EFFECTS OF ENVIRONMENTAL REGULATIONS ON INNOVATION AND FIRM COMPETITIVENESS

The case of small and medium size manufacturing firms in Norway

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Abstract

The traditional view of environmental regulations had been that environmental regulation has a negative effect on firms' innovation and competitiveness. However, this was disputed by Michael Porter in his hypothesis by arguing that environmental regulations can spur innovation that can offset the cost of compliance and thereby make a firm profitable. The study focused on manufacturing SMEs and lagged periods which are two vital areas that have been neglected in the Porter Hypothesis studies. The study used firm level secondary data from Norwegian manufacturing firms to examine the effects of environmental regulations on firm's innovation activities proxy by number of patents applications, and competitiveness as proxy by profitability and productivity. The study finds negative but significant effects of environmental regulations on firm's profitability and productivity, and negative but insignificant effects on patents applications. As a result, the study shows that environmental regulations negatively affects firm's innovations and competitiveness hence Porter Hypothesis is not realized in these SMEs. This could be an indication that these SMEs merely comply with environmental regulation but they do not develop or see any advantages to gain in developing green competencies. Therefore, there is urgent need for the government and all the stakeholders to formulate flexible environmental laws, interventions, incentives and advocacy that could encourage these SMEs to be more innovative, competitive and thereby saving the environment.

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List of abbreviations

EBITDA - Earnings Before Interest, Taxes, Depreciation and Amortization.

MNEs - Multinationals Enterprises

NAE - Norwegian Environmental Agency

PACE - Pollution Abatement Control Expenditure

PH - Porter Hypothesis

R&D - Research and Development

SMEs – Small and Medium Size Entreprises

TFP - Total Factor Productivity

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1 INTRODUCTION

1.1 Overview of the Porter Hypothesis

In 1991, Harvard Business School economist and strategy Professor Michael Porter came up with a hypothesis by arguing that well-designed regulation could actually result in innovation and improved competitiveness of firms (Adam B. Jaffe & Palmer, 1997; M. Porter, 1991). This hypothesis has since been known as Porter Hypothesis hereby referred to as PH. Until then, the traditional view of environmental regulation, held by virtually all economic scholars, policy makers and business managers was that environmental regulation reduces firms profits (Ambec, Cohen, Elgie, & Lanoie, 2013). M. E. Porter and Van der Linde (1995) further developed the hypothesis by arguing that environmental regulation can spur innovation that can offset the cost of compliance and thereby make the firm profitable. They argued that regulation can reduce inefficiencies, increase information gathering, reduce investment uncertainties, creates pressure that motivates innovation, and levels the transitional playing field. In addition, they further argued that regulation is needed in the case of incomplete offsets especially in the short term before learning can reduce the cost of innovation-based solutions (M. E. Porter & Van der Linde, 1995). The causal links of the PH can be summarized by Figure 1 below.

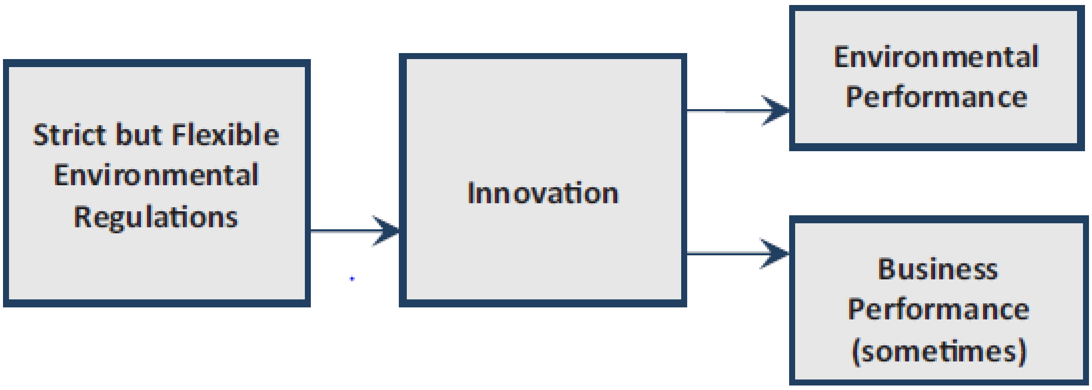

Figure 1: Schematic representation of the Porter Hypothesis: {Adapted from (Ambec et al., 2013)

The PH can be divided into three sub-aspects which are commonly known as the narrow, weak and strong versions of the PH. The three sub-aspects can be summaries as below:

- ***The narrow version of the Porter Hypothesis*** – Postulates that well designed and documented environmental regulation offers firms greater incentive to innovate and thereby improve firms' competitiveness (Koźluk & Zipperer, 2015). The argument is that flexible environmental regulation/policies, such as market-based instruments, increases firms' incentives to innovate compared to prescriptive regulation (Rubashkina, Galeotti, & Verdolini, 2015).

