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Female board representation and coupled open innovation: Evidence from emerging market multinational enterprises

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ABSTRACT

Little research has been done on female board representation in emerging market multinational enterprises (EMNEs). Our paper considers the role of female board representation and its impact on open innovation (OI) in the unique context of emerging markets. We draw on upper echelons and institutional theories to understand how female board representation and cross-country institutional contexts influence coupled OI. Combining a 10-year (2009–2019) dataset with a rich in-depth content analysis of 183 (EMNEs) engaged in OI, our results reveal a significant positive association between female board representation and a firm's commitment to coupled OI initiatives. We also find that country-level institutional factors affect and positively moderate the relationship between female board representation and coupled OI. In emerging market environments where managerial perception and cultural beliefs sometimes hinder the promotion of females into top positions, our work has implications for EMNEs regarding how they harness diversity. We contribute to the OI literature by showing that female board representation enhances corporate OI investment within EMNEs.

1. Introduction

This study is motivated by the evident paucity of research that investigates the influence of women on open innovation (OI) using empirical evidence from emerging market contexts. Special issue calls such as Arias-Pérez et al. (2022); von Briel and Recker (2017a,b) and Dabic et al. (2021) have asked for further research on the rewards, risks, costs, and the role of female board representation in the emergence of new forms of corporate innovation (Chen et al., 2018; Xie and Wang, 2020). The storyline in this paper is that if corporations want to make breakthroughs in the OI fields, corporate culture needs to encourage gender diversity at the top. OI activities are boundary-spanning and go beyond technical contributions (Fleming and Waguespack, 2007; Levina and Fayard, 2018). Hence, for firms operating in unique contexts, understanding internal organisational networks and country-level institutional frameworks is essential (Ponomareva et al., 2022). As emerging markets are still catching up on the OI phenomenon, using (i) female board representation, along with (ii) institutional contexts to understand how they may influence OI initiatives for emerging market firms is both right and timely.

Progressively, studies such as von Briel and Recker (2017a,b); Gassmann et al. (2010); Vanhaverbeke (2017) and West et al. (2014); prove that whilst OI may be a good approach to sharing innovation costs, it may not always bring benefits if such initiatives are not sustained over a longer period. Arias-Pérez et al. (2022), Greco et al. (2019) and Cheng and Groysberg (2020) also show that firms that lack supportive internal, inter-organisational networks and gender balance in the upper echelons affect the sharing, acceptance, and success of new OI ideas. Despite the efforts by OI thinkers such as von Briel and Recker (2017a,b) and Brunswicker and Chesbrough (2018) there is room for current research to focus on the impact female board members can make on OI, especially, in emerging economies where OI might be a new phenomenon.

Using an example from the emerging market context, Güler Sabanci – the first female CEO and board chair of Sabanci Holdings (an MNE in our sample), is characterised by her focus on collaborative and sustainable

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innovation. Based in Turkey–a growing emerging economy, her management philosophy is that success should be defined by building networks that satisfy stakeholders (Financial Times, 2010). She is an example of a female board member that has pushed the company to re-focus on philanthropy and pioneered huge long-term OI investments (Financial Times, 2010). Further, Kim Hyun-suk – current president and CEO of Samsung (another innovative MNE in our sample), fosters OI and new technology start-ups through a culture of diversity, in terms of gender and ideology.

Hence, in a complete departure from the existing OI research, our study argues that there is a need to ultimately pay attention to gender diversity and institutional contexts and their impact on OI initiatives. The literature confirms that OI costs continue to rise, and OI-related R&D investments do not always create value for firms. Although Bogers et al. (2018b) identified managerial cognition as an OI barrier, they did not specify how broadening managerial cognition reduces functional fixedness to assure OI success in emerging economies. Fundamentally, the findings of the current OI literature are empirically centred on advanced economies, leaving OI activities in emerging economies largely unexplored.

The theoretical framing and sample used to execute this study are unique in two ways.

Firstly, the justification for our theoretical assemblage of upper echelons and institutional theories is anchored on the fact that OI decisions require huge long-term financial commitments, made at the board level and within a context of an external environment, outside of the firm. Therefore, understanding the nature and top management team's characteristics, the role of institutions and the contexts within which firms operate are important variables that enhance our understanding of the OI phenomenon (Hambrick and Mason, 1984; Galbreath, 2011; Griffin et al., 2021; North, 1991; Post and Byron, 2015). The configuration and orientation of boards have been used to examine firm performance, R&D expenditure, and CSR (Ponomareva et al., 2022; Post and Byron, 2015). In most cases, OI investments are not financially beneficial in the short term, but He and Jiang (2019) and Ramani and Mukherjee (2014) confirm that female board members are long-term oriented.

Therefore, our study is driven by two research questions: what is the relationship between female board representation and OI? And to what extent do country-level institutional factors moderate female board representation? Specifically, we contribute to the OI literature by showing that female board representation minimises *managerial blind spots* which significantly enhances coupled OI activities. We find that firms with higher female board representation are more likely to engage in coupled OI. The findings of our work have key implications for EMNEs.

Secondly, our findings are based on a sample of 183 MNEs from 16 emerging economies, mostly members of BRICs countries (i.e., Brazil, Russia, India, China, and South Africa). Emerging economies have become important stakeholders in the global economy and are experiencing substantial growth and economic development, amidst several institutional constraints (Adams et al., 2019; Meyer and Grosse, 2018). During the early and mid-1980s, several emerging economies gained support from the Bretton Woods Institutions to implement structural adjustments and economic reform programmes to liberalise and privatise their industries to encourage innovation (Adams et al., 2014, 2019). Whilst significant investment opportunities abound, the prevalence of institutional voids creates contextual difficulties that affect OI initiatives. Although emerging economies comparatively require OI to sustain their industries, there is presently no study that captures *coupled* OI practices in that context combining a multi-dimensional analytical approach including empirics with in-depth content analysis. The study provides a 2-step system generalised method of moments (GMM) and quantile regressions to further validate the robustness of the empirical results.

This paper is structured and proceeds as follows: section 2 reviews the existing literature. Section three presents the methods and data used in the study. Section four explains the methods, results, and findings, while sections five, six and seven present the discussion, implications, and conclusion.

2. Theoretical background

2.1. OI research

The OI concept is "a paradigm that assumes that firms can and should use external as well as internal ideas, internal and external paths to market, as firms look to advance their technology" (Chesbrough, 2003, p.24). Conducting OI is of great strategic importance. Wang et al. (2015) highlighted that firms that participate or lead in OI are more likely to develop intangible resources from multiple stakeholders participating in the process. Harhoff et al. (2003) and Parida et al. (2012) also argue that business customers possessing profitable channels are usually motivated to bring novel products and market knowledge outside of the organisation's boundaries. OI can be carried out in three different ways depending on how knowledge flows to and from firms: (a) inbound OI, (b) outbound OI, and (c) coupled OI (Lopes and de Carvalho, 2018).

Inbound OI refers to bringing external knowledge or technology into a firm's innovation process (i.e., knowledge inflow); outbound OI refers to bringing internal knowledge or technology to an external environment (i.e., knowledge outflow) (Cassiman and Valentini, 2016; Huizingh, 2011). Coupled OI refers to the OI process that combines knowledge inflows and outflows (Enkel et al., 2009; Gassmann and Enkel, 2004; Piller and West, 2014; West and Bogers, 2014). Due to the different modes of knowledge flow, implementing and maintaining the distinct modes of OI is also different. According to Greco et al. (2016) and West et al. (2014); inbound and outbound OI is often associated with lower risks and costs due to the clear and fixed innovation objectives and *unidirectional knowledge flows*. Coupled OI can be viewed as complex due to the *multi-sided innovation objectives*, a large number of participating stakeholders and *multidirectional knowledge flows* (von Briel and Recker, 2017a,b; Greco et al., 2016; Sims and Seidel, 2017). The antecedents of OI require mature and diverse OI management capabilities and reputations (Barrett et al., 2021).

So far, the majority of OI literature tends to highlight the openness of innovation processes by simply focusing on (a) the antecedents of OI, (b) the processes of OI, and (c) performance outcomes (e.g., Lopes and de Carvalho, 2018; Love et al., 2011; Randhawa et al., 2016). Table 1 provides a detailed illustration, examples, potential challenges as well as the strategic implications of OI.

Despite the openness of innovation initiatives, how firms respond to the *unclear, complex, and multi-directional knowledge flows* in relation to the different modes of OI is underexplored. Therefore, the present study uses upper echelons theory to argue that the decisions and OI outcomes of firms are a reflection of their most powerful actors – the board responsible for OI decisions (Hambrick and Mason, 1984). Adams and Ferreira (2009), Campbell and Mínguez-Vera (2008), and Campbell and Mínguez-Vera (2008) demonstrated that female board representation significantly influences decision-making, better strategic orientation and effective board functioning. Lu and Wang (2021) also found female board representation to improve internal governance mechanisms including board size as a critical mass of females influences strategy, strengthens the role of non-executive directors, and serves as a control structure against high-interest shareholders.

2.2. Upper echelon and institutional theories

Upper echelon theory (UET) is appropriate to explain how and why firms engage in OI in three ways. First, strategic choices such as adopting and implementing OI projects are often influenced by the board. Second, the board is responsible for sustaining OI processes, including staff motivation, partner selection, sequencing of OI adoption and adoption

Table 1
Comparison of different types of OI.

