Environmental management practices, environmental technology portfolio, and environmental commitment: A content analytic approach for U.K. manufacturing firms

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Abstract

This study investigates how various aspects of environmental management practices EMPs (operational, strategic, and tactical) undertaken by firms influence their environmental technology portfolios ETPs (pollution control and pollution prevention). It also explores the role of environmental commitment of firms on the influence of EMPs on ETPs. This study uses data from content analysis of annual reports, and corporate social responsibility reports available from corporate websites of 76 UK manufacturing firms from eight different industrial sectors across two years using a time lag (2010-2012). We have controlled for industry type, economic performance and firm size in all our analyses. The findings of our study show that operational and tactical practices influence both the ETPs significantly but strategic practices influence only pollution prevention activities of firms. Further, we have found that environmental commitment positively moderates the influence of operational and tactical practices on pollution prevention but not on pollution control activities. There is no such moderating role on the influence of strategic practices on either pollution prevention or pollution control. Our finding generally highlight the short-term pollution control view; manufacturers focus on cost saving, operational efficiency, and being compliant with the environmental regulations rather than having a long-term strategy perspective. The use of strategic practices tends to have stronger influence on long-term pollution prevention activities. Once firms improve their level of environmental commitment, their involvement in long-term pollution prevention activities improve.

Key words: Content analysis, environmental management practices, environmental technology portfolio, regression analysis, UK manufacturing, secondary data.

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1. Introduction

> *Creating a strong business and building a better world are not conflicting goals--they are both essential ingredients for long-term success*. (William Clay Ford, Jr., Executive Chairman, Ford Motors)

Governmental regulations, corporate social responsibilities, and stakeholders' demands make environmental management practices (EMP) an integral part of organisations' strategic planning process (Berrone and Gomez-Mejia, 2009; Herremans, Herschovis, and Bertels, 2009; Montabon, Sroufe, and Narasimhan, 2007). EMPs are generally classified into three categories: operational practices (OP), tactical practices (TP) and strategic practices (SP) (Montabon et al., 2007). OP are internally focused, shop floor orientated activities that can reduce waste (such as recycling production materials), as well as save cost (like substituting waste materials into other products). TP, on the other hand, have both internal and external foci. It includes activities such as design and development of products/ processes to meet environmental standards (internal) and initiatives that involve external stakeholders such as suppliers and customers. SP involves activities with long-term goals undertaken by firms towards external constituents. It includes set of objectives, plans, and policies established by top managers.

EMPs are generally expected to improve environmental technology portfolio (ETP) of firms (Klassen and Whybark, 1999a, 1999b; Sarkis and Cordeiro, 2001; Thoumy and Vachon, 2012; Vachon. 2007). ETPs comprise both pollution prevention (PP) and end-of-pipe pollution control (PC) technologies. Extant research has shown that firms can achieve competitive advantage by adopting EMPs and ETPs. For example, there is a significant body of literature that explores how a firm can use EMP or ETP to improve its financial and environmental performance (e.g. Hofer, Cantor and Dai, 2012; Montabon et al., 2007; Thoumy and Vachon, 2012). The findings show that there is a “win-win” situation for firms that adopt a certain set of EMPs and ETPs to improve performance. However, research is largely silent on the relative association of EMPs (OP, TP and SP) adopted by firms on their choice of ETPs (PC and PP). For instance, there is little research that explains how a firm can configure its EMP choice (OP, TP, or SP) if it prioritizes PC as a way to cut down environmental cost or be compliant to the environmental requirements. This is a significant research gap as firms need to identify a match between their EMPs and ETPs to achieve their environmental objectives (Klassen and Whybark, 1999a, 1999b; Montabon et al., 2007). This study uses institutional theory (North, 1996) as the basis to answer this research objective. This theory highlights that firms are guided by their environments (such as social, political, economic and cultural) in strategic decision-making. In doing so, this research attempts to provide a new understanding of the use of institutional theory to explain an EMP-ETP configuration. Therefore, the first objective of this study is to find out: which EMP will lead to which ETP?

Manufacturers differ in terms of their commitment to adopt EMPs. Some firms are less committed to meet their environmental obligations and choose to design their EMPs solely to meet the regulatory compliances. Whereas, some firms are more committed to improve their environmental requirements, take a proactive initiative, invest in resources, and design EMPs that go far beyond the regulatory requirement (Henriques and Sadorsky, 1999; Herremans et al., 2009). Conventional wisdom suggests that firms with high levels of environmental commitment are more likely to adopt higher levels of EMP (such as TP and SP) in order to achieve long-term ETPs (such as PP). On the other hand, firms with low levels of environmental commitment are likely to focus more on cost saving EMPs (OP) and ETPs (PC). However, literature refutes such assumptions. For instance, Thoumy and Vachon (2012) find that green projects that involve less intensive procedural changes (infrastructural) are more beneficial than those projects that require extensive changes (structural). Therefore, even highly committed firms may be sceptical before adopting EMPs or targeting ETPs that require significant investment in terms of resources and managerial effort. Firms often use proactive environmental initiatives merely as a window dressing (Skapinker, 2008). In a survey with 189 manufacturers, AMR Research group finds that, instead of considering environmental sustainability initiatives as strategic imperatives, a majority of firms adopt a compliance-based approach to meet regulatory requirements (Environmental Leader, 2010). Therefore, it is not clear how environmental commitment influences firms to choose their portfolio of EMPs and is a significant research gap. Based on the premises of institutional theory and motivation of firms to adopt environmental proactivity, this study attempts to explain the moderating role of environmental commitment on EMP-ETP configuration fit. Hence, the second objective of this study is to find out the right match of EMP-ETP selection for firms with high versus low levels of environmental commitments.

To explore these two research objectives, this study uses data from 76 UK firms from 8 different manufacturing sectors. The data is collected through content analysis of publicly available information from their websites for two years. Content analysis of published reports available through corporate websites offer audited and authenticated information that firms like to communicate with their stakeholders and is widely used as source of unbiased and reliable data (Jose and Lee, 2006; Montabon et al., 2007).

