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The impact of open innovation on the environmental sustainability practices and international sales intensity nexus: A multicountry study

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ABSTRACT

Amid growing environmental concerns and increasing customer demand for environmental sustainability practices (ESP), international firms strive to develop ESP and leverage resources across their global networks as key players in global innovation systems. In this context, we investigate whether adopting an open innovation (OI) strategy is a viable solution to meet the demand for ESP and foster internationalization. Specifically, this study examines the potential moderating effect of OI on ESP because both entail the ability to coordinate, orchestrate, and synchronize networks to enhance international sales. Our study encompasses a multicountry sample of 514 internationally operating manufacturers. The findings reveal that simultaneous efforts to adopt OI with suppliers and ESP constrain the positive association between ESP and international sales intensity. We provide theoretical arguments to elucidate this counterintuitive finding, thereby revitalizing the discussion on the role of international firms' adoption of ESP and sustainable innovation.

1. Introduction

Internationally operating firms are rethinking their practices in response to customer concerns and changes in policies driven by environmental and climate crises. This adaptation to ongoing changes involves fostering a network approach to developing new sustainable practices, reorganizing available resources, and innovating (Doh et al., 2021). However, these firms encounter numerous challenges when incorporating environmental sustainability practices (ESP) (Rygh, 2019; PricewaterhouseCoopers, 2022), potentially jeopardizing their international sales if they do not innovate to address these challenges. As innovation often originates beyond organizational boundaries, such as through open innovation (OI) practices (Bogers et al., 2020; Chesbrough, 2003; Laursen & Salter, 2006), firms are increasingly adopting OI. This approach is a viable solution for enhancing the development and incorporation of ESP and fostering activities in foreign markets (Simba et al., 2024). Therefore, developing ESP and an effective network capability for innovation, exemplified by OI adoption, is vital to compete successfully in today's global landscape.

To date, manufacturers have implemented successful strategies for international expansion (Wu et al., 2007; Lartey et al., 2021). However, the new context, characterized by a stronger emphasis on ESP, presents significant challenges, as manufacturers now face increasing pressure for immediate results in both environmental sustainability and international involvement (Barbosa et al., 2021; Montiel et al., 2021). Given the need for instantaneous results from internationalization and innovation efforts (Puig et al., 2018; Golovko & Valentini, 2010), manufacturers are increasingly adopting cost-saving and agile approaches, such as OI (Temel et al., 2013; Chen et al., 2016; Romero-Martínez, 2017).

Because the associated risk is shared among collaborators, the OI approach is increasingly used to generate "creative" solutions for complex problems requiring many highly interdependent choices. By fostering firm interconnectedness with crucial stakeholders, such as suppliers and customers, the OI approach provides access to global resources and benefits internationally operating firms (Luo, 2021). This approach surpasses the conventional closed innovation model, which relies solely on a firm's internal resources and has proven to be moderately successful in addressing market needs. Concurrently,

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network capabilities are crucial for international firms because strong and trustworthy relationship structures with key stakeholders enable firms to gain in-depth knowledge and provide solutions based on novel concepts to address their challenges. Essentially, network connections through OI enhance linkage advantages (e.g., better-connected and orchestrated interfirm linkages and better linkages with customers) and suggest growing internationalization gains (Simba et al., 2024). Moreover, scholars concur that the beneficial embedding of networks and the path toward successful OI activities are based on synchronization. This synchronization involves integrating and coordinating actions to effectively manage a firm's resources, thereby supporting a successful strategy for resource orchestration (Carnes et al., 2022; Sirmon et al., 2011).

There are numerous examples of internationally operating firms simultaneously adopting ESP and OI practices (Bogers et al., 2020). This topic has garnered the attention of both academics and practitioners, as evidenced by Kimpimäki et al. (2022), Lartey et al. (2021), and Zahoor et al. (2021). However, adopting OI to meet the requirements of environmentally sustainable manufacturing processes and its impact on internationalization remain under-researched (Simba et al., 2024). Therefore, this study's central research question is as follows: *To what extent does adopting environmental sustainability practices and open innovation strategies affect manufacturers' international sales intensity?*

Drawing on the network approach to internationalization (Johanson & Vahlne, 2009; Vahlne, 2020) and the relevance of orchestration and resource synchronization within networks (Carnes et al., 2022; Pitelis & Teece, 2018; Sirmon et al., 2011), this study contributes to the discussion on ESP and OI effects on international sales. It also elucidates the role of internationally operating firms as connectors of global innovation systems (GIS), integrating the perspectives of the focal firm and GIS, as suggested by Zhao et al. (2021). First, our study broadens the scope of the international business and environmental sustainability literature by examining the potential positive impact of adopting ESP on international sales intensity. This study also delves into these firms' challenges in managing supplier–customer relationships, highlighting the relative practicality of a focal firm in implementing backward orchestration and synchronization within the supply chain network for OI instead of achieving similar coordination with international customers' networks. Second, while the existing literature emphasizes the positive effects of OI on firm performance, our findings present a somewhat counterintuitive view. Specifically, by decoupling OI in upstream (supplier) and downstream (customer) contexts, our study suggests that a manufacturer's openness to collaborative innovation could constrain ESP's effectiveness on international sales.

The argument from existing literature posits that innovation systems tend to be regionally embedded (Freeman, 1995; Lundvall, 1992), making it easier for international firms to foster ESP backward within regionally embedded innovation ecosystems than forward within the international network of customers. This diversion of resources from international sales efforts would simultaneously propagate ESP best practices across other GIS in which the international firm or its supply chain participates. However, following Zhao et al.'s (2021) argument, international firms can experience different dynamics across regions and nations due to heterogeneous innovation capabilities in each innovation ecosystem. This can make them more inclined to collaborate in OI initiatives with suppliers than with customers. Thus, our argument is rooted in the tradition of innovation systems, as innovation is the engine of regional and national economic growth and must be socially and environmentally responsible for addressing sustainability challenges in both realms (Freeman, 1996; Lundvall et al., 2002).

Additionally, technological/industrial innovation systems are networks of technological knowledge (Carlsson et al., 2002). Nonetheless, firms' spatial knowledge linkages are moderated by the context of regional and national innovation systems (Chang, 2009). Thus, internationally operating firms are a crucial part of Asheim and Isaksen's (2002) regionalized national innovation system because the suppliers of knowledge are located outside the regional system, and these external actors significantly contribute to the innovation efforts of regional firms. When internationally operating firms participate, OI becomes a specialized knowledge network within and between regional, national, and GIS, necessitating coordination and orchestration by the firm. Furthermore, our study acknowledges international firms' efforts to positively influence society and the environment. Specifically, our study expands upon the role of internationally operating firms in innovation ecosystems, as outlined by Nylund et al., 2021). We do this by incorporating the notion of "connectors" proposed by Binz and Truffer (2017) and by examining the structural couplings among the resources of multilocational innovation subsystems, which aims to foster ESP upward within the regional supply chain and host markets through OI initiatives with suppliers.