	Inbound OI	Outbound OI	Coupled OI
Definition	Outside-in process: Bringing external knowledge or technology into a firm's innovation process (Cassiman and Valentini, 2016; Huizingh, 2011)	Inside-out process: Bringing internal knowledge or technology to an external environment (Cassiman and Valentini, 2016; Huizingh, 2011)	Outside-in and inside-out processes: Combining knowledge inflows and outflow
How does knowledge or technology flow?	Internal use of external knowledge Two-sided unidirectional knowledge inflow	External use of internal knowledge Two-sided unidirectional knowledge outflow	Active collaboration with partners to innovate Multi-sided and multi-directional knowledge inflow and outflow
Number of partners involved	Low to moderate number of partners who possess specific external knowledge or technologies	Moderate to high number of partners who need specific internal knowledge or technologies	Moderate to high number of partners who possess specific external knowledge or technologies and partners who need those
Examples	Technology sourcing from universities and research institutes (Howells et al., 2012) Technology transfer agreement (Scuotto et al., 2020) Technology licensing (Lichtenthaler, 2010) Product idea crowdsourcing (Liu et al., 2020)	Technology transfer agreement (Scuotto et al., 2020) Technology licensing (Lichtenthaler, 2010) Accelerator program at Samsung Technology selling	User communities for product co-development Open-source software communities Joint R&D centres or alliances Innovation clusters
Strategic implications	Lower transaction costs Long-term relationships Effective communication with favoured external sources (Ferreras-Mendez et al., 2015)	Gain financial resources from underused knowledge or technologies Exploring new opportunities like digital servitisation Extending network relationships Build up reputations	Exchange of tacit and explicit knowledge (Faems et al., 2007) Intensive communications among strategic partners (Teirlinck and Spithoven, 2013) Reduce technology market inefficiencies (Lichtenthaler, 2013) Reduce costs of technology exploitation (Belderbos et al., 2010)
Potential risks and challenges	**Relatively lower:** Efficiently scouting external knowledge Efficiently exploiting external knowledge Legal contracting issues	**Relatively lower:** Data and technology protection Monitoring partners to protect brand image Preventing opportunistic behaviours Legal contracting issues	**Relatively higher:** Coordinating with several partners of different types (Un et al., 2010) Facilitating reciprocal exchange among partners (Sims and Seidel, 2017) Maintaining activeness among collaboration channels (Greco et al., 2016) More intensive efforts to protect internal intellectual property or ideas from opportunistic partners (Dahlander and Gann, 2010) Strategic assets ownership conflicts and other legal or equity issues Information management

mechanisms. Kim et al. (2015) noted that the upper echelon can pose pressures on initiating and implementing strategically important projects. Third, Barrett et al. (2021), show that OI literature overlaps with UET. Therefore, the impact of founder/CEO managerial characteristics, such as functional background, career experiences, industry experience, networks, and entrepreneurial orientation of OI processes are interconnected.

The UET suggests that the behavioural characteristics of the top management team (TMT) can have an enduring impact on organisational behaviours, strategic choices, and performance outcomes (Hambrick, 2007; Hambrick and Mason, 1984). As gender-diverse boards have a long-term strategic orientation (Adams and Funk, 2012; Díaz-García et al., 2013), and boards of directors have great influence over the strategic direction of firms and are also responsible for OI initiatives, we examine the potential relationship between female board representation and coupled OI. Despite its original focus on top management team members, the upper echelons also include board members since they constitute "supra top management teams" (Finkelstein et al., 2009, p.11). Most studies related to UET mainly investigate and explain how the experiences, education levels values, and personal attributes of members in the firm's upper echelons affect the interpretations of strategic issues which then affect firm choices (Hambrick, 2007).

Apart from the analysis of individual characteristics, an increasing number of UET studies show the strategic importance of group diversity. The influence of upper echelon team's influence on OI decisions occurs primarily in two ways: board monitoring and board strategy involvement (Attah-Boakye et., al., 2021; Miletkov et al., 2017; Post and Byron, 2015). Board members can monitor the firm's OI activities and control managerial opportunism (Zahra and Pearce, 1989). The board can also engage in strategic advising and supporting, strategy development and decision-making (Linck et al., 2008). Through these two key activities, boards with varied compositions can function as different boundary-spanning mechanisms that link organisations with external resources and networks (Miletkov et al., 2017). They can function as different information channels within firms (Connelly et al., 2011). Accordingly, a demographically diverse board can play a significant role in influencing organisational behaviours and sustaining growth by improving organisational performance (Oxelheim and Randøy, 2003; Rosenstein and Wyatt, 1990).

Besides the UE influence, country-level institutional contexts affect internal and external knowledge exchanges and appropriation. Strategic actions are also enabled or constrained by external institutions and the moderating role of institutions on the innovation mechanisms of firms is well reported. Tsinopoulos et al. (2018) argued that the motivation for achieving social legitimacy can strengthen or weaken organisational routines and the management of daily operations. Consequently, we use institutional theory as one of our theoretical lenses to explore how factors such as control corruption and women parity index (WPI) (also referred to as gender parity index) moderate the effect of females on coupled OI. The institutional theory examines how social influences affect firms' strategic choices (Chu et al., 2018; DiMaggio and Powell, 1983; Hidefjäll et al., 2023; Johansson et al., 2021a). Firms operate in an environment consisting of formal and informal institutions which are likely to strengthen or attenuate the influences of UET characteristics. The UET and related studies have shown that the extent to which board members can influence firm outcomes is dependent on or moderated by the environment where a firm operates (Haleblian and Finkelstein, 1993; Hambrick, 2007). Following the same logic, our research integrates these two theoretical perspectives (i.e., UET and institutional theory) to explain factors influencing OI adoption choices.

3. Hypotheses development

3.1. Female board representation and coupled OI

There are two reasons why we are arguing that more females in UE teams could be a strategic necessity in managing OI. First, female directors can bring different cognitive frames to the board based on their differences in experiences, knowledge base, and risk awareness (Carpenter and Westphal, 2001; Hillman and Dalziel, 2003). Peterson and Philpot (2007) show that women directors on boards are more likely to hold advanced degrees and provide diverse perspectives and information for decision-making. Second, the unique traits and cognitive frames of women board members can encourage deep discussion and integration of existing information and knowledge (Loyd et al., 2013), value interdependence, cohesiveness, and tolerance (Adams and Funk, 2012; Rosener, 1995), facilitate communication and knowledge integration inside and outside of the organisations and promote collaborations (Bart and McQueen, 2013). For example, by using a survey among 317 Norwegian firms, Torchia et al. (2011) found that a significant percentage of women directors on board positively affect organisational innovation which is the creation or adoption of a new idea or behaviour of an organisation (Daft, 1978; Damanpour, 1996). Attah-Boakye et al. (2020) used a panel data analysis of 472 emerging market multinational enterprises (EMNEs) to confirm that gender diversity positively affects corporate innovation investment. Dai et al. (2018) also indicate that promoting women to the upper echelons improves firm knowledge integration and firm innovation performance. Directors on board are often viewed as primary agents responsible for generating, spearheading and approving OI mandates (Shaikh and Randhawa, 2022). They can either advise or engage in strategy development to affect whether and how OI can be carried out (Wincent et al., 2009).

Consolidating the findings from existing research, we extend that female board representation can influence a firm's OI adoption via board monitoring and board strategy involvement. Such findings stretches beyond the stereotypical notation of gender (Johansson et al., 2021b; Malmström et al., 2017a, b, Malmström et al., 2018). Women directors on board can advise and bring new and diverse perspectives into board discussion and decision-making, thus making firms more open to change and more likely to see the feasibility and potential for change. They are more likely to challenge the status quo and tradition and make other board members and executives receptive to new approaches to innovating, as highlighted by behavioural psychology research (Eagly, 2009). For example, Post et al. (2021) examined company documents from 150 multinational companies after women joined the C-suite, they showed a significant cognitive shift: a 10 per cent increase in openness to change. They further argued that women who joined senior positions changed how the top management team thinks about innovation and wider approaches to creating values through innovation, which provide inference to how female directors function on board. Díaz-García et al. (2013) also supported that a high level of gender diversity within R&D teams directly leads to more radical product innovations.

Post et al. (2021) observed that when TMTs have more female executives on board, firms tend to shift from a traditionally masculine and proactive approach (i.e., focusing on knowledge buying) to a more traditionally feminine and collaborative approach (i.e., focusing on knowledge building and sharing). Their findings show that the link to knowledge development and communication is females on the board. Furthermore, female directors on board tend to be more considerate about multiple stakeholders and guide firms on how to openly innovate and how to create coopetition (Groysberg and Bell, 2013). Nadeem's (2019) content analysis of Chinese IPO prospectuses from 2009 to 2017 found that board gender diversity and female board representation have positive relationships with intellectual capital disclosure.

Women directors on board are often senior leaders or executives and have experienced a more difficult and tough selection process and requirements (Glass and Cook, 2016). Their experience, expertise and by their 'natural design' (Nielsen and Huse, 2010) become better managers of multiple stakeholders, OI projects, and better at conflict management. Given that OI is conducted through purposive inflows and outflows of knowledge to accelerate internal innovation and expand the use of innovations (Chesbrough, 2003, 2006), multiple stakeholders (i.e., research institutes, customers, end-users, suppliers, competitors, government, and network partners) are often involved. Therefore, initiating and managing OI requires capabilities of managing multi-lateral information sharing inside and outside of firms. Randhawa et al. (2016); Enkel et al. (2009) show that facilitating collaborations, building up joint decision-making processes, and addressing conflicts from various stakeholders are the primary requirements for successful OI initiatives compared with closed innovation. Female directors on board are more likely to be participative and communal and have the knowledge and capabilities to communicate and effectively negotiate with stakeholders (Eagly and Johnson, 1990; Rudman and Glick, 2001). As a result, firms with gender-diverse boards are more likely to initiate and manage OI effectively. Based on the arguments above, we hypothesise that higher female board representation promotes a coupled OI.

Hypothesis 1. Female board representation is positively related to a firm's coupled OI.

3.2. Moderating role of country-level institutions

The positive association between female board representation and firm OI may need to be considered in different country-level or macro-environmental contexts as suggested by Simsek et al. (2005). Thus, country-level factors can influence board-level micro-processes (Byron and Post, 2016). The extent to which female board representation can positively influence firm outcomes depends on the context where diverse knowledge, skills, and values are appreciated and leveraged (Brammer et al., 2007; Gabaldon et al., 2016; Post and Byron, 2015). Country-level institutional context is an important environmental factor influencing female board representation and firms' innovation decisions. Grosvold and Brammer (2011) argued that female board representation influences are significantly subject to national institutional systems.

The meta-analysis conducted by Post and Byron (2015) identified that the relationship between female board representation and firm performance varies by firms' institutional contexts. The relationship is positive in countries with greater gender parity and negative in countries with low gender parity. Gender parity refers to the extent to which women have equal access to resources and opportunities for education, economic participation, employment, and political empowerment (Hausmann et al., 2012). The institutional theory argues that organisational actions are constrained or enabled by the institutional conditions within a given social context (Scott, 1987; Zucker, 1987). Using observations of firms in 48 countries from 1997 to 2016, Askarzadeh et al. (2022) found that institutional differences moderate the influence of female board representation and the types of risks firms undertake.

