

Eco-environmental footprint and value chains of technology MNEs operating in emerging economies

Abstract

Drawing from signalling theory and the multinational global value chain (GVC) literature, this study examines a critical question “does the adoption of eco-friendly technology improve firm value?”. In addressing this question, we test a panel dataset for 633 technology multinational enterprises (TMNEs) operating in 15 emerging economies and covering ten years from 2009 to 2019. This paper provides new insight into the increasing CO₂ emission concerns, especially from the emerging economies and household consumption perspectives. Our study reveals that the adoption of eco-friendly technology by TMNE’s global value chains (GVC) operations will lead to an increase in firm value and increase total environmental spending. Consequently, CO₂ footprints in emerging countries will be reduced. Our findings are robust, controlling for several firm-level and country-level variables in our analysis. The practical, managerial and policy implications of our study are discussed.

Keywords: Environmental footprint, global value chains, technology multinational enterprises, emerging economies, signaling theory.

JEL classification codes: F18, F23, Q56.

1. Introduction

Globalisation was already subjected to considerable academic and political debate and criticism prior to the COVID-19 pandemic (Buckley and Hashai, 2020). The main causes for these debates were the economic inequalities between the global North and South (Ullah *et al.*, 2021; Adams *et al.*, 2018), the fragility of global supply chains and networks, the encouragement of wastefulness, human rights violations, and a total disregard for the environment (Giuliani and Macchi, 2013; Dentoni *et al.*, 2018). TMNEs reduce operational costs within value chains by pursuing a relentless drive towards digitisation and platformisation of business strategy by embedding advanced technology (see Buckley and Enderwick, 2020). These concerns have partially fueled populism and nationalism, which has also triggered increased protectionism and categorical rejection of the institutional arrangements that helped the globalisation process decades after the Second World War. The de-globalisation debates became apparent during the pandemic when wealthy nations pursued their interest by encircling others to procure and supply personal protective equipment by paying more (House of Commons, 2021; Livingston *et al.*, 2020). Nevertheless, the problem is that, for many years, studies on international business have focused on how TMNEs grow by utilising their core competencies to maximise revenue for the shareholders (Kano and Verbeke, 2019). In this regard, studies have failed to remodel globalisation to seek a better balance between the profits of the finance economy vis-à-vis the low wages of the production economy.

Specifically, whilst the speed and scope of change brought about by the evolving nature of globalisation have been immeasurable during the last three decades, international business theories have tended to focus primarily on how firms use their existing resources and capabilities to maximise revenue through complex governance structures and systems (Williamson, 1979; Casson and Buckley, 2014). These structures have been built around operational efficiency and cost optimisation using a set of concepts such as transaction cost

theory and internalisation theory. On the one hand, typical MNEs own a substantial part of their industries' global value chains. Therefore, local, and international activities are carried out in-house (internalisation) or through an alternative channel outside the normal procurement option (externalisation) to maintain control of their patents, copyright, and intellectual capital. On the other hand, global value chains have become increasingly geographically dispersed, with operational activities coordinated across and beyond organisational and national economies simply for profitability reasons. Under such circumstances, complex governance structures provide strategic shields against institutions that attempt to hold MNEs, whose activities create environmental problems, accountable for their actions

Understandably, the growth of Silicon Valley firms and the *platformisation* of digital value activities of technology multinational enterprises exposes them to different institutional settings and environments simultaneously. High-interest and high-powered stakeholders demand signals that demonstrate corporate environmental accountability. This paper follows the call made by Weill and Woerner (2015) that it is time for both researchers and stakeholders to evaluate the threats and opportunities posed by digital disruption, not only within the digital technology eco-system, but also the environmental management setup, and set out their intentions to explicit commitment to CSR and corporate socially responsible practices.

As MNEs increasingly respond to stakeholder demands to define their CSR intentions and practices, we are therefore provided with a good opportunity to examine how the new forms of technology-driven global value chains (TD-GVCs) could change an organisation's corporate reputation by decreasing their net carbon footprint and increasing environmental expenditure. A pre-COVID-19 world that was struggling to deal with the challenges of global poverty both in developing and developed economies, and the inherent environmental degradation that comes with this, implies that gross disregard for the core concept of ethics must be repurposed and pursued to improve an unpredictable post-COVID world (Schwab and

Malleret, 2020). Our paper, therefore, seeks to examine how the impact of digitisation and technology-enabled platformisation of GVCs, aimed at maximising shareholder returns, could co-exist in tandem with ideal business ethics from the perspective of TMNEs operating in emerging markets. In addition, understanding the geographical, regional, and internal political-economic factors (Kano, Tsang, & Yeung, 2020) which shape operations and supply chain management systems enables us to isolate and examine the signals stemming from MNEs' CSR activities to investors and local institutions. Specifically, our paper seeks to highlight that the eco-environmentally friendly activities of MNEs involved in the value chain around the globe transmit positive signals to various market actors such as investors, customers, government agencies and environmental pressure groups, among others.