This research framework comprises three primary constructs: ESP, OI, and international sales. The components and their interrelations are introduced in the following section. Next, we outline the analytical method employed, fractional regression. The subsequent section presents the main findings along with several sensitivity analyses. Section five discusses the implications of theory and practice. The final section presents the conclusions and offers promising avenues for future research.

2. Theoretical underpinnings and hypotheses

Global networks and innovation have been found to improve foreign sales in the current landscape, characterized by environmental pressure and changing market demand (Eduardsen et al., 2022; Zahoor et al., 2021). As numerous scholars have emphasized, sustainable innovation ability and successful resource orchestration positively impact organizational performance, especially in manufacturing (Obradović et al., 2021). The theoretical framework of our research builds upon the network approach to internationalization (Johanson & Vahlne, 2009; Vahlne, 2020) and acknowledges the relevance of resource orchestration and synchronization (Pitelis & Teece, 2018; Sirmon et al., 2011).

Networking plays a central role in internationalization theory. Networks enable risk sharing and broaden the sources of knowledge to access external resources that can facilitate better international sales intensity (Eduardsen et al., 2022). Internationalization represents "the degree to which a firm's sales revenue or operations are conducted outside its home country" (Elango & Pattnaik, 2007, p. 542). An underlying assumption of network approach is internationalization across borderless markets, which enhances the identification and exploitation of international opportunities (Johanson and Mattsson, 1988; Holm et al., 1996), thereby fostering a virtuous loop of increasing international sales intensity. Networks formed by manufacturers are among the most relevant forces shaping the global landscape. The relationships between partners within these networks positively affect internationalization. Furthermore, the liability of outsidership to networks of international trade holds a central position in internationalization theory (Johanson & Vahlne, 2009), prompting firms to gradually commit resources to international activities as they acquire experiential knowledge from these networks.

The network approach to international involvement resonates with various cross-border value-creating activities. Networks facilitate interconnected actors' access to knowledge, opportunities, and resources. They are critical for firms to access complementary technologies and jointly solve problems, which helps them overcome internal resource limitations, thereby increasing innovation performance and ultimately affecting international sales (Wang & Huang, 2018; Scalera et al., 2018; Johanson & Vahlne, 2009; Vahlne, 2020). However, the benefits of networks are amplified by firms' capacity to orchestrate and synchronize resources, indicating the relevance of structuring resources (e.g., human, financial, social, and technological) to foster growth and value creation.

The orchestration view focuses on how firms manage and coordinate resources, assets, and capabilities to maintain competitiveness by

integrating "selected technologies, individuals and other resources in new products and processes regardless of location and across organizational boundaries" (Lessard et al., 2016, p. 214). Accordingly, a manufacturer's success depends on its ability to orchestrate and synchronize the resources available through network links (Carnes et al., 2022; Pitelis & Teece, 2018). A manufacturer's competitive position depends on controlling valuable, rare, inimitable, and unsubstitutable assets. In practice, orchestration coupled with global networks enables manufacturers to optimize performance and address the shift from "just in time" to "just in case" through tight collaboration with suppliers and customers (Hanspal, 2020).

Therefore, a vital question for both internationalization and OI is how to orchestrate networks and disseminate ESP across various stakeholder networks (of both the focal firm and subsequent tiers of agents in each network) to spread the positive impact of these practices to society (Simba et al., 2024). However, this orchestration and synchronization also present coordination challenges. As a result, we may observe the net effect of two opposing forces: the benefits stemming from learning from the network and the costs associated with an increasing number of networks that require orchestration and synchronization.

2.1. Environmental sustainability and international sales

As manufacturers are integrated into global supply chains with significant sustainable development potential (Bi et al., 2016), sustainability has become a critical issue within the international business domain (Buckley et al., 2017). This stream of research highlights the relevance of firms' resources and networks (Mendiluce et al., 2022) in adopting environmental practices to address regulations (Rugman & Verbeke, 1998) or "green barriers" to product export outflow (Zhu et al., 2012), thereby strengthening international performance (Chen et al., 2016; Christmann & Taylor, 2001; Hult et al., 2018; Hojnik et al., 2018). For example, the European Community Directive on Waste Electrical and Electronic Equipment mandates that electrical equipment manufacturers implement and comply with environmental management practices, laws, and regulations to export their products to the European Union. Furthermore, a report published by the United Kingdom Department for International Trade (2021) recognized the competitive advantage of UK manufacturers with the increased adoption of sustainable practices in international trade.

Global competition and the continual increase in customers' environmental expectations further highlight the importance of ESP. Zhou et al. (2023) reported that environmental certification positively impacts export performance, especially in countries with open economies. Anjum et al. (2023) discovered that involvement in international networks and cross-border collaborations foster reciprocal relationships. Stakeholders endorse initiatives linked to developing eco-friendly offerings while expecting mutual benefits through access to a larger share of foreign market trade. Bueno-García et al. (2022) proposed that adopting environmental practices enables businesses to expand the scope of their foreign market operations, thereby allowing them to cope with various environmental regulatory requirements. Similarly, Bellesi et al. (2005) suggested the need for focal firms to enhance synergy through networks. These networks encourage suppliers to adopt environmental strategies in response to increasing environmental awareness among customers. This practice has occurred among numerous internationally operating firms, such as Xerox, Ericsson, Microsoft, IBM, Ford, GM, Toyota, and Walmart, which have publicly urged their suppliers to improve environmental practices and demonstrate environmental commitment to maintain competitiveness in foreign markets (Birchall, 2010; Chan, 2010; Christmann & Taylor, 2001; Mendiluce et al., 2022). This request follows a change in customer demands. For instance, according to the United Kingdom Office for National Statistics, more than half of UK drivers aged 16–49 years are likely to switch from fuel-powered vehicles and hybrids to all-electric vehicles within the next decade (Swallow, 2021). Therefore, adopting sustainability practices is expected to facilitate international sales because it is a demand-driven factor that legitimizes foreign firms in international markets. This suggests the following hypothesis:

H1. : The greater the effort toward environmental sustainability practices, the higher the international sales intensity.