Institutions include both formal (i.e., laws, rights, corruption regulations, government efficiency and effectiveness) and informal institutions (i.e., gender parity, culture, codes of conduct, local norms). Both formal and informal institutions are created and maintained to ensure social stability (North, 1991). It is worth noting that the institutional environment can constrain but also enable organisations' actions, such as innovation, knowledge transfer, and OI (DiMaggio and Powell, 1983; Adams et al., 2019). Due to its openness, sharing, and collaboration nature, OI requires informal institutional support, such as a collectivist culture that encourages sharing and community building and customer or user willingness to co-develop. The OI process and its improvement also need a set of formal institutional support (Caraça et al., 2009). Collaborated innovation project success often takes place in a qualified institutional environment where the virtuous circle of

innovation is more likely to be sustained (Greco et al., 2017).

Qualified institutional arrangements are also crucial to ensure open science, broader and faster knowledge dissemination, and faster innovation (Bogers et al., 2018a). For example, Von Briel and Recker (2017) found potential barriers to OI, which is relevant to the quality of formal institutional context. Specifically, they highlighted whether stakeholders feel comfortable and secure sharing their knowledge, whether strategic partners' knowledge assets can be protected by legislation, whether data and knowledge protection regulations are effective, whether corporate structures provide an appropriate governance model for OI, and whether financial regulations are in place.

OI by nature requires sharing knowledge in different ways, including bringing knowledge to the firm, externalising knowledge to the environment, and exchanging knowledge (OECD, 2008). Hence, firms often need to consider how to address concerns that arise from the legal environment when they are deciding and implementing OI. For example, the case study conducted by von Briel and Recker (2017a,b) highlighted that data/knowledge protection regulations tend to be the common checkpoints for decision-makers when implementing OI initiatives. Established legislation for protecting knowledge assets, reputation, copyright, and other intellectual properties can promote an increasing number of contributors to OI (Alexy and Reitzig, 2012). Countries with high institutional quality provide legal assurance and ease stakeholders' concerns. Consequently, it also makes female board members feel at ease to put forth ideas and persuade OI decisions. Historically, weak institutional contexts with less respect for females are often based on conservative paternalism (Soss et al., 2011; Turpel, 1993). Hence, even if female board members can and are willing to promote firm OI, they are seen as weak, stereotyped, and criticised by other board members and investors (Boulouta, 2013). The empirical findings from Leiponen and Helfat (2010) connect our arguments by showing a positive relationship between openness and innovation outcomes in economies where institutional quality is high. Grosvold (2011) argued that the quality of national governance can positively spill over and lead to more proportion of female board representation which further increases women board members' power on board.

Against the backdrop of the above discussions, the subsequent hypotheses (2a-2c) attempt to confirm if institutional characteristics such as control corruption, governance effectiveness, and gender parity moderate the positive association between female board representation and coupled OI as reported in the literature by Lee et al. (2020); Anokhin and Schulze (2009); Gyamfi and Sein (2021); Barasa et al. (2017).

Hypothesis 2a. . Governance effectiveness at country level positively moderates the relationship between female board representation and coupled OI.

Hypothesis 2b. Control of corruption at country level positively moderates the relationship between female board representation and coupled OI.

Hypothesis 2c. Women parity index at country level positively moderates the relationship between female board representation and coupled OI.

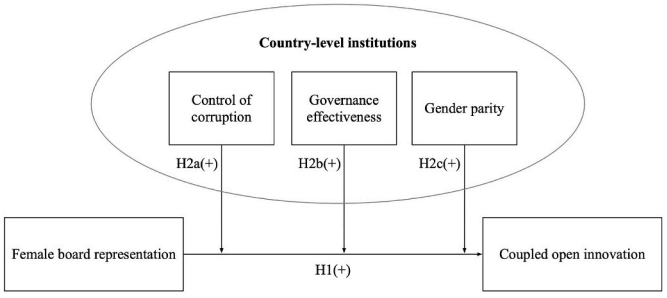

Fig. 1. Conceptual framework.

Fig. 1 shows the independent, dependent, and moderating variables which provide the conceptual framework used as the starting point for the analysis. The subsequent sections explain the methods, results and findings.

4. Method

The dataset used in our analysis is drawn from multiple sources consisting of secondary data and unique handpicked data collected from annual reports of EMNEs to examine the relationship between female board representation and coupled OI. As our research also examines the moderating role of country-level institutions, panel data from a cross-country EMNE sample is deemed appropriate. Corporate governance data was collected from Thomson Eikon while country-level institutional quality data was collected from the World Bank dataset. After deleting inconsistent data as well as removing outliers, we arrived at a total sample size comprising 183 companies across 10 different industry sectors from 16 emerging economies covering periods from 2009 until 2018. The corpus of variables used in this study is guided by our conceptual framework (see Fig. 1) and the hypotheses to be tested.

4.1. Measures

4.1.1. Dependent variable: Coupled OI

To examine our hypotheses, we espoused a novel measure of coupled OI using in-depth content analysis by the whole research team into phases. In the first phase, we started with a collection and review of the annual reports and information from the official websites published by all the 183 EMNEs in our dataset. Innovation-related information disclosed in these public reports and official websites is of strategic importance to all MNEs. They also met the international financial reporting standards (IFRS) as its a requirement for all listed firms (Yan et al., 2018). The whole research team then manually handpicked firm-level data on OI and critically examined the reported and collated OI evidence via meticulous content analysis.

Specifically, we used keywords such as "open innovation", "OI" "co-creation", "collaborations", "cooperation", "collaborative innovation/projects", "openness", "crowdsourcing" "innovation communities", "external innovation", "R&D alliances", "R&D joint ventures", "technology acquisition", "technology brokering", "university research", "institute research", "user innovation/involvement", "technology transfer", "technology sharing", "research staff exchange" (West and Bogers, 2014; Randhawa et al., 2016), and other advanced search criteria. The initial evidence gathered was checked by the whole research team.

In the second phase, we used a compendium of OI literature and definitions as a guide (see Table 1) and content analysis of our sampled firms' annual reports to manually handpicked the inbound OI, outbound OI and coupled OI data. To operationalise the variables, we differentiated three types of OIs. Key definitions are provided in section 2. In short, the inbound OI measures knowledge inflow from external sources and the outbound OI measures knowledge inflow from internal sources. Coupled OI represents the OI process that combines knowledge inflows and outflows (Gassmann and Enkel, 2004; Enkel et al., 2009; Piller and West, 2014; West and Bogers, 2014).

In the third phase, we differentiated the purpose of OI under each category: product, process, organisational, and marketing. Specifically, whilst product innovation denotes the introduction of new or modified product and service technologies, process innovation represents the introduction of new or modified production methods and technologies. We also adopted the introduction of new and efficient methods as organisational innovation and the introduction of new marketing strategies and methods as marketing innovation based on OECD (2008) definitions.

In the fourth phase, the results were then summarised based on a combination of the categorisations of OI. This is evidenced in Appendix

1. Results at this phase were also checked by the whole research team followed by multiple rounds of discussions to ensure consistency.

In the final phase, we used the literature to define coupled OI. We then gave a value of 1 if the firm's operations and activities during the financial year as reported in their annual financial statement provide evidence of at least three out of the four attributes of the coupled OI, otherwise zero. We used the binary method for two reasons. First, considering the qualitative nature of our dataset we noted that the binary approach offers the best option for operationalising our dependent variable. Second, we followed previous studies such as Garriga et al. (2013) who used a binary method in capturing six survey responses that measure firms' internal and external innovation. Third, in testing our models for any possible multicollinearity issue, we noted from our variance inflation factor test that, using the binary method to measure our DV provides a better alternative than using the composite index of the 8 subcomponents of the inbound and the outbound OI as DV. This has also been captured in equation (1).

In this equation, production (inbound) represents the internally generated production knowledge/technology that assists in new product development or the modification of the existing product. Whereas production (outbound) represents externally generated production knowledge or technology that leads to the development of new production methods or improvement of the existing methods. Process (inbound) internally generated knowledge or technology that leads to the introduction of new efficient organisational approaches, methods and capabilities that can optimise firms' outputs and profitability. Process (outbound) provides similar results but is externally generated. The inbound OI also include the development of newly advanced and efficient technological methods that can optimise firm performance whiles the outbound OI captures the introduction of such organisational technology from outside sources. The inbound and outbound marketing component of OI captures the latest and more advanced marketing systems and approaches from internal/external sources that can enhance the overall marketing approach of innovating firms (OECD, 2008).

4.1.2. Independent variable: Female board representation

A common measure used by existing female board representation literature (e.g., Torchia et al., 2011; Post and Byron, 2015; Attah-Boakye et al., 2020) focused on the number of women on each board. Therefore, we followed these studies in measuring female board representation by looking at the percentage of women on the board, or female board representation during the financial year. Empirical studies based on UET have always contended that promoting more females to the board strengthens the diverse skills-set at the top echelons. Thus, the involvement of women on the board in any capacity (i.e., with or without executing powers) could serve as an impetus for initiating environmental transparency, innovation, and strategic change (Triana et al., 2014; Liao et al., 2015; Attah-Boakye et al., 2020).

4.1.3. Moderating variables: Control of corruption, governance effectiveness and WPI

The institutional theory contends that a robust and efficient country-level institutional framework can increase public trust and investor confidence, facilitating firm innovativeness. For example, Lee et al. (2020); Torchia et al. (2011) show that countries that have quality legislation, good governance systems and corruption control measures can facilitate lower transaction costs, speed up transaction processes and increase competition, and innovation at the firm level. Against this backdrop, therefore, we include control corruption, governance effectiveness, and WPI in our variable mix to examine their moderating effect on coupled OI.

Control of corruption is measured by the index of corruption among private and public sectors retrieved from the World Bank and used by other studies (e.g., Anokhin and Schulze, 2009; Attah-Boakye et al., 2020). The World Bank corruption index includes petty bribes as well as grand forms of corruption. We follow the work of Anokhin and Schulze (2009); Attah-Boakye et al. (2020) in operationalising governance effectiveness by assessing the quality of governance in the public sector, including independence from political pressures, quality of policy formulations and implementation as well as government commitment to such policies obtained based on the World Bank data.

The WPI (or gender parity index), on the other hand, is a socio-economic composite index that measures if women and men have the same opportunities for economic participation, educational attainment, health and survival and political empowerment produced for the World Economic Forum by Hausmann et al. (2012). Instructively, a WPI between 0.97 and 1.03 indicates parity between women and men, whereas a WPI below 0.97 indicates a disparity in favour of males.

