributes to this literature by integrating the institutional dimension in a conceptual model which we use to analyze the governance decisions related to new product design activities. We argue that the institutional setting shapes the firm's perception of the risks and difficulties involved in contracting and innovating (Franczak et al., 2023; Thornton et al., 2012). Therefore, it influences the perceived transaction costs and the learning gains from alternative modes of purposeful interaction with different partners (Nelson and Sampat, 2001) and, consequently, the rationale for choosing co-creation. Accounting for the firm's characteristics and product architecture, our results support our argument.

Second, this study contributes to the stream of international business (IB) literature that increasingly considers institutions as comparable sets of norms and habits with different levels of efficiency (Abdi and Aulakh, 2012; Berry et al., 2010; Cuervo-Cazurra and Pananond, 2023; Ponte and Sturgeon, 2014), and considers that the perceived distance with the partners' institutional environment influences the firm's business decisions. Our study highlights that business and especially innovation constitute a social and interactive process (Freeman, 2004; Lundvall, 2016) in which institutions shape firm capabilities, cognition and management of exchanges (Corsaro, 2022; Franczak et al., 2023; Munjal et al., 2022; Thornton, et al., 2012). Our theoretical model proposes that national institutions influence the

firm's perception of the transactions and learning hazards involved in exchanges with value-chains partners, and consequently shape its views about how to manage these risks (including with partners operating in the same institutional setting). Our results corroborate our hypothesis.

Third, our work contributes to the stream of the innovation and new product development literature which discusses the role of co-creation and collaboration to deal with issues perceived as uncertain and costly. We draw on insights from institutional economics theory to underline that institutions influence firm views on the uncertainties which need to be addressed and the learning processes which need to be fostered, and in turn influence how they structure and manage linkages for new product design (Freeman, 1995, 2004; Nelson, 1993; Nelson and Sampat, 2001; North, 1990).

2. THEORETICAL BACKGROUND AND HYPOTHESES

2.1. Prior research on collaboration for new product design and development

The large body of work discussing the rationale for inter-firm collaboration to govern R&D and new product development activities with value-chain partners mostly employs two theoretical lenses: transaction cost economics and capabilities.

Studies using a transaction cost economics lens tend to conceptualize firm collaboration in terms of the costs and benefits of monitoring and coordinating exchanges compared to other governance modes and especially outsourcing contracts (Baldwin and von Hippel, 2011; Gulati and Nickerson, 2008; Gulati and Singh, 1998). Most of these studies test the mirroring hypothesis that the degree of organizational integration with suppliers for new product development reflects the product architecture (Colfer and Baldwin, 2016; Elia, Massini and Narula, 2019; MacCormack et al., 2012). Collaboration over R&D and product design (and its associated benefits) seems to be determined largely by factors that influence the transaction costs involved in knowledge exchanges such as the types of knowledge development activities, technological interdependence, and the specificity of the asset being developed

(Hofman, Halman and Song, 2017; Lumineau et al., 2022), the technological challenge posed (Brusoni, Prencipe and Pavitt, 2001; van der Wouden, 2020), and the phase in the industry life cycle (Chesbrough and Kusunoki, 2001; Kapoor and Adner, 2012; Pisano, 1991). Collaboration for innovation is considered to be more likely and more beneficial in a context of rapidly evolving technologies when the product architecture is ambiguous and difficult to codify and the market is poorly defined (Bhaskaran and Krishnan, 2009; Brusoni et al., 2001; Burton and Galvin, 2022; Chesbrough and Kusunoki, 2001).

Studies that adopt a capabilities perspective suggest that firms with different capabilities pursue different objectives, have different perceptions, and take different governance decisions which lead to specific learning paths (Jacobides and Winter, 2005; 2012). Hence, collaboration for R&D, product design and development may be also a strategy for entry to new technological and market areas, and/or access to widely distributed knowledge which is difficult for the firm to reproduce (Rothaermel and Deeds, 2004; Cozzolino and Rothaermel, 2018). For example, collaboration enables access to technology, and knowledge about how to solve problems, technical breakthroughs and failed approaches. It facilitates product customization and, thus, early access to resources and markets, and provides opportunities to influence technical standards and regulation (Chesbrough, Lettl and Ritter, 2018; Pisano, 1991; Powell, Koput and Smith-Doerr, 1996).

Both of these approaches highlight learning and coordination issues and provide "additive" perspectives on the firm's decisions about the governance of innovation activities (Argyres et al., 2012, p. 1214; Burton and Galvin, 2022). Indeed, Gereffi et al. (2005) suggest that the 'relational' mode of governance is preferred when the firm's ability to codify complex transactions is low (i.e., the case of an integral product architecture requiring exchanges of tacit knowledge between buyers and suppliers), and partners' capabilities are high. In this context, it is difficult to specify contracts in advance. Exchanges take the form of incomplete contracts which result in more capable suppliers having higher bargaining power.

Coordination in this case requires trust building (Gereffi et al., 2005; Kloyer and Scholderer, 2012; Lumineau et al., 2022).

Reducing uncertainty and coordination costs and improving access to sources of relevant knowledge and resources are closely intertwined in the governance decision (Argyres et al., 2012; Burton and Galvin, 2022). Therefore, understanding how firms govern their innovation activities requires consideration of factors that are beyond the firm's control such as the features of the system in which the firm operates (Jacobides and Winter, 2005, 2012; Ponte and Sturgeon, 2014). The way that the local system rewards (or penalizes) certain types of interactions is indicative of the potential advantages of certain modes of governance for learning and appropriation of value (Jacobides and Winter, 2005; Nelson and Sampat, 2001). That is, a particular learning path (Freeman, 1995, 2004; Lundvall, 2016; Malerba and Nelson 2011) and a particular governance form may be more frequent in some particular institutional setting (Dorobantu et al., 2017). This means that the firm's perception of the risks and opportunities of specific forms of governance of operational and innovation activities with value-chain partners will vary with the institutional environment (Ponte and Sturgeon, 2014).

Despite a large stream of work on inter-firm collaboration for R&D and product design, and on the mirroring hypothesis in dyads within the value-chain, the part played by the institutional context is mostly ignored (Kano et al., 2020).

2.2. Conceptual Framework

Institutional economics theory posits that "when it is difficult to transact, institutions matter" (North, 1990, p. 12). Institutions "(together with the technology employed) determine the costs of transacting and the cost of transformation" (North, 1990, p. 34), and as a consequence, promote the development of specific capabilities and the creation and diffusion of specific knowledge and resources (Freeman, 1995, 2004; Lundvall, 2016; Nelson, 1993). By setting the rules of the game, national institutions shape the human interactions in the system and how people and organizations learn and "get things done" (Nelson and Sampat,

2001). Institutions benefit asymmetrically different business strategies and experiences (Chesbrough, 1999; Corsaro, 2022; Nelson, 1993; Santangelo et al., 2016). Therefore, although institutions are more than scenarios to which the firm's strategies must adapt (Jackson and Deeg, 2008; Withley, 2000), they shape rather than determine firms' plans and behaviors (Franczak et al., 2023; Nelson, 1991; North, 1990).

Building on this theoretical perspective, we hope to provide a better understanding of the firm's decisions related to the governance of innovation activities with value-chain partners. We consider the co-creation of new product design with value-chain partners as a relational mode of governance in which the partners have space to exchange tacit knowledge and decide jointly on design specifications (Gereffi et al., 2005; Henkel et al., 2013). This "often creates mutual dependence and high levels of asset specificity" (Gereffi et al., 2005, p. 84). Co-creation of and collaboration over new product design can be understood as an intermediate mode of governance mode located between 'modular governance', which involves more or less detailed outsourcing contracts, and 'hierarchical governance', which is characterized by vertical integration (Gereffi et al., 2005).

However, since innovation activity involves increasingly shorter innovation cycles and is more often located outside the firm's boundaries, vertical integration of innovation activities is becoming less practical (Ambos et al., 2021; Baldwin and Von Hippel, 2011; Zobel and Hagedoorn, 2020) whereas co-creation allows close monitoring of value-chain partners and access to essential technology and resources (Gulati et al., 2012b; Henkel et al., 2013). In other words, as knowledge sources become more distributed, governance via co-creation allows a relatively integrated approach to new product design (Gulati et al., 2012a,b; Vasudeva et al., 2020).

We conceptualize a firm's engagement in co-creation for new product design with value-chain partners as depending on the national institutional context, *ceteris paribus*. The institutional setting influences the firm's valuation of opportunities and judgement of risks

(Franczak et al., 2023; Thornton et al., 2012) and consequently structures the linkages the firm establishes and how they interact (Freeman 1995, 2004; Lundvall, 2016; Malerba and Nelson, 2011; Nelson and Sampat, 2001). That is, the institutional setting can influence the firm's perception of the benefits and costs of engaging in co-creation with value-chain partners.

The choice of governance mode for new product design activities with value-chain partners depends on the perceived transactional costs of learning and coordination (Colfer and Baldwin, 2016; Hofman et al., 2017; Lumineau et al., 2022; MacCormack et al., 2012). These costs are likely to increase with the expected difficulty to communicate, learn and innovate, and with the difficulty to monitor partners' capabilities and behavior (Afuah, 2000; Argyres et al., 2012; Burton and Galvin, 2022; Colfer and Baldwin, 2016; Kloyer and Scholderer, 2012; Jacobides and Winter, 2012). Thus, our model focuses on two aspects of the institutional setting which influence the perceived uncertainty about transactional and learning costs in product design innovation activities (Pietrobelli and Rabellotti, 2011): 1) the national rule of law, which determines confidence in and abidance by national law, property rights, and contracts (Abdi and Aulakh, 2012; Mickiewicz, Stephan and Shami, 2021), and 2) the national technological infrastructure, which defines access to scientific and technological knowledge, and the mechanisms for the production and commercialization of innovative products and technologies (Freeman, 2004; Weiss and Birnbaum, 1989).

The national rule of law shapes firms' perceptions of the market transaction costs associated with monitoring opportunistic behavior and enforcing contracts (Abdi and Aulakh, 2012; Mickiewicz et al., 2021). The national technological infrastructure influences their perception of the possibilities to engage in a range of activities related to the generation and diffusion of knowledge, and thus the uncertainty associated with new product design activities (Furman, Porter and Stern, 2002; Palmer, Toral, Truong and Lowe, 2022; Weiss and Birnbaum, 1989).

In what follows, we explain how the rule of law and national technological infrastructure influence the perceived costs and uncertainty associated with monitoring and enforcing contracts, innovating, and building capabilities. Specifically, we consider how, *ceteris paribus*, differences in the national rule of law and technological infrastructure influence the firm's decision to co-create new product design with value-chain partners. Thus, while we acknowledge and account for the role of product and firm characteristics on that decision, our focus is on the influence of the institutional context. Figure 1 summarizes our ideas.

[Figure 1 about here]

2.3. Research Hypotheses

2.3.1. Co-creation of product design and national rule of law.

The degree to which the local actors are familiar with and comply with the national law reflects the ability of the administration to enforce the law, maintain order, and arbitrate disputes. It also determines the extent to which firms trust national institutions to enforce contracts and property rights, and their expectations about opportunistic behavior by partners (Abdi and Aulakh, 2012; Thornton et al., 2012). By influencing perceived transaction hazards, the extent to which the institutional setting enforces contracts and property rights may influence firms' governance decisions (Pietrobelli and Rabellotti, 2011; Santangelo et al., 2016).

In countries with a governance structure and legal system which do not enforce societal rules, contracts, or laws, actors have fewer incentives to comply with national rules, fulfil contracts, or respect tangible and intangible property rights (Mickiewicz et al., 2021). Absence of systematic penalization of abuses of property rights and non-compliance with contracts will reduce the costs and increase the frequency of opportunistic behavior by the firm's partners, leading to the perception of higher transaction hazards (Abdi and Aulakh, 2012; Dorobantu et al., 2017; Hussen and Cokgezen, 2021).

In this context, governing new product design and development activities with value-chain partners through arm's length contracts will increase the firm's exposure to opportunistic behavior: "Contract as mere promise is not self-enforcing" (Williamson, 2002, p. 188). Inability to anticipate every possible situation means that complex contracts related to new product design may suffer from omissions which open the possibility for unanticipated demands to renegotiate contracts or refusals to comply with contract conditions (Gulati et al., 2012b; Williamson, 2002). If national institutions are unable to enforce property rights protection and arbitrate contractual impasses and breakdowns, firms may prefer collaborative (non-market) modes of monitoring and coordinating transactions, and arbitrating disputes (Dorobantu et al., 2017; Krammer, 2019), reducing their capability to draft tight outsourcing contracts (Kloyer and Scholderer, 2012).