Furthermore, the changes brought about by the COVID-19 pandemic have led organisations to reconsider their current approach in implementing global value creation strategies. Our paper has the potential to amplify the extent to which environmentally friendly GVC concepts could remove waste and reduce costs for MNEs, thereby sustaining long-term profitability. In this digital and post-COVID era, examining the impact of eco-friendly technology and other firm-level factors on the global value chain (GVC) from the perspective of emerging countries is, therefore, timely and relevant.

The rest of the paper is structured and proceeds as follows. Section two presents the theoretical framing of our work. Section three describes the data and research design adopted in this study. Section four presents the results of the empirical work and findings, while section 5 concludes the paper with a discussion of the findings, considering the research's limitations.

2. Theoretical framework

Nanry *et al.* (2015) defined digital value chains as newly digitally-enabled technologies that MNEs use to produce and distribute goods and services. These include industrial internet, 3-D printing, robotics, the Internet of Things and data analytics tools. These technologies used to create value for global firms are deemed to be the inputs for the fourth industrial revolution (Kimani *et al.*, 2020). The global value chain (GVC) embodies “a complex and dynamic economic network made up of inter-firm and intra-firm relationships” (Gereffi, 2014, p.10). The interrelationships among GVC governance, firm performance and GVC performance have been widely discussed (Kano, Tsang, & Yeung, 2020). From a top-down perspective, the success of GVC as a whole is often linked with lead firms (Marchi, Maria, Golini, & Perri, 2020). Various financial indicators of lead firms have been applied as proxies to GVC success in existing literature, including sales and profit growth (Griffith & Myers, 2005) and return on assets (Buckley & Tian, 2017; Lampel & Giachetti, 2013). There are also studies elaborating on the control power of lead firms (Casson, 2013; Strange & Newton, 2006), the ability to minimise transaction costs (Buckley, 2009), as well as on the corporate social responsibility performance of GVC leaders (Enderwick, 2018). From a bottom-up perspective, some GVC studies focus on how GVC stakeholders could upgrade their position in their GVCs or the internationally dispersed network (Azmeah & Nadvi, 2014; Chen *et al.*, 2016; Ponte & Ewert, 2009; Kano *et al.*, 2020). However, how MNEs involved in GVCs create value remains a key research gap.

The rising phenomenon of digitisation has brought complex implications for GVC research and called for updated understandings of the research gaps mentioned above. For MNEs, digital technologies reduce barriers to diversification, provide platformisation for digital business models, and facilitate connectedness among different actors across the world efficiently and flexibly (Coviello *et al.*, 2017; Nambisan *et al.*, 2019). Whilst there are many

advantages of digital technologies, it is important to understand the limitations. Digital technologies may reduce MNEs entry requirements and intensify internal competition within a TD-GVC, thus disadvantaging participating firms. In other words, MNEs participating in a TD-GVC may become more vulnerable and interchangeable while coping with the geographically dispersed market in an increasingly intensive manner (Kano *et al.*, 2020). This paper makes theoretical contributions to existing GVC research by exploring how and what TMNEs do to create value in the context of TD-GVC in emerging economies. More specifically, we ask (a) does eco-friendly technology adoption by TMNE's improve firm value? (b) should companies prioritise their value chain for profit maximisation to the detriment of the environment?

Signalling theory provides a theoretical rationale for answering the proposed research questions. The theory has been widely used to investigate firm marketing, management, strategy, and international business behaviour. The core tenet of signalling theory addresses information asymmetry in the marketplace (Spence, 1973, 2002). Information asymmetry refers to the situation where different social actors or people know different things (Stiglitz, 2002, p.469). The existence of information asymmetry between social exchange actors can generate adverse selections, *i.e.*, distorted information that results in a misrepresentation of a firm's actual quality and moral hazard (Mavlanova, Benbunan-Fich, & Koufaris, 2012). However, not all information asymmetry is equally important. For example, information asymmetry about quality and intent is significant (Stiglitz, 2000). Signalling theory proposes that firms send out observable and credible signals to convey unobservable firm quality to outside actors without perfect information (Bergh, Connelly, Ketchen, & Shannon, 2014; Connelly *et al.*, 2011). Distinguished by observable and credible signals regarding firm visions, actions and capabilities, information asymmetry could be primarily alleviated (Bergh, Ketchen, Orlandi, Heugens, & Boyd, 2019; Connelly *et al.*, 2011).

Signalling theory can be suitably applied to investigating TMNE strategic actions in the context of global value chain involvement since a significant amount of information asymmetry arises (Carter, 2006; Samiee & Chirapanda, 2019). Information asymmetry is salient in the global value chain. The degree of information asymmetry depends on how a firm operates (Bergh *et al.*, 2019; Connelly *et al.*, 2011; Vasudeva *et al.*, 2018). Involvement with GVCs exposes firms to an environment where signals are diverse due to differences in institutions, cultures and economic development (Nguyen, Barrett, & Nguyen, 2014). The liabilities of foreignness and outsiders, derived from such differences, also lead to information asymmetry for firms involved in GVCs (Johanson & Vahlne, 2009). It has been argued that firms need to overcome these liabilities during their internationalisation process (Vahlne & Johanson, 2017). However, GVC stakeholders suffer these liabilities to possess perfect information. Due to institutional environment differences between the home and host countries and are unfamiliar with a foreign firm's quality, credibility, intent, and capabilities (Pietrzak, Chlebicka, Kraciński, & Malak-Rawlikowska, 2020). All these give rise to misunderstanding, miscommunication and inaccurate information, and a significant amount of information asymmetry between GVC stakeholders (Reuer & Ragozzino, 2014; Reuer *et al.*, 2012). This enhances the amount of mutual information asymmetry and a firm reliance on signals (Reuer *et al.*, 2012; Vasudeva *et al.*, 2018).