- ***The weak version of the Porter Hypothesis*** **-** Asserts that environmental regulation can lead to an increase in environmental innovation and performance. The assumption is that firms are profit maximizing entities, so naturally they will try to innovative to reduce the cost of compliance (Tomasz Koźluk and Vera Zipperer, 2015). This version of PH therefore affirms the positive effect of well-crafted environmental regulations on environmental innovation (Rubashkina et al., 2015).
- ***The strong version of the Porter Hypothesis*** – This version of PH asserts that innovation induced by well-crafted environmental regulation could more than offset the regulatory costs and, consequently, increase firms' competitiveness and productivity (Rubashkina et al., 2015). This version rejects the assumption of perfect markets and the argument that firms are profit maximizing. Instead, it assumes that firms are not operating fully efficiently by leaving some profit opportunities unused. Hence the regulations could help firms corrects their inefficiencies thereby bringing into realization extra profits which can in some cases be even greater than the cost of compliance (Koźluk & Zipperer, 2015).

Since the inception of the PH, several studies have been conducted around the world looking at one of or combinations of the PH versions. The results have generated a lot of interest and debate among scholars who find different evidence at the conclusion of their studies. Positive results have been found by Carrión-Flores and Innes (2010) in the US toxic emission, Lee, Veloso, and Hounshell (2011) in the automobile industry, Wayne B. Gray and Shadbegian (2003) in pulp and paper mills industry, Testa, Iraldo, and Frey (2011) in construction sector and Costantini and Crespi (2008) in energy technology industry. In addition, positive results have also been observed at country level, Murty and Kumar (2003) in India by use of panel study of 92 firms, Yang, Tseng, and Chen (2012) using an industry-level panel dataset in Taiwan, Arouri, Caporale, Rault, Sova, and Sova (2012) in Romania and Popp (2005a) using patents data from the United States, Japan, and Germany. Other positive results include Ambec and Barla (2002), Riveiro (2008) and Brunnermeier and Cohen (2003), Horbach (2008).

Some studies have found mixed results, Lanoie, Laurent-Lucchetti, Johnstone, and Ambec (2011) found strong support for the “weak” version, qualified support for the “narrow” version, but no support for the “strong” version. While Franco and Marin (2015) found negative results on productivity but positive results on innovation. Still other studies have found negative results, such studies includes Feichtinger, Hartl, Kort, and Veliov (2005) on profitability, Adam B. Jaffe, Peterson, Portney, and Stavins (1995) on competitiveness, Rexhäuser and Rammer (2014) on profitability, Wayne B Gray and Shadbegian (1995) on productivity in three industries (paper, oil, and steel).

The above differences in empirical results on PH shows that there is no consensus in the empirical literature hence the need for further research. A potential problem with these results is that estimation may be confounded by heterogeneity bias and measurement error, which may explain the existence of conflicting results (Berman & Bui, 2001). One of the ways to overcome the above challenges is to consider studying PH in the manufacturing industries. The argument being that manufacturing industries are more exposed to the effects of environmental regulation. This might be because such firms produce toxic emissions that cuts across all the major pollution factors, air, water and soil. Thus there are strict environmental attentions to manufacturing industries that are the principle sources of such pollutants (Carrión-Flores & Innes, 2010).

Due to the above argument, manufacturing industries have received much interest and studies on PH with different results. Costantini and Mazzanti (2012) found partial support for the strong version of PH and strong support for the weaker version of PH, Mohnen and Van Leeuwen (2015) found strong corroboration of the weak and a nuanced corroboration of the strong version of the PH while Adam B. Jaffe and Palmer (1997) found positive relationship with innovation but not R&D expenditure. Other studies have focused on the other components of PH, Hamamoto (2006) found positive relationship with the R&D expenditures but negative relationship with the average age of capital stock, Carrión-Flores and Innes (2010) found support for innovation, Becker (2011) found a negative effect on productivity, Kneller and Manderson (2012) found no effect on total R&D or total capital accumulation, Alpay, Kerkvliet, and Buccola (2002) found that environmental regulation had no impact on the profitability or productivity and Berman and Bui (2001) found positive effects on productivity.

However most studies on PH targeting manufacturing firms have focused on the large and bigger firms or rely on macro-economic data (Rexhäuser & Rammer, 2014) while leaving out small and medium sized firms (hereby referred to as SMEs). Yet SMEs are crucial actors for the adoption and the diffusion of innovation as they constitute the majority of business in many countries. Studies such as Mazzanti and Zoboli (2006) and Klemetsen, Bye, and Raknerud (2013) have focused on bigger firms leaving out SMEs, hence the need to look at SMEs which might be much affected by environmental regulations. This is because larger firms have better opportunities and abilities than smaller firms to reduce environmental impact due to their financial and human resources (Kammerer, 2009).

In addition, most previous studies have not adequately accounted for the dynamic aspects of the PH as innovation and PH relationships takes time to manifest. Most of the studies have focused on time zero/current time, which does not allow for the observation of the dynamic aspect of PH. This can be overcome by introducing lags (3 - 4 years) in the studies (Ambec et al., 2013; Carrión-Flores & Innes, 2010; Franco & Marin, 2015; Adam B. Jaffe & Palmer, 1997; Lanoie, Patry, & Lajeunesse, 2008). Therefore it is important that future research should focus more on the dynamic impacts of the PH (Ambec et al., 2013).

1.2 Objective of the study

The objective of the study was to investigate the lagged relationship between environmental regulation, innovation and competitiveness of manufacturing SMEs firms in Norway. The study targeted manufacturing SMEs with 0-50 employees by looking at the "narrow" and "strong" versions of the PH at firm level. To achieve the above stated objective, the study was designed to answer the following research question:

Research question: How does environmental regulation affects firm's innovation activities and competitiveness.