New product design collaborations with suppliers and customers allows closer monitoring of the partners' conduct and compliance with contracts/agreements and increases the motivation to achieve the agreed goals (Bhaskaran and Krishnan, 2009; Lindenberg and Foss, 2011). Co-creation helps to build trust and commitment, and enables the sharing of costs and benefits (Bhaskaran and Krishnan, 2009; Gulati and Nickerson, 2008; Kim et al., 2020; Solinas et al., 2022). Specifically, it enables suppliers' activities and their management of uncertainties in the innovation process to be monitored, which reduces the risk of agreement failure and of an unsatisfactory outcome (Hohberger et al., 2020; Lumineau et al., 2022; Williamson, 2002).

Similarly, co-creation enables the focal firm to monitor the extent to which customers' requests for an upgraded product design are compatible with the improvements being incorporated (Gulati et al., 2012b; Vasudeva et al., 2020). Hence, in addition to providing access to complex knowledge not specified in a contract but necessary to satisfy customers, co-creation allows monitoring and enforcement of customers' engagement in procurement agreements (MacCormack et al., 2012).

In turn, value-chain partners involved in joint design and joint decisions about product design have an incentive to make the joint endeavor successful (Gulati and Nickerson, 2008; Gulati et al., 2012b; Lindenberg and Foss, 2011). This "makes the costs of switching to new partners high" (Gereffi et al., 2005, p. 86). Suppliers may customize their innovation efforts to the specificities of the focal firm's product architecture (Henkel et al., 2013; Vasudeva et al., 2020). This is likely to link the value of the suppliers' products to the focal firm's ability to create value from the joint new product design activities (Azmeh and Nadvi, 2014; Lumineau et al., 2022). Similarly, customers involved in co-creating with the focal firm may upgrade the product to make the focal firm's products more relevant and provide increased competitive advantage. These aspects are likely to ensure that agreements and contracts with the focal firm are fulfilled (Appiah et al., 2021; Sako and Zylberberg, 2019; Vasudeva et al., 2020).

At the same time, co-creation with value-chain partners allows these partners to access the focal firm's proprietary knowledge and provides opportunities to exploit this knowledge for individual gain (Henkel et al., 2013). In countries with weak rule of law, this behavior is unlikely to be penalized (Pietrobelli and Rabellotti, 2011). However, the efforts and investments made by customers and suppliers in co-creation with the focal firm, and the trust developed from working together are likely to reduce opportunistic behavior (Gulati et al. 2012b; Kim et al., 2020; MacCormack et al., 2012). The literature shows that close interaction builds trust, which lowers the (perceived) probability that partners will act opportunistically (Gulati and Nickerson, 2008; Solinas et al., 2022).

In countries where national courts enforce laws, property rights, and contract conditions, and penalize abuses of property rights and non-compliance with contracts, the actors can expect lower transaction and contract enforcement costs and lower levels of opportunistic behavior (Hussen and Cokgezen, 2021; Krammer, 2019; Mickiewicz et al., 2021). In an institutional setting that promotes confidence, firms will find less valuable governance modes that allow close monitoring of partners' efforts (Colfer and Baldwin, 2016). This allows the

firm to develop tight outsourcing contract drafting competence, which reduces the risk of incomplete contracts (Kloyer and Scholderer, 2012).

It would seem, therefore, that the strength of the national rule of law affects firms' perception of transaction costs and choice of the most efficient mode of governance of interaction with value-chain partners for new product design (Nelson and Sampat, 2001; North, 1990). Firms in settings that encourage attentional focus on protecting property rights and contract conditions will prefer collaborative governance of exchanges such as co-creation with value-chain partners (Dorobantu et al., 2017; Thornton et al., 2012). Thus, we hypothesize that:

H1: *Co-creation with customers and suppliers is more likely for firms operating in countries characterized by weak rule of law.*

2.3.2. Co-creation of product design and the national technological infrastructure.

The technological infrastructure refers to the system "in which technological knowledge is produced and distributed" (Weiss and Birnbaum, 1989, p. 1018). It is defined by the organizations (e.g., universities, research institutes, standards organizations, metrology laboratories, and business services) involved in the development and diffusion of scientific and technological knowledge, and the network of linkages among these organizations and with firms (Freeman, 2004; Furman et al., 2002; Weiss and Birnbaum, 1989). The level of investment in the generation of new knowledge and diffusion activities determines the extent 1) of national organizations' involvement in the development and diffusion of state-of-art technologies and practices, 2) of the development of linkages among users and producers of knowledge and technologies which are focused on the development of both generic and customized technologies and services, and 3) of the firms' capacities to absorb available knowledge and innovation inputs and to learn by exchanging (Aghion and Jaravel, 2015; Feldman and Florida, 1994; Furman et al., 2002; Lee, 2020).

By defining the extent to which firms may be supported in screening and selecting information to develop and commercialize new technologies and products and access new markets (Aghion and Jaravel, 2015; Feldman and Florida, 1994; Justman and Teubal, 1995), the national technological infrastructure shapes the firm's perception of the possibilities to access knowledge from beyond its value chain and to learn and build new capabilities (Palmer et al., 2022; Pietrobelli and Rabelotti, 2011). These aspects might influence the perceived costs of coordinating new product development activities with value-chain partners through the market.

In countries with weak/atrophic technological infrastructures, knowledge available from science and technology organizations is not oriented to firms' long-term objectives (Weiss and Birnbaum, 1989) and specialized business services are underdeveloped (Justman and Teubal, 1995, Palmer et al., 2022; Teubal and Andersen, 2000). Few firms will have the capacity to learn and create value from this external knowledge (Aghion and Jaravel, 2015; Lee, 2020). Communication and interactions with organizations involved in the generation and diffusion of knowledge and technology are unlikely to support the design, selection, and implementation of market relevant product changes (Freeman, 2004; Weiss and Birnbaum, 1989). If national technological infrastructure creates few learning opportunities, the search for relevant knowledge sources and development of new products will be perceived as costly (Aghion and Jaravel, 2015; Weiss and Birnbaum, 1989).

In such contexts, governing new product design and development activities with value-chain partners through arm's length contracts will not only greatly reduce the firm's opportunities to learn but will also increase its perceived market transaction costs. Innovation involves knowledge recombination and knowledge search "which requires rather extensive networks of information flows and rather free informal contacts over a fairly long period and often of a rather unpredictable kind" (Freeman, 2004, p. 567). Hence, to design new valuable

products firms need access to “information about the state of the art, technological assistance, and transfers of the technology itself” (Weiss and Birnbaum, 1989, p. 1017).

If national organizations invest little in the generation and diffusion of continuous streams of basic and industry-specific knowledge, and have weak linkages with firms, the latter may resort to using their value chains to search for and screen information, and generate and diffuse knowledge, learning, and innovation (Malerba and Nelson, 2011; Pietrobelli and Rabellotti, 2011). Collaboration over new product design with value-chain partners provides access to relevant knowledge sources, improves the firm’s search scope and problem-solving capacity, and accelerates and extends its learning options (Appiah et al., 2021; Vasudeva et al., 2020). It allows articulating innovation decisions with the value-chain objectives while enhancing technological and market capabilities and decreasing uncertainty and innovation costs (Gulati et al., 2012a; Strange and Humphrey, 2019). In other words, co-creating with value-chain partners in institutional settings characterized by a weak technological infrastructure can reduce the costs of costs of learning and knowledge exchange significantly.

Suppliers might exploit the incentives offered by the focal firm to collaborate on new product design activities in order to increase the effectiveness of their own innovation activities (Appiah et al., 2021; Pihlajamaa, Kaipia, Säilä and Tanskanen, 2017). Suppliers can customize inputs and components to fit the focal firm’s specific needs, and mobilize resources to support the focal firm’s problem-solving activities, share ideas and suggestions that enhance the focal firm’s innovation efforts, and disclose relevant information that allows for the development of improved and new inputs and components (Homfeldt, Rese and Simon, 2019; Lumineau et al., 2022; Pihlajamaa et al., 2017).

Co-creation with customers increases learning opportunities exponentially. It permits the focal firm to contextualize its learning efforts and to access information related to current needs in order to steer its innovation efforts (Franke, Von Hippel and Schreier, 2006; Gambardella and von Hippel, 2019; von Hippel, 1998). In addition, customers who can

identify a real response to their requests will be more likely to provide information about technologies, innovation objectives, expected uses, and performance of different components, and to support the focal firm's innovation process (Appiah et al., 2021; Lawson, Krause and Potter, 2015; Pihlajamaa et al., 2017).

In countries with well-developed technological infrastructures, national organizations invest in the generation and use of state-of-the-art knowledge about technologies and practices, and maintain links with firms (Aghion and Jaravel, 2015; Furman et al., 2002). This allows firms to remain up to date with new knowledge and to obtain knowledge from technically competent partners (Grillitsch and Nilsson, 2015; Lee, 2020). In these contexts, customized support related to market opportunities and scientific and technical advances to support innovation and product design activities is more likely (Feldman and Florida, 1994; Palmer et al. 2022; Teubal and Andersen, 2000).

This results in the perception of fewer difficulties related to accessing knowledge and inputs, and greater engagement in activities related to technological change and innovation (Aghion and Jaravel, 2015; Weiss and Birnbaum, 1989; Santangelo et al., 2016). The ability of firms to identify and access learning opportunities and resources beyond their value-chains reduces the perceived costs associated with market exchanges for new product design. This reduces the value of co-creation with value-chain partners to access new and complementary knowledge and technical know-how (Colfer and Baldwin, 2016; Pietrobelli and Rabellotti, 2011; Strange and Humphrey, 2019).

In sum, the national technological infrastructure defines access to relevant knowledge, capability building and learning activities, and specialized services supporting the design and commercialization of new and/or more efficient products (Freeman, 2004; Grillitsch and Nilsson, 2015; Pietrobelli and Rabellotti, 2011). Countries with atrophic/weakly developed technological infrastructures focus the firm's attention on how to solve their problems and reduce the costs of generating and diffusing knowledge. This can lead to consideration of the

value-chain as the locus of innovation regardless of the skills or location of these partners (Pietrobelli and Rabellotti, 2011; Strange and Humphrey, 2019). Firms may engage in co-creation for new product design with value-chain partners in the expectation of joint learning to enlarge their knowledge pool and search and problem-solving capacities. Based on the above, we posit that:

H2: *Co-creation with customers and suppliers is more likely for firms operating in countries characterized by atrophic/weak technological infrastructure*.

3. METHODS

3.1. Data

We examine governance decisions in different institutional settings using secondary data from the IMSS-VI survey implemented in 2013-14 in 22 countries. The IMSS is a periodic international survey of manufacturers in the assembly sector, aimed at obtaining information on manufacturing and value-chain strategies (IMSS, 2017). It is administered by an international network of operations strategy scholars coordinated by a central team (IMSS, 2017). IMSS-VI data are the latest data available.

The individual country questionnaires are in the local language and are administered by local researcher teams who guarantee anonymization and confidentiality of responses. The sample countries – with very diverse institutional settings and high levels of international trade – are located in Europe, America, and Asia.

The survey targets firms with over 50 employees in six different industry sectors (fabricated metal products, electrical equipment, machinery and equipment, motor vehicles, trailers and semi-trailers, other transport equipment, and computer, electronic and optical products). OECD (2011) categorizes these industries as medium-low, medium-high, and high-tech; hence, the sample includes industries that differ in terms of development of new technologies and degree of technological uncertainty. The country teams select firms based primarily on random sampling using national databases; in some countries, convenience

sampling, e.g., addition of firms included in previous survey rounds, complements these databases.

The survey collects data at the firm manufacturing-plant level. Respondents were production or operations managers who received email or phone invitations to participate in the survey. Questions about strategy, practices, and performance were clear and concise, and distributed across different parts of the questionnaire to minimize guessing and induced responses. Questions about to the plant's manufacturing activities – including those used to measure (some of) our variables – were included in the section which asked specifically about the plant's dominant activity: the "activity which is considered to best represent the plant". The first question in that section asked respondents to provide a brief textual description of the "most important product of the plant" (example: "wrapping machine") to direct the respondents' focus to the plant's dominant activity (and associated product) when responding to the succeeding questions.