Although digital technologies have been argued to reduce information asymmetry by alleviating these liabilities through convenient communication and frequent information exchange, studies also found that TD-GVC is more likely to show a high level of information asymmetry (Mavlanova, Benbunan-Fich, & Koufaris, 2012; Jean, Kim, Zhou, & Cavusgil, 2021). Physical separation in a digital business setting more likely generates the risk of opportunistic behaviour (Pavlou, Liang, & Xue, 2007; Geigenmueller, 2010). It would be more costly to search and identify suitable partners (Jean & Kim, 2020). Firms involved in GVC

need to consider conveying their unobservable firm quality and intentions through observable signals, especially in a digital setting (Doh, Rodrigues, Saka-Helmhout, & Makhija, 2017; Samiee & Chirapanda, 2019). In brief, our study aims to increase understanding of how TMNEs involved in TD-GVCs can create value and their strategic priority through signalling theory. We present the related hypotheses in the following sections.

2.1 Hypothesis

Signalling theory holds that firms send out signals to convey their underlying quality. The quality of a firm refers to “the underlying, unobservable ability of the signallers” to outside receivers (Connelly *et al.*, 2011, p 43). TD-GVC is viewed as a geographically and culturally dispersed value-creating virtual network. Firms can absorb knowledge from spillovers and expand their network, reducing liabilities of foreignness and outsiders. TD-GVC can also be viewed as a signalling environment where mutually exchanges signals to reduce information asymmetry. In such a context, reducing mutual uncertainty of participation tends to be a critical task (Clarke & Liesch, 2017). For example, participating firms involved in TD-GVC need to select reliable, solid, and stable partners to risk and uncertainty resulting from information asymmetry (Jean et al., 2021), which also applies to customers, investors, and others. Signalling a strong firm capability to reduce the information asymmetry tends to be one of the main ways to mitigate stakeholders’ risk perceptions and facilitate trust-building. As firms are increasingly involved in TD-GVC, signalling a firm’s underlying quality to reduce mutual information asymmetry would be imperative. Our theoretical framework is presented in **Figure 1**.

Insert **Figure 1** here

For TMNEs within TD-GVCs, we first propose that signalling a strong financial performance is crucial based on two reasons. On the one hand, firms signalling their positive

financial performance are more likely to gain confidence and support from foreign investors and shareholders (Trahms, Ndofor, & Sirmon, 2013). Firms with a strong financial performance can be viewed as stable and promising investment targets. On the other hand, foreign customers and potential strategic partners may have a better impression as the receivers of this positive signal. For example, foreign customers are likely to perceive that the products or services offered by the firms are more trustworthy and well-accepted across countries. Existing and potential TD-GVC partners may regard the firms as less risky and be more willing to collaborate, thus facilitating more opportunities for knowledge exchange, networking, and further capability development. Under the same rationale of reducing information asymmetry, firms involved in TD-GVCs also prefer to find responsible partners to minimise uncertainty. This research focuses on return on equity as the proxy of financial strength. We hypothesise the following:

H1. For TMEs, a higher return on equity has significant positive association with firm value.

Firm engagement in environmental protection is mainstream within the global value chains literature (UNCTAD, 2012). Since the call for MNEs to invest and respond to environmental issues has been intensified, the number of ethically-minded or environmentally-minded stakeholders has significantly increased worldwide (Lund-Thomsen & Lindgreen, 2014). High spending for organisations concerning environmental initiatives is viewed as a signal showing the responsible nature of a wide array of TD-GVC stakeholders. It also signals a firm's commitment to environmental protection and intention to undertake social responsibility within foreign countries. Ethically minded customers and investors would perceive MNEs with high environmental expenditure as responsible firms and would be more willing to offer support in

the longer term. Potential partners may view the firms as reliable partners worth collaborating with and perceive value in building long-term relationships. We hypothesise the following:

H2. For TMEs, higher environmental spending has a significant positive linkage with firm value.

TMNEs involved in TD-GVCS need to signal their unobservable strength concerning innovation. As involvement in GBVs has increased, the importance of innovation has been intensified due to the requirement of firm localisation to multiple diverse host markets (Kano *et al.*, 2020). To avoid uncertainty, firms involved in TD-GVCs often prefer to find partners with strong innovation to minimise uncertainty. Firms signalling the adoption of environmentally friendly technologies often indicate a strong innovation capability and gain more support from foreign investors (Marchi *et al.*, 2020). From a foreign customer perspective, they would receive signals indicating such firms as high potential innovators.

Similarly, existing and potential TD-GVC partners would be more willing to collaborate in innovation and new product development, further facilitating opportunities for knowledge exchange, networking and capability development. At the same time, adopting environmentally friendly technology is a signal of proactively undertaking social responsibility to a wide array of TD-GVC stakeholders who are likely to support such a firm. We hypothesise the following:

H3a. For TMNEs, Eco-friendly technology adoption has a significant positive association with firm value.