The paper contributes to the literature in several ways. First, research on the causal link between EMP and ETP is rather limited. Hence, it is critical to know how firms can use individual components of EMP to focus on either end-of-pipe PC or more long-term PP or both. In doing so, this study contributes to the literature that has explored the role of EMP and ETP in isolation (Klassen and Whybark, 1999a, 1999b; Montabon et al., 2007) but rarely on each other. Using institutional theory as the backdrop, this study attempts to explain the EMP-ETP configuration fit for manufacturing firms. Second, this study investigates how environmental commitment of firms (high versus low) influences the causal link in the EMP-ETP configuration. This is important, as firms may not always have the expertise or resources for environmental investment irrespective of their commitment. Hence, it is crucial for them to know the appropriate mix of EMPs that they can adopt to implement ETPs that reflect their environmental commitment. Finally, this study uses content analysis to obtain data from corporate websites. This responds to the call for the use of innovative secondary data sources in operations management research. Use of content analytic data is imperative in non-U.S. contexts as databases such as Toxic Release Inventory (TRI) is largely absent or underdeveloped in most of the countries.

2. Literature review and hypotheses

2.1 Environmental management practices

An organisation’s EMP is characterised by its motivation, sensitivity and response towards changes in the environment (Dahlmann et al., 2008). Environmental management literature defines EMP as the techniques and policies employed by an organization to tackle environmental changes (Montabon et al., 2007). However, the categorization of EMP is complex and not straightforward. Extant research has proposed a variety of constructs to categorize EMP. For example, Gonzalez-Benito (2008) categorizes EMP into four dimensions: planning and organisation, logistics processes, product design, and internal production management. The first dimension signifies rational, coordinated, strategic planning activity of a firm; and the remaining three dimensions involve more operational (tactical) functions of a firm. Banerjee (2002) describes EMPs as corporate environmentalism that integrates environmental concern into corporate decision-making process. He classifies it into two dimensions: environmental orientation that refers to the responsibility of a firm towards the environment; and environmental strategy focus that is the degree of integration of environmental issues into the corporate planning process.

Following Montabon et al.'s (2007) and Sroufe et al.'s (2002) arguments, this study classifies EMP into three categories: operational (OP), tactical (TP), and strategic (SP). However, this three level categorization of EMP is sometimes fluid and overlapping (see Sroufe et al., 2002 for an excellent discussion on EMP categorization). OP involves day-to-day decisions undertaken by firms at their shop floor level to tackle environmental issues. Apart from operational issues such as recycling, re-use of waste and environmental management, literature proposes advanced manufacturing technology (Gonzalez-Benito 2008; Klassen, 2000; Klassen and Whybark, 1999a) and supply chain management practices (Zhu and Sarkis, 2004) as components of OP.

TP, on the other hand, involves both internally and externally focused environmental management exercises that affect medium term deployment of resources (Montabon et al., 2007; Sroufe et al., 2002). As per Klassen and Whybark (1999a, b), TPs involve initiatives related to structural changes in operational systems such as changes in plant capacity, production equipment and production technology to contain waste in production process. Firms that follow TP have limited cross-functional involvement to tackle environmental issues (Klassen and McLaughlin, 1996). Such firms often follow a reactive approach and simply comply with the environmental regulations.

SP involves coordinated planning, and implementation of controls established by top managers. Klassen and Whybark (1999a) describe strategic environmental planning a key part of environmental management orientation. Gonzalez-Benito (2008) label strategic environmental initiative as ‘planning and organization’ and define it as ‘practices related to development of EMS’. Long-term, strategic environmental orientations include integration of cross-functional areas within an organization to tackle environmental issues through product and process redesign (Klassen and McLaughlin, 1996).

2.2 Environmental technology portfolio

Environment management literature often classifies pollution control (PC) and pollution prevention (PP) as components of environmental technology portfolio (ETP) (Klassen 2000; Klassen and Whybark, 1999a, b). Shrivastava (1995) defines ETP as all environmental technologies to reduce the negative influences of firm’s environmental impact and improve their environmental performance. Klassen (2000) posits that a firm can improve its environmental performance by capturing and controlling pollution after generation and before release to the environment (the PC technology) and by reducing pollution even before their initial generation (the PP technology). PC refers to end-of-pipe technology that captures, treats and disposes waste at the end of production process. Russo and Fouts (1997) describe PC as short-term, compliance strategy that relies on pollution abatement. Such hazard control technology is often an environmental objective for firms that do not have resources to implement new environmental technologies (Berrone and Gomez-Mejia, 2009). PP, on the other hand, aims to minimize pollution at various stages of production process and require structural investments in product and process redesign (Klassen and Whybark, 1999a, b). PP is often the environmental objective for firms with superior resource base as it offers a unique competitive advantage (Russo and Fouts, 1997). Apart from PC and PP, literature also classifies management systems defined as the integrative investments that underpin both prevention and control technologies as the third aspect of ETP (Klassen and Whybark, 1999a and 1999b). As management system includes activities related to both PC and PP, therefore extant studies often do not consider it as a separate influencer to environmental performance (e.g. Klassen and Whybark, 1999a; Sarkis and Cordeiro, 2001). Following this argument, this study considers only PC and PP as independent constructs of ETP.

2.3 Relationship between EMPs and ETPs

Extant research has largely focused on the role of EMPs and ETPs separately as antecedents to improve financial, manufacturing, and environmental performances of firms. For example, Montabon et al. (2007), using content analysis of reports available through corporate websites, obtain significant positive relationship between EMP and firm performance. They suggest that operational EMPs such as recycling, proactive waste reduction efforts; tactical EMPs such as adopting eco-efficient products, following specific environmental design targets; and strategic EMPs such as surveillance of the market to look for opportunities to adopt environmental friendly products and processes positively influence the environmental and financial performance of firms. On the other hand, Klassen and Whybark (1999a) using data from furniture industry find that firms use PC to achieve short-term regulatory compliance and PP to achieve long-term manufacturing and environmental performance. Hence, the positive influence of EMP (OP, TP, and SP) and ETP (PC and PP) on performance is already established. However, research is relatively scarce on how individual constructs of EMPs and ETPs are interlinked.

In order to establish this relationship, this study uses institutional theory as the backdrop. Institutional theory suggests firms adopt their strategies and implement decision making based on the social, political, cultural, and economic environments (North, 1996). This theory is widely used in environmental research to explain why firms facing similar institutional pressures adopt different environmental practices. For example, Delmas and Toffel (2008) find firms adopt certain EMP (ISO 14001 as environmental standards) when they respond to institutional pressures from market constituents (such as customers, suppliers, and competitors) and focus on other EMP (participate in government-initiated voluntary environmental programs) when they respond to institutional pressures exerted by non-market constituents (such as government, NGOs, and the media). They argue that institutional pressures exerted by market constituents guide firms to adopt EMPs that achieve “beyond compliance” goals, whereas institutional pressures exerted by non-market constituents lead firms to adopt EMPs that secure “avoid sanctions” objectives. Therefore, this study argues that different constituents of institutional pressures (both market and non-market) force firms to adopt different sets of EMPs (OP, TP, or SP) to achieve beyond compliance technologies for competitive advantage (PP) or to achieve pollution abatement technologies to meet regulatory requirements (PC).