Questionnaires were sent to 7,167 firms and resulted in 931 valid responses (13% response rate). Comparison of respondents and non-/late respondents shows no statistically significant differences (t-tests with $p>0.05$) with publicly available indicators of size (sales) and market performance (return on sales). Several data quality checks were performed, clarifications were sought from some respondents, and a few questionnaires were discarded.

As usual, some of the questionnaires were not completed; also, due to lack of information on the national institutional variables, we had to exclude observations from Taiwan. This resulted in a final sample of 636 firm observations in 21 countries. The samples used to analyze co-creation with suppliers and co-creation with customers are slightly different although (coincidently) the number of observations is the same.[1] Table 1 provides an overview of the samples.

[1] Our supplier (customer) sample includes 25 observations with missing information for some variables; those firms are not included in the customer (supplier) sample. This results in the same final number of observations in the supplier and customer samples but not exactly the same set of firms.

[Table 1 about here]

While our data are from the pre-covid-19 period, they cover the post-financial crisis period when value-chains were already central to global production of consumer goods and represented the largest share of global trade (OECD, 2013, 2022; Grabs and Ponte, 2019). In addition, co-creation for product design began long before 2013-14 (IMSS-VI survey date) although the share of firms that did not collaborate for innovation is still much higher than the one that did. Also, although the evolution of digital technologies may have made some exchanges cheaper or more effective, the collaboration decision is based mainly on monitoring and coordination costs and expected capabilities development. Therefore, we would not expect a drastic change in the frequency of firms' engagement in cooperation with supply chain partners.[2]

3.2. Measures

3.2.1. Dependent variables

Our dependent variables, co-creation with suppliers and co-creation with customers, are dichotomous variables measuring whether or not the firm engages in co-creation for new product design with, respectively, suppliers and customers. These variables were constructed based on the responses to two survey questions asking about current level of use of "joint decision-making with key suppliers (customers) about product design/modifications, process design/modifications, quality improvement and cost control" scored on a 1-5 scale (1 'none'; 5 'high') (see Table 2). They take the value 1 for a score of 4 or 5 (high degree of use of co-creation) and 0 otherwise. We used this binary measure rather than the original 1-5 scale due

[2] For instance, Eurostat (2022) data from the 2014 and 2020 Community Innovation Survey of the EU27 countries shows that the share of firms that did not collaborate for innovation ranged between 50% and 85% in both years. Also, the percentage of innovative firms that engaged in cooperation with clients or customers from the private (public) sector increased only slightly from 7.8% (2.7%) to 9.3% (3.8%), and the percentage of innovative firms that engaged in cooperation with suppliers of equipment, materials, components, or software increased from 12.5% to 13.8%.

to the low number of observations at the extremes ('1' and '5'). The use of dichotomous variables for co-creation is in line with the extensive prior literature on collaboration for innovation (Belderbos et al., 2004; Hagedoorn et al., 2018).

3.2.2. Independent Variables

Main variables of interest

To proxy for national rule of law in the focal firm's country of operation, we follow the prior literature (Abdi and Aulakh, 2012; Galang, 2012; Mickiewicz et al., 2021) and use the World Bank 2012 Worldwide Governance Indicators (WGI) on rule of law. This indicator reflects "perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence" (World Bank, 2018). It refers to the perceptions of a large number of different agents (citizens, business firms, NGOs) collected by more than 30 underlying sources of data produced by different types of organizations (think-tanks, non-governmental organizations, international organizations, and private sector firms). The indicator ranges from -2.5 to 2.5 and in our sample it ranges from -0.49 to 1.95, with a standard deviation of 0.87.[3]

To proxy for the national technological infrastructure in the focal firm's country of operation, we follow the literature and use 2012 national R&D expenditure as a percentage of GDP taken from the World Bank Development Indicators (Furman et al., 2002; Guler,

[3] Table 2 shows that among the countries in the WGI dataset this indicator ranges from -2.5 to 2.5. The 2012 WGI dataset shows that the minimum across countries was -2.45 (Somalia), the maximum was 1.95 (Norway), and the average was 0. The IMSS-VI dataset includes mostly firms located in developed and emerging countries (Table 1) but rule of law is far from homogeneous, with Brazil, China, and India showing a negative rule of law indicator below the average of all the countries covered; Hungary, Italy, Malaysia, Romania, and Slovenia showing a positive but below 1 rule of law indicator; and the remaining countries showing a positive above 1 rule of law indicator. Overall, the countries included in the IMSS-VI dataset tend to have a comparatively strong rule of law: the average for the surveyed firms is above 0 (the average across all countries in the WGI dataset). However, in terms of the surveyed firms' locations, we observe significant variation, including countries reporting a negative rule of law indicator.

Guillén and MacPherson, 2002).[4] In our sample, this variable ranges from 0.49% to 4.42% with a standard deviation of 0.9.

Although national indicators evolve slowly, we follow the literature and apply a one-year lag to these two national variables relative to our measurement of the dependent variable (Guler et al., 2002). Since the co-creation decision is an important strategic decision, it would have been taken before the questionnaire was administered.

Control variables

In line with the literature, we identified and included a number of controls which could influence the firm's decision to co-create with value-chain partners. There is a large literature on governance of innovation activities and the mirroring hypothesis which proposes an association between product architecture and the organization of interactions with suppliers (Cabigiosu and Camuffo, 2012; Colfer and Baldwin, 2016; MacCormack et al., 2012). Similarly, the extensive literature on global value chain governance provides evidence of an association between product architecture characteristics (especially the degree of modularity) and the lead firm's governance decision (Buciuni and Pisano, 2021; Gereffi et al., 2005; Verbeke et al., 2021; Sako and Zylberberg, 2019). This suggests the need to control for product architecture characteristics.

These characteristics reflect the firms' learning routines and define how improvements or modifications can be incorporated in the product design (Brusoni et al., 2001). In particular, the degree of modularity of the product architecture (whether it is modular or integral) refers to the possibility of codification of the different components and their respective interfaces (Baldwin, 2008; Baldwin and Clark, 2000; Ulrich, 1995). We created a measure for whether the product design is integral or modular. We used the responses to a question on the product architecture of the dominant firm activity, rated on a scale from 1 (modular product design) to 5 (integrated product design). To allow comparison with the prior literature's results, the

[4] Data for India are for 2011; data for 2012 were not available.

variable 'integral product architecture' takes the value 1 for a score of 4 or 5 (a relatively high degree of integration in product design) and 0 otherwise.[5]

Since larger firms may have more organizational, human, and financial resources to enable and manage collaboration (Hagedoorn et al., 2018), we control for firm size using the logarithm of the number of the firm's employees. The expected benefits of co-creation – and hence the decision to engage in co-creation – seem to depend also on the firm's capacity to learn and absorb knowledge (Belderbos et al., 2004). We follow the literature and control for R&D intensity, measured as 1 plus the logarithm of the proportion of the firm's revenue spent on product/service-related R&D.

It is possible that multinational firms will have better knowledge transfer capabilities (McDermott, Mudambi and Parente, 2013). We control for whether the firm is a multinational using the (dummy) variable 'multinational' which takes the value 1 if the firm is a multinational (more than one plant in more than one country) and 0 if it has presence in just one country (Belderbos et al., 2004; Bernal, Carree and Lobskin, 2022).

Since we do not know the countries of location of customers and suppliers, we control for the extent of the firm's upstream and downstream exchanges with foreign partners. The variables 'exports' and 'imports' represent, respectively, the percentage (in total sales) of exports and imports of inputs. A firm with a large percentage of exports (imports) is more likely to have important foreign customer(s) (suppliers) compared to a firm with a small percentage of exports (imports). On the other hand, the attractiveness of collaboration with foreign partners might be decreased by expected increased costs of communication and

[5] Quantitative analyses testing the mirroring hypothesis tend to focus on the exchanges of a small number of firms operating in very specific product segments in a country, which allows collection of in-depth data on product architecture. As a consequence, these studies tend to measure the degree of product architecture modularity based on the number of functions performed by the components and the number of closed interfaces (see Cabigiosu and Camuffo, 2012; Furlan et al., 2014). We do not have that information, and given the cross-industry and cross-country nature of our data, differences in the number of functions and closed interfaces would tend to reflect firm product specificity rather than the degree of product architecture modularity. Hence, we prefer this alternative approach to characterize product architecture.

knowledge transfer (Belitski, Caiazza and Lehmann, 2021). Table 2 presents the variables used in our analysis.

[Table 2 about here]

To test for common method variance, we conducted a Harman single-factor test by loading all the variables into an exploratory factor analysis. Two factors with eigenvalues above 1 explain 69% of the variance. This suggests that common method variance may not be a concern in our data (Podsakoff and Organ, 1986; Podsakoff et al., 2003). Moreover, Doty and Glick (1998) highlight conditions (met by our data) that can alleviate concerns over common method bias, in particular the concreteness of the constructs (i.e., little judgment required to answer the questions), use of different data sources (IMSS and World Bank data), and different data collection periods (data on institutions refer to 2012; the survey was conducted in 2013-14).

3.3. Econometric approach

The nature of our data and the fact that our dependent variables are dichotomous suggest that a linear regression model is not appropriate. We implemented a three-level mixed effects probit approach to model the firm's decision to engage in co-creation (Rabe-Hesketh and Skrondal, 2012). Level 1 is the firm, level 2 is the country, and level 3 is the industry. In this approach, firms are nested in countries which are nested in industries. These respective nesting levels capture unobserved country-specific effects and unobserved industry-specific effects. For firm i in country j and industry k, $y_{ijk}^{S^*}$ and $y_{ijk}^{C^*}$ are the unobserved latent variables for co-creation with suppliers ('S') and customers ('C'). Let $h = S, C$. For suppliers, the three levels are given by:

$$y_{ijk}^{h^*} = \beta_{0jk}^{h} + \boldsymbol{x}_{3_{ijk}}^{h\prime}\boldsymbol{\beta}_3^h + \varepsilon_{ijk}^{h} \qquad (level\ 1) \qquad (1)$$

$$\beta_{0jk}^{h} = \beta_{00k}^{h} + x_{1_{jk}}\beta_1^h + x_{2_{jk}}\beta_2^h + U_{0jk}^{h} \qquad (level\ 2) \qquad (2)$$

$$\beta_{00k}^{h} = \gamma_{000}^{h} + U_{00k}^{h} \qquad (level\ 3) \qquad (3)$$

The observed outcomes – which correspond to our dependent variables – are represented by y_{ijk}^{h}, $h = S, C$:

$$y_{ijk}^{h} = 1 \; if \; y_{ijk}^{h^*} > 0$$

$$y_{ijk}^{h} = 0 \; if \; y_{ijk}^{h^*} \leq 0$$

As usual in multilevel analysis, this yields a reduced form equation:

$$y_{ijk}^{h^*} = \gamma_{000}^{h} + x_{1_{jk}}\beta_1^h + x_{2_{jk}}\beta_2^h + \boldsymbol{x}_{3_{ijk}}^{h\prime}\boldsymbol{\beta}_3^h + U_{00k}^{h} + U_{0jk}^{h} + \varepsilon_{ijk}^{h} \qquad (4)$$

In equation (1), the expected value of the dependent variable depends linearly on firm-specific variables: $\boldsymbol{\beta}_3^h$ is the effect of the firm level controls, with a firm-level error term (ε_{ijk}^{h}). Equation (2) indicates that this linear relationship can vary across countries: β_1^h is the effect of the country technological infrastructure, and β_2^h is the effect of the rule of law – our two main variables of interest – with a country-specific random intercept U_{0jk}^{h}. Equation (3) captures possible differences across industries through an overall intercept and an industry level random intercept U_{00k}^{h}. The error terms follow the standard assumptions in multilevel analysis.[6]

Equation (4) is our main estimation equation. The objective is to understand whether (and by how much) changes in our main variables of interest (national technological infrastructure and rule of law) induce changes in the dependent variable (firm co-creation decision) – the marginal effect, controlling for other possible explanatory factors.