As firms increasingly signal a strong innovation capability and environmental considerations, stakeholders would generally expect these firms to utilise their significant technological capacity to undertake more social responsibilities that favour the local

environment. In this sense, the firms signalling the adoption of eco-friendly technologies are often expected to, or are pushed to, commit more on CSR issues (such as environmental concerns) in different host countries (Agyukera-Caracuel, Aragón-Correa, Hurtado-Torres, 2011; Christmann & Taylor, 2001; McWilliams & Siegel, 2000; Padgett & Galan; Quazi, 2003). Roberts (2003) argued that firms are more likely to implement CSR activities as they become more reputational. TMNEs may be increasingly aware of the necessity to continually increase environmental investment and resend signals conveying their intents to the public (Stiglitz, 2000). While we expect the effect may be more significant for TMNEs involved in TD-GVC, signalling firms are signal receivers since TD-GVC is a mutual signalling environment.

H3b. For TMNE's, eco-friendly technology adoption has a significant positive association with environmental spending.

Differences concerning national culture and institutional quality in host countries may play a role in explaining the divergence of organisational behaviours and signalling behaviours in different local contexts (Hofstede, 2005; Adams *et al.*, 2019). However, we postulate that for TMNEs, the positive relationship between adopting eco-friendly technology and environmental spending would not be affected by differences in host countries' national culture and institutional quality. Information asymmetry tends to be more intensive for TMNEs operating in a host country that is culturally distant from their home country.. Similarly, when TMNEs are operating in a host country with a low institutional quality level, they also suffer intensive information asymmetry. In this situation, firms would emphasise sending signals of their underlying quality, receiving feedback from the international environment, and reinforcing positive signals (Reuer & Ragozzino, 2014). In order to minimise possible misunderstandings and secure acceptance in host countries, TMNEs need to commit more to

environmental issues to signal their social responsibility (Yang, Su, & Fam, 2012). When TMNEs are operating in a host country with a high level of institutional quality, disclosing key information and underlying quality tends to be legislated and institutionalised. Firms adopting eco-friendly technology are more likely to be recognised and more likely to be further expected to maintain or increase their commitment. As a result, the positive association between sending environmentally friendly signals would be less likely affected by [insert].

H4. For TMEs, adoption of eco-friendly technology has a significant positive association with environmental spending irrespective of the prevailing national culture and institutional quality in the emerging country.

3. Methodology and Data

3.1 Data and Sample

Our firm-specific variable data, including our ESG data, were collected from the Bloomberg database. Our country-level institutional data were extracted from the worldwide governance Indicators (WGI) project reports¹ from the World Bank. Hofstede's national cultural dimensions database archives collected our national cultural dimensions data. We used the Bloomberg ESG disclosure data for the following reasons; first, the Bloomberg ESG disclosure score is a comprehensive measure of ESG disclosure calculated from a total of 120 indicators covering three ESG dimension pillars of environment, social activities, and governance. Second, studies such as Halbritter and Dorfleitner (2015) argued that the Bloomberg ESG disclosure score database is recognised as one of the most updated and consistent ESG

¹ The Worldwide Governance Indicators (WGI) project provides reports on individuals and aggregate governance indicators for over 200 countries and territories over the period 1996–2019, for six dimensions of governance including Voice and Accountability, Political Stability and Absence of Violence, Government Effectiveness, Regulatory Quality, Rule of Law and Control of Corruption. Source; <https://info.worldbank.org/governance/wgi/>. Assessed on 17-05-2021.

disclosure databases. Bloomberg uses three main pillars in rating ESG disclosure scores of firms.

Our initial sample is based on 6,850 firm-year observations from 685 listed telecommunication multinational enterprises (TMNE's) from emerging economies. We then eliminated 520 observations with missing data relating to the independent variables. Our final sample was based on an unbalanced panel dataset of 6,330 firm-year observations, covering a period of 10 years (2000–2019). Our study also used Table 7 and 8 (please refer to our appendix for Table 7 and 8) to highlight the level of CO₂ carbon emissions in emerging economies based on household consumption per capita covering 15 years from 2005 to 2019.

3.2 Research context

The high economic growth and a significant increase in household consumption of high-tech products by people living in emerging countries continue to attract a multiplicity of TMNEs to the market. The “flooding” of firms into emerging economies has exacerbated the problems of CO₂ emission, and whilst they extract higher profits in these economies, their value chain directly or indirectly adds to the CO₂ problems for these countries. Most TMNEs operating in emerging markets are mainly duplicitous with their CO₂ disclosures, investment in research and development and environmental expenditure (Attah-Boakye et., al 2020). The key research questions that underpin this study are as follows; (a) for TMNEs, does eco-friendly technology adoption improve firm value? (b) should TMNEs prioritise their value chain for profit maximisation to the detriment of the environment? In summary, should the few equity-holders on the planet destroy contribute to environmental destruction for personal gain at the expense of future generations? Our paper highlights the need for academics, researchers, and policymakers to shift the emphasis from equity value addition to eco-friendly sustainable production for the longer-term benefit of the planet. Our study extends existing corporate governance literature by drawing on signalling theory together with a unique multi-stage panel

dataset (combinations of firm-level data, country-level data and country-level national cultural dimensions data) involving a total of 633 TMNEs covering 10 years from 2009 to 2019.