To answer the research question, the study analyzed the costs of complying with environmental regulations, innovative activity and firm competitiveness of manufacturing firms over time using firm level data. The study employed a 3 – 5 lag periods as it was assumed that innovation takes time to manifest and, because such lags allow for the possibility of capturing the dynamics aspect of PH. The above research question was further subdivided into three hypotheses as indicated by the concept in the diagram below (Figure 2).

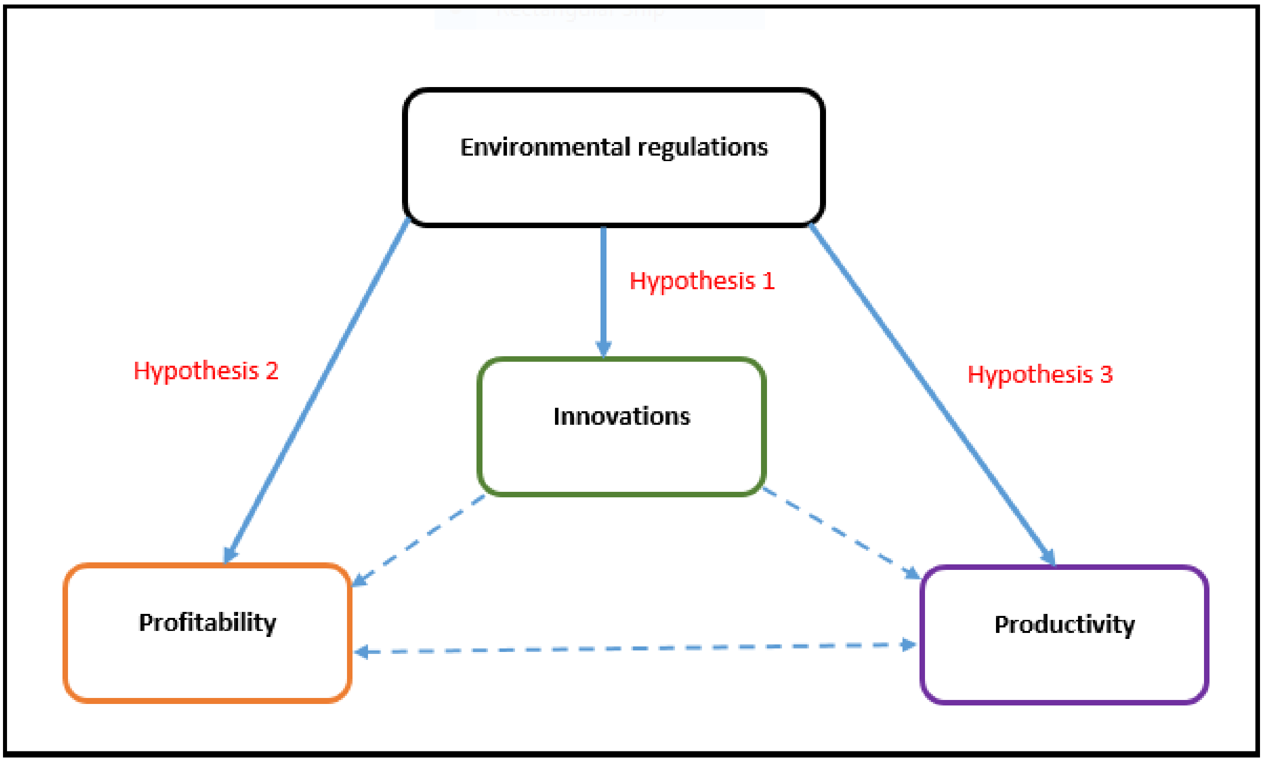

Figure 2: The study concept

The hypotheses attempt to relate the cost of environmental regulations to firm's innovations through patents and firm's competitiveness through profitability and productivity. The assumption was that enforcement of environmental regulations could spur innovations and thereby increasing firm's competitiveness through increased profitability and productivity.

The next chapter discusses the literature, gives overview of environmental regulations in Norway, discusses how SMEs reacts to environmental regulations, highlights the theoretical aspects of the PH, details the study hypotheses, and discusses how environmental regulations, innovations and competitiveness are measured at firm level. Methodology chapter describes the study design, data collection, processing and analysis. Results chapter summarizes the study findings, while the discussion chapter discusses the findings by relating it to theories in the literature. The conclusion section summarizes the findings of the study and suggests the way forward based on the study results.

2 LITERATURE REVIEW

This chapter is divided into four parts, part one introduces and highlights how environmental policies are implemented in Norway. Part two discusses the nature of SMEs and how they react to the environmental regulations or how they are affected by it. Part three discusses the various theories that have been put forward by scholars to try to explain the PH. Finally, part four details the various methods used in studies to measure environmental regulations, innovations and competitiveness and how the information was used to derive the study hypotheses.

2.1 Environmental regulations in Norway

In Norway, any emission that harms or may harm the environment is, as a general rule prohibited. Pollution is only allowed after obtaining a permit from Norwegian Environmental Agency (NEA). The Norwegian pollution act (Act of 13 March 1981 No.6)[1] concerns the protection against pollution and waste. The purpose of the Act is to protect the outdoor environment against pollution, to reduce existing pollution, to reduce the quantity of waste and to promote better waste management (NEA, 2016). NEA defines pollution as 1) the introduction of solids, liquids or gases to air, water or ground, 2) noise and vibrations, 3) light and other radiations to the extent decided by the pollution control authority, 4) effects of temperature, which cause or may cause damage or nuisance to the environment (NEA, 2016).