Unlike standard ordinary least squares, probit is a non-linear regression model in which the coefficients are not the marginal effects. Probit marginal effects depend on the values of each regressor. Thus, we compute the marginal effects at the sample mean of each regressor.

[6] The error terms are assumed to be uncorrelated with each other, U_{0jk}^{h} is assumed to be uncorrelated across countries, uncorrelated with the country-specific variables, and normally distributed; U_{00k}^{h} is assumed to be uncorrelated across industries and normally distributed; and ε_{jik} is an independently distributed error term from a $N(0, \sigma^2)$ distribution, uncorrelated across firms, countries, and industries.

4. RESULTS

Table 3 reports the descriptive statistics and correlation coefficients of the variables examined. Despite a variance inflation factor (VIF) of 2.03, the correlation coefficients of the national-level variables are above 0.3. We add them stepwise.

[Table 3 about here]

Table 4 presents the results. Model 1 is the baseline model and includes only the control variables. Model 2 adds only the national rule of law, and model 3 adds only the national technological infrastructure. Model 4 includes both national variables.

[Table 4 about here]

The results for the control variables are as follows. The coefficient of integral product architecture is positive and significant for explaining co-creation with suppliers (models 1-4, $p<0.01$) and customers (models 1-4, $p<0.05$). Model 4 (marginal effects) shows that firms with an integral product architecture are 9.9 (10.2) percentage points (pp) more likely to co-create new product design with customers (suppliers). This suggests that collaboration for new product design with value-chain partners is more likely for firms with an integral product architecture.

The coefficient of firm R&D intensity is positive and significant for explaining co-creation with suppliers (models 1-4, $p<0.05$) and customers (models 1-4, $p<0.1$). This suggests that the more engaged in new knowledge development and innovative activities, the more likely the firm will favor co-creation with value-chain partners. Firm size is positive and significant for explaining co-creation with customers (models 1-4, $p<0.01$) but not suppliers (significant only in models 1 and 3, $p<0.1$). This suggests that compared to co-creation with suppliers, co-creation with customers requires greater organizational capabilities. The coefficient of imports (models 2 and 4, $p<0.05$) is positive and significant for explaining co-creation with suppliers. The coefficient of multinationals is weakly significant for explaining

co-creation with suppliers (models 2 and 4, $p<0.1$) and not significant for co-creation with customers.

Regarding the main variables of interest, the coefficient of national rule of law is negative and significant for explaining co-creation with suppliers (model 2, $p<0.01$; model 4, $p<0.01$). Also, in model 2 ($p< 0.1$) but not model 4 it is significant and negative for explaining co-creation with customers. This provides partial support for H1 that co-creation is more likely among firms operating in countries with weak rule of law.

The coefficient of national technological infrastructure is negative and significant for explaining co-creation with customers (model 3, $p<0.01$; model 4, $p<0.05$). Also, in model 3 ($p< 0.01$) but not model 4 it is significant and negative for explaining co-creation with suppliers. This provides partial support for H2 that firms located in countries with a weakly developed technological infrastructure are more likely to engage in co-creation.

To obtain some indication of the magnitude of these effects, we computed the marginal effects for the full model (model 4) estimated at the sample means. We observe that a unit increase in the rule of law indicator reduces the probability of co-creation with suppliers by 10 pp, while an increase of 1 pp in national R&D expenditure reduces the probability of co-creation with customers by 6.5 pp.[7] Also, for model 4, we plot the predicted probabilities of co-creation under different institutional settings, i.e., different values for rule of law and national R&D expenditure, keeping all the other variables at their sample means (see Figure 2).

[Figure 2 about here]

Figure 2 (panel A) shows that the predicted probability of co-creation with suppliers varies significantly for different values of rule of law. For the highest and lowest values of

[7] A 1 unit increase in the rule of law indicator is a significant change, slightly below 1 standard deviation (see Table 3). Considering all the countries in the 2012 WGI dataset, a 1 unit increase in the rule of law indicator would move countries such as Brazil, China, and India from below average to above average countries, and would move Hungary, Italy, Malaysia, Romania, and Slovenia (all above average countries) to the top countries' group, with a rule of law indicator above 1.

rule of law in our sample, the probability of co-creation varies between 22% and 43%.[8] Panel D shows that the predicted probability of co-creation with customers varies significantly with different values of national R&D expenditure. For the highest and lowest values of national R&D expenditure, the probability varies between 27% and 49%.

4.1. Supplementary checks

We conducted a series of robustness checks that are described in detail in Appendix A. First, we focused on the subsample of firms with less than 30% exports or imports, which are thus less likely to be exposed to multiple (and different) institutional contexts. Second, we explored the possibility of data being cross-classified, i.e., the possibility that countries are not nested within industries and vice-versa. Third, we checked whether our results were robust to the coding applied to the main variables of interest, including to a coarser characterization of the firm's institutional context. Fourth, we checked for the robustness of our results to the coding of our dependent variables. All the results were similar to those reported in Table 4. Finally, we tested for possible endogeneity caused by firm characteristics being dependent on firm location. The results show that endogeneity is not a concern in our study.

5. DISCUSSION AND CONCLUSIONS

This paper set out to examine how the institutional environment shapes the micro-level governance of innovation activities. Drawing on institutional economics theory, we proposed that the firm's institutional setting influenced its perception of the net benefits of co-creation for new product design with value-chain partners. Our results suggest a significant association between the national institutional setting and the firm's governance decision for its innovation activities. Specifically, they show that co-creation is more likely in institutional environments

[8] The magnitude of the marginal effects is demonstrated by the fact that an increase in the rule of law indicator from its minimum (-0.49) to 0 (the average across all countries in the WGI dataset), as well as an increase from 0 to 0.5, leads to a 5.4 pp reduction in the probability of co-creation with suppliers, whilst an increase from 0.5 to 1 leads to a 5.1 pp reduction in the probability of co-creation with suppliers.

characterized by weak rule of law and weak/atrophic technological infrastructure, but not necessarily (as theoretically expected) with all value-chain partners.

In line with the literature, our theoretical explanations stress that the institutional environment, defining the rules of the game, structures the incentives for specific modes of interaction and learning (Nelson and Sampat, 2001; North, 1990). In institutional environments characterized by weak rule of law and atrophic technological infrastructure, firms may perceive a higher risk of opportunistic behavior by partners, and more difficulty in accessing relevant knowledge sources and knowledge partners for innovation (Franczak et al., 2023; Lee, 2020; Pietrobelli and Rabellotti, 2011; Palmer et al., 2022; Thornton et al., 2012; Weiss and Birnbaum, 1989). Governing innovation activities via cooperation reflects the firm's efforts to reduce the uncertainties related to innovation and technological change, and partners' behavior (Burton and Galvin, 2022; Dorobantu et al., 2012; Williamson, 2002). Co-creation may allow the firm to leverage knowledge sources and search and problem-solving capacities, and enable close monitoring of and building of trust with partners (Elia et al., 2019; Gulati et al., 2012a,b; Jacobides and Winter, 2005, 2012; MacCormack et al., 2012; van der Wouden, 2020).

Interestingly, and contrary to theoretical expectations, our results show that the influence of the institutional setting varies across upstream and downstream value-chain partners. Our findings suggest that co-creation with downstream partners is more likely in countries with an atrophic technological infrastructure, whilst co-creation with upstream partners is more likely in countries with weak rule of law. This suggests that upstream governance decisions may be associated more with the characteristics of institutions addressing transaction uncertainties resulting from opportunistic behavior, and that downstream decisions may be related more to institutions addressing transaction costs linked to innovation uncertainties.

Contractual risks related to supply agreements result in transaction and agency costs associated with knowledge exchange, while contractual risks related to sales agreements are

linked mostly to satisfying customer requirements (Williamson, 2002). When designing a new product, if a supplier fails to meet its contractual obligations (e.g., related to cost or quality targets), ultimately the firm is responsible for (and is most affected by) the associated problems (e.g., delayed product launch, poor quality product). In the case of customer dissatisfaction with the new design, the focal firm may try to reduce its contractual costs by renegotiating the price, supporting component integration, or revising the design of the new product. This could result in greater exposure of the firm to high contractual risks in transactions with suppliers compared to transactions with customers. Close collaboration for new product design enhances trust and increases motivation and monitoring of partners (Bhaskaran and Krishnan, 2009; Lindenberg and Foss, 2011; Solinas et al., 2022). Thus, in countries where firms cannot rely on national courts to enforce their rights to tangibles, intangibles, and signed contracts, or penalize abuses of property rights and non-compliance with contracts, the firm might focus on decreasing uncertainties and costs in their exchanges with suppliers (Pietrobeli and Rabellotti, 2011; Strange and Humphrey, 2019) and therefore might be more likely to partner with suppliers for co-creation.

If a new design is incompatible with technological and market trends or is unsuitable for integration in the customers' product architecture, the possibility of a high return from innovation effort is very small (Afuah, 2000; Franke et al., 2006). Hence, learning and innovation uncertainty may be stronger in transactions with customers than with suppliers (Appiah et al., 2021). Close collaboration with value-chain partners can allow the firm to leverage its search and problem-solving resources and capabilities and its access to specialized knowledge, which might increase the potential value of its new product design (Brusoni et al., 2001; Colfer and Baldwin, 2016; MacCormack et al., 2012). As a consequence, in countries with atrophic networks of linkages to support firm efforts to design and commercialize products, firms will perceive greater difficulty related to accessing specialized market and technology knowledge, as well as help in problem-solving activities

(Lee, 2020; Palmer et al., 2022). This is likely to result in non-market collaborative forms for new product design (Aghion and Jaravel, 2015; Dorobantu et al., 2017).

5.1. Implications for research

Our proposed theoretical model suggests that (besides product architecture) the institutional setting shapes the firm's perception of the costs and difficulties involved in contracting and innovating, and influences its decisions about the governance of innovation related activities. We have provided empirical evidence supporting our thesis, which has important implications for future theorizing and testing of the drivers of heterogeneity in firms' governance decisions in governance, IB, and innovation and new product development research.

First, it has implications for the governance literature (Burton and Galvin, 2022; Colfer and Baldwin, 2016; Gereffi et al., 2005). Heterogeneity of governance decisions across the globe needs to be understood as not only an issue of mirroring, but also as related to institutional embeddedness. In addition to the characteristics of the product architecture and perceptions of the different business institutional logics among value-chain partners, the institutional setting in which the firm operates influences the perceived transaction and learning hazards, and leads to development of a preference for certain modes of governance.

Second, the study has implications for IB research. Conceptualizations of institutional effects as "distance" rather than an embeddedness issue (Ponte and Sturgeon, 2014; Kostova et al. 2019) overlooks the influence of institutions on how the players define how things are done and the modes of interaction (Lundvall, 2016; Nelson and Sampat, 2001; Thornton et al., 2012). We stress that institutions not only provide sets of resources (or voids) but also shape firms' capabilities, cognition (including perception of transactions and learning costs), attentional focus, and views about how to overcome those hazards (Corsaro, 2022; Freeman, 2004; Kostova et al. 2019; Munjal et al., 2022; Nelson, 1993; Nelson and Sampat, 2001; Thornton, et al., 2012). Future research must recognize that governance decisions within

global value-chains are the result of the patterns of interactions for coordination and learning prevailing in the firm's institutional setting, rather than just an issue of institutional distance among partners operating in different institutional settings.

Third, by incorporating the notion that firms' innovation decisions are not taken in a void, our work has implications for the innovation and new product design literature (Freeman, 1995, 2004; Lundvall, 2016; Nelson, 1993). The institutional setting influences how the firm perceives problems and the chances of success, and how it identifies and selects among alternatives modes of interaction and learning (Dorobantu et al., 2017; Freeman, 2004; Thornton et al., 2012). This results in capabilities and strategies that are rooted regionally and intertwined globally (Freeman, 2002; Verbeke and Asmussen, 2016). Consequently, the firm's decision about the governance of new product development needs to be understood in the context of the characteristics of the national institutional setting.

5.2. Implications for practice

Our findings should be useful for managers of new product design activities. First, they suggest that managers should engage in co-creation with value-chain partners as a way to overcome the challenges associated with complex product architectures, and to mitigate some of the transactional and learning issues associated with new product design which are difficult to manage in contexts with weak institutions. Second, our study suggests that firms exchanging with value-chain partners in different locations should avoid a one-size-fits-all policy to govern product design activities. They should consider governance forms that are compatible with those prevailing in the partners' locations regardless of the institutional distance. This would allow the partners to focus on making the most from the actual exchange.