2.2. Environmental sustainability practices and international sales: the moderating role of open innovation

Environmental firm-specific advantages are recognized as the relevant drivers of firm profitability. However, creating ESP and meeting international environmental standards are becoming increasingly challenging (Aguilera-Caracuel et al., 2011). Specifically, environmental protection, customers' environmental concerns, and societal demand for low pollution have caused manufacturers to substantially modify value-creation routines, fostering the search for alternative solutions through multiparty relationships beyond firm boundaries (Lopez-Vega et al., 2016; Bogers et al., 2020). Accordingly, companies recognize that "… valuable ideas can come from inside or outside the company and can go to market from inside or outside the company as well" (Chesbrough, 2003, p. 43), forming the foundation of OI. As such, scholars and practitioners have acknowledged that OI with customers (downstream) and suppliers (upstream) enables technological leapfrog with low-cost, high-quality solutions and, ultimately, higher international performance levels (Romero-Martínez et al., 2017). The literature on internationalization and OI acknowledges the significance of networking as a key strategy for entering international markets (Simba et al., 2024). Firms embracing OI tend to develop stronger networking skills that are crucial for global expansion. This approach helps overcome resource limitations and other challenges, thus facilitating international expansion (Gassmann et al., 2010). For example, incorporating customer input into the development process leads to the manufacturing of products that better meet specific needs (Farha et al., 2022). Thus, to thrive in competitive global markets and ensure a premium on environmentally sustainable products, manufacturers are moving beyond closed innovation by leveraging relationships through various networks, as opposed to "arms-length" market links (Obradovic et al., 2021; Aragón-Correa & Sharma, 2003).

Empirical evidence supports the benefits of international firms engaging in various networks, signaling the potential positive effect of innovativeness through multiparty relationships with customers and suppliers (Aragón-Correa et al., 2016). This is particularly true because heterogeneous knowledge from external sources improves internal capabilities and performance (Ben Amara & Chen, 2020; Wang et al., 2021). Furthermore, stakeholders perceive environment-oriented R&D investments as positive signals. As such, manufacturers are increasingly engaging in OI to showcase improvements (Spithoven et al., 2011).

Moreover, adopting ESP in manufacturing is a complex task associated with increased operational costs, especially considering the unpredictability of the market and technological conditions (Bansal, 2019). Thus, companies across industries have adopted OI to gain a competitive edge to cope with environmental regulations and the rapidly changing business environment (Kimpimäki et al., 2022; Mortara & Minshall, 2011).

Scholars have noted that OI allows firms to engage in global knowledge networks with international partners, thereby becoming integral to GIS (Binz & Truffer, 2017). In today's environment of heightened competition and environmental pressure, this has facilitated the rapid development of sustainable, high-quality products and services (Lartey et al., 2021). Romero-Martínez et al. (2017) highlighted the positive effects of OI on international performance. Moreover, firms tend to adopt OI practices because of their high economic potential and ability to facilitate growth and development while adapting to changing markets (Chesbrough et al., 2018; Rauter et al., 2019).

As manufacturers openly interact and innovate with suppliers and customers, the positive effects of ESP implemented by focal firms can extend to society through multiple tiers within each stakeholder network. Furthermore, innovation necessitates expansion into international markets to realize quicker returns on investments than if the firm solely focuses on the domestic market (Golovko & Valentini, 2011). Because of the increased networking capabilities of firms using OI and the increased legitimation of firms implementing ESP to operate in international markets, both OI and ESP interact positively with increased levels of foreign sales. However, this association may become detrimental if the benefits of such increased capabilities to interact in a network do not compensate for the increased coordination costs. Nonetheless, empirical research suggests that the benefits are likely to outweigh the disadvantages. Accordingly, we propose the following hypotheses:

H2a. Upstream open innovation practices positively moderate the association between environmental sustainability practices and international sales intensity.

H2b. Downstream open innovation practices positively moderate the association between environmental sustainability practices and international sales intensity.

3. Methodology

3.1. Data

We used data from the sixth International Manufacturing Strategy Survey (IMSS-VI), a periodic international survey of manufacturers in the assembly industry. The IMSS aims to study manufacturing and value-chain strategies. The questionnaire addressed questions about the strategies, practices, and performance of manufacturing firms with over 50 employees across six different industries under the statistical classification of economic activities in the European Community (NACE): manufacture of fabricated metal products (NACE cat. C25), manufacture of computer, electronic, and optical products (NACE cat. C26), manufacture of electrical equipment (NACE cat. C27), manufacture of machinery and equipment (NACE cat. C28), manufacture of motor vehicles, trailers, and semi-trailers (NACE cat. C29), and manufacture of other transport equipment (NACE cat. C30). These industries span countries across Europe, America, and Asia, each of which is characterized by diverse institutional settings and significant levels of international trade.

The questionnaire collected data on a focal plant and its parent company. A team of researchers administered the questionnaire in each country and translated it from English into the local language when necessary. Respondents, typically production or operations managers, were assured that their responses would remain anonymous and confidential. To minimize guessing and induced answers, questions on strategies, practices, and performance were placed in different sections of the questionnaire.

Random sampling of national databases was the primary selection method. In certain countries, convenience sampling, such as adding firms from previous survey rounds, complemented the database. The sixth round of the study (the latest available)[1] collected data from manufacturers in 22 countries between 2013 and 2014. Questionnaires were sent to 7167 firms, yielding 931 valid questionnaires (13% response rate).[2] The comparisons between respondents and non/late respondents failed to reject the lack of significant differences in market performance at $p < 0.05$. Several data quality checks were performed, including seeking clarification from respondents and dropping unreliable questionnaires in a few cases. It is noteworthy that this low response rate could affect the results, as it could indicate low interest in the topic among firms - an issue addressed in the Discussion section.

Our final sample of usable responses included 514 observations (out of the 931 valid questionnaires) from 22 countries. Table 1 provides an overview of the data. Columns (2) and (3) contain the number of valid questionnaires received from each country and each country's share of the total, respectively. Columns (4) and (5) report the number of observations per country and each country's weight in the final sample, respectively. Finally, Columns (6) to (11) present the distribution of the sample observations across the six industries.

3.2. Measures

3.2.1. Dependent variable

Our dependent variable is the degree of internationalization in terms of international sales intensity–foreign sales to total sales (FSTS). The FSTS is an extensively used measure of internationalization that captures firms' reliance on foreign sales (Sullivan, 1994; Eduardsen et al., 2022).

3.2.2. Independent and moderating variables

The independent variable is the ESP index. This index was constructed based on efforts made in the past three years to implement (i) environmental certification (e.g., EMAS or ISO 14001), (ii) energy and water consumption reduction programs, (iii) pollution emission reduction and waste recycling programs, and (iv) supplier's sustainability performance assessment through formal evaluation, monitoring, and auditing using established guidelines and procedures. Responses were graded on a scale of 1 (none) to 5 (high).

The constructs that build the ESP index are consistent with the existing literature. Regarding item (i), Lartley et al. (2021) used data on firms' implementation and external certification (e.g., ISO 140001) of environmental management systems (EMS) as an indicator of environmental sustainability. The typical goals of EMS include pollution, resource usage, and waste reduction, as presented in items (ii) and (iii). Moreover, Golgeci et al. (2021) examined the influence of global value chains (GVCs) on the environmental sustainability of emerging market firms embedded within them. These firms often face demands to improve their environmental sustainability as a prerequisite for participation in GVCs. A closely related concept is environmental upgrading, item (iv) (Khattak & Pinto, 2018), which explores whether participants in a GVC can leverage the resources or opportunities it provides to upgrade their environmental practices.