NEA regulates and monitors the environmental performance of polluting operations involving more than 260 pollutants to air, water and soil that might cause health risk to human life, plants, animals and the ecosystem. The regulation consists of both non-tradable emission quotas and technology standards. When issuing permits, NEA assigns firms risk classes based on the strength of the recipient of the emission and emission level. The risk classes ranges from 1 – 4 with Class 1 comprising of firms considered to be potentially highly environmentally harmful while Class 4 is considered the least harmful. Usually, firms in Class 1 are faced with higher regulatory cost and subjected to more frequent, costly inspections, and higher fines (Klemetsen et al., 2013).

[1] https://www.regjeringen.no/en/dokumenter/pollution-control-act/id171893/

By law, NEA have been given unimpeded access to property where pollution may occur or has occurred, or which is or may be exposed to pollution. This is necessary for the exercise of its inspection/control duties to ensure that firms meet the set standards. NEA charges firms fees for application of permits, inspection/controls or other related decisions. The above fees are charged as per risk class which are calculated not to exceed the costs incurred by NEA in connection with administrative proceedings or control measures. In addition, a pollution fine may be imposed when there is contravention of the Act or when other related decisions are discovered (NEA, 2016).

2.2 SMEs and environmental regulations

Most studies on PH have focused on the large and bigger firms or rely on macro-economic data (Rexhäuser & Rammer, 2014) but have left out SMEs due to data constrains (D'Agostino, 2015). However SMEs are crucial actors for the adoption and the diffusion of innovation, as they constitute the majority of business in many countries. In addition, their numerous number rather than their size might have a significant impact on the environment (D'Agostino, 2015).

Generally, the definition of SMEs vary from countries to country with 0-50 or 0-100 employees being considered as the standard size of an SME (Klemetsen et al., 2013). The nature and size of SMEs may have some implications in PH studies. Firstly, unlike multinationals enterprises (MNEs), most SMEs are confined to a country (do not operate in many countries) and therefore have low capabilities to diffuse green technologies from home to foreign countries, and vice versa (D'Agostino, 2015). Therefore, their environmental innovation is likely to be in response to national environmental policies and regulation as they are unlikely to escape to pollution havens (D'Agostino, 2015). Secondly, SMEs have limited technological capacities and therefore may not likely respond promptly to environmental regulations with path-breaking innovations as does MNEs. Thirdly, SMEs may not have social and environmental strategies in place to deal promptly with ever changing regulations (D'Agostino, 2015).

In addition, the characteristic of SMEs could also affect PH studies. A study by Patton and Worthington (2003) found that the awareness of environmental impact and associated legislation by SMEs is often limited and responses tended to be mainly reactive and minimal. In general, they observed that environmental legislation and regulation seemed to impinge less on the day-to-day operations of SMEs than they do on larger firms, and tend to be seen as a `threat' to the business continuity rather than as an `opportunity' for creating or sustaining competitive advantage. Their conclusion was that for many SMEs, regulatory compliance was mainly perceived as a matter of business survival rather than as a springboard for enhanced environmental performance (Patton & Worthington, 2003).

2.3 Theories underlining Porter Hypothesis

Globally, the governments and societal concerns over the negative environmental impacts of commercial and manufacturing activities have led to a sharp increase in environmental regulations at various institutional levels such as multilateral, national, subnational and municipal levels (Rugman & Verbeke, 1998). This has led to the formulation of environmental policies to save the environment and protect human health. Environmental policies are usually in the form of command-and-control or market-based approaches (D'Agostino, 2015). Command-and-control regulations are used to force firms to take on the pollution control burden, regardless of the cost. This is usually done by setting a uniform standard for firms such as performance and technological based standards. On the other hand, market-based regulations employ instruments such as pollution charges, subsidies, tradable permits and some types of information programs. These are meant to encourage firms or managers to undertake pollution control efforts that are within their interests and that collectively meet the policy goals (Adam B Jaffe, Newell, & Stavins, 2002). In the above two cases, firms are usually required by the authorities to devote some inputs to pollution prevention or abatement, reduce production to minimize pollution or innovate ways to reduce or eliminate pollution (D'Agostino, 2015).

The analysis of the impact of environmental regulation on firms' strategies and industrial performance has led to a wide variety of academic and practitioners' perspectives and prescriptions. Thus there are variety of lenses for viewing environmental regulations at firm level. There are four main paradigms that have been used to explain the relationship, namely the conventional economy paradigm, conflicting impact of industrial and environmental performance paradigm, the win-win paradigm, and the Porter Hypothesis paradigm (Rugman & Verbeke, 1998).

Firstly, in the conventional economy paradigm, environmental regulation such as polluter pays are imposed on firms. Here, firms merely comply with environmental regulation but they do not see any advantages to gain in developing green competencies. Thus such firms do not invest in firm-level improvements to enhance their green performance beyond compliance with the environmental regulations. Secondly, in the conflicting impacts of industrial and environmental performance, firms reject the development of green capabilities in response to environmental regulations. The argument is that firms and managers are only interested in minimizing the perceived negative impact of environmental regulation on industrial performance. Thirdly, the win-win paradigm of sustainable development and green management which argues that greening has become inevitable as a result of external forces. Thus, firms will invest in the development of green capabilities because they view the environmental regulation as having a complementary impact on their industrial performance. Fourthly, the Porter Hypothesis paradigm which focuses on the development of green capabilities in innovation offsets. This is due to the complementary between the home based environmental regulation and industrial performance. However, the developments of such capabilities requires resources, substantial managerial effort and time (Rugman & Verbeke, 1998).