Extant studies find that firms adopt environmental practices and make investments according to their prioritization of ETPs. Vachon and Klassen (2006) categorize environmental practices into two types: integration of environmental activities with other organizations (environmental collaboration); and externalizing environmental activities using market based mechanisms (environmental monitoring). Firms sometimes like to adopt a reactive approach where the focus is to keep the suppliers and customers at arms-length. Vachon and Klassen (2006) classify this as environmental monitoring. Firms that adopt environmental monitoring do not involve other organizations such as suppliers in their strategic planning or in their manufacturing process. Rather, such firms tend to focus on reactive measures such as recycling, waste reduction, product, and packaging substitution. The reason for adopting such shop-floor based operational activities is to comply with the environmental regulations that involve quick-fix solutions to environmental regulatory requirements. Montabon et al. (2007) classify such approach as OP. Delmas and Toffel (2008) explain that institutional pressures from non-market constituents (such as regulators) lead firms to adopt such reactionary measures to comply with the environmental requirements. The focus of such firms is to avoid any regulatory penalty for non-compliance.

Vachon (2007) finds firms that adopt environmental monitoring allocate greater investment on PC activities rather than PP activities. Firms that tend to minimize short-term risk adopt reactive technology that involves less investment in making structural changes and highlight PC as their principal focus. Hence, this study argues that firms use OP not only to positively influence both ETPs but primarily use OP to achieve its PC objectives. Hence, this study hypothesizes that:

H1: There is a positive influence of OP on firms' ETP portfolio i.e. on (a) PP and (b) PC activities

H1c: OPs have a stronger positive influence on PC than on PP activities

Firms that adopt environmental monitoring also use environmental record, audits of their supplier using publicly disclosed environmental records and monitor suppliers' environmental records using certification such as ISO 14000 (Vachon and Klassen, 2006). Montabon et al. (2007) classify such approach, as TP. PP requires making changes to both product and process of manufacturing, while PC needs implementation of end-of-pipe compliance technologies. As TP comprises of externally focused practices such as monitoring suppliers as well as internally focused practices such as having environmental design goal targets, therefore it is likely that TP can cater to both long-term PP and short-term PC objectives. However, Thoumy and Vachon (2012) while exploring the influence of project complexity on ETP adoption argue that firms adopt infrastructural changes (like modifying certain procedures in the production process) to achieve PC, whereas such firms make structural changes on both of its product and process (such as input substitution, machine replacement) to achieve PP. As TP components (as adopted from Montabon et al., 2007) are largely used to address both product and process of manufacturing, therefore this study argues that firms adopt TP not only to positively influence both ETPs but primarily use TP to achieve its PP objectives. Integrating the above arguments, this study hypothesizes that:

H2: There is a positive influence of TP on firms' ETP portfolio i.e. on (a) PP and (b) PC activities

H2c: TPs have a stronger positive influence on PP than on PC activities

Firms that adopt environmental collaboration approach increase their collaboration with the suppliers and customers and develop strategic partnerships with them. Such collaborative efforts require direct involvement of the suppliers and customers in the firms' production process and the outcome is a joint development of environmental solutions. Delmas and Toffel (2008) propose such collaborative efforts with market constituents (like customers, suppliers) as firms' initiatives to demonstrate superior management culture and suggest that such firms engage more in PP activities. Montabon et al. (2007) classify such proactive collaborative efforts involving suppliers and customers in environmental decision-making as indicators of SP. They argue that forming strategic alliances with other organizations, integrating them as partners to tackle environmental issues, incorporating such collaborative initiatives within the corporate mission statements are characteristics of SP. Studies that consider relationship between firm manufacturing investment strategies and ETP activities reflect similar arguments. For instance, firms that prioritize PP rather than PC make investment in advanced process technologies that are innovative and require restructuring of the entire manufacturing process (Klassen, 2000). Firms make such investments to achieve long-term gain rather than short-term quick fix. Hence, this study argues that firms adopt SP not only to positively influence both ETPs but primarily use SP to achieve its PP objectives. Hence, this study hypothesizes that:

H3: There is a positive influence of SP on firms' ETP portfolio i.e. on (a) PP and (b) PC activities

H3c: SPs have a stronger positive influence on PP than on PC activities

2.4 Impact of environmental commitment on EMPs and ETPs

Henriques and Sadorsky (1999) describe environmental commitment as what a firm is actually doing or done with reference to environmental issues. Extant research has classified environmental commitment of firms based on their proactivity towards environmental issues. For example, Roome (1992) classifies firms into a spectrum starting from firms that follow a "noncompliance" strategy towards environment to firms that are "leading edge." Non-compliant firms are often constrained by cost to implement such initiatives whereas leading edge firms strive to become environmental leaders. Hunt and Auster (1990) use nomenclature like "beginners" to describe firms that tend to turn their back on environmental problems and "proactivist" that make environmental management its top priority. Henriques and Sadorsky (1999) classify firms as "reactive" where environmental planning is non-existent' and "proactive" where firms formalize environmental response strategy and actively follow environmental initiatives. Therefore, firms are likely to adopt different sets of EMPs based on their levels of environmental commitment.

Firms with high levels of environmental commitment align their corporate strategy for improved environmental performance and move beyond compliance (Herremans et al., 2008). They argue that highly committed organizations have dedicated environmental team/ departments, offer employee training on environmental issues, have specific reward policy to achieve environmental targets, survey the market to understand environment issues and implement them even before legislation is passed. Such firms also strive for voluntary environmental certifications, disclose their environmental policies and achievements, and possess several environmental awards. Hence, firms with high levels of environmental commitment are likely to focus on OP, TP and SP to improve their ETP practices. This argument is supported by the proposition of institutional theory. It highlights that highly committed firms are likely to serve interests of all market (such as customers, competitors, suppliers) and non-market (such as government, media) constituents while framing their business strategy (Delmas and Toffel, 2008). As each component of the EMP portfolio attempts to address different aspects of environmental strategy, so it is likely that highly committed firms focus on all OP, TP and SP while designing their environmental approach. Such argument is supported in literature that delves into the role of environmental proactivity and motivation. For example, Benito and Benito (2008) in their study with Spanish manufacturing companies find that environmentally proactive organizations implement advanced environmental management practices and adopt certifications like ISO 14001. They obtain that environmentally proactive firms implement advanced practices in areas of product design, logistics processes, and internal production processes to fulfil their environmental commitment. In another study, Benito and Benito (2005) argue that ethical, competitive and relational motivations (as components of environmental motivation) guide firms to adopt ISO 14001 and advanced EMPs. Therefore, firms with high levels of environmental commitment are likely to focus on all aspects of EMP (OP, TP, and SP). Contrary to the assumption, those highly environmentally motivated firms focus more on PP activities rather than on PC activities, Klassen and Whybark (1999b) find that such firms rather choose a balanced approach. In a study with furniture industry, they find that environmentally proactive firms invest in a balanced fashion (34% and 42% respectively) on their PP and PC technologies. Based on such arguments, this study proposes that firms with higher levels of environmental commitment are likely to use all three components of EMP (OP, TP, and SP) to improve both of their ETP (PC and PP) activities.