This study is not the first to use IMSS data to examine firms' environmental practices. Gimenez et al. (2012) analyzed the impact of firms' environmental and social practices across each bottom-line dimension. Similarly, Haleem et al. (2021) used IMSS data to build a sustainability index through confirmatory factor analysis (CFA).

The ESP index was built using CFA on the four sustainability practices outlined earlier. We obtained a single factor and retained the factor scores as the ESP index. Table 2 presents the results, including those obtained using all cases and only the final usable sample.

All standardized factor loadings exceeded 0.4, indicating a strong correlation between each practice and the (latent) ESP index, which is a good reliability indicator. Cronbach's alpha, the proportion of total variation attributed to the latent variable in the scale formed by the indicators, exceeded 0.7. Convergent validity was established because the average variance extracted (AVE) and composite reliability (CR) exceeded 0.5 and 0.7, respectively. The model's goodness-of-fit indicators also suggest a good fit: the standardized root mean square residual (SRMR) is 0.015 (0.022) using all (sample) observations, which is below the commonly accepted threshold of 0.1; the root mean square error of approximation (RMSEA) is 0.069 (0.1) using all (usable sample) observations, which is at or below the 0.1 threshold; the comparative fit

[2] Sousa and da Silveira (2017, p. 452) and Haleem et al. (2021, p. 6) provide further details on the response rate: 2586 of the initial 7167 agreed to participate in the survey, but only 1003 questionnaires were returned, and of those, 931 were considered valid if they contained no more than sixty percent missing items.

Table 1
Descriptive statistics.

					Number of observations (used in main model) in each industrial sector					
(1) Country	**(2)** Number of firms (survey)	**(3)** Weight in survey (%)	**(4)** Number of observations (used in main model)	**(5)** Weight in sample (main model) (%)	**(6)** manufacture of fabricated metal products	**(7)** manufacture of computer, electronic and optical products	**(8)** manufacture of electrical equipment	**(9)** manufacture of machinery and equipment	**(10)** manufacture of motor vehicles, trailers and semi-trailers	**(11)** manufacture of other transport equipment
Belgium	29	3.1%	21	4.1%	4	2	2	8	5	0
Brazil	31	3.3%	25	4.9%	7	4	6	2	4	2
Canada	30	3.2%	21	4.1%	13	1	2	4	1	0
China	128	13.8%	83	16.2%	16	19	12	17	14	5
Denmark	39	4.2%	29	5.6%	4	5	3	17	0	0
Finland	34	3.7%	25	4.9%	7	1	4	12	1	0
Germany	15	1.6%	4	0.8%	2	1	0	1	0	0
Hungary	57	6.1%	33	6.4%	9	2	6	11	5	0
India	91	9.8%	12	2.3%	2	4	2	3	1	0
Italy	48	5.2%	32	6.2%	9	1	5	14	1	2
Japan	82	8.8%	0	0.0%	0	0	0	0	0	0
Malaysia	14	1.5%	12	2.3%	5	3	2	1	1	0
Netherlands	49	5.3%	35	6.8%	14	5	3	10	1	2
Norway	26	2.8%	23	4.5%	15	0	0	7	0	1
Portugal	34	3.7%	25	4.9%	13	2	1	5	3	1
Romania	40	4.3%	31	6.0%	15	2	10	2	2	0
Slovenia	17	1.8%	16	3.1%	7	1	4	4	0	0
Spain	29	3.1%	18	3.5%	8	2	4	2	2	0
Sweden	32	3.4%	15	2.9%	4	0	1	6	3	1
Switzerland	30	3.2%	16	3.1%	3	1	4	7	1	0
Taiwan	28	3.0%	6	1.2%	0	4	2	0	0	0
USA	48	5.2%	32	6.2%	16	2	2	7	3	2
Total (weight within sample)	931	100%	514	100%	173 [34%]	62 [12%]	75 [15%]	140 [27%]	48 [9%]	16 [3%]

Table 2
Confirmatory Factor Analysis for all observations and for usable sample (indicated between brackets).

Factors:		**Standardized Loadings**	**Composite Reliability (CR)**	**Average Variance Explained (AVE)**	**Cronbach's Alpha**
Environmental Sustainability Practices index			0.84 (0.826)	0.571 (0.547)	0.833 (0.849)
ESP1	Environmental Certification (e.g., EMAS or ISO 14001)	0.661 (0.686)			
ESP2	Energy and water consumption reduction programs	0.849 (0.815)			
ESP3	Pollution emission reduction and waste recycling programs	0.847 (0.831)			
ESP4	Suppliers' sustainability performance assessment through formal evaluation, monitoring and auditing using established guidelines and procedures	0.64 (0.604)			

index (CFI) is 0.994 (0.986) and the Tucker–Lewis index is 0.982 (0.959) using all (usable sample) observations, both exceeding the 0.9 threshold.[3]

The main independent variables are OI practices upstream with suppliers and downstream with customers. Consistent with Laursen and Salter's (2006) notion that the most relevant external sources of innovation are "suppliers" and "customers," we proxied this concept using two questions about the dominant activity of the focal plant. For upstream OI, we asked about the current implementation of "joint decision-making with key suppliers (about product design/-modifications, process design/modifications, quality improvement, and cost control)." Similarly, for downstream OI, firms were queried about the current implementation of "joint decision-making with key customers (about product design/modifications, process design/-modifications, quality improvement, and cost control)." Responses were rated on a scale of 1 (none) to 5 (high) (Chesbrough & Appleyard, 2007; Bengtsson et al., 2015).[4]

We capture the moderation of OI upstream/downstream with two

[3] These items come from the effort put into implementing environmental and social sustainability practices over the past three years (on a scale of 1 to 5). The selected items are those directly related to environmental sustainability practices; the remainder, which we have not considered, refers to social sustainability practices

[4] This item is derived from the questions in IMSS-VI concerning the current level of implementation (in a scale of 1 to 5) of programs associated with external integration, namely (i) sharing information with key suppliers/customers, (ii) developing collaborative approaches with key suppliers/customers, (iii) joint decision making with key suppliers/customers, and (iv) system coupling with key suppliers/customers. Note that the item selected ((iii) joint decision making with key suppliers/customers) is more closely connected with the definition of OI practices. However, whether the remaining items can be interpreted as measures of OI is debatable. For instance, information sharing with suppliers/customers may not necessarily be related to product or process design innovations. Section 4.1 (sensitivity analysis) combines these measures into an OI index and shows that our results are unaffected by the specific measure used.

interaction variables—"ESP index × OI with suppliers" and "ESP index × OI with customers"—derived from multiplying the ESP index and the respective OI variable.[5]

3.2.3. Control variables

We included several control variables in our regression analyses: (i) firm-specific R&D investment, measured by the logarithm of one plus the proportion of revenues spent in product/service-related R&D; (ii) firm size, measured by the logarithm of the number of employees (Josefy et al., 2015); (iii) firm age, measured by the logarithm of the difference between 2013 (the year of the questionnaire) and the year the plant was established (Santoro et al., 2019).