3.3 Variables measurement

Considering that the central subject of this study revolves around GVC in a digital era, coupled with the nature of our research questions, we adopted a multi-dimensional variables specification in our corpus of variables by including combinations of firm-level variables, country-level variables and national cultural dimensions. We included these combinations in our variable sets to simultaneously explore some of the firm-level, country-level institutional, and national cultural factors that impact global value chain (GVC) and TMNE performance. Our firm-level corporate governance variables include market-to-book value, total environmental spending, CO2 eco-friendly technology (a categorical variable), research and development divided by sales, return on equity, the board size, CSR score, single block-shareholders leverage total revenue.

We first examined the firm-level determinants of TMNE performance. In other words, we examined the factors that impact firm performance using the market-to-book value (MTBV) as our dependent variable to measure firm performance. There are three reasons for using MTBV in measuring firm performance (or firm value) in our study. The market-to-book value (MTBV) represents the consolidated value addition (the GVC) or the market value of common equity divided by the consolidated balance sheet value of a firm's common equity. Second, MTBV is a good proxy to measure the value or performance (D'Amato, and Falivena, 2020). Third, by using MTBV, we were able to explore better the linkages between our variables of interest, especially eco-friendly technology, which is the global value-added MTBV of the firm.

Given that one of the research questions seeks to highlight the environmental spending determinants of TMNEs, we constructed another model using environmental expenditure as our dependent variable. In this way, we were able to identify both firm-specific and country-specific characteristics that determine TMNEs environmental spending. Our main variables of interest in this study include CO2 eco-friendly technology, research, and development expenditure, return of equity, single largest shareholders, board size and national institutional quality.

Our research questions and signalling theory guided the selection of our corpus of variables and hypothesis formulation. As part of our consistency and reliability test, we winsorised all continuous variables at 1% and 99 % percentiles (Abdelfattah and Aboud, 2020). Out of the 645 firms involved in our original dataset, we deleted 12 firms that had a considerable number of missing variables and inconsistent data. After winsorising and deleting the inconsistent data from our dataset, 633 firms remained in our dataset. The sample selections criteria and our variable definition and measurement tables are presented in **Tables 1** and **2**.

3.4 Control variables and the Hofstede six-culture dimensions

We controlled for leverage and sales revenue at the firm level and the national cultural dimension at the country level. Our country-level national culture and institutional variables were collected online from the Hofstede six national cultural dimensions. For the rest of our variables, we used Thomson Eikon as our central database except our ESG disclosure score data collected from the Bloomberg database. We used Thomson Eikon as our preferred database collection source since they have recently updated corporate governance variables and included ESG data for several MNTC's around the world. Our country-level institutional quality data were collected from the World Bank database using country-level regulatory quality as our main measure of country-level institutional quality.

It is worth mentioning that there are other measures of country-level institutional quality, such as the rule of law, governance effectiveness, corruption control. However, considering the nature of our research context of emerging countries and our variable signalling theory underpinnings, we opted for regulatory quality as our primary measure of country-level institutional quality. The country-level institutional data were included in our corpus of variables to examine the linkages between the prevailing country-level institutions and their impact on GVC activities (including TMNEs performance and environmental spending. Additionally, the inclusion of the six Hofstede national cultural dimensions was intended to deepen our knowledge and understanding of how different national cultures impact GVC in a digital era. Our regression analysis captures all six cultural dimensions: power distance, individualism vs collectivism, masculinity vs femininity, long-term vs short-term orientation, and indulgence vs restraint.

Concerning the six national cultural variables used in our study, the power distance index (PDI) is included to measure the extent to which the less powerful and vulnerable members of society expect power to be distributed. The Individualism and Collectivism (IDV) culture dimension is dualistic in measurement. The high side of the dimension focuses on a self-centric orientation in which individuals value only their interests and the interest of their immediate family. The opposite end of the spectrum represents a more pluralistic society that prioritises the common good of members within the society. The Masculinity versus Femininity (MAS) culture also has two dimensions in which the variable dimension emphasises achievement, assertiveness, and competition. On the other hand, emphasises modesty, caring for the weak and quality of life. The Uncertainty Avoidance Index (UAI) dimension explains the extent to which members of society react to the fact that the future is unknown. Usually, countries exhibiting high UAI rely on strict rules and regulations and maintain strong codes and vice versa. The long-term versus short-term variable (LTO) represents the long-term and

short-term aspirations and outlook of members of society. Finally, Indulgence Versus Restraint (IVR) represent a society that either allows relatively free gratification of basic human needs drives or suppresses gratification of needs employing strict codes and social norms.