On the other hand, firms with low levels of environmental commitment are less receptive to environmental concerns, see environmental initiatives as “cost-item,” have part-time or no environmental positions, follow avoidance strategies towards environmental disclosures, do not strive for environmental awards, and focus on short-term cost saving measures to comply with the environmental regulations and avoid penalty (Herremans et al., 2008). They lack environmental awareness, offer little or no training to their employees on environmental matter, have no commitment from senior managers, and often have very little procedure in place to tackle environmental issues with compliance to environmental regulations as sole objectives. Klassen and Whybark (1999b) classify such firms as compliant groups according to their environmental commitments and find them to focus on PC technologies rather than any long-term PP activities. Thoumy and Vachon (2012) find that firms achieve better financial returns when they focus on infrastructural projects on their environmental initiatives that include quick and easy elements like employee training (PC) rather than focus on long-term structural projects that require much higher investments (PP). This illustrates that firms with low environmental commitment whose objective is compliance and cost-cutting are less likely to go an extra mile on their environmental initiatives and will have minimalist approach towards implementing EMPs beyond the legal requirements or to aim for higher levels of ETP. Therefore, integrating such arguments, this study hypothesizes that:

H4: As the level of Environmental Commitment of firms increases, the positive influence of OP on (a) PP and (b) PC becomes stronger.

H5: As the level of Environmental Commitment of firms increases, the positive influence of TP on (a) PP and (b) PC becomes stronger.

H6: As the level of Environmental Commitment of firms increases, the positive influence of SP on (a) PP and (b) PC becomes stronger.

Figure 1 illustrates the conceptual framework for the study.

***** Please insert Figure 1 here ****

3. Method

3.1 Data collection: Use of corporate environmental reports

This study used content analysis of published environmental, corporate social responsibility, and annual reports of UK manufacturers available through the corporate websites to collect data. Jose and Lee (2007) define content analysis as the systematic tool to analyse a piece of text to investigate if certain words or concepts are within the text. Content analysis of corporate reports is widely used in environmental research (e.g. Henriques and Sadorsky, 1999; Hofer, Cantor and Dai, 2012; Montabon et al., 2007).

3.2 Sample selection

This study collected data for engineering-based UK manufacturing companies within eight specific sectors (SIC 28-35). The researchers chose these eight sectors based on their contribution to the manufacturing output. We first selected top 15 companies in these eight sectors in terms of annual turnover using Financial Analysis Made Easy (FAME) database. Out of the 120 firms shortlisted, some were subsidiaries of the same foreign parent company, some did not have detailed information on environmental initiatives on their annual reports or corporate social responsibility reports. Such companies were removed from the shortlist. The final sample resulted in 76 companies (see Table 1 for sample details). The companies were relatively medium to large size with respect to their annual turnover and number of employees. The sample size used in this study was similar to earlier studies on application of content analysis in environmental research (for example, Montabon et al., 2007 used 45 companies, Hofer et al. 2012 used 96 companies for content analysis).

**** Please insert Table 1 here. ****

3.3 Data collection method

Content analysis using human raters is often used in environmental research (e.g. Montabon et al., 2007). Following their method, this study collected electronic copies of environmental reports from the corporate websites of the 76 individual firms. The independent variables (EMPs) were obtained from 2009-2010 and the dependent variables (ETPs) were obtained from 2010-2011 environmental reports. Following Montabon et al. (2007), we selected a team of three independent raters that included faculty members of a university and postgraduate students. As human coding is subjective, the researchers organized a training workshop for the data collection team. In this workshop, the researchers briefed the team with the objectives of the research and provided them a coding sheet (adapted from Montabon et al., 2007) with detailed explanation of each item. Based on the literature search on the relevant constructs in the study, the researchers identified a list of key words and key phrases. The raters were asked to identify the key words/phrases in the company documents and read around the area where such keywords/phrases were identified. Then the raters were asked to subjectively evaluate the degree of involvement of the firm on environmental issues using the text around the keywords/phrases.

Data for each item was measured using a five point Likert scale where 1 represents low degree and 5 represents high degree of involvement of the firm with each environmental item. For the first five firms, the three raters together collected the data. In case of discrepancies, they discussed among themselves and agreed on a score. The researchers reviewed this data and discussed it with independent raters to understand their comprehension of the data collection process. For the remaining 71 firms, the raters independently collected the data without mutual discussion. A discrepancy in individual rating was present. Inter-rater reliability (following Shrout and Fleiss, 1979) was 0.72. The average of the scores from three independent raters was used in the data analysis. The researchers instructed the raters to collect data on the dependent and independent variables using the same downloaded electronic copies of environmental reports but at two different points in time with a one-month time lag in between. This was done to remove potential drawbacks of common method bias where the raters could have a desire to maintain consistency in their responses across variables. Past studies (such as Boso, Story and Cadogan, 2013) that collect data on both dependent and independent variables from the same individual often use a time lag to negate the influence of common method bias.

3.4 Measures

The items used to measure the constructs are briefly elaborated in the following pages. All of them are evaluated in the content analysis using a Likert type 5 point scale where 1: not doing it, 2: eludes to doing it,….5: quantitative measures, specified targets.

Environmental management practices: Environmental management literature often propose a variety of constructs and dimensions to measure EMP (such as Dahlmann et al., 2008, Gonzalez-Benito, 2008 and Zhu and Sarkis, 2004). However, studies that use content analysis approach to measure EMP (e.g. Hofer et al., 2012) frequently use the 33 items scale developed by Montabon et al. (2007) and Sroufe et al., (2002). Therefore, this research adopted this scale to measure operational, tactical, and strategic EMPs.