4.1.4. Control variables

Our research includes board size, single largest owners, environmental expenditure, ownership structure, total sales, leverage, market-to-book value (MTBV) and return on asset. We included board size as one of our control variables because UET argues that having more board members can provide an idiosyncratic skillset that can shape the strategic vision and direction of firms (Hambrick, 2007). We also include environmental expenditure because the burgeoning climate change arguments are gradually taking centre stage in corporate boardrooms. Therefore, the inclusion of environmental spending in our corpus of variables is important for two reasons: First, to foster sustainable economic transformation and address climate change issues, most EMNEs will be required to disclose their green commitment to be able to access investment capital (Irfan et al., 2022) as they seek investments from domestic and international stock markets to finance OI activities. Whilst OI investments and OI collaborations arising from participating in an international stock market bring their benefits, key environmental and social governance requirements (ESG) prevail whereby savvy eco-minded investors seek opportunities for green investments in innovation, wherever they may be. Second, previous studies argue that to achieve stakeholder trust and enhance corporate reputation, corporate innovation activities should include environmental spending that prioritises green technologies that provide solutions for waste recycling methods and overall reduction of global emissions (see Skordoulis et al., 2020). In a related study, Liao et al. (2017) also argued that most decisions by TMTs are now guided by environmental concerns. Hence, controlling for environmental expenditure in our study is imperative.

In addition to environmental issues, we control for the single largest owners because they can significantly influence coupled OI. This position on the importance of how the single largest shareholders can influence long-term investment decisions on innovation has been documented by several studies including Gedajlovic and Shapiro (1998); Choi et al. (2011), among others. To control for the differences in firm size and the nature of operations of the firms in our sample, we included control variables such as total sales, leverage and market-to-book value (MTBV) and return on assets (ROA). Table 2 provides the definitions of the variables used in this study.

4.2. Model specification

We operationalised the dependent variable (coupled OI) as a binary indicator function that takes a value of 1 if the firm's operations and activities during the financial year as reported in their annual financial statement provide evidence of at least three out of the four attributes of the coupled OI (please refer to the Table presented as appendix 1) otherwise zero (Please refer to the variable definition table). We then used the equation below as a baseline equation in testing hypothesis 1:

$$Coupled\ OI_{i,t} = \propto_0 + \beta_1 Environmental\ exp_{i,t} + \beta_2 BSize_{i,t} + \beta_3 FEMBR_{i,t} + \beta_4 SLO_{i,t} + \beta_5 Leverage_{i,t} + \beta_6 ROA_{i,t} + \beta_7 SalesRv(log)_{i,t} + \beta_8 MTBV(log)_{i,t} + \varepsilon_{i,t} \quad (1)$$

Table 2
Variables and their Definitions.

Variable name	Definition	Source
Firm-specific variables		
Coupled OI	Coupled OI is defined as the processes that combine knowledge and technology acquisition (inbound OI) and transfer (Outbound OI). Inbound OI measures the acquisition of knowledge and technology from external sources. Outbound OI measures the outward transfer of firm's knowledge and technology for external benefits. The coupled OI has four sub-components of (a) production (b) process (c) organisation and (d) marketing we give a value of 1 if the firm operations and activities during the financial year as reported in their annual financial statement provide evidence of at least three out of the four attributes of the coupled OI otherwise zero.	Hand-picked data from firm's annual report
Environmental expenditure	Total environmental expenditure for the financial year.	Thomson Eikon
Board size (BSIZE)	The total number of board members during the year.	Thomson Eikon
Female board representation (FEM)_	Percentage of women on a company board or female board representation during the year	Thomson Eikon
Single largest owner (SLO)	The percentage of share ownership of a single largest shareholder	Thomson Eikon
Leverage	Total company debt divided by shareholders equity	Bloomberg
Return on assets (ROA)	This is a proxy for firm performance measured as net income divided by average assets	Thomson Eikon
Sales Revenue (log)	Total revenue generated from operations during the financial year	Thomson Eikon
Market to Book ratio (MBR)	Market value of common equity divided by the balance sheet value of the common equity	Bloomberg
Country-level Institutional Quality		
Control corruption (CC)	An index that measures the level of corruption among private and public sectors. These include petty bribes and grand forms of corruption.	World bank indicators
Governance effectiveness (GE)	An index that measures the quality of governance in the public sector. This includes independence from political pressures, quality of policy formulations and implementations and governments commitments to such policies.	World bank indicators
Women Parity Index (WPI)	This is a socio-economic composite index that measures if women and men have the same opportunities for economic participation, educational attainment, health and survival and political empowerment. WPI between 0.97 and 1.03 indicates parity between women and men. WPI below 0.97 indicates a disparity in favour of males. We only used WPI as a moderating factor in our study.	World Bank indicator

Where coupled OI represents coupled OI in time t. $\propto_0$ is the constant term; β are the estimates of the regression coefficients; $\varepsilon_{i,t}$ is the error term. *Environmental Exp* is the total environmental expenditure during the financial year, *Bsize* represents board size, *FEMBR* is female board representation, *SLO* represents single largest shareholders (Block-shareholders), *Leverage* represents the total company debt divided by shareholders equity, *ROA* (is a proxy for firm performance), *SalesRv(log)* is the natural log of sales revenue, *MTBV* represents the market to book value.

To test hypotheses 2a, 2b and 2c, we included in our corpus of variables institutional factors such as control corruption, governance effectiveness and WPI to investigate if these factors moderate the association between female board representations and coupled OI. We used equation (2) below in testing hypotheses 2a, 2b and 2c.

$$Coupled\ OI_{i,t} = \propto_0 + \beta_1 EnvironmentalExp_{i,t} + \beta_2 FEMxWPI_{i,t} + \beta_3 FEMxCC_{i,t} + \beta_4 FEMxGE_{i,t} + \beta_5 Bsize_{i,t} + \beta_6 Leverage_{i,t} + \beta_7 SLO_{i,t} + \beta_8 ROA_{i,t} + \beta_9 MTBV_{i,t} + \varepsilon_{i,t} \quad (2)$$

Where *FEMxWPI* represents the combination of female board members and women parity index, *FEMxCC* is the combination of female board members and control corruption, and *FEMxGE* is the combination of female board members and governance effectiveness.

4.3. Descriptive statistics

Table 3 shows the sample characteristics of the study, while Tables 4 and 5 represent the summary statistics and the Pearson correlation matrix respectively. We noted some interesting findings from the summary statistics Table. For example, the results in Table 4 show that on average 73% of the EMNEs in our dataset engage in coupled OI, which in itself is quite remarkable from an emerging market perspective. Contrastingly, the average percentage of female representation at the board level is 15.5%, which is relatively low. The Pearson correlation matrix in Table 5 shows a significant positive association between board size and female board representation. This implies that larger boards usually include a relatively higher proportion of female members which is quite promising, to say the least. Also, we recorded a significant positive association between female board representation and coupled OI on our Pearson correlation matrix.

5. Results and discussions

Both the Pearson correlation matrix (please refer to Table 3) and our two regression results in Tables 6 and 7 revealed some interesting findings. For instance, the Pearson correlation matrix revealed a significant positive relationship between female board representation and OI. Also, we noted a positive relationship between environmental spending and OI. Again, each of our country-level institutional factors significantly moderates the positive association between female board representation and OI. Our baseline logistic regression model used a binary dependent variable of coupled OI with a value of 1 representing the presence of coupled OI and 0 representing the absence of coupled OI. First, the chi-square statistics of our baseline regression module

Table 3
Sample characteristics.

Country	Number of Companies	number of Industry sector
Brazil	14	6
Chile	3	3
China	22	7
Colombia	3	1
Czech Republic	1	1
India	21	7
Indonesia	4	3
Malaysia	4	4
Mexico	5	4
Peru	2	1
Russian	13	5
South Africa	16	5
South Korea	21	6
Taiwan	39	8
Thailand	8	5
Turkey	7	5
Total	**183**	**10**

Table 4
Descriptive statistics.

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
Coupled OI	1748	0.729	0.444	0.000	1.000
Environmental Exp (log)	1748	1.124	1.513	1.037	1.491
Board Size	1748	10.581	3.737	2.000	37.000
FEM Board Rep	1748	0.155	1.153	0.120	0.590
Block Shares	1748	0.296	0.253	0.000	0.864
Leverage	1748	0.025	0.051	0.000	0.571
Return on Assets	1748	0.148	0.342	0.052	0.487
Sales Revenue (log)	1748	19.041	2.557	13.155	26.204
MTBV	1748	2.643	5.672	0.200	51.970
FEMB x WPI	1748	3.464	4.277	0.000	19.665
GD x CC	1748	6.629	8.615	0.000	40.165
GD x GE	1748	6.383	8.321	0.000	39.952

Please note: MTBV represents the market-to-book value of firms; GD x CC is an interactive measure of female board representation and control corruption; GD x GE represents an interactive measure of female board representation and governance effectiveness; FEMB x WPI is an interactive measure that represents female board representation and control women parity index. * Shows significance at the 0.05 level.

Table 5
Pairwise correlations.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) Coupled OI	1.000											
(2) Environmental Exp	0.046	1.000										
(3) Board Size	0.057*	0.012	1.000									
(4) FEM Board Rep	0.100*	0.122*	0.139*	1.000								
(5) Block Shares	0.092*	0.112*	0.197*	0.119*	1.000							
(6) Leverage	0.131*	−0.016	0.141*	0.158*	0.157*	1.000						
(7) Return on Assets	0.063*	−0.014	−0.022	0.047	0.089*	0.433*	1.000					
(8) Sales Revenue (log)	0.076*	0.030	−0.127*	−0.290*	0.051*	−0.407*	−0.288*	1.000				
(9) MTBV	0.037	0.025	−0.099*	0.169*	0.017	0.034	0.317*	−0.098*	1.000			
(10) FEMB x WPI	0.109*	0.052	0.205*	0.419*	−0.004	0.133*	0.094*	−0.339*	0.080*	1.000		
(11) GD x CC	0.122*	0.037	0.224*	0.272*	−0.004	0.089*	0.003	−0.274*	0.003	0.210*	1.000	
(12) GD x GE	0.123*	0.037	0.229*	0.272*	−0.005	0.089*	0.004	0.273*	0.002	0.208*	0.299*	1.000

Please note that Environmental Exp. represents environmental expenditure. FEM Board rep shows female board representation, sales revenue (log) represents the natural log of total sales revenue of the firm during the financial year * Shows significance at the 0.05 level.