Additionally, we accounted for whether the firm operates multiple plants across different countries by including (iv) the dichotomous variable *multinational,* assigned a value of 1 for multinational firms (regional or global firms with more than one plant in more than one country) and 0 otherwise. The underlying rationale is somewhat similar to that of Belderbos et al. (2004): multicountry firms are comparable to internationally operating firms and may exhibit distinct behaviors due to potential benefits, such as multiplant economies of scale (Pfaffermayr, 1999) or improved knowledge transfer (Minbaeva, 2007).

We controlled for (v) the *import intensity* in the relationship with the firm's suppliers, which we proxied using the percentage of imported inputs. Finally, we controlled for (vi) the rule of law in the plant's country using the World Bank's Worldwide Governance Indicator based on the 2012 rule of law. This indicator has been used in the literature as a proxy for firms' regulatory institutional contexts (Lavie & Miller, 2008). It "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). Kaufmann et al. (2006) argued that country rankings based on these indicators are highly robust across different weighting schemes when aggregating the various data sources.

3.2.4. Industry standardization

Table 3 briefly describes each variable extracted from the IMSS-VI survey.

Differences across industries may be essential for explaining the relationship between ESP, OI, and international sales intensity. Therefore, we standardized each firm-specific explanatory variable by industry using all available observations rather than just our sample observations.[6] The measurement of each variable was based on the standard errors derived from the industry mean. This procedure enables the aggregation of variables from different industrial sectors into a single regression framework while also identifying firms that exhibit abnormal values in their respective industries. The rule of law is a country-specific variable, and we standardized it using all available observations (i.e., we did not standardize this variable by industry).[7] Furthermore, the dummy *multinational* and the dependent variable were not standardized. Table 4 presents the descriptive statistics and correlation coefficients for the unstandardized variables.

3.3. Econometric approach

The regression equation is as follows:

$$y_{ik} = \beta_0 + x'_{1_i}\beta_1 + \boldsymbol{x}'_{2_{ik}}\boldsymbol{\beta}_2 + \varepsilon_{ik} \quad (1)$$

y_{ik} is the international sales intensity of firm k in country i; β_0 is the intercept; β_1 is the effect of the (observed and standardized) country-specific rule of law (x'_{1_i}); $\boldsymbol{\beta}_2$ is a vector of the firm level's (industry-standardized) variables included in the vector $\boldsymbol{x}'_{2_{ik}}$; ε_{ik} is an independently distributed disturbance.

We employed fractional regression analysis. The dependent variable is bounded between 0 and 1; therefore, fractional probit approach is more suitable than ordinary least squares (OLS) (Papke & Wooldridge, 1996; Wulff & Villadsen, 2020; Eduardsen et al., 2022). OLS does not constrain the predicted values to the interval between 0 and 1 and assumes that the marginal effect of each variable is constant. It is not plausible in this context that a nonlinear approach, such as fractional probit model, is adequate. Our approach ensures that the predicted values of the dependent variable are within their natural bounds (Arregle et al., 2012; Adegbesan & Higgins, 2011) and the possibility of observing values at the boundaries (Wagner, 2001). Therefore, we estimate $E(y|\boldsymbol{x}) = \Phi(\boldsymbol{x}'\boldsymbol{\beta})$, where $\Phi(.)$ is the standard normal distribution, and $\boldsymbol{x}'\boldsymbol{\beta}$ is the right-hand side of Eq. (1). We report robust standard errors to account for possible heteroscedasticity.

4. Results

Table 5 presents three different models: Model (1) is control-only; Model (2) includes the main direct effects, namely the ESP index, OI with suppliers, and OI with customers; Model (3) incorporates ESP's interaction terms with OI with suppliers and OI with customers. Unlike standard OLS regression, fractional probit is a nonlinear regression model in which the coefficients do not signify marginal effects. The probit marginal effects depend on the value of each regressor. Therefore, we report the coefficient estimates in Table 5 and discuss the marginal effects below. All comments below are based on estimating the effects at the mean for all other variables.

The coefficient of firm R&D intensity is significantly and positively associated with international sales intensity ($p < 0.05$). Specifically, when comparing a firm with 1 *SD* above the industry mean of R&D intensity with another firm at the industry mean, the former exhibits a 2.9% point increase in FSTS. Tests for estimates of firm size and firm age failed to reject the hypothesis that they are zero at $p < 0.1$.

The "multinational" and "import intensity" coefficients have a significant positive association with FSTS at $p < 0.01$. A multinational firm in a particular industrial sector demonstrates 10% points higher international sales intensity than a domestic firm in the same sector. Similarly, the estimated marginal effect for import intensity is 0.14, implying that a firm importing 1 *SD* more inputs than the industry mean will have 14% points higher FSTS than a firm at the industry mean.

Finally, the coefficient for the national rule of law is significantly positive at $p < 0.01$. A firm with 1 *SD* in the country's rule of law is positively associated with 4.6% points higher FSTS than a firm at the mean.

The coefficient of the ESP index showed a significant positive association with FSTS at $p < 0.05$. This coefficient can be interpreted as the *direct* association between ESP and international sales intensity. A firm with a 1 *SD* ESP index higher than the industry mean will have 3.2% points higher FSTS than a firm at the industry mean. Our estimates for OI with suppliers and OI with customers are statistically insignificant, indicating the independence of these variables from FSTS. The estimated coefficient for the interaction "ESP index × OI customer" was not statistically significant. However, the ESP index × OI supplier estimate showed a significant negative association with FSTS at $p < 0.05$. OI with suppliers moderates the association between the ESP index and FSTS. A firm with a more prevalent OI with suppliers exhibits a less positive association between the ESP index and FSTS than a firm with less OI with suppliers. Specifically, if we compare a firm whose OI with

[5] This multiplication is carried out after we perform the industry standardization described (below) in Section 3.2.4.

[6] Standardization by industrial sector using only our sample observations showed relatively small differences. We performed and reported a sensitivity analysis, which confirmed that the impact on the results was negligible.

[7] We have also standardized this variable using only our sample observations. We present the results of this alternative standardization procedure in the sensitivity analysis Section (4.1).

Table 3
Variables description.