Among the four paradigms, the PH has been fronted as the best model for the dual realization of firms' competitiveness and environment conservation. Therefore, over the years, many studies have been done by scholars on PH thereby raising large theories and literature in economics on the theoretical arguments that try to explain it. Among the theoretical approaches are behavioral arguments, market failures (market power, asymmetric information, research and development [R&D] spillovers), and organizational failure (Ambec et al., 2013). These factors may explains why firms may either achieve a positive or negative PH results.

2.3.1 The behavioral arguments

According to Azjen's theory of planned behavior, a person's behavior is driven by the intention to act and that intention is shaped by a person's prevailing attitude towards the behavior, perceived social norms and perceived behavior control. In addition, organizational and cultural systems may impact on the intention to act (Petts, 1998). This argument can be adapted for firms especially in relation to industrial activity and management. It is evident that a firm's environmental strategies such as conformance, regulation, and industrial standard practices and action towards environmental preservation are associated with the managerial interpretations of environmental regulation as either threats or opportunities. Thus, categorizing environmental regulation as opportunities rather than as threats not only helps managers to reduce the ambiguity and unpredictability surrounding environmental technologies and information but also enables the transfer of technologies and information to other employees in the organization hence facilitating organizational learning (Sharma, 2000).

Another perspective brought forward by Aghion, Dewatripont, and Rey (1997), is that the manager's behavior is a combination of both the need for profit maximization and conservative management. Thus, profit maximizing firms will innovate at finite intervals to maximize the net present value of the firm's profit flows, or the manager's conservative management aspect will results in managers being concerned with conserving their position and benefits of control over the firm while at the same time minimizing 'efforts'. On the other hand, managers of SMEs may be more interested in running their businesses 'quietly without interrupting their habits' (Aghion et al., 1997). On the contrary, another argument for firms and managers behavior assumes that firms are not all profit maximizers but are driven my managers who have motivations and objectives other than profit maximization. Because of this, managers may resist changes, being mainly concerned with preserving their position and benefits of control over the firm. Thus, environmental regulation may be the needed push to help the adamant managers to embrace change (Aghion et al., 1997).

The adoption of the environmental strategy and regulation by managers may also be due to conformance or voluntary. Conformance may be caused by pressure from the government, pressure groups or competitors while voluntary is where firms initiate actions to reduce environmental impact, not to conform to standards but as organizational and managerial choice, which usually go beyond the set environmental standards. However such voluntary firms may add complexity to their firm processes thereby increasing the risk to the firm and manager. Thus, managers who view such risks as threats to their jobs or firms are more likely to be risk averse and therefore seek to minimizing losses rather than maximizing gains. Therefore, such managers are unlikely to search for innovative environmental technologies for the fear that such technologies may disrupt their current firm processes (Sharma, 2000). The manager may also be risk-averse in terms of investment decisions, where he will have a tendency to under-invest in risky opportunities as he puts more weight on bad outcomes than on good ones. But environmental regulation may push or bring the manager's decision closer to the optimal one by affecting the marginal value of expenditure in risk-averse opportunities (Ambec & Barla, 2006). In addition, the manager may have private information (information rent) about the outcome of an investment but is biased in his choice of the investment, choosing not to invest on costly but profitable opportunities. Environmental regulation can reduce informational rent, thereby increasing investment in more risky but profitable opportunities (Ambec & Barla, 2006). Therefore the key to realizing the PH and thereby success in pollution prevention and firm competitiveness is to influence the managers' knowledge, behavior and attitude towards both environmental regulation and innovations (Cordano & Frieze, 2000).

2.3.2 Market failure

Market failure theory assumes that in addition to the environmental externality problem, there is the issue of market failure. Here, firms are assumed to be profit maximizers but market failures prevent them from fully realizing their profit potential, something that might be partially overcome through environmental regulation (Ambec et al., 2013). Usually, market failures associated with environmental pollution interact with market failures associated with innovation and diffusion of new technologies. Pollution is viewed by the firms as an external cost which they have no incentives to minimize hence creating imbalance. However, environmental regulation attempts to equalize this imbalance by raising the incentives for a firm to minimize these externalities. This is usually achieved by internalizing environmental costs or by imposing a limit on the level of environmental pollution (Adam B. Jaffe, Newell, & Stavins, 2005). In addition, market failure can also be due to the disruption of the existence of market equilibrium, a well-defined system that yields the cost-effective environmental standards at the least cost. However, environmental regulation could promote the simultaneous trading by all firms, a condition necessary for the market to always reach the cost-effective equilibrium (Atkinson & Tietenberg, 1991). Market failure could take effect through many forms, such as market power, asymmetric information or research and development (R&D) spillovers among others.