5.3. Research limitations and future research directions

Our study has some limitations which suggest directions for future research.

Our data did not allow us to account for the importance to the firm of suppliers and customers, or the existence of long-term relationships with these actors. Future research could examine whether engagement in co-creation depends on the relevance of customers and suppliers in terms of the firm's total sales and inputs, and the extent of repeated exchanges with these value-chain partners. Also, although we considered the extent of firms' upstream and downstream exchanges with foreign partners, and checked the robustness of our results in a sample with low involvement in imports/exports, we lacked information on partners' locations. Other things being equal, such information might reveal whether the institutional logic underlying the choice of governance to manage innovation activities differs for partners embedded in the same or a different institutional setting. That is, it would allow examination of the effect of both institutional distance and institutional embeddedness on the firm's governance decisions and provide a better understanding of which value-chain partners might be used for co-creation.

It is possible that the effect of the institutional environment on the firms' decision to co-create with value-chain partners might depend on the firm's capacity to manage the learning and transactional issues associated with exchanges with value-chain partners. Future research could investigate whether there are firm characteristics that make firms more independent of their institutional setting. For example, compared to domestic firms, multinationals have more experience of spanning institutional settings (Stendahl, Schriber and Tippmann, 2021), which allows them to more easily mobilize resources from the wider ecosystem to foster their innovation activity, increase efficiency, and resolve disputes (Chang, Chung and Mahmood, 2006; McDermott et al., 2013; Rana and Sørensen, 2021; Verbeke et al., 2021). Future research could focus on the rationales for multinationals governance decisions and examine subsidiaries vs. headquarters, multinationals from the global south vs. those from western countries, compared to domestic firms, across institutional settings.

Most of the 21 countries in our sample have high exposure to world trade, and some regions are underrepresented (the sample does not include Africa and includes only one South American country). In addition, our sample includes relatively high-tech industry sectors. Further research could investigate whether our results hold for a bigger and broader sample of world countries and for firms in low-tech industry sectors. The rapid diffusion of technologies which has occurred since the survey was administered has likely increased firms' exchange and communication abilities (Pagell, 2021), and future research could check the extent to which different forms of organizing and coordinating the co-creation process are still linked to the type of national institutions.

Finally, our work could be complemented by an in-depth analysis of differences in firm knowledge boundaries, product architecture, value-chain structure, and the type of co-creation process (e.g., for conceptualization or for problem-solving). Case study research could examine new product development activities in firms producing specific products within different value chains in different countries. The findings might shed light on the potential differences in the aims and coordination of co-creation processes involving both downstream and upstream partners compared to those involving only suppliers or customers. It might reveal differences in the characteristics of the co-creation innovation activities and the influence of national institutions on the decision to engage in co-creation. This research would contribute also to the ongoing debate on the importance of global value-chains vis-à-vis national institutions (including industry specific initiatives) for supporting firms' learning and product upgrading (Freeman, 2002; Verbeke and Asmussen, 2016).

REFERENCES

Abdi, M., & Aulakh, P. S. (2012). Do country-level institutional frameworks and interfirm governance arrangements substitute or complement in international business relationships?. *Journal of International Business Studies*, 43(5), 477-497.

Afuah, A. (2000). How much do your co-opetitors' capabilities matter in the face of technological change?. *Strategic Management Journal*, 21(3), 397-404.

Aghion, P., & Jaravel, X. (2015). Knowledge spillovers, innovation and growth. *Economic Journal*, 125 (583), 533-573.

Ambos, B., Brandl, K., Perri, A., Scalera, V. G., & Van Assche, A. (2021). The nature of innovation in global value chains. *Journal of World Business*, 56 (4), 101221.

Antonakis, J., Bastardoz, N., & Rönkkö, M. (2019). On Ignoring the Random Effects Assumption in Multilevel Models: Review, Critique, and Recommendations. *Organizational Research Methods*, 24(2), 443-483.

Appiah, G., Bonsu, S. K., & Sarpong, D. (2021). The unpowered customer: Co-creation as tactics of the weak. *Journal of Business Research*, 133, 317-326.

Argyres, N. S., Felin, T., Foss, N., & Zenger, T. (2012). Organizational economics of capability and heterogeneity. *Organization Science*, 23(5), 1213-1226.

Azmeh, S., & Nadvi, K. (2014). Asian firms and the restructuring of global value chains. *International Business Review*, 23(4), 708-717.

Baldwin, C. and Clark, K. (2000). *Design Rules*, Cambridge, MA: MIT Press.

Baldwin, C. Y. (2008). Where do transactions come from? Modularity, transactions, and the boundaries of firms. *Industrial and Corporate Change*, 17(1), 155-195.

Baldwin, C. Y. (2022). Design rules: past and future. *Industrial and Corporate Change* (forthcoming).

Baldwin, C. Y., & von Hippel, E. (2011). Modelling a paradigm shift: from producer innovation to user and open collaborative innovation. *Organization Science*, 22(6), 1399-1417.

Belderbos, R., Carree, M., Diederen, B., Lokshin, B., & Veugelers, R. (2004). Heterogeneity in R&D cooperation strategies. *International Journal of Industrial Organization*, 22(8-9), 1237-1263.

Belderbos, R., Gilsing, V., Lokshin, B., Carree, M., & Sastre, J. F. (2018). The antecedents of new R&D collaborations with different partner types: On the dynamics of past R&D collaboration and innovative performance. *Long Range Planning*, 51(2), 285-302.

Belitski, M., Caiazza, R., & Lehmann, E. E. (2021). Knowledge frontiers and boundaries in entrepreneurship research. *Small Business Economics*, 56(2), 521-531.

Bernal, P., Carree, M., & Lokshin, B. (2022). Knowledge spillovers, R&D partnerships and innovation performance. *Technovation*, 115, 102456.

Berry, H., Guillén, M. F., & Zhou, N. (2010). An institutional approach to cross-national distance. *Journal of International Business Studies*, 41(9), 1460-1480.

Bhaskaran, S. R., & Krishnan, V. (2009). Effort, revenue, and cost sharing mechanisms for collaborative new product development. *Management Science*, 55(7), 1152-1169.

Brusoni, S., Prencipe, A., & Pavitt, K. (2001). Knowledge specialization, organizational coupling, and the boundaries of the firm: why do firms know more than they make?. *Administrative Science Quarterly*, 46(4), 597-621.

Buciuni, G., & Pisano, G. (2021). Variety of innovation in global value chains. *Journal of World Business*, 56(2), 101167.

Burton, N., & Galvin, P. (2022). Modularity, value and exceptions to the mirroring hypothesis. *Journal of Business Research*, 151, 635-650.

Cabigiosu, A., & Camuffo, A. (2012). Beyond the "mirroring" hypothesis: product modularity and interorganizational relations in the air conditioning industry. *Organization Science*, 23(3), 686-703.

Castellano, K., Rabe-Hesketh, S., & Skrondal, A. (2014). Composition, Context, and Endogeneity in School and Teacher Comparisons. *Journal of Educational and Behavioral Statistics*, 39(5), 333-367.

Chang, S. J., Chung, C. N., & Mahmood, I. P. (2006). When and how does business group affiliation promote firm innovation? A tale of two emerging economies. *Organization science*, 17(5), 637-656.

Chesbrough, H., & Kusunoki, K. (2001). The modularity trap: innovation, technology phase shifts and the resulting limits of virtual organizations. In I. Nonaka & D. Teece (Eds.), *Managing Industrial Knowledge*. London, UK: Sage.

Chesbrough, H., Lettl, C., & Ritter, T. (2018). Value creation and value capture in open innovation. *Journal of Product Innovation Management*, 35(6), 930-938.

Chesbrough, H.W. (1999). The organizational impact of technological change: a comparative theory of national institutional factors. *Industrial and Corporate Change*, 8(3), 444-484.

Chesbrough, H.W., & Appleyard, M.M. (2007). Open innovation and strategy. *California Management Review*, 50(1), 57-76.

Choksy, U. S., Ayaz, M., Al-Tabbaa, O., & Parast, M. (2022). Supplier resilience under the COVID-19 crisis in apparel global value chain (GVC): The role of GVC governance and supplier's upgrading. *Journal of Business Research*, 150, 249-267.
Colfer, L.J., & Baldwin, C.Y. (2016). The mirroring hypothesis: theory, evidence, and exceptions. *Industrial and Corporate Change*, 25(5), 709-738.
Corsaro, D. (2022). Explaining the Sales Transformation through an institutional lens. *Journal of Business Research*, 142, 1106-1124.
Cozzolino, A., & Rothaermel, F. T. (2018). Discontinuities, competition, and cooperation: Coopetitive dynamics between incumbents and entrants. *Strategic Management Journal*, 39(12), 3053-3085.
Cuervo-Cazurra, A., & Pananond, P. (2023). The rise of emerging market lead firms in global value chains. *Journal of Business Research*, 154, 113327.
Dorobantu, S., Kaul, A., & Zelner, B. (2017). Nonmarket strategy research through the lens of new institutional economics: an integrative review and future directions. *Strategic Management Journal*, 38(1), 114-140.
Doty, D. H., & Glick, W. H. (1998). Common method bias: does common methods variance really bias results?. *Organizational Research Methods*, 1(4), 374:406.
Elia, S., Massini, S., & Narula, R. (2019). Disintegration, modularity and entry mode choice: Mirroring technical and organizational architectures in business functions offshoring. *Journal of Business Research*, 103, 417-431.
Eurostat (2022). Science, technology and Innovation Data. https://ec.europa.eu/eurostat/web/science-technology-innovation/data/database (accessed 12th January 2023).
Feldman, M. P., & Florida, R. (1994). The geographic sources of innovation: technological infrastructure and product innovation in the United States. *Annals of the association of American Geographers*, 84(2), 210-229.
Fischer, D., Greven, A., Tornow, M., & Brettel, M. (2021). On the value of effectuation processes for R&D alliances and the moderating role of R&D alliance experience. *Journal of Business Research*, 135, 606-619.
Franczak, J., Lanivich, S.E., & Adomako, S. (2023). Filling institutional voids: Combinative effects of institutional shortcomings and gender on the alertness–Opportunity recognition relationship. *Journal of Business Research*, 155, 113444.
Franke, N., Von Hippel, E., & Schreier, M. (2006). Finding commercially attractive user innovations: a test of lead-user theory. *Journal of Product Innovation Management*, *23*(4), 301-315.
Freeman, C. (1995). The 'National System of Innovation'in historical perspective. *Cambridge Journal of Economics*, 19(1), 5-24.
Freeman, C. (2002). Continental, national and sub-national innovation systems—complementarity and economic growth. *Research Policy*, 31(2), 191-211.
Freeman, C. (2004). Technological infrastructure and international competitiveness. *Industrial and Corporate Change*, 13(3), 541-569.
Furlan, A., Cabigiosu, A., & Camuffo, A. (2014). When the mirror gets misted up: modularity and technological change. *Strategic Management Journal*, 35(6), 789-807.
Furman, J. L., Porter, M. E., & Stern, S. (2002). The determinants of national innovative capacity. *Research Policy*, 31(6), 899-933.
Galang, R. M. (2012). Government efficiency and international technology adoption: the spread of electronic ticketing among airlines. *Journal of International Business Studies*, 43(7), 631-654.
Gambardella, A., & Von Hippel, E. (2019). Open sourcing as a profit-maximizing strategy for downstream firms. *Strategy Science*, 4(1), 41-57.
Gereffi, G. , Humphrey, J. & Sturgeon, T. (2005) The governance of global value chains, *Review of International Political Economy*, 12(1), 78-104,
Goldstein, H. (2011). *Multilevel statistical models* (4th edition). John Wiley and Sons.
Grabs, J., & Ponte, S. (2019). The evolution of power in the global coffee value chain and production network. *Journal of Economic Geography*, 19(4), 803-828.
Grillitsch, M., & Nilsson, M. (2015). Innovation in peripheral regions: do collaborations compensate for a lack of local knowledge spillovers?. *The Annals of Regional Science*, 54(1), 299-321.
Gulati, R., & Nickerson, J.A. (2008). Interorganizational trust, governance choice, and exchange performance. *Organization Science*, 19(5), 688-708.
Gulati, R., & Singh, H. (1998). The architecture of cooperation: managing coordination costs and appropriation concerns in strategic alliances. *Administrative Science Quarterly*, 43(4), 781-814.
Gulati, R., Puranam, P., & Tushman, M. (2012a). Meta-organization design: Rethinking design in interorganizational and community contexts. *Strategic Management Journal*, 33(6), 571-586.
Gulati, R., Wohlgezogen, F., & Zhelyazkov, P. (2012b). The two facets of collaboration: Cooperation and coordination in strategic alliances. *The Academy of Management Annals*, 6(1), 531-583.
Guler, I., Guillén, M. F., & Macpherson, J. M. (2002). Global competition, institutions, and the diffusion of organizational practices: the international spread of ISO 9000 quality certificates. *Administrative Science Quarterly*, 47(2), 207-232.
Hagedoorn, J., Lokshin, B., & Zobel, A. K. (2018). Partner type diversity in alliance portfolios: multiple dimensions, boundary conditions and firm innovation performance. *Journal of Management Studies*, 55(5), 809-836.