Environmental technology portfolio: Literature does not propose an established scale to measure ETP suitable for use in content analysis based studies. However, few alternatives to PC and PP such as contamination control and prevention (Zeng et al., 2011), environmental practices (Zhu and Sarkis, 2004), and innovation of PP technologies (Christmann, 2000) do exist. In absence of a unified scale to measure ETP, this research adapted 9 items based on Klassen (2000), and Klassen and Whybark (1999b) to measure PP and PC activities.

Literature also suggests that there is a time lag between adoption of EMPs and their influence on environmental outcomes (Hofer et al., 2012). Following this argument, we introduced a time lag of 1 year between the adoption of EMPs and their influence on ETPs to address the temporal sequence. 1-year time lag was appropriate as longer lags might introduce the effect of other extraneous factors such as technological innovations, overall economic situations influencing the whole industry. Hence, this study collected data on EMP constructs from 2010-2011 and ETP constructs from 2011-2012 corporate reports.

Environmental commitment: Darnall et al. (2010) identified a list of items to measure environmental proactivity of firms. Based on their work, this study adopted 6 items to measure environmental commitment.

Control variables: This study used three objective, financial measures obtained from financial reports as controls in this study (1) size of the firm (2) its economic performance (3) the industry category where it belongs.

Size- Larger firms have more resources available for environmental initiatives, are more scrutinised, and tend to have higher propensity of environmental disclosure (Rankin, Windsor and Wahyuni, 2011). Following their argument, this study used natural logarithm of the market capitalisation to control the influence of firm size, to negate the impact of outliers and high skewness in raw data (Table 1 provides the details of the sample profile).

Economic performance- ETP prioritization often depends on economic performance of the firm (Klassen and Whybark, 1999a, b). A financially healthy firm is likely to engage more in voluntary environmental initiatives aiming to achieve PP. We measured economic performance using return on assets (ROA), which is the ratio of the income before interest and tax to the total assets (Rankin et al. 2011).

Industry category- Firms belonging to more regulated industries follow stringent EMPs as compared to firms in less regulated industries as costs associated with non-compliance are significantly higher in the former category (Henriques and Sadorsky, 1999). To account for the differences due to the nature of the industry, we included seven dummy variables to represent the eight industry sectors with fabricated metal (SIC 28) used as the reference.

4. Data analysis

This study has used structural equation modelling using partial least squares (PLS) to test the hypotheses. PLS is an extension of traditional least squares based regression and uses iteration to extend regression principles for the case of more complex constructs. Please refer to Hair et al. (2013) for a detailed description of PLS path modelling. We used the SmartPLS software (Ringle et al., 2005) for conducting PLS analysis.

The analysis is done in two stages (Anderson and Gerbing, 1998). In the first stage, we test the measurement model. This involves checking unidimentionality of our constructs (construct validity). In the second stage, the relationships among the constructs as shown in Figure 1 and the hypotheses are tested using the structural model.

Stage 1: Measurement reliability and validity

The results of construct validity are shown in Table 2. Our study has six constructs: Operational EMPs, Tactical EMPs, Strategic EMPs, Environmental Commitment (EC), Pollution Prevention (PP), and Pollution Control (PC). Some of the items from the initial scale were removed due to insufficient loading on the constructs. Table 2 also shows the indicators finally used to measure the six constructs. Cronbach's Alpha and composite reliability measure internal consistency of the constructs and a minimum value of 0.7 for these values is considered acceptable for existing scales (Nunnally, 1978). Average variance extracted (AVE) is the other measure used here to verify construct validity. It is generally recommended that the minimum AVE should be 0.50, as this indicates that 50% or more of the variance is explained by the indicators of the constructs (Fornell and Larcker, 1981). As shown in Table 2, all the constructs have AVE above the minimum recommended level of 0.5, composite reliability above the minimum recommended level of 0.7, and Cronbach's Alpha above the minimum recommended level of 0.7. This establishes measurement reliability and validity.

**** Please insert Table 2 here. ****

In addition, we show discriminant validity of our constructs using Table 3. Discriminant validity is the extent to which items from one construct discriminate from items representing another construct (Braunscheidel and Suresh, 2009). This is usually done by showing that internal reliability of a construct is more than its correlation with other constructs. Table 3 shows correlation among constructs, and the bold values in the diagonal show composite reliability values. It can be seen that composite reliability value of a construct is greater than the correlation of the construct with our constructs (shown in the corresponding row and column values). This establishes discriminant validity, highlighting that that none of our constructs shares more variance with another construct than with its own indicators,

**** Please insert Table 3 here. ****

Stage 2: Testing the hypotheses

<u>Direct effects:</u>

Having established construct validity, we first test our direct hypotheses (H1-H3) using PLS. Results are shown in Table 4 and in Figure 2. Please note that the three control variables (Industry type, economic performance using return on assets (RoA) and firm size) have been included in all the PLS regressions below. OPs influence both the ETPs at 0.1 level of significance, but have negative influence on PP. This result does not support H1a but supports H1b. However, it should be noted that while several studies (e.g., Tellis and Wernerfelt, 1987; Wright et al., 2013) have considered 0.1 level as acceptable level of significance, some other studies have considered this level as statistically insignificant relationship. Since the magnitude of coefficient for PC (0.31) is higher than the coefficient for PP (0.12), our H1c is supported. TPs positively influence both ETPs at 5% level of significance, supporting H2a and H2b. However, the magnitude of influence of TP on PP (0.18) is not larger than the influence of TP on PC (0.47) and hence H2c is not supported. While SPs exert a very strong significant influence on PP, they do not have significant influence on PC. This result supports H3a but not H3b. Since the magnitude of influence of SP on PP is higher than that on PC, H3c is also supported.

**** Please insert Table 4 here. ****

Moderating effects:

We have used the moderation option of SmartPLS software to test our moderating hypotheses H4-H6. Table 5 below shows the results of moderating impacts of environmental commitment on the influence of the three EMPs on the two ETPs.

**** Please insert Table 5 here. ****

The second and third column relate to the moderating impact of EC on the influence of OPs on PP and PC. The moderating impact is captured using the product term (OP × EC) in Table 5 and the significance of the moderator is assessed by the significance of the product term. The moderating impact of EC on the influence of OP on PP is high (0.16) and significant at 5% level, supporting our H4a. On the other hand, H4b on the moderating impact of EC on the influence of OP on PC is not supported.