Table 6
The effects of firm-level factors on coupled open innovation.

	(1)	(2)
VARIABLES	Logit	System GMM-2step
Environmental Expenditure (log)	0.102**	0.121**
	(0.102)	(0.103)
Board size	0.293***	0.187**
	(0.028)	(0.025)
Female Board Representation	0.374***	0.553***
	(0.013)	(0.005)
Block Share Holders	0.155***	0.211***
	(0.104)	(0.015)
Leverage	0.627***	0.153**
	(0.086)	(0.036)
Return on Assets	0.125**	0.138**
	(0.066)	(0.054)
Sales Revenue (log)	0.182**	0.125**
	(0.066)	(0.086)
MTBV	0.381***	0.150**
	(0.028)	(0.028)
Constant	0.554*	0.595*
	(1.063)	(0.055)
Observations	1215	1215
Pseudo R-squared	0.378	
AR (1)		0.248
AR (2)		0.321

Standard errors in parentheses ***p < 0.01, **p < 0.05, *p < 0.1. Two steps system GMM is used to test the robustness of our results in models 2 and 4 respectively.

Table 7
The moderation effects of country-level institutional factors on coupled OI.

	(2)	(3)
VARIABLES	Logit	System GMM-2 steps
Environmental Exp (log)	0.146**	0.127**
	(0.019)	(0.031)
FEM x WPI	0.442***	0.450***
	(0.020)	(0.020)
FEM x CC	0.113	0.112
	(0.126)	(0.129)
FEM x GE	0.277***	0.213***
	(0.022)	(0.024)
Board Size	0.0150**	0.227***
	(0.030)	(0.023)
Leverage	0.504***	0.372***
	(0.020)	(0.031)
Block-share holders	0.144	−0.131
	(0.117)	(0.135)
Return on Assets	0.439***	0.134**
	(0.021)	(0.034)
MTBV	0.0463*	0.0273
	(0.123)	(0.132)
Constant	0.585***	0.521***
	(0.063)	(0.087)
Observations	1203	1198
Pseudo R-squared	0.425	57.8
AR (1)		0.243
AR (2)		0.325

Please note: Standard errors in parentheses ***p < 0.01, **p < 0.05, *p < 0.1.

recorded is less than the 0.05 conventional threshold of (p-value <0.0001) implying that our model is significant. Also, the pseudo-R-square of 0.378 and 0.425 for the baseline logistic regression and the moderating factors logistic regression respectively (please refer to Tables 6 and 7) confirm that the model's predictive power is significant.

We used a two-step system GMM to test the robustness of our two

regression models (please refer to model 2 in Tables 6 and 7). The p-value of our AR (1) and AR (2) (Arellano and bond estimators) were all insignificant at 0.248 and 0.321 respectively implying that our model does not suffer from autocorrelation problems.

To test hypothesis 1, we used the baseline regression results in Table 6. The baseline regression results explored firm-level variables that influence couple OI. The second regression results in Table 7 investigated the extent to which country-level institutional factors moderate the effect of female board representation on coupled OI. Our study focuses on addressing two key research questions. First, to investigate if there is any association between female board representation and coupled open innovation. Second, to examine if institutional factors such as governance effectiveness, control corruption and woman parity index moderate to linkages between female board representation and coupled open innovation.

5.1. The relationship between female board representation and coupled OI

The baseline logit regression and our robust two-steps system GMM results in Table 6 show a significant positive association between female board representation and coupled OI in both our model 1 ($\beta = 0.374$, $p < 0.013$) and model 2 – system GMM regression-two-step ($\beta = 0.553$, $p < 0.005$) respectively. (please refer to Table 6, the p-values represent the standard errors of the regression co-efficient). This shows that our findings are robust and consistent across the logistic regression model and our robust two-step system GMM. This result supported hypothesis 1 and is consistent with the underpinning argument of the UET that having more female board members can exert a sizable positive influence on coupled OI activities. Besides, our results agree with scores of studies contending that having more females on corporate boards increases divergent views which enhances creativity and innovation (e.g., Ain et al., 2021; Yarram and Adapa, 2021; Espig et al., 2021; He and Jiang, 2019; Nadeem et al., 2020; Attah-Boakye et al., 2022Attah-Boakye et al., 2022). Our results, therefore, imply that encouraging more females to study science, technology, engineering and mathematics and supporting and promoting them into top positions will contribute significantly to corporate innovation and reduction in Co2 emissions (Le Loarne-Lemaire et al., 2021). Our study extends the literature by providing empirical evidence that is based on data collected from 183 EMNEs operating in 16 emerging economies. Our results imply that legislation that supports the promotion of more females to the board can positively influence OI activities.

5.2. The moderating effect of institutional factors on the association between female board members and coupled OI

Given that the EMNEs in our dataset operate in emerging economies that usually have problems with weak institutions, we investigated the moderating effect of institutional factors on the baseline results in Table 6. Previous studies such as Terjesen et al. (2015); Grosvold and Brammer (2011) have argued that women's representation on corporate boards is shaped by country-level institutional factors such as the social, political and economic structures. However, studies that specifically examine how country-level institutional factors moderate female board participation in coupled OI are limited. As such, this study contributes to the literature by investigating the extent to which country-level institutional factors moderate female board members' effects on coupled OI. This could explain why EMNEs and emerging markets, in general, are playing catch up on the OI phenomenon.

5.3. How control corruption moderates the effect between female board members and coupled OI

To analyse hypothesis 2a, we test how the control of corruption moderates the effect of female board representation on coupled OI using our baseline logit regression in model 1 and robust two-steps system GMM results in model 2 (please see Table 7). Our results revealed that control corruption positively moderates the effects between female board representation and coupled OI (please refer to Table 7, model 1: $\beta = 0.113$, $p < 0.126$). and model 2 – system GMM regression-two-step ($\beta = 0.112$, $p < 0.129$) respectively This finding supports hypothesis 2a. This finding also corroborates with previous empirical studies that contend that, unlike their male counterparts, female board members in the upper echelons are usually less likely to engage in corrupt practices (Xia et al., 2018). Additionally, empirical studies such as Lee et al. (2020) and Pirtea et al. (2019) contend that although country-level institutional quality plays a vital role in firm-level innovation, poor institutional quality such as corruption and poor governance has a significant negative effect on OI. Our results imply that having more female board members will not only lessen corrupt practices but also strengthen coupled OI.

5.4. How governance effectiveness moderates the link between female board members and coupled OI

To test hypothesis 2b, we included governance effectiveness in our logit regression model in Table 7. Our result revealed that governance effectiveness moderates the significant positive association between female board representation and coupled OI ($\beta = 0.277$, $p < 0.022$). This result supports hypothesis 2b and is also consistent with the two steps system GMM robustness test ($\beta = 0.213$, $p < 0.024$) on model 2 in Table 7. Our findings corroborate with other studies such as Afrifa et al. (2020) who argued that country-level governance factors may influence firm-level innovation and environmental spending. They showed that corruption and poor governance stifle firm innovation. We extend their findings by enhancing our understanding of how good governance at the country level can improve diversity within top management teams and improve OI initiatives. Traditionally, firms that operate in countries with weak institutions tend to have a low GPI index because promoting females to the board is affected by cultural biases. The findings from our study imply that governments in emerging economies can use legislations that support the promotion of women to the upper echelon as a measure of promoting firm-level innovation and enhancing economic growth.

5.5. How WPI moderates the effects between female board members and coupled OI

To test hypothesis 2c, we included the WPI (also sometimes referred to as gender parity index) in our corpus of variables. The purpose is to investigate if higher WPI moderates the positive association between female board representation and coupled OI. Our model 1 baseline logit regression results in Table 7 revealed that higher female board members combined with WPI have a significant positive effect on coupled OI ($\beta = 0.442$, $p < 0.020$). Similarly, this significant result is supported by our robust two steps system GMM in model 2 in Table 7 ($\beta = 0.450$, $p < 0.020$). These interesting findings are consistent with hypothesis 2c and other studies such as who argue that women parity, diversity, inclusion, and equity are essential for knowledge production and corporate innovation. Besides, WPI has long been the central focus for science, technology, engineering and mathematics (STEM) international network organisations aimed at supporting female STEM education in most emerging economies. Our study provides new and interesting insights into the role of female board members.

To be specific, as most emerging economies seems to relegate the contributions of female to the periphery, this finding is crucial for entrepreneurship and innovation management studies in the future. To the best of our knowledge, this study is the first to highlight the significant positive association between the moderating effects of female board members and coupled OI based on a 10-year dataset with a rich in-depth content analysis of 183 EMNEs operating in emerging markets.

5.6. Robustness

To test the robustness of the regression models, we used the variance inflation factor (VIF) to ascertain if any of our modules suffered from multicollinearity problems. All our regression models passed the VIF test, implying that none of our models suffered from any multicollinearity problem. Second, we looked for a suitable estimation approach by following the work of Arellano and Bond (1991); Arellano and Bover's (1995) two steps system Generalised Methods of Moments (GMM) approach that handles endogeneity and multicollinearity issues effectively. First, we used the logistic baseline regression model in examining the linkages between the variables of interest and coupled OI. We used logistic regression because of the binary nature of our dependent variable. This approach is consistent with previous empirical studies such as Greco et al. (2016) who used dummy variables as a dependent in examining the effect of OI on firm performance.

Additionally, we adopted Arellano and Bond's (1991); Arellano and Bover's (1995) two steps systems GMM approach in addressing the issues of unobserved heterogeneity, endogeneity issues and reverse causality. The results were consistent and robust across all the regression models used. The p-value of our AR (1) and AR (2) (Arellano and bond estimators) were all insignificant at 0.248 and 0.321 respectively implying that our module does not suffer from autocorrelation problems. Also, the p-value recorded for our Hansen test in our GMM model was insignificant implying that our model does not suffer from endogeneity issues.

To bolster the robustness of our results, we used quantile regression that provides more in-depth insights into regression results (Benoit and Van den Poel, 2009) to investigate if the association between female board representation and coupled OI is positive and significant at different tiers of our datasets. We adopted the quantile regression approach to perform further investigations in case our baseline linear regression has missed out any possible linkages between the female board representation and coupled OI. We noted that, with exception of the 25th quartile that revealed a weak positive association between female board representation and coupled OI (albeit without WPI moderating effects), our results remain unchanged with the 75th and the 50th quartile regressions. Accordingly, our results from Table 8 revealed a positive and significant association between female board representation and coupled OI for the 75th and 50th quantile regressions. However, the results for the 25th quartile (lower quartile regression) revealed a positive but weak association with coupled OI without the female parity index moderating factor.