Firstly, market failure can take effect through market power such as market competitiveness. André, González, and Porteiro (2009), argues that environmental regulation can create competitiveness by solving a coordination failure among firms. Market competitiveness can also overcome market failure by introducing urgency in the decision-making process of innovating firms. Such urgency reduces the slack, that is the amount of free-cash available to managers, therefore market competition can act as a disciplinary device to foster technology adaptation and growth (Aghion et al., 1997). In addition, Rege (2000) argues that regulation can improve firms' competitiveness by requiring firms to produce at the environmental standards at which they claim to produce. Since consumers have stronger preferences for goods of higher environmental quality, high environmental standard of production may increase sales and also helps in product differentiation (Rege, 2000). Environmental regulation can also benefit firms by creating scarcity rents. With scarcity rents, it is possible for environmental regulations to induce innovation and improve firm performance. This is because as the regulation binds, the firm's willingness to pay for the alternate technology increases and at the same time their innovation becomes profitable (Mohr & Saha, 2008). Therefore, environmental regulation can motivate a firm to shift into green production in such a way that both the firm and the environment benefits (André et al., 2009).

Secondly, market failure can occur through asymmetric information, the assumption is that consumers prefer goods that are produced using green technology and are willing to pay a premium for such goods but are limited due to asymmetric information about the production. Environmental regulation can help firms overcome this by solving the information problem, encourages firms to adopt environmental policies which can results in reduced emission levels. Reduced emission levels could help reduce industrial inefficiency and raise performance which can intern raise the output of green products (Mohr & Saha, 2008). Due to increased environmental awareness, market studies has shown that consumers have preferences for products produced with cleaner technologies. Konar and Cohen (2001), found that firms that had better environmental regulation had higher intangible assets, suggesting that firms are rewarded in the marketplace for taking environmental actions. This evidence therefore shows that the purpose of environmental regulation is not only to correct for negative environmental externalities (Sinclair-Desgagné, 1999) but also aims to identify and eliminate the production inefficiencies and regulatory disincentives that may prevent the simultaneous improvements in both productivity and environmental quality (Murty, Kumar, & Paul, 2006). Another view of environmental regulation and asymmetric information is that a cost-efficient green product has a potential to generate both, higher profits and consumer surplus, yet its adoption is impossible without regulations. The regulation forcing firms to produce green products can also help them reach a Pareto-improving equilibrium. In addition, by imposing simultaneous adoption, the first-mover disadvantage from investing in the new innovation or technology (Constantatos & Herrmann, 2011) is eliminated. Asymmetric information can also occur at the managerial level, for example, a manager whose limited time and attention is split between short term financial returns and reduction of long-term environmental risk would choose to spend more time and attention on the former over the later. However, environmental regulation could facilitate the convergence of the two by making them become complementary, leading to higher payoffs for the manager and the firm (Sinclair-Desgagné, 1999).

Thirdly, market failure can occur through research and development (R&D) spillovers. It is believed that if firms are to acquire tacit knowledge, then they must undergo step-by-step technological progress or decompose R&D activities into research and development aimed at development of new fundamental paradigms or product lines (Aghion et al., 1997). However, R&D activities can in some cases results in market failure. The assumption is that firms undertake R&D before they compete in the market yet competitiveness is dependent on the sequential timing of the R&D and the output decisions (Greaker, 2003). Hart (2004), argues that environmental regulation may increase growth by inducing R&D that is underprovided because of market failures in the R&D sector (Hart, 2004). Environmental regulation can also increase production cost by triggering a restructuring of the capital stock in such a way that average productivity increases. The reason being that in some cases the downsizing of the firm due to the stricter environmental policy can be accompanied by a modernization effect, resulting in a reduction in the age of the capital stock and in an increase in the average productivity of the capital stock (Xepapadeas & de Zeeuw, 1999). Popp (2005c) points out that profit maximizing firms will only choose to invest in R&D if an environmental policy is in place due to the uncertain nature of R&D. The potential for spillovers also raises the possibility that firms who wait may have an advantage of avoiding the risk of the uncertainty in R&D. These firms can only choose to adopt those innovations that prove most successful, thereby free-riding on spillovers of research without having to pay fixed R&D costs (Popp, 2005c). On the contrary to the above, however, Feichtinger et al. (2005) points out that age of the capital stock and productivity can increase when a stricter environmental policy is imposed.

2.3.3 Organizational failure

Organizational failure has also be used to explain the PH. There is no clear consensus within disciplines as to what organizational failure is, how it occurs and its consequences. On one hand, the organization studies (OS) and organizational psychology (OP) literature argues that managers are the principal decision makers of the firm and, consequently, their actions and perceptions are the fundamental cause of organizational failure. On the other hand though, the industrial organization (IO) and organization ecology (OE) scholars have assumed the role of the environment as a cause of organizational failure. They reason that managers are constrained by exogenous industrial and environmental constraints leaving them with little real strategic choices, and hence managers' role should be ignored. Despite the lack of consensus by scholars on the definition of failure, there is a broad consensus on the meaning of failure which has been described as "a deterioration in an organization's adaptation to its micro-niche and the associated reduction of resources within the organization which may results in total exit from the market or turnaround" (Mellahi & Wilkinson, 2004). The symptoms of organizational failure may include shrinking financial resources, negative profitability, shrinking market, loss of legitimacy, exit from international markets, and severe market share erosion. Organizational failure can be a result of environmental, ecological, organizational and psychological factors (Mellahi & Wilkinson, 2004).