Similarly, as the other columns of Table 5 show, EC moderates the influence of TPs on PP (at a low 0.1 significance level) but does not moderate the influence of TPs on PC. This supports H5a but not H5b. The last two columns show that H6a and H6b are not supported; EC does not moderate the influence of SPs on PP or PC.

5 Discussions, contributions and implications

The empirical findings linking EMPs to ETPs suggest that overall a positive relationship exists between the constructs. Therefore, firms are better off by investing in all aspects of environmental practices to reach their PC and PP goals. Note that the results in Table 4 show that OP and TP have significant influence on both PP and PC, while SP has significant influence only on PP but not on PC. This point to the focus of UK firms on relatively short-term practices to improve their environmental performance. Among the three EMP constructs, the results show firms that focus on cost reduction and environmental compliance (PC) objectives, the influence of short-term, shop floor orientated practices such as recycling and using environment friendly packaging (OP) is the most impactful. On the other hand, the influence of SP on PP is the most significant and has the largest impact coefficient (0.77), implying that for firms that concentrate on long-term, extensive product and process structural changes (PP) objectives, the impact of coordinated strategic planning and top management initiatives such as forming strategic alliances with stakeholders to achieve environmental standards (SP) is the most influential.

A comparison of the magnitude of the coefficients in Table 4 in response to our Hypotheses H1a-H3c reveals insights that are more interesting. Note that the coefficient of the impact of OP on PC (0.31, $p<0.10$) is higher than the coefficient of the impact of OP on PP (-0.12, $p < 0.10$), and further that the impact of TP on PC (0.47, $p<0.05$) is higher than the coefficient of the impact of TP on PP (0.18, $p < 0.05$). This indicates that UK firms focus more on the role of OP and TP to achieve their ETP objectives with an emphasis on PC rather than on PP. On the other hand, the impact of SP on PP (0.77, $p<0.01$) is much higher and highly significant than the coefficient of the impact of SP on PC (0.04, not significant). This suggests that UK firms tend to use strategic practices to achieve long term pollution prevention opportunities.

In addition, the moderating influence of environmental commitment (EC) shown in Table 5 reveal several interesting results. The product term for OP and TP (i.e., OP × EC, 0.16, $p<0.05$ and TP × EC, 0.10, $p<0.1$) are positive and significant when PP is the dependent variable. This means that the influence of OP on PP and TP on PP tend to increase for firms with higher levels of EC than for firms with lower levels of EC. Combined with the results of direct effects in Table 4, this results highlight that, though UK firms tend to emphasise more on PC than on PP (as per Table 4), firms with higher level of EC actually tend to focus substantially more on PP. Thus environmentally committed firms have longer-term orientation on pollution prevention.

The results of Table 5 also show that the product term of SP with EC (i.e., SP × EC) do not have a moderating influence. Thus, the levels of environmental commitment do not seem to have a significant impact on the link between SP and PP or PC. In other words, environmentally committed firms do not seem to use their SPs any better than other firms. We argue that this result is quite consistent with the direct effects of SP as shown in Table 3, which showed that SPs have very large, positive and very significant influence only on PP but not on PC. The level of environmental commitment does not moderate since all types of firms (with all levels of environmental commitment) are actually using SPs to achieve long-term goals of pollution prevention. In the next section, we explain the findings using theoretical lenses and provide their implications.

5.1 Research implications and institutional theory perspectives

The first objective of this study is to examine how a firm can use individual constituents of EMP (OP, TP, and SP) to improve its ETP (PC and PP) objectives. In doing so, this study uses the institutional theory (North, 1996). The empirical results are consistent with the underpinning that market and non-market constituents have different sets of pressures on firms to adopt different combination of EMP-ETP portfolio. Extant research has obtained that institutional pressure from non-market constituents (like regulatory bodies) make firms to adopt “avoid sanction” approach (Delmas and Toffel, 2008). Such non-market constituents view environmental activities as negative externalities and cost component. Therefore, firms are likely to use cost-saving initiatives (such as waste reduction, reusable packaging) that are typically OP related activities to serve the needs of these constituents.

Our results reiterate that firms that adopt such approach focus on OP to achieve PC objectives. On the other hand, institutional pressure from market constituents (like customers and suppliers) makes firms to adopt “beyond compliance” goals (Delmas and Toffel, 2008). Our findings are consistent and show that firms adopt SP (like involve customers, suppliers in their environmental initiatives, form alliance with them) to achieve PP objectives. Therefore, this study establishes the causal relationship between EMP and ETP based on the arguments of institutional theory and by relating the motivation of firms to adopt different EMP-ETP configuration when exposed to market and non-market institutional constituents. Apart from establishing the application of institutional theory to understand EMP-ETP linkage, this study extends literature in several ways. Past research has focused on the role of EMP and ETP as antecedents to financial and environmental performance as separate research streams (Klassen and Whybark, 1999b; Montabon et al., 2007; Thoumy and Vachon, 2012). However, rarely such studies highlight the linkage between these two environmental constructs. This is essential as achieving end- of-pipe PC or more strategic PP objectives require firms to adopt different sets of EMPs. This study contributes to establish such linkage.

The second objective of this study is to examine how environmental commitment influences firms to choose their EMP-ETP portfolio. The finding contradicts popular notion that the environmentally proactive firms strive to improve PP activities. In fact, our study shows that firms with all levels of environmental commitment tend to use strategic environmental management practices to achieve their long-term pollution prevention objectives. Our study further shows environmentally proactive firms stress on PC activities with a focus on cost reduction, and operational benefits rather than with a long-term strategic perspective. This study establishes that even highly environmentally committed firms use OP and TP (and not SP) to achieve their environmental objectives. Delmas and Toffel (2008) argue that different organizational structures within firms often dictate how they respond to isomorphic institutional pressures. Such structures influence managers' receptivity to institutional pressure. This research extends this argument by obtaining greater role of negative externalities as viewed by non-market constituents as principal determinants of managers' commitments towards environmental initiatives.

Research that explores the role of EMPs between environmental leaders and challengers find that the leaders lag behind the challengers in implementing environmental activities (Hofer et al., 2012). They argue that EMPs have short-lived innovativeness and easily imitable (particularly the practices which are more operational or lack real competitive advantage). Past research that explores environmental management practices of British firms characterise them as adopting short-term, risk avoidance attitude towards environmental initiatives with cost reduction, as primary motive (like Dahlmann et al, 2007; Ghobadian et al, 1995; Zhuang and Synodinos, 1997). Literature that focuses on the role of environmental practices and performance also report such discrepancies. Thoumy and Vachon (2012), find a negative relationship between firm's PP activities and its profitability. This study extends such findings by exploring the difference in EMP-ETP linkage between firms with different levels of environmental commitment. This is the second contribution of this study.