Variable	Role	Measurement	Description	Source
1. international sales intensity	dependent; firm-specific	percentage (0-100)	foreign sales over total sales	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?
2. firm R&D intensity (percentage of revenues spent in R&D)	control; firm-specific	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
3. firm size (number of employees)	control; firm-specific	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 age (years since the plant was established)	control; firm-specific	integer	number of years	Constructed using IMSS VI, item CP10 (year in which the plant was established): [2013 (year questionnaire was administered)] - [response to CP10]
5. multinational (dummy variable)	control; firm-specific	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 firm); 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. import intensity	control; firm-specific	percentage (0-100)	firm input purchases coming from foreign suppliers (imports) as a percentage of total purchases	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?
7. country rule of law	control; country-specific	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), the 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.
8. Environmental Sustainability Practices index	independent; firm-specific	continuous	factor loadings	Index constructed using CFA on a selection of IMSS VI items (SM1): Indicate the effort put in the last 3 years into implementing: (i) Environmental Certification (e.g., EMAS or ISO 14001); (ii) energy and water consumption reduction programs, (iii) pollution emission reduction and waste recycling programs, (iv) supplier's sustainability performance assessment through formal evaluation, monitoring and auditing using established guidelines and procedures, (scale: 1 'None' −5 'High')
9. upstream open innovation	moderating; firm-specific	integer between 1 and 5	1 =None; 5 =High	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)
10. downstream open innovation	moderating; firm-specific	integer between 1 and 5	1 =None; 5 =High	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)

Table 4
Summary statistics.

Variable	Observations	Mean	Std. Dev.	Range		Correlation coefficients (* significant at 5% level)								
				Min	Max	1	2	3	4	5	6	7	8	9
1. international sales intensity (% of foreign sales to total sales)	514	54.35	36.93	0	100	1								
2. firm R&D intensity	514	9.15	13.29	0	99	0.1 *	1							
3. firm size	514	2 086	7361	15	94,000	0.03	0	1						
4. firm age (years)	514	39.84	34.19	1	240	0.06	-0.12 *	-0.02	1					
5. multinational (dummy)	514	0.51	0.50	0	1	0.36 *	0.05	0.16 *	0.01	1				
6. import intensity	514	43.15	32.35	0	100	0.48 *	0.02	-0.01	0	0.41 *	1			
7. country rule of law	514	0.88	0.90	-0.49	1.95	0.29 *	-0.05	-0.05	0.29 *	0.3 *	0.36 *	1		
8. Environmental Sustainability Practices index	514	-0.12	0.93	-1.88	1.72	0.14 *	0.02	0.14 *	-0.03	0.2 *	0.1 *	-0.14 *	1	
9. Upstream open innovation	514	3.00	1.04	1	5	0.12 *	0.11 *	0.06	-0.12 *	0.1 *	0.04	-0.15 *	0.32 *	1
10. Downstream open innovation	514	3.11	1.11	1	5	-0.01	0.11 *	0.1 *	-0.08	-0.01	-0.02	-0.11 *	0.29 *	0.39 *

Table 5
Main results.

Dependent variable: international sales intensity	(1) Coefficient (robust std. error)		(2) Coefficient (robust std. error)		(3) Coefficient (robust std. error)	
firm R&D intensity	0.097	* *	0.091	* *	0.086	* *
	(0.042)		(0.043)		(0.043)	
firm size	0.051		0.027		0.024	
	(0.048)		(0.051)		(0.05)	
firm age	-0.004		0.001		0.006	
	(0.045)		(0.045)		(0.045)	
multinational (dummy)	0.317	* **	0.275	* **	0.274	* **
	(0.093)		(0.092)		(0.092)	
import intensity	0.390	* **	0.382	* **	0.388	* **
	(0.049)		(0.049)		(0.049)	
country rule of law	0.102	* *	0.125	* **	0.125	* **
	(0.044)		(0.045)		(0.044)	
ESP index			0.100	* *	0.096	* *
			(0.046)		(0.046)	
OI supplier			0.077		0.064	
			(0.051)		(0.049)	
OI customer			-0.039		-0.035	
			(0.048)		(0.046)	
ESP index X Upstream OI					-0.097	* *
					(0.046)	
ESP index x Downstream OI					-0.002	
					(0.047)	
constant	-0.050		-0.015		0.015	
	(0.062)		(0.063)		(0.064)	
Number of observations	514		514		514	
Wald test	163.2		181.2		194.4	
Pseudo-R^2	0.12		0.12		0.13	

suppliers and ESP are both 1 *SD* above the industry's average to another firm at the industry mean, the former will have 3.15% points higher FSTS than the latter but will also experience a negative indirect impact of the interaction, attributed to the moderating effect of OI with suppliers, resulting in the association being 3.32% points less positive.

Fig. 1 illustrates the interaction effect. When OI with suppliers is 1 *SD* above the industry mean, the slope of the ESP index is nearly flat (red line), whereas it is steeper for a firm with an OI with suppliers below 1 *SD* of the industry mean.

4.1. Sensitivity analysis

We conducted several sensitivity checks to rule out the possibility of undue influence of the excluded observations on our results. First, we standardized each firm-specific variable by industry, built the ESP index using all observations instead of the 514 usable observations, and performed a new estimation. The results were broadly similar, alleviating concerns regarding the impact of the excluded observations.

Second, we used certain items from the IMSS-VI questionnaire as indicators of OI with suppliers and customers. We took a broader perspective by including four questions regarding the firm's effort in (i) sharing information with key suppliers/customers, (ii) developing collaborative approaches with key suppliers/customers, (iii) joint decision-making with key suppliers/customers, and (iv) system coupling with key suppliers/customers in a new construct built using CFA. Estimating our baseline equation using these two new OI indexes did not affect our main results, as we still obtained a significantly negative estimate for the interaction between OI with suppliers and the ESP index.

5. Discussion

5.1. Implications for theory

Research has shown that international firms need to innovate and adopt mutually reinforcing practices in response to evolving environmental requirements. This adaptation is essential for fostering performance and ensuring the positive environmental impacts of economic activity (Laursen & Foss, 2003; Golovko & Valentini, 2011; Verbeke, 2021). However, innovations with positive environmental impacts entail risks, and there is a time lag between the effort being made and the return being obtained. Consequently, some firms still require assistance in achieving environmental sustainability and economic performance (Barbosa et al., 2021). Thus, the central question is whether and to what extent the implementation of environmental practices affects a firm's capacity to attract the interest of international markets. Network and orchestration approaches can explain a firm's performance in