Firms may fail due to coordination problems, a situation that is generally achieved through lack of proper communication and habits that results in systematic errors and losses (Sinclair-Desgagné, 1999). Therefore the role of management in organizations is to ensure coordination, as the survival and success of the organization depends on it. Therefore, managers must effectively coordinate actions of individuals and groups within an organization by focusing their efforts towards organizational goals. However with time and growth, it becomes more difficult to coordinate individuals and groups (Henriques & Sadorsky, 1996). It has been observed that many firms use rule of thumbs to make and implement decisions and choices, in the short run, these procedures dominate the decision making processes (Sinclair-Desgagné, 1999). This can be overcome by environmental regulation, in that in response to environmental regulations, a firm may adopt an environmental plan that provide all its employees with an opportunity to become familiar with its environmental position thereby reducing the coordination costs (Henriques & Sadorsky, 1996). In addition, environmental regulation may force such firms to reconsider their processes or re-engineer their existing routes thereby bringing the firm closer to its private optimum and realization of low-hanging fruits (incremental innovation). On the other hand, re-engineering the processes and routines may be costly to the firm, a factor that might be attributed to their resistance to change. However, environmental regulation could alleviate such cost through subsidized training and diffusion of best business practices (Sinclair-Desgagné, 1999).

Taking a different view, Ambec and Barla (2002) argue that organizational failure can be used in relation to the profit maximizing firms. They argue that regulation creates external pressure that helps to overcome organizational inertia. They assume that the most polluting firms are the most productive yet productivity is manager's private information. Firm must therefore offer rents to reward truthful report of high productivity but the possibilities of renegotiation prevent them from reducing these rents by distorting production. But environmental regulation can distort production so that unproductive and polluting technologies becomes less attractive (Ambec & Barla, 2002).

The above theories are very useful in trying to explain and understand the PH but could be insufficient in explaining fully the firm and manager's behavior and response toward environmental regulations. This is because firm behavior and response towards regulations could be influenced by other indigenous and exogenous factors that may not be fully captured or explained by the above theories. In addition, these indigenous and exogenous factors could influence firm and managers response to other factors that are not directly related to regulations but could benefit environment and increase firm competitiveness as delayed spillover effects.

2.4 Measurement of environmental regulations, innovations and competitiveness at firm level

In theory there are many methods and proxies that are used in the PH studies as a measure or proxy for environmental regulations, innovations and competitiveness at firm level. Below is a brief discussion of some of them and how they will lead in answering the research question.

2.4.1 Environmental regulations

Environmental regulation can be proxy by Pollution Abatement Control Expenditures (PACE) or environmental permits/taxes. PACE captures the sum of capital and current expenditure on environmental protection activities. Such costs includes expenditure used to collect, treat, reduce, prevent or eliminate pollutants and pollution resulting from the company's activities (Kneller & Manderson, 2012). PACE costs include salaries and wages, fuel and electricity, materials, equipment leasing, depreciation of abatement capital, and payment to governmental units for waste collection and disposal (Becker, Pasurka Jr, & Shadbegian, 2013; Brunnermeier & Cohen, 2003) or the sum of pollution control equipment expenditure on wastewater, waste gas, waste disposal, and noise (Yang et al., 2012). Several studies have used PACE as a proxy to environmental regulation (Becker, 2011; Becker et al., 2013; Brunnermeier & Cohen, 2003; Hamamoto, 2006; Lanjouw & Mody, 1996; Rubashkina et al., 2015) with substantial success.

The advantage of using PACE is that it acts as an indicator of demand for environmental responsive innovation (Lanjouw & Mody, 1996), entails information on both pollution abatement capital and operating costs incurred by manufacturing firms (Brunnermeier & Cohen, 2003). In addition, it as a useful indicator as it encapsulates not just regulation but monitoring, enforcement and the strength of marketplace signals patented (Lanjouw & Mody, 1996)**.** However, the disadvantages of using PACE are that, it omit costs that are difficult to quantify (e.g. time spent on maintaining abatement equipment), productivity of other inputs (used for production), and that it might be sensitive to pollution abatement activities (Wayne B. Gray & Shadbegian, 2003). It is also problematic when one is interested in bidirectional effects, as innovation can lower PACE costs directly, but indirectly raise them due to a stimulated tightening in emission standards (Carrión-Flores & Innes, 2010). PACE data is also not readily available and therefore can only be obtained through primary data such as surveys. Overall, PACE is a good proxy for environmental regulations, however, due to difficulties in obtaining PACE data, hypothesis involving this variable was dropped from the study.

Environmental regulation can also be proxy by a combination of environmental permits/taxes, inspection/control and fines. The use of environmental permits and taxes as a proxy to environmental regulation has been employed in some studies with substantial results (Franco & Marin, 2015; Riveiro, 2008). The argument is that environmental taxation captures effects that pass through the inducement innovations, increasing resource efficiency and reducing the tax base (Costantini & Mazzanti, 2012). In addition, it represents a market-based measure rather than a command-and-control measure (Franco & Marin, 2015), and that environmental taxes are recommended to encourage innovation in environmental technologies than market based instruments (Klemetsen et al., 2013). Environmental permits/taxes may include licenses, consents, registrations, notices and direct legislation applications (Kneller & Manderson, 2012).