Hanchane, S. & Mostafa, T. (2012). Solving endogeneity problems in multilevel estimation: an example using education production functions. *Journal of Applied Statistics*, 39(5), 1101-1114.
Henkel, J., Baldwin, C. Y., & Shih, W. (2013). IP modularity: Profiting from innovation by aligning product architecture with intellectual property. *California Management Review*, 55(4), 65-82.Hertenstein, P., & Alon, I. (2022). A learning portal model of emerging markets multinationals. *Global Strategy Journal*, 12(1), 134-162.
Hofman, E., Halman, J. I., & Song, M. (2017). When to use loose or tight alliance networks for innovation? Empirical evidence. *Journal of Product Innovation Management*, 34(1), 81-100.
Hohberger, J., Kruger, H., & Almeida, P. (2020). Does separation hurt? The impact of premature termination of R&D alliances on knowledge acquisition and innovation. *Research Policy*, 49(6), 103944.
Homfeldt, F., Rese, A., & Simon, F. (2019). Suppliers versus start-ups: Where do better innovation ideas come from?. *Research Policy*, 48(7), 1738-1757.
Hussen, M. S., & Çokgezen, M. (2021). The impact of regional institutional quality on firm innovation: evidence from Africa. *Innovation and Development*, 11(1), 69-90.
IMSS (2017). The international manufacturing strategy survey, available at: http://www.manufacturingstrategy.net (accessed 29 March 2020).
Jackson, G., & Deeg, R. (2008). Comparing capitalisms: Understanding institutional diversity and its implications for international business. *Journal of International Business Studies*, 39 (4), 540-561.
Jacobides, M. G., & Winter, S. G. (2005). The coevolution of capabilities and transaction costs: explaining the institutional structure of production. *Strategic Management Journal*, 26(5), 395-413.
Jacobides, M. G., & Winter, S. G. (2012). Capabilities: Structure, agency, and evolution. *Organization Science*, 23(5), 1365-1381.
Justman, M., and Teubal, T., (1995). Technological infrastructure policy (TIP): creating capabilities and building markets. *Research Policy*, 24(2), 259-281.
Kano, L. (2018). Global value chain governance: A relational perspective. *Journal of International Business Studies*, 49(6), 684-705.
Kano, L., Tsang, E. W., & Yeung, H. W. C. (2020). Global value chains: A review of the multi-disciplinary literature. *Journal of International Business Studies*, 1-46.
Kapoor, R., & Adner, R. (2012). What firms make vs. what they know: how firms' production and knowledge boundaries affect competitive advantage in the face of technological change. *Organization Science*, 23(5), 1227-48.
Kim, D. W., Trimi, S., Hong, S. G., & Lim, S. (2020). Effects of co-creation on organizational performance of small and medium manufacturers. *Journal of Business Research*, 109, 574-584.
Kloyer, M., & Scholderer, J. (2012). Effective incomplete contracts and milestones in market-distant R&D collaboration. *Research Policy*, 41(2), 346-357.
Kostova, T., Beugelsdijk, S., Scott, W. R., Kunst, V. E., Chua, C. H., & van Essen, M. (2019). The construct of institutional distance through the lens of different institutional perspectives: Review, analysis, and recommendations. *Journal of International Business Studies*, 51, 467-497.
Krammer, S. M. (2019). Greasing the wheels of change: bribery, institutions, and new product introductions in emerging markets. *Journal of Management*, 45(5), 1889-1926.
Lawson, B., Krause, D., & Potter, A. (2015). Improving supplier new product development performance: the role of supplier development. *Journal of Product Innovation Management*, 32(5), 777-792.
Lee, D. (2020). The role of R&D and input trade in productivity growth: Innovation and technology spillovers. *The Journal of Technology Transfer*, 45(3), 908-928.
Lindenberg, S., & Foss, N. J. (2011). Managing joint production motivation: the role of goal framing and governance mechanisms. *Academy of Management Review*, 36(3), 500-525.
Longoni, A., & Cagliano, R. (2015). Environmental and social sustainability priorities. *International Journal of Operations & Production Management*, 35(2), 216-245.
Lumineau, F., Jin, J. L., Sheng, S., & Zhou, K. Z. (2022). Asset specificity asymmetry and supplier opportunism in buyer–supplier exchanges. *Journal of Business Research*, 149, 85-100.
Lundvall, B. Å. (2016). *The learning economy and the economics of hope*. Anthem Press.
MacCormack, A., Baldwin, C., & Rusnak, J. (2012). Exploring the duality between product and organizational architectures: a test of the "mirroring" hypothesis. *Research Policy*, 41(8), 1309-1324.
Malerba, F., & Nelson, R. (2011). Learning and catching up in different sectoral systems: evidence from six industries. *Industrial and Corporate Change*, 20(6), 1645-1675.
McDermott, G., Mudambi, R., & Parente, R. (2013). Strategic modularity and the architecture of multinational firm. *Global Strategy Journal*, 3(1), 1-7.
Mickiewicz, T., Stephan, U., & Shami, M. (2021). The Consequences of Short-Term Institutional Change in the Rule of Law for Entrepreneurship. *Global Strategy Journal*, 11(4), 709-739.
Munjal, S., Varma, S., & Bhatnagar, A. (2022). A comparative analysis of Indian and Chinese FDI into Africa: The role of governance and alliances. *Journal of Business Research*, 149, 1018-1033.
Nelson, R. R. (1993). *National innovation systems: a comparative analysis*. Oxford University Press.
Nelson, R. R. (1991). Why do firms differ, and how does it matter?. *Strategic Management Journal*, 12(S2), 61-74.
Nelson, R. R., & Sampat, B. (2001). Making sense of institutions as a factor shaping economic performance. *Journal of Economic Behavior and Organization*, 44(1), 31-54.

North, D. (1990). *Institutions, institutional change, and economic performance*. Cambridge, MA: Cambridge University Press.
OECD (2011). ISIC Rev. 3 Technology Intensity definition. OECD, Paris. http://www.oecd.org/sti/ind/48350231.pdf (accessed 29 March 2020).
OECD (2013). Interconnected Economies: Benefiting from Global Value Chains. OECD Publishing, Paris, DOI: http://dx.doi.org/10.1787/9789264189560-en
OECD (2022). Global value chains and trade. https://www.oecd.org/trade/topics/global-value-chains-and-trade/
Pagell, M. (2021). Replication without repeating ourselves: Addressing the replication crisis in operations and supply chain management research. *Journal of Operations Management*, *67*(1), 105-115.
Palmer, M., Toral, I., Truong, Y., & Lowe, F. (2022). Institutional pioneers and articulation work in digital platform infrastructure-building. *Journal of Business Research*, 142, 930-945.
Pietrobelli, C. & Rabellotti, R. (2011), Global value chains meet innovation systems: Are there learning opportunities for developing countries?, *World Development*, 39 (7), 1261-1269.
Pihlajamaa, M., Kaipia, R., Säilä, J., & Tanskanen, K. (2017). Can supplier innovations substitute for internal R&D? A multiple case study from an absorptive capacity perspective. *Journal of Purchasing and Supply Management*, 23(4), 242-255.
Pisano, G. P. (1991). The governance of innovation: vertical integration and collaborative arrangements in the biotechnology industry. *Research Policy*, 20(3), 237-249.
Podsakoff, P., & Organ, D. (1986). Self-reports in organizational research: problems and prospects. *Journal of Management*, 12(4), 531-544.
Podsakoff, P., MacKenzie, S., Jeong-Yeon, L., & Podsakoff, N. (2003). Common method biases in behavioral research: a critical review of the literature and recommended remedies. *Journal of Applied Psychology*, 88(5): 879-903.
Ponte, S. & Sturgeon, T.J. (2014). Explaining governance in global value chains: A modular theory-building effort. *Review of International Political Economy*, 21(1), 195-223.
Powell, W. W., Koput, K. W., & Smith-Doerr, L. (1996). Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. *Administrative Science Quarterly*, 41(1), 116-145.
Rabe-Hesketh, S., & Skrondal, A. (2012). *Multilevel and longitudinal modeling using Stata* (3rd ed.). College Station, TX: Stata Press Publication.
Rana, M. B., & Sørensen, O. J. (2021). Levels of legitimacy development in internationalization: Multinational enterprise and civil society interplay in institutional void. *Global Strategy Journal*, 11(2), 269-303.
Rothaermel, F. T., & Deeds, D. L. (2004). Exploration and exploitation alliances in biotechnology: A system of new product development. *Strategic Management Journal*, 25(3), 201-221.
Sako, M., & Zylberberg, E. (2019). Supplier strategy in global value chains: shaping governance and profiting from upgrading. *Socio-Economic Review*, 17(3), 687-707.
Santangelo, G. D., Meyer, K. E., & Jindra, B. (2016). MNE subsidiaries' outsourcing and insourcing of R&D: The role of local institutions. *Global Strategy Journal*, 6(4), 247-268.
Solinas, G., Meloso, D., Banal-Estañol, A., Seldeslachts, J., & Kretschmer, T. (2022). Competition, formal governance and trust in alliances: An experimental study. *Long Range Planning*, 55(5), 102240.
Stendahl, E., Schriber, S., & Tippmann, E. (2021). Control changes in multinational corporations: Adjusting control approaches in practice. *Journal of International Business Studies*, 52(3), 409-431.
Strange, R., & Humphrey, J. (2019). What lies between market and hierarchy? Insights from internalization theory and global value chain theory. *Journal of International Business Studies*, 50(8), 1401-1413.
Teubal, M., Andersen, E. (2000). Enterprise restructuring and embeddedness: a policy and systems perspective". *Industrial and Corporate Change*, 9(1), 87-111.
Thornton, P. H., Ocasio, W. & Lounsbury M. (2012). *The Institutional Logics Perspective: A New Approach to Culture, Structure and Process*. Oxford: Oxford University Press.
Ulrich, K. T. (1995). The role of product architecture in the manufacturing firm. *Research Policy*, 24(3), 419-440.
van der Wouden, F. (2020). A history of collaboration in US invention: changing patterns of co-invention, complexity and geography. *Industrial and Corporate Change*, 29(3), 599-619.
Vasudeva, G., Leiponen, A., & Jones, S. (2020). Dear enemy: The dynamics of conflict and cooperation in open innovation ecosystems. *Strategic Management Review*, 1(2), 355-379.
Verbeke, A., & Asmussen, C. G. (2016). Global, local, or regional? The locus of MNE strategies. *Journal of Management Studies*, 53(6), 1051–1075.
Verbeke, A., Hutzschenreuter, T., & Pyasi, N. (2021). The dark side of B2B relationships in GVCs–Micro-foundational influences and strategic governance tools. *Journal of Business Research*, 135, 816-828.
Verhoef, P.C., Beckers, S. F. M., & van Doorn, J. (2013). Understand the perils of co-creation. *Harvard Business Review*, 91(9), 28-28.
Von Hippel, E. (1998). Economics of product development by users: the impact of "sticky" local information. *Management Science*, 44(5), 629-644.
Weiss, A. R., & Birnbaum, P. H. (1989). Technological infrastructure and the implementation of technological strategies. *Management Science*, 35(8), 1014-1026.
Williamson, O. E. (2002). The theory of the firm as governance structure: from choice to contract. *Journal of Economic Perspectives*, 16(3), 171-195.