6. Contributions

Although studies on innovation are gaining popularity, the ones that examine how female board representation drives OI in emerging economies are scarce. Given the lack of a consistent and reliable database on EMNEs, the best efforts of undertaking a painstaking content analysis to serve as a starting point was a crucial path to take to gain insights into reality (Bell et al., 2022). This study is only the starting point for the OI management literature in the emerging markets context which calls for further studies using unique methodologies to enhance our understanding of this interesting line of research. To the best of our knowledge, our study is the first of its kind to combine rich in-depth content analysis with a 10-year dataset to understand how female board representation influences coupled OI from EMNEs.

Our study makes contributions to the innovation management literature on several fronts. Firstly, our study extends the literature on female board representation by examining how the WPI moderates the linkages between female board representations and coupled OI. Secondly, the findings from our study have implications for how EMNEs deal with issues of diversity. Theoretical contributions and implications are discussed below.

6.1. Theoretical contributions

This research makes four theoretical contributions to the OI research field. First, we contribute internal and external contingencies of coupled OI. Most of the literature focuses on explaining (a) OI outcomes (b) whether and when firms adopt OI and (c) the unfolding of the different modes of OI. Specifically, the literature highlights the openness of innovation processes or the mode of openness by simply focusing on the

Table 8
Robustness Test using Quantile Regression.

	(1)	(2)	(3)	(4)	(5)	(6)
Quantile Regression without Moderation			Quantile Regression with WPI Moderation			
VARIABLES	(75th Quartile)	(50th Quartile)	(25th Quartile)	(75th Quartile)	(50th Quartile)	(25th Quartile)
Environmental Spending (log)	0.1791***	0.1157*	0.0178	0.1156***	0.0465	0.0328
	(0.0051)	(0.0082)	(0.0649)	(0.0084)	(0.0343)	(0.0425)
Female Board Representation*	0.4705***	0.3823**	0.0176	0.3926***	0.3783***	0.4096***
	(0.0027)	(0.0504)	(0.1282)	(0.0035)	(0.0096)	(0.0028)
Board Size	0.1847*	0.2160***	0.1985***	0.0573*	0.1166***	0.1313***
	(0.0506)	(0.0054)	(0.0078)	(0.1046)	(0.0087)	(0.0081)
Block Share	0.0651***	0.0147	0.0138**	0.0604**	0.0711**	0.1202***
	(0.0141)	(0.1099)	(0.0456)	(0.0160)	(0.0098)	(0.0015)
leverage	0.1586**	0.4458***	0.2562***	0.3166***	0.5133***	0.5582***
	(0.0143)	(0.0120)	(0.0134)	(0.0097)	(0.0087)	(0.0029)
Return on Assets	0.8656***	0.2548**	0.2734***	1.2756***	0.9501***	0.8585***
	(0.0064)	(0.0180)	(0.0124)	(0.0011)	(0.0035)	(0.0775)
Sales Revenue	0.1050	0.1120	0.1090	0.2170***	0.2100***	0.2010***
	(0.1017)	(0.1005)	(0.1019)	(0.0002)	(0.0003)	(0.0003)
MTBV	0.1653***	0.0334***	0.0115***	0.1912***	0.0631**	0.0791***
	(0.0012)	(0.0006)	(0.0074)	(0.0010)	(0.0026)	(0.0017)
Constant	0.2240***	0.1283*	0.0839	0.5528***	0.1575**	0.0382
	(0.0271)	(0.0157)	(0.0088)	(0.0412)	(0.0618)	(0.0405)
Observations	701	701	701	701	701	701
Pseudo R-Square	0.1881	0.1764	0.2061	0.1831	0.1394	0.3095

Please Note WPI represents –female parity index. Also, the first three models represent results without moderation effects and models (4)–(6) represent results with the moderation effect (female board representation x Female parity index). In all the six models our result revealed positive and significant association between female board representation and coupled open innovation for the 7th and 50th quantile. However, the results for the 25th quartile (Lower quartile revealed positive but weak association with coupled open innovation without female parity index moderation factor. Same was recorded when we moderate female board representation with female parity index. Also, standard errors in parentheses ***p < 0.01, **p < 0.05, *p < 0.1.

antecedents, the processes, and the performance outcomes if a firm engages in OI (e.g., Freel and Robson, 2017; Lopes and de Carvalho, 2018; Love et al., 2011; Randhawa et al., 2016). Our paper has clarified that OI can be carried out in different modes, such as inbound, outbound, and coupled in emerging market contexts. However, there is a lack of understanding of whether and why firms engage with OI differently. Our results highlight that female board representation and country-level institutions are crucial explanatory factors for how EMNEs approach OI. Our empirical findings are necessary to build up a more comprehensive understanding of the internal and external contingencies of OI from a unique context.

Second, we contribute by extending the human and leadership perspective in the OI literature. Although micro-foundations have received limited attention in OI literature, recent studies recognised that the human side of openness does have a significant influence on the adoption of OI practices (e.g., Barrett et al., 2021; Bogers et al., 2018b). For example, a few studies have explored the CEO characteristics on OI modes, the role of employee diversity in a firm's adoption of inbound OI (Bogers et al., 2018b), and the CEO characteristics on OI practices (Barrett et al., 2021). These studies have not focused specifically on the role of female board representation and their effects on coupled OI, especially in emerging market contexts.

In this research, therefore, we extend this stream of literature and provide a novel insight by introducing and explaining the influence of female board representation on coupled OI. Practical and theoretical inferences from the UET as well as Sabanci Holdings, and Samsung examples used as evidence in our introduction provide the rationale to argue that female board representation can provide firms with opportunities, motivation, and abilities to positively engage with coupled OI practices (Eagly, 2009; Glass et al., 2016b; Post et al., 2021). How we capture couple OI is novel, and the subsequent statistical analyses and results validating the positive role of female board representation contribute toward building a complete picture of how diversity affects OI adoption decisions. Given that OI activities are boundary-spanning and go beyond technical expertise (Levina and Fayard, 2018), our results could be extended to argue that OI research needs to consider diversity (both in terms of gender and ideas) at the functional, managerial, executive and board levels.

Third, our research contributes to the moderating role of the institutional context in the relationship between female board representation and coupled OI. Inferring from the core tenets of the institutional theory, we argue that high institutional quality can help increase female board members. This finding brings new insights to the research stream that the effect of a firm's micro-foundations on OI adoption is dependent on the institutional conditions of the host country as well. Thus, although the extant OI literature emphasises that institutions are important environmental factors in innovation inputs, outputs, and performance. We complement existing studies and argue that the institutional environment is crucial to OI processes.

Finally, our research contributes a new approach to measuring coupled OI. Our research adopts content analysis to capture the evidence of inbound, outbound and coupled OI to further construct coupled OI measures. Existing studies commonly use sources of information and knowledge for innovation activities developed by Laursen and Salter (2006) to measure the breadth and depth of OI (see for example Dreschsler and Natter, 2012; Freel and Robson, 2017; Love et al., 2014; Ovuakporie et al., 2021; Tang et al., 2021). The measurement approach used by these OI studies focuses on the inputs of OI because it is difficult to capture the nuanced process of how OI is carried out. Therefore, our new approach to measuring OI could make up for the shortcomings of previous OI measurements and can be replicated. Future studies may follow the same approach with more advanced content analysis techniques such as natural language processing or supervised machine learning to build up a larger sample of observations for theory testing.

6.2. Practical implications

So far, this study has argued that promoting women into the upper echelons of EMNEs must not be done as a show-off to policymakers, as has been the case for MNEs from developed economies (see Terjesen and Sealy, 2016) but effectively engaging them to shape OI decisions. Thus, female board representation is not enough unless women are engaged in upper echelons and are involved and also seen as a resource to the firm rather than meeting gender diversity quotas. Terjesen and Sealy (2016) confirm that the appointment of women into the upper echelons of firms is only seen as ceremonial simply to avoid compliance with corporate governance rules in developed economies.

Even if the appointment of female directors is perceived as 'ceremonial' (Dobbin and Kalev, 2017) or supporting role (Samara et al., 2019) women in emerging economies in general and in most cases do not get the opportunities to contribute their quota to corporate decision-making. This study argues that the presence of female directors in the upper echelons would preserve corporate reputation, legitimacy, and goodwill for EMNEs, most of whom struggle to deal with the tag of human rights violations prevalent in developing economies (See Ullah et al., 2021). Even if the appointment of women on boards is a box-ticking exercise and the role of the board is reduced to rubber stamping duties, our findings show a significant improvement of coupled OI initiatives when the board increases its number with female participation.

In addition to the global green crusade, governments need to encourage EMNEs to put in place OI initiatives focusing on eco-technology knowledge exchange strategies that can help reduce carbon footprints because the impact of global warming seemingly affects economic growth. Policymakers in emerging economies do need to strengthen their corporate governance codes to compel EMNEs to appoint women into the upper echelons. Policymakers could encourage MNEs to extract mutually beneficial eco-efficient production, process and marketing, and technology OIs that can help the net-zero agenda which has become an essential tool for reversing climate change.

Moreover, in the current globalised world of constant change, disruptive technologies and drive for corporate sustainability, the boardroom need for diversity is a pressing issue driven by investors (both institutional and private), who currently use eco-innovation (Ahmad and Wu, 2022; Nguyen and Adomako, 2022) as requirements for long-term investments. Given the current surge in demand for sustainable products vis-à-vis the impact of global warming in emerging economies, governments and regulators may need to encourage EMNEs to comply with ethical principles of doing business which could create an expectation by customers for sustainably sourced materials used in producing goods and services.

Emerging economies do need to ensure EMNEs comply with local regulations. In addition, country-level institutional and legal requirements must be enforced to encourage EMNEs to adopt sustainable methods of production through knowledge sharing and OI. Strong institutions are needed to protect patents, copyright and trade secrets of firms who participate in OI. Local stock markets could introduce a sustainability performance index consisting of compliance to ethical principles, gender and boardroom diversity and commitment to green principles of production including, outsourcing, nearshoring, offshoring, and near-sourcing to reduce their environmental impact in emerging economies through coupled OI. Apart from South Africa which has a strong corporate governance index linked to stock performance, most emerging economies in our dataset do not have it, therefore, such countries could implement a new policy to address this.