3.5 Model specification and variable testing

To test our hypothesis, we employed the panel data regression model as set out below:

$$\begin{aligned}
 MTBV_{i,t} = & \alpha + \beta_1 ENVEX(\log)_{i,t} + \beta_2 ECOTEC_{i,t} + \beta_3 R\&D/sales_{i,t} + \beta_4 ROE_{i,t} + \\
 & \beta_5 BOARDSIZE_{i,t} + \beta_6 CSR\ SUS_{i,t} + \beta_7 BSHARE_{i,t} + \beta_8 LEVG_{i,t} + \beta_9 SALES(\log)_{i,t} + \\
 & \beta_{10} INSTQ_{i,t} + \sum_{i=1}^{n=6} \beta_{12} NCDV_{i,t} + \varepsilon_{i,t}
 \end{aligned} \tag{1}$$

We used equation 1 to test our first two hypotheses by examining the association between our control variables and the firm's market-to-book value (MTBV). The variables used in Equation 1 are *MTBV*, *ENVEX*, *ECOTEC*, *R&D/sales*, *ROE*, *BOARDSIZE*, *CSRSUS*, *BSHARE*, *LEVG*, *SALES*, *INSTQ* and *NCDV*, which represent; market-to-book value (dependent variables). The independent variables are corporate environmental expenditure, eco-friendly technology, research, and development expenditure divided by sales, return on equity, board size, corporate social responsibility sustainability disclosure, single block-shareholders, leverage, sales revenue, institutional quality and the six national cultural dimension respectively. To test variables 3-4, we used Equation 2, as set out below, substituting our dependent variable of *MTBV* in Equation 1 with *ENVEX* to enable us to examine the linkages between firm-level and country-level determinants of corporate environmental spending. We included equation (2) with corporate environmental expenditure as our dependent variable in our model:

$$\begin{aligned}
 ENVEX(\log)_{i,t} = & \alpha + \beta_1 MTBV + \beta_2 ECOTEC_{i,t} + \beta_3 R\&D/sales_{i,t} + \beta_4 ROE_{i,t} + \\
 & \beta_5 BOARDSIZE_{i,t} + \beta_6 CSR\ SUS_{i,t} + \beta_7 BSHARE_{i,t} + \beta_8 LEVG_{i,t} + \beta_9 SALES(\log)_{i,t} + \\
 & \beta_{10} INSTQ_{i,t} + \sum_{i=1}^{n=6} \beta_{12} NCDV_{i,t} + \varepsilon_{i,t}
 \end{aligned} \tag{2}$$

3.6 Robustness

All our regression models passed the VIF test, implying that none of our models has suffered from any multicollinearity problems. Second, we looked for a suitable estimation approach to handle endogeneity issues effectively. Our Hausman test (or the augmented regression test for endogeneity) suggested that the fixed-effects estimation model should be used as a preferred model to partially minimise endogeneity problems, including unobserved heterogeneity, in our model (Ullah *et al.*, 2020). Other estimations, such as system GMM and lagged values, can better overcome simultaneity. The nature of our longitudinal panel dataset and our diagnostic tests suggested that fixed effects were an appropriate estimation approach. Endogeneity in the estimation process can often cause concern for studies of this nature, and inappropriate estimation can potentially lead to a spurious correlation between the chosen variables. Strict exogeneity is a fundamental assumption of fixed estimation. According to this assumption, our corpus of variables and the six-country culture dimensions used in our regression analysis were not affected by any changes in the corporate environmental expenditure practices in the current and previous years.

4. Discussions and findings

To test our prediction of Hypothesis 1, we used regression analysis models 1-9 in **Table 5** in examining the linkages between returns on equity from the global TMNEs GVC and market-to-book value from the signalling theory perspective. Our results confirmed Hypothesis 1 by revealing a significant positive association between returns on equity and market-to-book value. The results in model 2 - 9 in **Table 5** regarding the significant positive association between returns on equity and market-to-book value were consistent. Our finding combines signalling theory and previous empirical studies implying that an increase in the market-to-book value signals better overall corporate financial health – which provides the predictions

regarding the firm's excess returns over the period (Pontiff. And Schall 1998). Our results provide significant ongoing policy implications and a useful signal for corporate mergers and acquisitions. To secure a better merger and acquisition deal, the target firm should exhibit a higher market-to-book ratio (Attah-Boakye et., al 2020).

Insert **Table 5** here

Considering Hypothesis 2, we included the corporate environmental spending firm-level variable into our corpus of variables in Table 5 to explore the association between corporate environmental spending and firm value. We noted a significant positive association between total environmental spending and market-to-book value (firm value). Our findings confirm Hypothesis 2 and suggest a significant positive relationship between total environmental expenditure and firm value. While the results were consistent throughout models 1 – 9 in **Table 5**, it also highlights interesting policy implications for managers and policymakers. Therefore, firms that engage in efficient environmental management practices (Klassen and McLaughlin 1996) increase their environmental spending and commit to environmental sustainability to achieve significant performance (Gupta and Gupta 2020). Our findings reinforce the signalling theory and previous empirical studies that imply that higher corporate environmental spending signals legitimate corporate environmental reputation that can yield superior firm performance (Toms 2002)