World Bank (2018). Worldwide Governance Indicators. http://info.worldbank.org/governance/wgi/#doc. Accessed 29 March 2020.
WTO (World Trade Organization). (2017). Global Value Chain Development Report 2017. Measuring and analyzing the impact of GVCs on economic development. https://www.wto.org/english/res_e/publications_e/gvcd_report_17_e.htm.
WTO (World Trade Organization). (2019). Global Value Chain Development Report 2019. Technological innovation, Supply chain trade, and workers in Globalized world. https://www.worldbank.org/en/topic/trade/publication/global-value-chain-development-report-2019.
Zobel, A. K., & Hagedoorn, J. (2020). Implications of open innovation for organizational boundaries and the governance of contractual relations. *Academy of Management Perspectives*, 34(3), 400-423.

TABLES AND FIGURES

Figure 1: Drivers for the governance of supply-chain exchanges for new product design

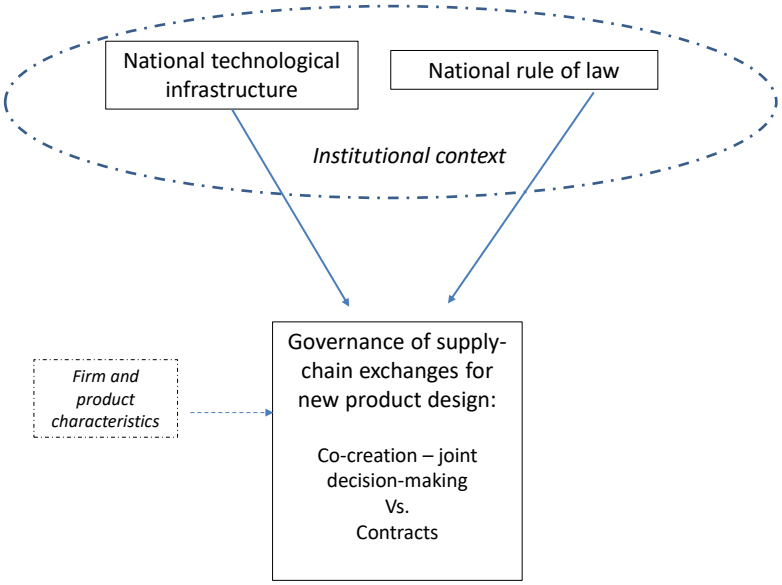

Figure 2: Predicted probabilities of co-creation with suppliers and customers under different national institutions

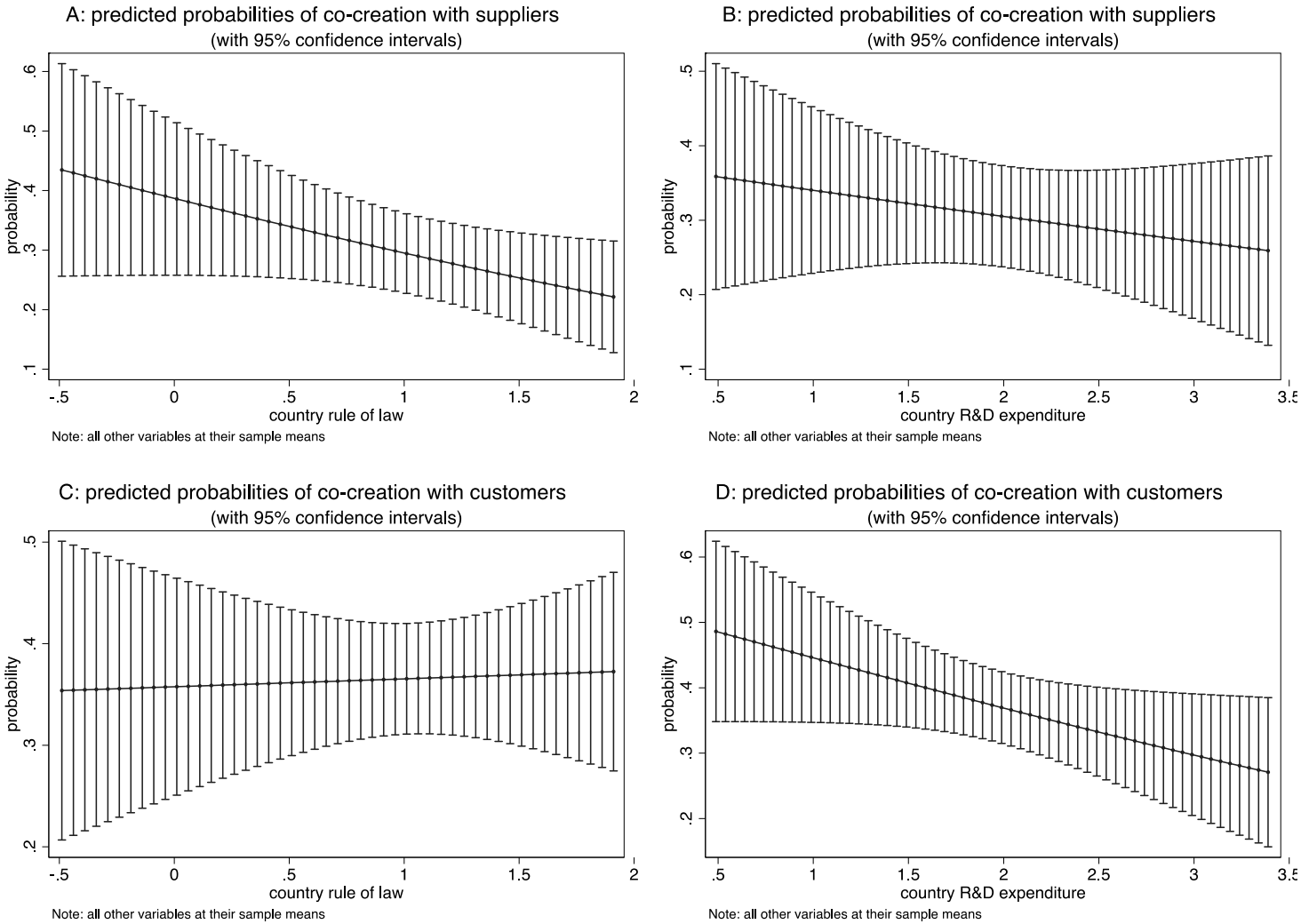

Table 1: Descriptive statistics

					Number of observations in final sample in each industrial sector: suppliers (customers)					
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**
Country	Number of firms (survey)	Weight in survey (%)	Number of observations in final sample: suppliers (customers)	Weight (%) in final sample: suppliers (customers)	manufacture of fabricated metal products	manufacture of computer, electronic and optical products	manufacture of electrical equipment	manufacture of machinery and equipment	manufacture of motor vehicles, trailers and semi-trailers	manufacture of other transport equipment
China	128	13.8%	93 (84)	14.6% (13.2%)	18 (16)	24 (20)	10 (9)	21 (20)	15 (14)	5 (5)
Japan	82	8.8%	80 (79)	12.6% (12.4%)	17 (17)	7 (7)	31 (31)	8 (8)	7 (7)	10 (9)
Italy	48	5.2%	40 (40)	6.3% (6.3%)	9 (10)	1 (2)	8 (6)	18 (18)	1 (1)	3 (3)
Netherlands	49	5.3%	37 (37)	5.8% (5.8%)	16 (16)	5 (5)	3 (3)	10 (10)	1 (1)	2 (2)
Romania	40	4.3%	37 (36)	5.8% (5.7%)	19 (18)	2 (2)	10 (10)	4 (4)	2 (2)	0 (0)
Hungary	57	6.1%	36 (36)	5.7% (5.7%)	11 (11)	2 (2)	6 (6)	12 (12)	5 (5)	0 (0)
USA	48	5.2%	33 (35)	5.2% (5.5%)	16 (16)	3 (4)	2 (2)	7 (8)	3 (3)	2 (2)
Denmark	39	4.2%	29 (29)	4.6% (4.6%)	4 (4)	4 (4)	3 (3)	18 (18)	0 (0)	0 (0)
Finland	34	3.7%	27 (26)	4.3% (4.1%)	8 (7)	1 (1)	5 (5)	12 (12)	1 (1)	0 (0)
Brazil	31	3.3%	26 (26)	4.1% (4.1%)	7 (7)	4 (4)	6 (6)	2 (2)	5 (5)	2 (2)
Portugal	34	3.7%	25 (26)	3.9% (4.1%)	13 (14)	2 (2)	1 (1)	5 (5)	3 (3)	1 (1)
Norway	26	2.8%	23 (23)	3.6% (3.6%)	15 (15)	0 (0)	0 (0)	7 (7)	0 (0)	1 (1)
Canada	30	3.2%	22 (24)	3.5% (3.8%)	13 (15)	1 (1)	2 (2)	5 (5)	1 (1)	0 (0)
Belgium	29	3.1%	22 (22)	3.5% (3.5%)	5 (5)	2 (2)	2 (2)	8 (8)	5 (5)	0 (0)
Switzerland	30	3.2%	20 (16)	3.1% (2.5%)	4 (3)	1 (1)	5 (4)	9 (7)	1 (1)	0 (0)
Spain	29	3.1%	20 (20)	3.1% (3.1%)	9 (9)	1 (1)	4 (4)	3 (3)	2 (2)	1 (1)
Sweden	32	3.4%	18 (18)	2.8% (2.8%)	5 (5)	0 (0)	1 (1)	7 (7)	3 (3)	2 (2)
Slovenia	17	1.8%	16 (16)	2.5% (2.5%)	7 (7)	1 (1)	4 (4)	4 (4)	0 (0)	0 (0)
India	91	9.8%	14 (23)	2.2% (3.6%)	2 (4)	5 (7)	2 (5)	4 (5)	1 (1)	0 (1)
Malaysia	14	1.5%	12 (13)	1.9% (2%)	5 (5)	3 (3)	2 (3)	1 (1)	1 (1)	0 (0)
Germany	15	1.6%	6 (7)	0.9% (1.1%)	4 (4)	1 (1)	0 (0)	1 (2)	0 (0)	0 (0)
Taiwan	28	3.0%	0 (0)	0% (0%)						
Total [weight within sample]: suppliers (customers)	931	100%	636 (636)	100% (100%)	207 [33%] (208 [33%])	70 [11%] (70 [11%])	107 [17%] (107 [17%])	166 [26%] (166 [26%])	57 [9%] (56 [9%])	29 [5%] (29 [5%])
[weight within survey]					[30%]	[13%]	[16%]	[25%]	[10%]	[5%]

Table 2: Variable description

Variable	type	description	source
1. co-creation with customers (dummy variable)	dummy (0/1)	1, if firm engages in co-creation for new product design with customers (question response 4 or 5); 0 otherwise	IMSS VI, item SC6: Indicate the current level of implementation of joint decision making with key customers (about product design/modifications, process design/modifications, quality 1 improvement and cost control) (scale: 1-5)
2. co-creation with suppliers (dummy variable)	dummy (0/1)	1, if firm engages in co-creation for new product design with suppliers (question response 4 or 5); 0 otherwise	IMSS VI, item SC6: Indicate the current level of implementation of joint decision making with key suppliers (about product design/modifications, process design/modifications, quality 1 improvement and cost control) (scale: 1-5)
3. firm size (number of employees)	integer	number of employees at the firm	IMSS VI, item A1: size of the business unit your plant belongs to (number of employees in 2012)
4. firm R&D intensity (percentage of revenues spent in R&D)	percentage (0-100)	R&D costs as a percentage of firm revenues	IMSS VI, item A5: approximately what proportion of the business unit annual sales is invested in product/service related research and development
5. multinational (dummy variable)	dummy (0/1)	1 if the firm is a multinational, with plants in more than one country; 0 otherwise	IMSS VI, item G1: what type of configuration has your manufacturing network: Stand-alone (only this plant belongs to the company); Domestic (all the plants are located in one country); Regional (all the plants are located in one continent); Global (plants are located in different continents)
6. exports (percentage of sales exports)	percentage (0-100)	percentage of firm sales to foreign customers (exports)	IMSS VI, item SC4: where do you sell the finished products/services resulting from your plant's dominant activity: this country; outside the country but within the continent; outside this continent.
7. imports (percentage of input imports)	percentage (0-100)	percentage of firm input purchases coming from foreign suppliers (imports)	IMSS VI, item SC4: where do you source the raw materials, parts/components, subassemblies/systems: this country; outside the country but within the continent; outside this continent.
8. integral product architecture (dummy variable)	dummy (0/1)	1, if the firm has an integral product architecture (question response 4 or 5); 0 otherwise	IMSS VI, item B2: How would you describe the complexity of the dominant activity: 1=modular product design ... 5= integrated product design
9. country R&D expenditure	percentage (0-100)	country R&D expenditure as a percentage of GDP	World Bank Development Indicators, Research and development expenditure (% of GDP) in 2012 (code GB.XPD.RSDV.GD.ZS): Expenditures for research and development are current and capital expenditures (both public and private) on creative work undertaken systematically to increase knowledge, including knowledge of humanity, culture, and society, and the use of knowledge for new applications. R&D covers basic research, applied research, and experimental development.
10. country rule of law	real number between [-2.5;2.5]	Estimate of governance (ranges from approximately -2.5 (weak) to 2.5 (strong) governance performance)	World Bank's Worldwide Governance Indicator (WGI), rule of law in 2012: reflects perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.