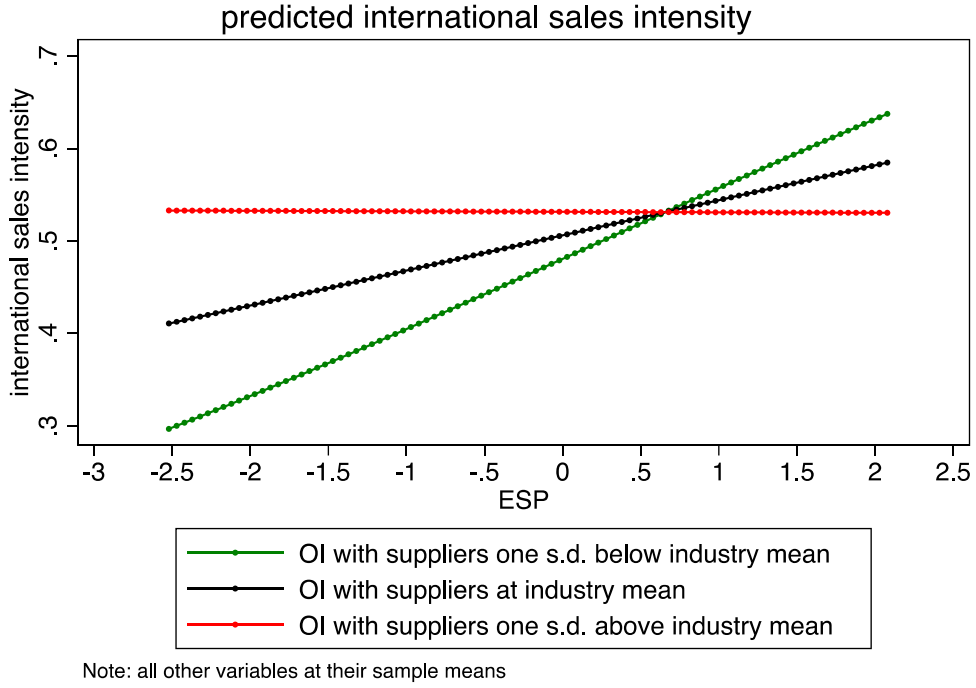

Fig. 1. Predicted international sales intensity as a function of the ESP index and upstream OI (e.g., with suppliers).

coordinating key factors of GVCs: resources, networks, relationships, assets, and inputs. In this context, this study answers the call from Simba et al. (2024) for empirical research on how OI can cope with these risks by sharing them among different actors within GVCs. Internationally operating firms involved in OI practices can also act as critical connectors of the structural couplings among the factors of GVCs and across multilocational innovation subsystems, as stated by Binz and Truffer (2017). In our study, this phenomenon is evidenced through OI with suppliers but not with customers, thereby attenuating the positive association between ESP and FSTS.

Contrary to our expectations, we did not find evidence that OI does not moderate the association between environmental sustainability and internationalization. Instead, we observed a significant constraining effect of OI with suppliers on the positive relationship between ESP and superior international sales intensity. These findings somewhat contradict the results of Chistov et al. (2023), who noted the absence of moderating effects, although their study focused on the nexus of sustainability and growth. However, this discrepancy warrants further analysis through the lens of the network approach to internationalization and orchestration views within the context of diverse innovation ecosystems and the role of internationally operating firms.

Given the observed positive correlations between sourcing internationally (import intensity) and a country's rule of law, there is a notable association with internationally operating firms having higher levels of international sales. The association with a country's rule of law highlights the importance of mitigating country risk stemming from political instability, which is a significant risk factor for international business. Consequently, we anticipate a negative interactive association between OI with suppliers, ESP, and FSTS. As firms transition toward environmentally sustainable development and collaborate with suppliers to implement such practices, we expect the FSTS growth to be lower. This is because the net effect we observe is dependent on the coordination costs associated with both types of networking, namely orchestrating and synchronizing the OI network with suppliers and simultaneously the network established for international sales. Although a higher OI with suppliers should entail superior capability to orchestrate and synchronize any network, the marginal additional coordination costs of both outweigh the potential benefits. Furthermore, OI with suppliers typically occurs within national or regionally embedded innovation systems. Thus, this collaboration may foster ESP upstream, as internationally operating firms in those locations often impose requirements to secure legitimacy. However, allocating resources to collaborate with suppliers within regional and national innovation systems may detract resources from fostering international sales. Nonetheless, OI with suppliers in regional and national innovation systems may facilitate the dissemination of ESP and extend to other regional and national innovation systems as the focal firm's supply chain expands internationally. This indirect effect, although beyond the scope of our study, warrants further investigation in future studies because it is closely linked to the role of internationally operating firms as connectors between and within GIS.

Furthermore, the contra-intuitive finding of the different slopes signals that OI with suppliers may shift the manufacturer's focus. Instead of pushing the ESP forward through the international network, it pulls its supply chain network, indicating certain limitations of OI (Audretsch & Belitski, 2022; Lu & Chesbrough, 2021; Madanaguli et al., 2022) and challenges in combining complex business processes (Chistov et al., 2023; Ketata et al., 2015). Scholars agree that knowledge generated via global networks requires additional resources for absorption, adaptation, and implementation (Ascani et al., 2020; Nooteboom et al., 2007). Additionally, competition may foster opportunistic behavior during OI, as partners engage in fierce knowledge appropriation.

Our results indicate that OI with customers does not have a statistically significant moderating effect on the relationship between ESP and international sales intensity. There are several potential explanations for this somewhat unexpected finding. First, unlike ESP and OI with suppliers, OI with customers does not exhibit a positive or statistically significant correlation with international sales intensity (see Table 4). According to the network approach to internationalization, customers may not be a decisive source of knowledge or resources for firms to overcome their internal limitations to innovate and ultimately boost international sales. This could be attributed to difficulties in advancing OI practices because the focal firm often adapts to its customers' requirements, making it challenging to synchronize ESP and OI with customers. Following this supplier–customer logic, the focal firm can request that its supply chain adopt ESP to increase international sales intensity (Bellesi et al., 2005). However, this association is stronger when the focal firm is minimally involved in OI with suppliers. Consequently, there is a problem of attention and insufficient resources to synchronize and orchestrate both types of networks (forward with international customers and backward with suppliers). Consistent with the findings of Spithoven et al. (2011), OI with suppliers can provide insight into how a firm's ESP are integrated into the final products via its supply chain. By engaging in OI with suppliers who may not prioritize ESP as much as the manufacturing firm, the latter could somehow "devalue" the perceived value of its ESP efforts in the eyes of customers. Second, the insignificant moderating effect of OI with customers on the ESP–international sales intensity nexus may be associated with its signaling value. OI with customers may not be perceived similarly to OI with suppliers. It could be that it is not considered a signal of how ESP are embedded in final products; alternatively, it could be an inoperable signal, as it does not convey helpful information to aid the firm's customers in making ESP-conscious purchasing decisions. For instance, because the customer is misled—through OI with the manufacturing firm—into believing they have control of the product, they are thus "unempowered" (Appiah et al., 2021).

The lingering question is whether there is a proper way to orchestrate these factors and generate synergy across networks so that international sales can benefit from them. Internalization theory suggests that multinational enterprises are inclined to internalize valuable factors to capture sustainable value (Pitelis & Teece, 2009, 2010). Orchestration also implicates innovation (Dhanaraj & Parkhe, 2006), as evidenced by the co-creation of value in OI practices in our study. However, our findings highlight that when a firm seeks a positive association between ESP and FSTS, it should perform innovation in-house rather than openly innovate with suppliers, particularly during ESP implementation. Otherwise, FSTS may experience lower growth because of the diverted focus. Thus, firms should focus on enhancing their ability to resolve the tension between orchestrating international sales and managing the interaction between OI with suppliers and sustainable practices.