5.2 Managerial implications

The study provides several implications for managers as well. First, firms are often in dilemma which EMPs (operational or strategic) they need to adopt to improve their ETPs (cost reduction/ compliance or more resource intensive prevention activities). This study shows that operational OP is more suitable for compliance based PC activities, whereas strategic SP is more suitable for prevention orientated PP activities. Therefore, managers can make informed decisions about their environmental resource allocation strategies. Second, firms that strive to become more committed towards environment often will choose strategic (SP) and concentrate on prevention (PP) activities. This study shows that even such environmentally committed firms can achieve their PP objectives by focusing on OP and TP activities. Thoumy and Vachon (2012) highlight that firms are financially better off by focusing on infrastructural projects rather than structural projects that are more "hardware centred." This study reiterates this argument and provides empirical evidence that firms with high levels of environmental commitment can achieve their PP objectives by adopting less resource intensive and more shop floor orientated activities such as recycling and waste reduction that involve employees on a day-to-day basis and integrating external stakeholders like customers and suppliers (rather than being top management centred).

6. Limitations and future research

In spite of these contributions, this study is not free from limitations. Due to the lack of firm-level secondary environmental data for UK manufacturers (like TRI database in the United States context), this study resorts to the content analysis of the firm produced environmental reports. As Tangpong (2011) argues that use of content analysis can be useful to both qualitative and quantitative operations management researchers, therefore this provides evidence and validates the choice of subjective, firm reported environmental measures. Future research can address this issue by choosing firms from other countries, obtain both secondary objective environmental performance measures (like from TRI database) and subjective content analysis data from corporate reports. This can provide additional insights and corroborate the findings of content analysis results. However, the approach used in this study is perhaps imperative in many non-U.S. contexts. Second, relying on firm self-reported voluntary disclosures may have its own limitations, as firms would like to portray them in the best possible light. To minimize this limitation, this study crosscheck the firm reported measures (such as on environmental awards and recognitions) with the award granting bodies to increase the validity of the data. Future studies can include methodological variations, such as using longitudinal data on environmental initiatives to improve robustness of the results.

To summarize, this study highlights that the motivation to achieve the environmental targets is still economics driven. However, given the growing importance of conformity to environmental regulations, changing landscape to incentives to comply with environment (like carbon trading programmes), UK policy makers need to offer the right package of incentives to manufacturing firms to make them more environmentally proactive.

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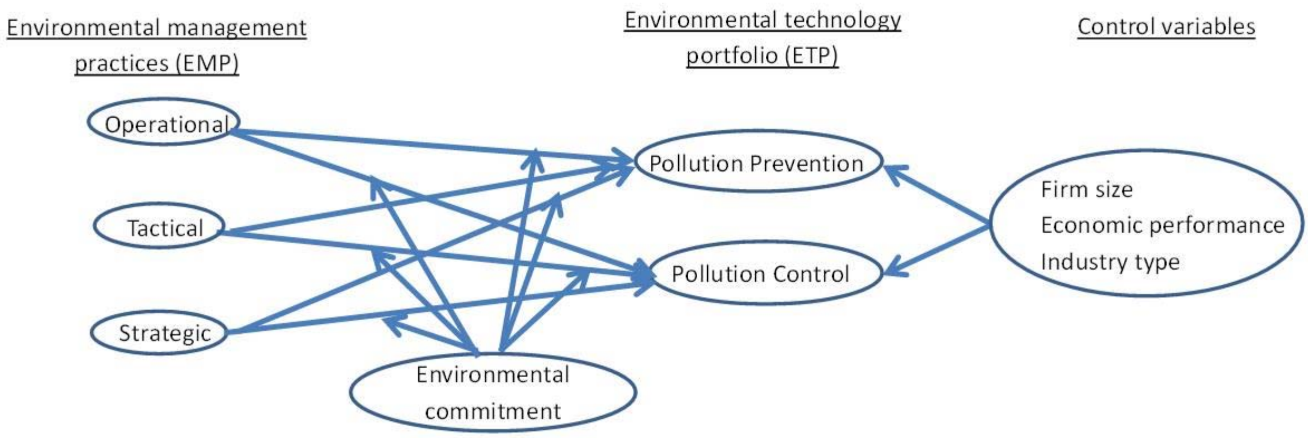

Figure 1: A conceptual Framework for investigation of relationship between environmental management practices, environmental technology portfolio and the role of environmental commitment