Table 3: Summary statistics

Type of variable	Variable	Observ.	Mean	Std. Dev.	Range		Correlation coefficients (* significant at 5% level)									
					Min	Max	1	2	3	4	5	6	7	8	9	10
dependent	1. co-creation with customers (dummy variable)	884	0.37	0.48	0	1	1									
dependent	2. co-creation with suppliers (dummy variable)	872	0.41	0.49	0	1	0.398*	1								
independent; firm-specific	3. firm size (number of employees)	929	2,963	11,967	3	150,000	0.064	0.08*	1							
independent; firm-specific	4. firm R&D intensity (percentage of revenues spent in R&D)	807	10.20	13.87	0	100	0.114*	0.077*	0.023	1						
independent; firm-specific	5. multinational (dummy variable)	931	0.47	0.50	0	1	-0.001	0.007	0.142*	0.098*	1					
independent; firm-specific	6. exports (percentage of sales exports)	771	51.80	36.46	0	100	0.031	-0.012	0.008	0.074	0.364*	1				
independent; firm-specific	7. imports (percentage of input imports)	775	41.64	32.61	0	100	0.065	0.007	0.055	0.016	0.395*	0.496*	1			
independent; firm-specific	8. integral product architecture (dummy variable)	909	0.53	0.50	0	1	0.141*	0.141*	0.006	0.044	0.025	0.12*	0.039*	1		
independent; country-specific	9. country R&D expenditure	903	1.98	0.90	0.49	3.42	-0.187*	-0.12*	0.065	0.077*	0.175*	0.003	-0.029*	-0.073*	1	
independent; country-specific	10. country rule of law	931	0.85	0.87	-0.49	1.95	-0.195*	-0.104*	0.023	0.001	0.317*	0.245*	0.338*	-0.047	0.637*	1

Table 4: Multi-level mixed effects probit estimation of decision to engage in co-creation with customers and suppliers

	(1)		(2)		(3)		(4)		(4) - marginal effects	
	Coefficient (std. error)		Coefficient (std. error)		Coefficient (std. error)		Coefficient (std. error)		Coefficient (std. error)	
Co-creation with suppliers										
firm size	0.058 (0.035)	*	0.045 (0.035)		0.071 (0.035)	**	0.049 (0.036)		0.017 (0.012)	
firm R&D intensity	0.121 (0.056)	**	0.130 (0.055)	**	0.139 (0.056)	**	0.133 (0.055)	**	0.046 (0.019)	**
multinational (dummy)	0.129 (0.128)		0.219 (0.128)	*	0.149 (0.128)		0.215 (0.129)	*	0.075 (0.045)	*
imports	0.003 (0.002)		0.005 (0.002)	**	0.002 (0.002)		0.004 (0.002)	**	0.001 (0.001)	**
country rule of law			-0.317 (0.074)	***			-0.288 (0.098)	***	-0.100 (0.034)	***
country R&D expenditure					-0.227 (0.073)	***	-0.041 (0.091)		-0.014 (0.031)	
integral product architecture (dummy)	0.327 (0.111)	***	0.298 (0.11)	***	0.296 (0.112)	***	0.295 (0.111)	***	0.102 (0.038)	***
constant	-1.448 (0.252)	***	-1.184 (0.247)	***	-1.043 (0.277)	***	-1.137 (0.268)	***	n/a	
Co-creation with customers										
firm size	0.100 (0.034)	***	0.092 (0.034)	***	0.106 (0.034)	***	0.104 (0.035)	***	0.039 (0.013)	***
firm R&D intensity	0.107 (0.054)	**	0.104 (0.054)	*	0.117 (0.054)	**	0.116 (0.054)	**	0.044 (0.02)	**
multinational (dummy)	-0.086 (0.122)		-0.035 (0.125)		-0.063 (0.121)		-0.057 (0.124)		-0.022 (0.047)	
exports	-0.001 (0.002)		-0.001 (0.002)		-0.001 (0.002)		-0.001 (0.002)		0.000 (0.001)	
country rule of law			-0.143 (0.076)	*			-0.019 (0.095)		-0.007 (0.036)	
country R&D expenditure					-0.185 (0.067)	***	-0.174 (0.087)	**	-0.065 (0.033)	**
integral product architecture (dummy)	0.280 (0.108)	***	0.275 (0.108)	**	0.265 (0.107)	**	0.266 (0.107)	**	0.099 (0.04)	**
constant	-1.191 (0.234)	***	-1.045 (0.243)	***	-0.860 (0.253)	***	-0.861 (0.253)	***	n/a	
N (suppliers)	636		636		636		636		636	
N (customers)	636		636		636		636		636	
Wald (chi-square) (suppliers)	25.3		42.1		33.6		41.9		n/a	
Wald (chi-square) (customers)	20.7		23.6		27.8		27.8		n/a	

*** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level

APPENDIX A – SUPLEMENTARY CHECKS

Below we describe the robustness checks summarized in section 4.1 in more detail. Results are available upon request.

First, in the absence of information on the location of the firm's collaboration partners, we control for the share of firm exports (imports). However, international co-creation practices may be governed by multiple institutional contexts. Therefore, as a sensitivity test, we circumscribed our sample to firms with less than 30% exports or imports, which are less likely to be exposed to multiple (and different) institutional contexts, allowing us to focus on the influence of the national context on firm's co-creation practices. The results from using the 379 (374) observations of suppliers (customers) are similar to those obtained for the full sample (636 observations).

Second, we tested for whether data might be cross-classified, i.e., that countries were not nested within industries and vice-versa. Implicitly, the hierarchical structure of the data for firms nested in countries that are nested in industries assumes that each lower-level unit belongs to only one higher level unit, which would imply that the firm belonged to only one country (which is consistent with our data), and that each country was linked to just one industry. The data show that in each country firms tend to concentrate in specific industry sectors which suggests that the one-to-one mapping implicitly assumed in our chosen nesting structure may be appropriate. However, to check for any potential effect on our results, we estimated model 4 using a (computationally intensive) cross-classified method (Goldstein, 2011). The results are similar to those in Table 4.

Third, we checked the robustness of our results to the coding of our main variables of interest. We searched for other indicators which potentially might capture the national technological infrastructure and identified six potential measures from the World Bank Indicators and the World Economic Forum: (1) number of R&D workers (per million population), (2) scientific and technical journal articles (per million population), (3) percentage of the population using the Internet in the three months previous to the survey, (4) number of

patent applications (residents and non-residents) per million population, (5) education system quality, (6) quality of math and science education. The correlation coefficients of R&D expenditure as a percentage of GDP and these variables are quite high, ranging from 0.45 for (4) to 0.79 for (1). Since these variables might reflect different (and possibly complementary) aspects of the national technological infrastructure (Freeman, 2004; Feldman and Florida, 1994), we conducted an exploratory factor analysis which resulted in one factor with eigenvalues above 1 explaining 81% of the total variance. In the regression, we replaced national R&D expenditure with the factor loading. The results are similar to those reported in Table 4.

We also searched for other potential indicators for rule of law and identified eight measures from the WGI, Transparency International, Property Rights Alliance and the World Economic Forum: (1) WGI Voice and Accountability, (2) WGI Political Stability, (3) WGI Government Effectiveness, (4) WGI Regulatory Quality, (5) WGI Control of Corruption, (6) Corruption Perceptions Index, (7) International Property Rights Index, (8) Global Competitiveness Index – Pillar 1 – Institutions. The correlation coefficients of country rule of law and variables (1)-(8) are relatively high and range from 0.58 to 0.99. Because these could be seen as different (and possibly complementary) aspects of the national rule of law, we conducted an exploratory factor analysis. We obtained one factor with eigenvalues above 1 explaining 94% of the total variance. We re-estimated the full model 4 replacing rule of law with the factor loading index. The estimated coefficients are mostly similar to those in Table 4, although in the customer equation the significance of R&D expenditure as a percentage of GDP decreases to 10%.

Fourth, as the correlation coefficients of our national variables confirm, institutions "make up an interconnected web that in various combinations shapes choice sets in various contexts" (North, 1990, p. 67). We tested a coarser characterization of the institutional context based on the rule of law and technological infrastructure. We used the median of countries' R&D expenditure as a percentage of GDP to distinguish countries with strong (above median) and weak (below median) technological infrastructures. We followed a similar procedure to

distinguish between countries with strong and weak rule of law (based on the median). We then split the observations into three country groups: 1) 'high' for both high R&D expenditure and strong rule of law; 2) 'intermediate' for high score on only one of the indicators;[9] and 3) 'low' for countries with both low R&D expenditure and weak rule of law. We reran the full model 4 using as explanatory variables the country group dummy variables instead of the rule of law and R&D expenditure as a percentage of GDP (the 'high' country group was the reference category).

The results show that the likelihood of co-creation with suppliers or customers increases significantly for firms located in countries with either an atrophic/weak technological infrastructure or weak rule of law or both, compared to firms located in countries where both technological infrastructure and rule of law are strong.[10] This is in line with hypotheses H1 and H2.

Fifth, we checked the robustness of our results to the coding of our dependent variables. In response to recent calls (Ponte and Sturgeon, 2014; Kano et al., 2020), we examined whether our model might explain the persistence of specific governance forms over the node, i.e., the upstream node (between a focal firm and its suppliers) and the downstream node (between the focal firm and its customers). We created an ordinal and a dichotomous variable. The ordered co-creation variable takes the value 2 for co-creation with both suppliers and customers, 1 for co-creation with either suppliers or customers, and 0 otherwise. The dichotomous co-creation variable takes the value 1 only for firms engaging in co-creation with both suppliers and customers and 0 otherwise. This approach also shows whether our results are affected by our implicit assumption that the firm's decision to co-create with suppliers is independent of the decision to co-create with customers; for some firms, the co-creation decision could involve both suppliers and customers.[11] The results of model 4 for ordered engagement in co-creation

[9] A category with high knowledge base and low rule of law (and vice versa) includes a relatively small number of observations which is why we grouped these observations in an 'intermediate' category.

[10] The coefficients of the intermediate country groups and the coefficients of the low country group are not statistically different.

[11] We thank a referee for suggesting this interpretation.

support H2 (the coefficient of R&D expenditure is negative and significant); the results for persistence of co-creation in downstream and upstream nodes support H1 (the coefficient of rule of law is negative and significant). We also estimated these models using the coarser characterization of the institutional context developed in the previous robustness test. The results show that the likelihood of co-creation with suppliers and customers simultaneously increases significantly for countries with atrophic/weak technological infrastructure or/and weak rule of law, as predicted by H1 and H2.

Finally, we tested for possible endogeneity caused by firm characteristics being dependent on firm location. For example, large or R&D-intensive firms may tend to locate in particular countries. The firm level variables might be correlated with the random intercept – country. To check whether this was a concern, we followed the literature and ran our regressions including country means for all the firm level variables. Antonakis, Bastardoz and Rönkkö (2021) describe this as correlated random effects modeling (see also Castellano, Rabe-Hesketh and Skrondal, 2014; Hanchane and Mostafa, 2012). We tested whether those additional regressors in model 4 were statistically significant (Antonakis et al., 2021). Since the coefficients of the additional variables are statistically not different from 0 ($p>0.1$), correlation between the country random intercept and the firm level regressors does not appear to be a concern.