Our findings have some key human resource implications. EMNEs need to consider recruiting more women into upper positions and be given responsibilities that would engage their natural gifts (Eagly and Johnson, 1990), idiosyncratic knowledge and skills (Eagly et al., 2003). In addition, EMNEs need to demonstrate explicit commitment to innovation by allowing women to be engaged in OI initiatives, as they have a

rare opportunity to do so in emerging economies. More importantly, women in the upper echelons of EMNEs must be involved in OI initiatives because their innate nurturing giftings (Eagly and Johnson, 1990) could provide practical solutions to the OI activities that deal with global warming challenges confronting emerging economies (Attah-Boakye et al., 2022).

6.3. Limitations

Access to data and institutional weaknesses are well-documented challenges for researchers whose work focuses on emerging economies (Wright et al., 2005; Wyrwich et al., 2022). Our paper embraced content analysis due to the lack of data and studies that focuses on coupled OI activities in emerging markets. Consequently, because of missing and inconsistent data, we could not separate the board distribution in terms of female board members with executing powers and NEDs who are without it. To address this gap, we divided our data into quantiles to re-examine the effects between female board representation and coupled OI which could have been missed using linear regressions. Therefore, we cannot assume that our findings are generalisable across different countries with different economic development indicators.

In addition, whilst our definition and categorisation of OI are founded upon the extant literature and in-depth content analysis of the annual reports of the sampled firms, it might not be possible to assume that our findings apply to unrelated sectors and in other countries outside of our sample. Although several empirical studies use proxy or combinations of indicators in constructing OI (e.g., Popa et al., 2017), we were unable to find the best-fit measure in defining OI, hence relying on a proxy in measuring OI. Despite these limitations, the nature of our unique multi-dimensional panel dataset coupled with the GMM approach makes our results robust and reliable. The GMM approach is well suited for our data as well as ensuring that all related basic assumptions underlying our regression model are met, having undertaken further robustness to ensure consistency of our findings and implications.

7. Conclusion and areas for future research

The board dynamics of firms and UET has been crucial in contributing to the ongoing debate that female board representation has a significant impact on OI activities of EMNEs. This study extends the literature by arguing that EMNEs must not only increase investments in OI initiatives but must also encourage female engagement and contribution. Our data reveals that doing so reduces the degree of functional fixedness of male-dominated boards and improves the quality of board cognition in maximising opportunities for sustaining OI initiatives. Unlike developed country MNEs that are compelled by corporate governance codes to increase the percentage of women on corporate boards, EMNEs need to see the importance of female board representation as critical to the success of OI activities. More crucially, there is a need for investors, policymakers, and future research to understand how the neurocognitive efficacy of the management process could be improved by advocating for gender-diverse boards in emerging economies.

Although corporate governance codes spreading around the world elevates the role of the board to a supervisory role, it also requires an understanding of the strategic direction of firms. The influence of corporate boards on the strategic decisions of firms has been well explored over the years (e.g., Carpenter and Westphal, 2001; Judge Jr and Zeithaml, 1992; Luciano et al., 2020). The involvement of the board of directors in strategic decisions (whether they occupy an executive position or NEDs) can be viewed as an institutional response or as a strategic adaptation to external pressures on the firm. Given the recent intensification of external regulatory pressures on corporate accountability, it is difficult to assume that non-executive or outside directors will engage in rubber stamping exercises by supporting OI initiatives that require huge long-term commitment and investments. Therefore, whilst the role of board members (especially females) may not be so straight, our data analysis extends the literature by evidencing an unequivocal linkage between the engagement of females on corporate boards and coupled OI. Using the WPI and quantile regressions strengthens our position on how female board representation, directly and indirectly, increased OI initiatives which seem to also enhance firm performance.

Although agency theorists highlight the role of the board as an independent control mechanism, our study suggests a much more important role for female board representation as a control mechanism for enhancing corporate performance as they may provide ongoing advice to top management on possible strategic choices on coupled OI. Further, we follow the work of Carpenter and Westphal (2001) in bringing to the fore that boards are meant to serve as a strategic consulting unit when it comes to strategic decisions related to OI. We also follow the work of Luciano et al. (2020) who argued that the board is a strategically oriented multi-team system, and they work independently to enhance corporate innovation. Our work departs from these arguments by asserting that female board representation improves the schemata or the 'knowledge structures' needed to advise on coupled OI initiatives for EMNEs.

The study concludes by arguing that OI is vital for economic growth and prosperity, particularly in the context of developing and emerging economies. Hence, government legislation that supports the promotion of female members to corporate boards could yield positive results both at the firm and country levels. Our data is based on 183 EMNEs, therefore, future studies could increase the sample size of our current data. Moreover, separating the board distribution in terms of executive members and NEDs would have highlighted the degree to which they influence strategic decisions. Although the institutional factors played a significant moderating role in our study, they did not account for the majority of cultural factors. Therefore, our next study will use the Hofstedian cultural dimensions to re-classify the sampled EMNEs based on their country of origin to understand how each dimension influences OI initiatives in that context. It would also be interesting to employ quantile regressions to understand the percentage of female involvement and its corresponding impact on OI. Future expansion on other corporate governance variables such as firm ownership, board size and firm age to examine how they affect OI would be interesting.

Author consent

The authors agree to the submission of the manuscript to this journal.

Ethical standards

All authors confirm that the paper is not currently being considered for publication by any other journal.

Research involving human participants and/or animals

This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent

We declare that no aspect of this study involved individual participants and so there is no identifying information in the attached manuscript.

Declaration of competing interest

All authors confirm that they do not have any potential conflict of interest neither did they receive funding from any organisation to support the data collection process, write-up and presentation of the

manuscript.

Data availability

Data will be made available on request.

Appendix 1. : Sample Firms and their OI Initiatives

No. of MNEs	ID	Name	Country	Inbound OI				Outbound OI				Coupled OI			
				Prod	Pros	Org	Mkt	Prod	Pros	Org	Mkt	Prod	Pros	Org	Mkt
1	2	Arcelik	Turkey	●				●		●		●	●	●	
2	4	Eregli Celik	Turkey	●	●	●		●					●	●	
3	5	Ford Otomotiv Sanayi	Turkey					●	●	●		●	●	●	
4	6	Haci Omer Sabanci Hldg	Turkey	●	●	●						●	●	●	
5	7	KOC holding	Turkey	●	●	●	●					●	●	●	●
6	12	Tupras TKI.PEL.RFNE	Turkey									●			
7	13	Turkcell Iletisim Hzm.	Turkey	●				●	●	●	●	●	●	●	●
8	14	Yapi Ve Kredi Bankasi	Thailand	●	●	●			●	●			●	●	
9	15	Central Pattana	Thailand	●	●	●						●	●	●	
10	16	Indorama ventures	Thailand	●								●	●	●	
11	17	IRPC	Thailand	●				●	●	●		●			
12	18	PTT	Thailand	●	●	●			●	●		●	●	●	
13	20	PTT Global Chemical	Thailand	●	●							●	●	●	
14	21	Siam Cement	Thailand	●	●	●			●	●		●	●	●	
15	23	Thai Union Group	Thailand	●				●	●			●	●	●	
16	28	Asustek Computer	Taiwan									●	●	●	
17	29	AU optronics	Taiwan	●				●				●			
18	32	Cathay Finl.HLDG	Taiwan	●	●	●		●				●	●	●	
19	33	Chailease Holding	Taiwan	●								●			
20	36	Chicony Electronics	Taiwan	●	●	●						●	●	●	
21	37	China Airlines	Taiwan		●	●	●								
22	42	Chunghwa Telecom	Taiwan	●	●	●	●	●				●	●	●	●
23	44	Compal electronics	Taiwan	●	●	●		●				●		●	
24	45	Coretronic	Taiwan	●	●	●		●				●	●	●	●
25	46	CTBC FINL HLDG	Taiwan	●	●	●						●	●	●	●
26	48	Epistar	Taiwan	●	●	●		●				●	●	●	
27	50	Evergreen Marine	Taiwan		●	●							●	●	
28	51	Everlight Electronics	Taiwan	●				●				●	●	●	
29	52	Far eastern new century	Taiwan	●				●		●		●		●	
30	56	Formosa petrochemical	Taiwan	●	●	●						●		●	
31	57	Formosa plastics	Taiwan	●				●				●	●	●	
32	58	Formosa taffeta	Taiwan	●	●			●				●	●	●	●
33	61	Hon hai precn.ind.	Taiwan	●				●				●	●	●	●
34	63	Innolux	Taiwan	●								●			
35	67	Lite-on technology	Taiwan	●	●	●									
36	69	Micro-star international	Taiwan	●	●	●	●								
37	70	Nan ya printed cub.	Taiwan	●	●			●				●		●	
38	71	Nanya technology	Taiwan	●	●	●		●	●			●			
39	73	Pixart imaging	Taiwan	●	●	●	●	●	●				●	●	
40	74	Powertech technology	Taiwan	●	●	●	●	●	●			●	●	●	●
41	75	President chain store	Taiwan	●	●	●	●		●			●	●	●	●
42	76	Qisda	Taiwan	●		●		●				●		●	
43	77	Quanta computer	Taiwan	●	●	●	●	●		●		●	●	●	
44	78	Shin kong finl.hldg.	Taiwan		●	●	●		●				●		●
45	80	Sino-amer.silicon prds.	Taiwan	●	●	●						●			
46	81	Taiwan semicon.mnfg.	Taiwan	●	●	●		●				●	●	●	●
47	82	Tatung	Taiwan	●			●	●				●			●
48	84	Tsrc	Taiwan	●	●		●	●				●	●		
49	85	Tung ho stl.enter.	Taiwan	●	●							●	●		
50	87	Uni-president ents.	Taiwan	●	●		●	●				●			●
51	89	United micro eltn.	Taiwan	●	●	●	●	●				●	●	●	
52	90	Vangd.intl.semicon.	Taiwan	●	●							●	●		
53	92	Winbond eltn.	Taiwan	●		●		●				●			
54	95	Wpg holdings	Taiwan	●	●	●	●	●	●	●		●	●	●	
55	107	Doosan hvy.inds.and con.	South Korea	●	●	●		●				●			
56	108	Doosan infracore	South Korea	●	●	●	●	●	●			●		●	
57	110	Hana financial group	South Korea	●	●	●	●		●			●	●		
58	112	Hankook tire	South Korea	●	●	●	●	●				●	●	●	●
59	115	Hyundai engr.& con.	South Korea	●	●	●		●				●	●		
60	116	Hyundai heavy industries	South Korea	●	●	●		●				●	●		
61	118	Hyundai Motor	South Korea	●	●	●	●	●	●	●	●	●	●	●	●
62	122	Kia Motors	South Korea	●	●	●	●	●	●	●		●	●	●	●
63	126	KT	South Korea	●	●	●		●	●			●	●	●	●
64	129	LG Chem	South Korea	●	●			●				●	●		
65	130	LG Display	South Korea	●	●	●	●	●	●			●	●	●	●
66	131	LG HHLD.& HLTH.cRE	South Korea	●	●		●	●	●			●	●		