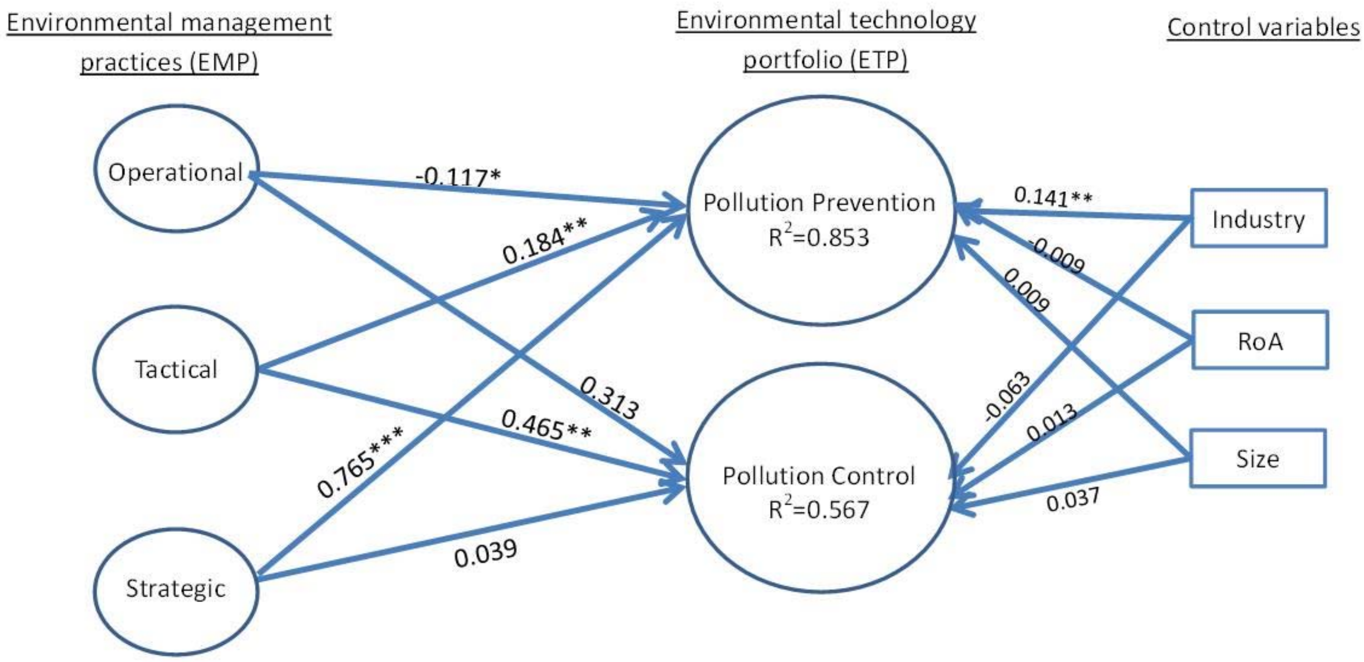

Figure 2: PLS results: Direct effects of environmental management practices on environmental technology portfolio (*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$)

Table 1: Details of sample

Industries	No. of firms	Annual turnover (in thousands of GBP)			Number of employees		
		<1,000,000	1,000,000-10,000,000	>10,000,000	< 1000	1000-10,000	>10,000
Fabricated metal (SIC 28)	10	4	5	1	3	3	4
Machinery & Equipment (SIC 29)	10	2	6	2	2	3	5
Office machinery and computers (SIC 30)	11	6	4	1	3	4	4
Electrical Machinery and Apparatus (SIC 31)	10	5	5	0	1	5	4
Radio, Television and Communication equipment (SIC 32)	11	4	6	1	1	7	3
Medical Precision and Communication equipment (SIC 33)	8	4	3	1	4	2	2
Motor vehicles (SIC 34)	8	3	4	1	1	5	2
Other Transport (SIC 35)	8	4	3	1	0	6	2
Total	**76**	**32**	**36**	**8**	**15**	**35**	**26**

Table 2: Measurement reliability and validity.

Constructs and their items	Loading	AVE	Composite Reliability	Cronbach's Alpha
Operational practices (OP)		0.54	0.93	0.92
Recycling: Does the company recycle its office papers, plastic bottles etc.	0.67			
Waste reduction (proactive): Talk in terms of proactive approaches to environmental issues such as reduction before waste is produced	0.74			
Waste reduction (reactive): Talk in terms of reactive approaches to environmental issues such as scrubbers, incinerators	0.74			
Remanufacturing: rebuilding a product where some parts are recovered, replaced	0.67			
Substitution: replacing an environmentally hazardous material with others	0.70			
Consume internally: consume waste, scrap internally	0.82			
Packaging: returnable, reusable, recyclable, reduced packaging	0.75			
Spreading risk: shifting environmental responsibility to third party	0.71			
Creating market for waste products	0.79			
Energy: conservation, efficiency, fuel recovery	0.71			
Environmental information: *cost accounting, tracking*, accounting for environmental costs	0.77			
Tactical practices (TP)		0.60	0.94	0.93
Supply chain management: *suppliers,* environmental dimensions in sourcing suppliers	0.73			
Early supplier involvement: are *suppliers* involved in new product development	0.79			
Environmental standards for suppliers	0.79			
Environmental audits for suppliers: suppliers, audits- are suppliers audited on environmental information	0.81			
Use of life cycle analysis	0.65			
Design: eco-efficient products/ processes	0.82			
Specific design targets: quantification of *design goals*	0.81			
Environmental risk analysis: do the company assess *risk / audit* of materials to the environment, to people	0.77			
Environmental management systems (EMS)	0.78			
Communications: communications with stakeholders about environmental activities	0.82			
Strategic practices (SP)		0.84	0.94	0.91

Integration with long-term business strategy: are environmental considerations integrated to *long-term planning*	0.96			
Corporate policies and procedures: *integrated management*-detail and extent of involvement throughout the organization	0.93			
Employee programmes: do they mention *employee training* programmes on environmental issues	0.86			
Pollution Prevention (PP)		0.83	0.94	0.90
Modify *existing product's design* for environmental requirements	0.94			
Changing *material acquisition* for environmental requirements	0.93			
Changing *production system* for environmental needs	0.87			
Pollution Control (PC)		0.61	0.82	0.68
Cleaning up past *environmental spills*	0.68			
Installing new equipments at the *end of the process*	0.89			
Air/ water/ waste pollutant collection	0.77			
Environmental Commitment (EC)		0.71	0.91	0.86
Benchmark environmental performance	0.84			
Environmental criteria in the *evaluation/ compensation of employees*	0.75			
Communicate the environmental plan to *employees*	0.86			
Communicate their environmental plan to *stakeholders*	0.90			

Table 3: Discriminant Validity

	OP	TP	SP	PP	PC	EC
OP	**0.93**[1]					
TP	0.82	**0.94**				
SP	0.73	0.83	**0.94**			
PP	0.63	0.78	0.91	**0.94**		
PC	0.71	0.72	0.61	0.61	**0.82**	
EC	0.77	0.84	0.72	0.65	0.87	**0.91**

[1] Diagonal values are composite reliabilities

Table 4: Results of direct effects (*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$)

Dependent Variable ->	PP	PC	Hypotheses
Control Variables			
Industry	0.14**	-0.06	
RoA	-0.01	0.01	
Size	0.01	0.04	
Independent Variables			
OP	-0.12*	0.31*	H1a: no support
			H1b: support
			H1c: support
TP	0.18**	0.47**	H2a: support
			H2b: support
			H2c: no support
SP	0.77***	0.04	H3a: support
			H3b: no support
			H3c: support
R^2	0.85	0.57	

Table 5: Moderating effect of EC (*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$)

Dependent variables	PP	PC	PP	PC	PP	PC
Control variables						
Industry	0.38***	-0.05	0.33***	-0.04	0.15**	-0.03
RoA	0.02	-0.02	0.01	-0.03	-0.01	-0.03
Size	-0.01	0.09*	-0.04	0.09*	0.01	0.09*
Independent variables						
OP	0.23**	-0.03				
TP			0.56***	-0.05		
SP					0.81***	-0.05

EC	0.32**	0.87***	0.07	0.90***	0.02	0.91***
Interaction variables						
OP × EC	0.16** H4a: support	0.13 H4b: no support				
TP × EC			0.10* H5a: support	0.06 H5b: no support		
SP × EC					0.01 H6a: no support	0.04 H6b: no support
R^2	0.87	0.66	0.72	0.63	0.85	0.62