Insert **Table 6** here

To test our Hypothesis 3a and 3b, we included unique firm-level eco-friendly technology on our regressions **Tables 5** and **6**. Our eco-friendly technology variable examines

whether firms adopt eco-friendly technology in their global value chain (GVC) operations. Our findings from models 1–9 revealed a significant positive association between firms that adopt eco-friendly technology in their GVC operations and firm performance, thereby confirming our Hypothesis 3a. Additionally, we noted a significant positive association between firms adopting eco-friendly technology in their GVC operations and firm total environmental spending, confirming our Hypothesis 3b. Our findings are consistent with the signalling theory and other previous studies that argued that firms that announce the adoption of eco-friendly technology for their global supply chain signal superior corporate reputation (Gupta and Gupta 2020; Toms 2002), which usually increases firm value (Bose and Pal 2012)

Results confirm Hypothesis 2 that suggests a significant positive relationship between total environmental expenditure and firm value. While the results were consistent throughout models 1 – 9 on **Table 5**, it also highlights interesting policy implications for managers and policymakers. While studies confirm the increasing popularity of environmentally friendly supply chain management, empirical studies examining the linkages between the adoption of eco-friendly technology, firm-level total environmental spending, and firm value simultaneously are absent in the literature. Our studies, therefore, provide a new perspective to the existing literature by highlighting the significant effects of eco-technology adoption on GVC, firm environmental reputation and firm value all in one study. Our study offers practical and anecdotal evidence that supports the need for TMNE's adaptation of eco-friendly technology in GVCs to achieve sustainable growth (Gupta and Gupta 2020; Toms 2002), higher profit and firm value (Bose and Pal 2012). The link between eco-friendliness and sustainable growth of GVCs is supported by examples in the existing literature, whereby TMNEs such as Xerox and Hewlett-Packards have successfully implemented manufacturing and recycling operations (eco-friendly technology waste disposal systems) into their GVC which has resulted in an increase in their overall corporate profit (Bose and Pal 2012),

To test our Hypothesis 4, we included five Hofstede national cultural dimensions into our corpus of variables, with country-level institutional quality as a control variable. We then used our regression result on **Table 5**, models 5 – 9, and **Table 6**, models 5 - 9, to further examine if the presence of country culture can impact our results for Hypothesis 3a and 3b. We noted a significant positive association between eco-friendly technology and firm value on **Table 5**, models 5-9, and a significant positive association between eco-friendly technology and total environmental spending on **Table 6**, models 5 - 9, confirming our Hypothesis 4. This result implies that whilst differences in host country national culture may impact organisational behaviours (Hofstede, 2005), the significant positive association between adopting eco-friendly technology and firm value and/or corporate environmental spending would not be affected by differences in host country national culture characteristics. Our results are congruent with other previous eco-friendly technology studies that argued that the availability of greater eco-friendly technical knowledge within a company moderates its vulnerability to country-level culture or exogenous institutional factors such as demand for new environmental legislation (Horbach, 2016). Our results yielded a positive but insignificant association between eco-friendly technology adoption and book-to-market value (firm value) regarding country-level institutional quality.

We recorded a significant negative association between these corporate governance mechanisms and total environmental spending, such as board size, leverage, and single largest shareholders (ownership structure) regarding other corporate governance attributes, such as board size, leverage, and single largest shareholders (ownership structure), we recorded a significant negative association between these corporate governance mechanisms and total environmental spending. We were unsurprised by these findings since some of these TMNEs “prioritise” their profit against environmental spending due to recruiting more board members. The very nature of this activity implies cutting down on environmental spending. On the

contrary, we noted a significant positive association between the largest single shareholders and book-to-market value. This result is consistent with signalling theory that posits that a higher book-to-market value signals excess long-term returns to investors (Pontiff and Schall, 1998). Contrary to Toms' (2002) environmental reputation argument that single largest shareholders sometimes undertake high environmental expenditure to promote their reputation, our findings yielded a significant positive association between single largest block shareholders and firm environmental spending. Regarding national cultural diversities and their effect on firm environmental spending, we noted from our results on **Table 6**, models 5 – 9, that with exception of power distance index and indulgence versus restraints, which have a significant negative association with total environmental spending, our result revealed a significant positive relationship between the remaining three national culture dimensions (individualism vs. collectivism, uncertainty avoidance and long term vs. short term orientation) and total firm environmental spending.

Table 7 highlights the CO₂ challenges the emerging countries face in our dataset. The figures show key summary statistics about CO₂ emissions broken down per household consumption, per capita, the share of global cumulative CO₂ emissions and the CO₂ emissions embedded in trade between emerging countries and the rest of the world. We noted that the CO₂ emission from household consumption and the share of the global cumulative CO₂ emissions from emerging countries in our dataset on average exceeds the 1.5 degrees CO₂ target. The CO₂ emission levels of these emerging countries could be further impacted. As these countries' economies continue to grow, citizens will become richer, and household consumption will rise, which will consequently increase CO₂ emission in these countries. It is also worth mentioning that the BRICS emerging countries (Brazil, Russia, India, China and South Africa) are among the emerging countries with the highest CO₂ emissions from household consumption.

Additionally, the CO2 emission from household consumption in Malaysia, Poland, and South Korea are three times higher than the 1.5 CO2 global emissions expected target.