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(*continued*)

No. of MNEs	ID	Name	Country	Inbound OI				Outbound OI				Coupled OI			
				Prod	Pros	Org	Mkt	Prod	Pros	Org	Mkt	Prod	Pros	Org	Mkt
67	132	LG Innotek	South Korea	●	●			●	●			●	●		
68	133	Lotte chemical	South Korea	●	●		●	●				●	●		●
69	141	samsung c&t	South Korea	●	●		●	●	●		●	●	●		●
70	142	Samsung electronics	South Korea	●	●	●	●	●	●	●	●	●	●	●	●
71	143	Samsung elto.mechanics	South Korea	●	●	●	●	●	●	●	●	●	●	●	●
72	144	Samsung engineering	South Korea	●	●		●	●				●	●		●
73	145	Samsung fire & mar.in.	South Korea	●	●		●	●				●	●		●
74	146	Samsung heavy inds.	South Korea	●	●	●		●				●	●	●	
75	147	Samsung sdi	South Korea	●				●				●	●		
76	161	Barloworld	South Africa	●				●				●	●		
77	164	Drd gold	South Africa	●	●	●		●				●		●	
78	167	Exxaro resources	South Africa	●	●	●	●	●				●	●	●	●
79	169	Growthpoint prop	South Africa	●	●	●	●	●		●		●	●	●	
80	170	Harmony gold mng.	South Africa	●		●			●	●		●		●	
81	173	Impala platinum	South Africa	●	●							●	●	●	
82	174	Kumba iron ore	South Africa	●	●	●		●	●	●		●	●	●	●
83	175	Massmart	South Africa		●	●							●	●	
84	177	Mondi	South Africa	●	●							●	●		
85	178	Nedbank group	South Africa												
86	179	Netcare	South Africa	●	●				●	●		●	●	●	●
87	182	Reunert	South Africa	●	●							●	●	●	
88	183	Sappi	South Africa	●	●			●				●	●	●	
89	184	Sasol	South Africa	●		●		●				●		●	●
90	185	Standard bank group	South Africa	●	●	●			●	●		●	●	●	
91	186	Wesizwe platinum	South Africa		●	●			●	●			●	●	
92	188	Alrosa	Russia	●		●	●	●	●	●		●			●
93	189	Fed.hygn.co. Rushydro	Russia	●		●		●	●			●		●	
94	190	Fsk yees	Russia	●								●			
95	191	Gazprom	Russia	●	●							●	●	●	
96	199	Moscow exchange	Russia	●		●						●		●	●
97	200	Nk lukoil	Russia	●		●						●		●	
98	203	Oc rosneft	Russia	●	●	●		●	●	●		●	●	●	
99	207	Rosseti	Russia	●				●				●	●	●	
100	208	Rostelecom	Russia	●	●			●		●		●	●	●	
101	209	Severstal	Russia	●	●	●		●	●			●	●	●	
102	210	Sistema jsfc	Russia	●	●	●		●				●	●	●	
103	212	Tatneft	Russia	●	●	●		●	●	●		●	●	●	●
104	213	Tmk oao	Russia	●	●	●		●				●	●	●	●
105	235	Buenaventura 'v'	Peru	●				●				●	●	●	
106	239	Nexa resources peru	Peru	●	●	●		●	●	●		●	●	●	●
107	241	Alfa 'a'	Mexico	●	●	●						●	●	●	
108	242	Alpek de cv	Mexico	●	●	●		●				●	●	●	
109	244	Cemex cpo	Mexico	●	●	●		●	●	●		●	●	●	●
110	246	Fomento economico mexicano	Mexico	●	●	●						●	●	●	
111	248	Gpo finance banorte	Mexico	●	●	●			●	●		●	●	●	
112	258	Ammb holdings	Malaysia	●	●	●						●	●	●	●
113	259	Brit.amer.tob.(malaysia)	Malaysia	●								●		●	
114	260	Media prima	Malaysia	●	●	●						●	●	●	
115	264	Telekom malaysia	Malaysia	●	●	●		●	●			●	●	●	
116	267	Bank danamon indonesia	Indonesia	●	●	●	●		●	●		●	●	●	●
117	273	Jasa marga	Indonesia	●				●				●	●		
118	276	Telekomunikasi indonesia (persero)	Indonesia		●	●							●	●	
119	277	United tractors	Indonesia	●	●	●						●	●	●	
120	280	Acc	India	●		●						●		●	
121	291	Cipla	India	●	●	●		●		●		●	●	●	
122	293	Divis laboratories	India	●				●				●	●	●	●
123	295	Dr reddys laboratories	India	●				●				●		●	●
124	297	Glenmark pharmaceuticals	India	●				●				●			
125	298	Havell's india	India	●		●	●					●	●	●	
126	300	Hindustan petroleum	India	●		●		●		●					
127	301	Hindustan unilever	India	●	●	●	●					●	●	●	
128	302	Indian oil	India	●		●	●	●	●			●		●	●
129	303	Itc	India	●		●	●	●	●			●		●	●
130	307	Maruti suzuki india	India	●	●	●	●	●	●	●	●	●	●	●	●
131	310	Pidilite industries	India	●		●		●				●		●	
132	311	Piramal enterprises	India	●		●		●				●	●	●	●
133	314	Tata consultancy svs.	India			●			●	●		●	●	●	●
134	315	Tata motors	India	●	●	●	●	●	●	●	●	●	●	●	●
135	316	Tata power	India	●	●	●		●	●	●		●	●	●	
136	318	Tech mahindra	India	●	●	●	●	●		●		●	●	●	●
137	319	Ultratech cement	India	●	●			●	●	●		●	●	●	
138	320	Upl	India	●	●	●		●				●	●	●	
139	321	Vedanta	India	●	●	●		●				●	●	●	
140	322	Wipro	India	●	●	●	●	●		●		●	●	●	●

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No. of MNEs	ID	Name	Country	Inbound OI				Outbound OI				Coupled OI			
				Prod	Pros	Org	Mkt	Prod	Pros	Org	Mkt	Prod	Pros	Org	Mkt
141	325	Cez	Chez Republic	●	●			●				●	●	●	
142	328	Banco davivienda pref.	Colombia	●		●		●	●			●	●	●	
143	329	Bancolombia	Colombia	●		●		●		●		●		●	●
144	330	Celsia esp	Colombia	●		●						●	●	●	●
145	344	Chin.comms.cnut.gp. 'H'	China	●				●				●		●	
146	345	China coal energy 'a'	China	●				●	●	●		●		●	
147	348	China intl.mar.ctrs. (gp.) 'A'	China		●	●	●	●				●	●	●	
148	349	China national building material 'h'	China	●	●	●				●		●	●	●	●
149	352	china res.sanjiu med.& pharm.'a'	China	●	●	●		●				●	●	●	
150	353	china shenhua en.'a'	China	●	●	●		●	●			●	●	●	
151	355	china state con.engr.'a'	China	●		●		●		●		●		●	●
152	356	china telecom 'h'	China	●	●	●		●				●		●	
153	357	china utd.net.comms.'a'	China	●	●	●		●				●		●	
154	358	chongqing changan autmb. 'a'	China	●		●		●				●	●	●	●
155	359	cosco ship.en.trsp.'a'	China		●	●			●	●			●	●	
156	361	crrc 'a'	China	●		●		●				●		●	●
157	362	daqin railway 'a'	China		●	●							●	●	
158	363	Dongfeng motor gp.'h'	China	●	●	●		●				●	●	●	●
159	366	Huadong medicine 'a'	China	●	●	●	●	●	●	●	●	●	●	●	●
160	371	luxshare precn.ind.'a'	China	●	●	●						●	●	●	
161	376	sdic power holdings 'a'	China	●				●				●			
162	377	Shai.fosun pharm.(group) 'a'	China	●	●	●	●	●	●	●	●	●	●	●	●
163	379	shanghai pharm hdg.'a'	China	●				●	●		●	●	●	●	●
164	381	sichuan kelun pharm.'a'	China	●	●	●		●		●		●	●	●	
165	383	tianma microels.'a'	China	●	●	●		●				●	●	●	
166	386	zhaojin mining ind.'h'	China	●								●			
167	392	Banco de credito e inversion	Chile	●		●						●		●	
168	394	Colbun machicura	Chile		●	●	●						●		●
169	397	Empresas cmpc	Chile	●	●	●				●		●	●	●	
170	412	Banco do brasil on	Brazil	●	●	●	●					●	●	●	
171	415	Braskem pn series 'a'	Brazil	●	●	●		●				●	●	●	
172	417	Centrais eletr bras- eletrobras on	Brazil	●								●			
173	418	Cia energetica de minas gerais pn	Brazil	●		●						●		●	
174	428	Cpfl energia on	Brazil	●				●				●			●
175	430	Duratex on	Brazil	●				●				●	●	●	
176	433	Embraer on	Brazil	●		●						●		●	
177	434	Energias do brasil on brazil	Brazil	●				●		●		●		●	
178	435	Engie brasil energia on	Brazil	●				●	●	●	●	●	●	●	●
179	437	Gerdau pn	Brazil	●	●			●				●	●	●	
180	441	JBS on	Brazil	●	●	●			●	●		●	●	●	
181	443	Light on	Brazil	●		●		●				●		●	
182	454	Petroleo brasileiro on	Brazil	●				●				●	●	●	●
183	469	Weg on	Brazil	●	●	●		●				●	●	●	

Note.
● = Evidence in the subcategory of OI has been identified.
Prod = Product innovation refers to the introduction of new or modified products (OECD, 2008).
Pros = Process innovation refers to the introduction of new or modified production methods (OECD, 2008).
Org = Organisational innovation refers to the introduction of new organizational methods (OECD, 2008).
Mkt = Marketing innovation refers to the introduction of new marketing methods (OECD, 2008).

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