One might expect that implementing ESP will increase the international activity of the firm due to social and environmental concerns at the local level. Our results corroborate this expectation. However, one would also expect OI practices with suppliers or customers to be compatible with increased FSTS. Surprisingly, neither type of OI appeared to have a positive association with increased FSTS. Nonetheless, context and time are crucial in organizational research, and future studies could revisit this issue to delineate the boundary conditions under which the association becomes significant, particularly within the framework of GIS.

5.2. Implications for practice

International firms are increasingly adopting ESP in response to the alleged "polluters" label. With the global consensus on the need for ESP and achieving significant reductions in environmental pollution, manufacturers face additional pressure to meet international environmental laws and regulations, given their perceived responsibility for up to 66% of all environmental issues (Foundation for International Environmental Law and Development, 2018).

Consequently, international firms are actively seeking new ways to generate environmentally sustainable ideas and reconstruct the value-creation process to meet environmental regulations and satisfy

customer demands. Furthermore, these firms are progressively publicizing their green activities while engaging in environmental upgrading in society through environmental leadership (portrayed by opening intellectual property and collaborating with customers). OI, recognized for its flexibility, transparency, and trust-building capacity with crucial stakeholders, has emerged as the go-to strategy. However, the association between environmental sustainability, OI, and international sales is not as straightforward, as depicted in Fig. 2.

This study suggests that adopting sustainable practices promotes international sales, as customers highly value environmentally conscious offerings (see Quadrants II, III, and IV). However, engaging in OI with suppliers can constrain the positive association between sustainable practices and FSTS (see Quadrant IV). Consequently, as organizations endeavor to address the challenges stemming from environmental pressure, they often fail to achieve multidexterity (Demir & Angwin, 2021). Accordingly, due to the numerous complexities associated with adopting OI practices, such as partners' opportunistic behavior and phenomena like noninvented, nonshared innovations, among others (Marzi et al., 2022), a viable solution with the potential to boost international sales is to either internalize sustainable innovation or deconstruct the simultaneous adoption of ESP and OI.

6. Conclusion

This study examines the association between OI, ESP, and international sales intensity, as well as the potential moderating effect of OI on the relationship between ESP and international sales intensity. Our findings revealed a positive association between ESP adoption and international sales intensity. This result supports manufacturers' environmental sustainability orientation and reflects the advantages of their efforts to reduce environmental footprints, which boosts the firm's global reputation and legitimizes the firm to sell internationally. However, the simultaneous adoption of OI with suppliers and ESP reduces the intensity of foreign sales. Our potential explanation for this finding is twofold. On one hand, the focal firm's attention deviates from pushing forward the orchestration and synchronization of the international network to pulling backward the orchestration and synchronization of the supply chain network for OI. On the other hand, the focal firm's position is relevant to understanding the dynamics of supplier–customer relationships. It seems more manageable for the focal firm to facilitate backward orchestration and synchronization of the supply chain network for OI than to do the same forward with the international customers' network. If members of the supply chain network engaged in OI can maintain their relationship with the focal firm, they must synchronize their efforts with those of the focal firm. Similarly, because the focal firm occupies a pivotal position within the international customer network, it must synchronize its activities with this network rather than drive them. Consequently, internationally operating firm act as connectors, facilitating structural couplings among GIS and across multilocational innovation subsystems through their engagement in OI initiatives with suppliers. Our results can be extrapolated to further understand the role of systemic actors, such as international firms, in regional and national innovation systems to achieve sustainable development goals (SDGs). It is worth noting that Asheim and Isaksen's (2002) regionalized national innovation system offers better grounds for this because the suppliers of knowledge for international firms may be located outside the regional or national systems. Therefore, scholars should explore dyadic supplier–customer relationships as potential mechanisms for explaining the global diffusion of ESP in pursuit of the SDGs. This necessitates further investigation of the inter- and intra-connections within and between GIS from an industry-technological perspective, which becomes particularly relevant when internationally operating firms are diversified and operate in several global industries. Building on our findings, OI initiatives with suppliers can trigger the spread of ESP only if the upstream actors in the supply chain also act as connectors and diffusers.

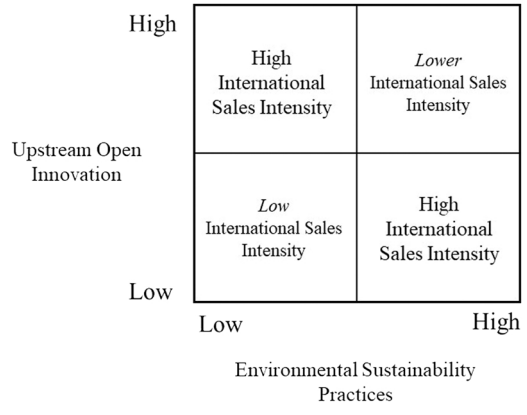

Fig. 2. International sales strategic windows positioned at the interplay of Environmental Sustainability Practices and Upstream Open Innovation.

This research has certain limitations. The IMSS does not provide a more detailed categorization of OI practices, such as inbound or outbound OI practices with domestic or international partners, which future studies can address. Furthermore, since the IMSS captures respondents' self-reported measures, which may suffer from retrospective bias, further development of secondary and longitudinal objective metrics is required. Additionally, although the FSTS ratio is one of the most widely used metrics, internationalization is a multidimensional construct (Marshall et al., 2020). Thus, future studies should complement our research with multiple indicators, including the speed of post-international expansion, among others. Moreover, not all countries place equal emphasis on environmental sustainability. Accordingly, the quest for environmental sustainability may be more relevant in regionalized advanced markets, such as the EU, than in emerging or developing markets, an issue that future studies should address.

Furthermore, future research could address another limitation of this study, namely the relatively low survey response rate. Although, as noted in Section 3.1, there appears to be no nonrespondent bias, a 13% response rate remains. Although Mellahi and Harris (2015) noted that there are no clear boundaries between what is considered acceptable and unacceptable response rates, their sample of 1093 survey-based papers published between 2009 and 2013 report a mean (median) response rate of 45% (40%). However, they also highlighted that nonresponse biases are particularly relevant in determining the acceptability of a survey's response rate. Methodological studies with simulations are needed to clarify the potential impact of a low-response-rate bias on the estimates.

Overall, the positive association between ESP and internationalization is likely to be influenced by the extent of a focal firm's engagement in OI practices with its suppliers. Typically, this open collaboration occurs in proximity to the market. This partly explains the observed relocation of foreign activities and the increased emphasis on local rather than global markets to support internationally operating firms environmental sustainability and legitimation. This potential moderating effect warrants further investigation.

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Declaration of Competing Interest

none.

Data availability

The authors do not have permission to share data.

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