Insert tables 7

5. Contributions and implications

Although increasing CO2 emissions continues to dominate the headlines and represents a global challenge, studies examining how the adoption of eco-friendly technology leads to better firm value and increases environmental expenditure for TMNEs from emerging markets remains absent from the extant environmental sustainability and ethics literature. As such, our knowledge and understanding of this field is limited.

This research contributes to existing GVC literature by highlighting an alternative view of the global value chain. Our paper sets out to empirically examine the environmental footprints of the digital value chains of TMNEs operating within an emerging markets context to explore how eco-friendly digital value chains improve firm value. We have argued that TMNEs should prioritise a commitment to business ethics and eco-friendly outsourcing, nearshoring and offshoring as part of their strategic competitive posturing (Adams *et al.*, 2018) within their value chain system. International business scholarship endears GVC as a profit-making or an efficiency-related decision. For example, existing GVC literature largely focuses on how to achieve economic values by using financial performance indicators, such as market capitalisation (Jacobides & Tae, 2015), profit growth (Griffith & Myers, 2005), and return on assets (Lampel & Giachetti, 2013). We argue that the focus of GVC research could be extended from a global economic value chain to a chain that creates value to environmental sustainability, such as sustainable systems of production and consumption of goods and services globally.

Moreover, we argue that MNEs could send correct signals to stakeholders by underscoring new ways to become eco-friendly. Therefore, we extend the efficiency and internalisation hypothesis used within international business circles for several years to incorporate contemporary digital environmental footprints in an intensively competitive era of platformisation. The progressive discussions related to de-globalisation create tensions about the high level of profit within the finance economy (the winner takes all approach) towards the low profits of the finance economy by supporting poor communities in the global south through consistent eco-friendly sourcing transportation and distribution of digital goods and services.

Our research contributes to the signalling theory by adding that adopting eco-friendly technologies and undertaking corporate environmental responsibility are positive signals conveying unobservable firm quality. Existing studies primarily focus on how firms can send signals (Carter, 2006), how firms can make signals more observable (Certo, Daily, & Dalton, 2001), and the interpretation of signals (Perkins & Hendry, 2005). New types of positive signals and the portfolio of positive signals have received limited attention (Connelly *et al.*, 2010). In this study, we found that new initiatives such as wastewater treatment, solar and wind harvesting technologies present untapped areas for large MNEs to show their underlying strengths across the world. We have also highlighted the effectiveness of developing a portfolio of positive signals to reinforce firm reputation, which is one of the unaddressed signalling theory gaps. Embracing biodegradable technologies and low-powered non-electric energy systems to produce new forms of computers and digital systems presents growth opportunities within emerging market economies.

Our research also contributes to signalling theory by delineating the role of the signalling environment, which is under-researched (Connelly *et al.*, 2011; Sanders & Boivie, 2004). Interestingly, we found that eco-friendly technology adoption positively affects TMNEs' corporate environmental spending regardless of cultural differences and institutional

quality levels. Positive signals are perceived or received in the same light, despite the liability of foreignness and outsiders, which potentially leads to information asymmetry when firms engage in GVC (Johanson & Vahlne, 2009). Despite the difference in institutions and cultures and the level of economic development (see Nguyen *et al.*, 2014), the positive signals of eco-friendly environmental initiatives can be observable across diverse contexts. This finding also extends and enhances our understanding of the approaches TMNEs can adopt to deal with their liabilities when they engage in greenfield investments and international joint ventures. Therefore, as GVCs are influenced by internationalisation requirements as well as the localisation determinants of emerging economies (Buckley and Casson, 2019), eco-friendly environmental activities could be used as a mediating instrument that enhances the clarity of signals sent by TMNEs to stock markets, investors, and other key stakeholders.

This paper argues that institutional weaknesses should be used as an opportunity to support local eco-friendly initiatives, such as the introduction of LED bulbs and CFL lighting system, both at production sites and supply chain networks. These eco-friendly technologies reduce energy use, lower CO₂ emissions, and better environmental footprints for TMNEs. These are observable signals that demonstrate firm decision quality to outsider stakeholders who otherwise may have imperfect and incomplete information about the firm's activities. These strategies would effectively enable digital TMNEs to deal with information asymmetry from the signaling theory perspective effectively.

Some critical policy implications are going forward. First, TMNE adoption of eco-friendly digital technologies, such as solar and renewable energy systems, in their GVC operations will cut costs and increase supply chain efficiency and corporate profitability. Second, embracing eco-friendly production and distribution systems would create an overall efficiency within the digital and platform-based eco-system. Eco-friendly production technologies will reduce corporate reputational risk by sending positive signals to outsiders.

For example, Hewlett Packard and other mobile phone companies that used ISO 14001 initiatives by recycling old computers and phones have embraced environmentally friendly production, transportation, and goods recycling. These programmes would benefit emerging countries who normally suffer from waste dumping, human rights violations, low wages and unethical behaviours of MNEs' subsidiaries.

Overall, the argument presented in this paper is simple: sustainable GVCs through the adoption of eco-friendly technology improves TMNEs' green credentials, which ultimately wins more business or increases demand for the products and/or services. Increased demands drive profitability and greater firm value in the longer term. Future studies could use a fresh dataset to examine the relationship between green global value chains and their impact on profitability for MNEs operating within developed economies.

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