The advantage of using environmental permits are that they relate to environmental policy stringency, since they are often subjectively elicited from managers or policy makers' surveys and could be deemed somewhat arbitrary in their construction (Costantini & Mazzanti, 2012). They are also better than PACE or emission measurement which are likely to be endogenous due to confounding factors and reverse causality (Franco & Marin, 2015). In addition, the data on environmental taxes are easily available (Franco & Marin, 2015). On a positive view, firms can also exploit the governmental environmental grants/subsidies which may be considered as positive input of environmental regulation (Mazzanti & Zoboli, 2006). From the above discussion, it therefore better to measure environmental regulation using two or more proxies.

2.4.2 Innovations

In general term, innovation can be defined as a new or significantly improved product (good or service), process, organizational method or marketing method that creates better benefits compared to the alternatives (Rexhäuser & Rammer, 2014). However, innovation may or may not be successful in actually raising productivity or lowering costs hence the need to measure innovation using different methods (Kneller & Manderson, 2012). Therefore many PH studies have employed the use of patents, R&D expenditure, and process/product innovation to measure innovation at firm level.

Many studies on PH have used patent as a proxy to environmental innovation (Brunnermeier & Cohen, 2003; Adam B. Jaffe & Palmer, 1997; Klemetsen et al., 2013; Lee et al., 2011; Popp, 2001, 2005a; Rubashkina et al., 2015). Patents associated with environmental regulation may include but are not limited to patents involving hazardous or toxic waste destruction or containment, recycling or reusing waste, acid rain prevention, solid waste disposal, alternative energy sources, air pollution prevention and water pollution prevention (Brunnermeier & Cohen, 2003). In addition, patents can be classified in relation to the polluting factor such as water pollution, hazardous waste prevention, disposal and control, recycling and alternative energy (Carrión-Flores & Innes, 2010). The number of patents in relation to the cost of environmental regulation was therefore used to formulate the first hypothesis.

Hypothesis 1: Environmental regulation increases the chances of firm innovation activities through increased patents filing.

The advantage of using patent data is that it is readily available in highly disaggregated forms, distinguishing between innovation type, provides a measure of diffusion of the innovation and provides a good indicator of R&D activity (Popp, 2005c) and indicative of the level of innovative activity (Popp, 2006). However, patents have some limitation as not all successful research results are patented, the firm may want to keep the invention secret, and the quality of patents varies widely as some patents have been noted not to have any commercial values

(Popp, 2005a). Thus, Popp (2005a) concludes that results of studies based on patent data should be interpreted as the effect on an average patent, rather than specific inventions.

Other studies on PH have used R&D expenditure as a proxy to innovation (Adam B. Jaffe & Palmer, 1997; Popp, 2006; Rubashkina et al., 2015; Zhao & Sun, 2015). The advantage of using R&D expenditure as a measure of innovation is that it represent an input of the knowledge production function and measure the effort of private firms in pursuing innovation (Rubashkina et al., 2015), and that such data are available by governments or firms. However, R&D expenditures are affected by exogenous shifters of both demand and supply and therefore difficult to measure (Adam B. Jaffe & Palmer, 1997) and that it might be affected by firm size, the location of the facility and the sector to which the firms belongs. These factors may affect opportunities and incentives for investment in R&D (Lanoie et al., 2011).

Other studies have also used product or process innovations by arguing that new or improved product or process may be as a result of environmental regulation or other exogenous factors. Therefore, process or product innovation can have a direct impact on firm profitability through either improved products or processes that are green. In terms of product innovations, firms that are able to introduce a product that is new to their market (market novelty) gain a (temporary) monopoly position that can be transferred into a price premium. Process innovation can result in production cost reduction that might allow the innovating firm to keep unit costs below the market average, providing sources for extra profits (Rexhäuser & Rammer, 2014). Some studies have used this in firm survey to measure innovation (Ford, Steen, & Verreynne, 2014; Rennings & Rammer, 2011; Rexhäuser & Rammer, 2014). From the above discussions, measuring innovation using one proxy may be considered insufficient hence the need to use more proxies. However, due to difficulties in obtaining R&D data, product and process innovation data, hypotheses involving these variables ware dropped from the study.

2.4.3 Competitiveness

Firm competitiveness can been proxy by both profitability and total factor productivity (TFP).

i) Profitability

Firm performance can be accessed through profitability. Klemetsen et al. (2013) used profit margin as a measure of profitability. They calculated profit margin by dividing profits by total revenue. Other studies have however used return on sales as a measure of profitability by defining return on sales as pretax profit over sales (Rexhäuser & Rammer, 2014). But in order to reduce item non-response, they asked firms to state their return on sales on a categorical level by distinguishing seven classes, given as a percentage of pre-tax profit in total sales (Rexhäuser & Rammer, 2014). However, firms' profitability may be affected by other endogenous and exogenous factors hence may not relate directly to cost of environmental regulations. The relationship between profit margins and the cost of environmental regulation lead to the formulation of the second hypothesis.

Hypothesis 2: Environmental regulations increases firm competitiveness by increasing profitability

Firm's profit margin can also be determined by EBITDA, which is an acronym for earnings before interest, taxes, depreciation and amortization. EBITDA is calculated from the formula below.

EBIDTA = Revenue – Expenses (excluding tax, interest, depreciation and amortization) … (1)

EBIDTA is essentially net income with the interest, taxes, depreciation, and amortization added back to it. The advantage of using EBIDTA as measure of profitability is that it can be used to analyze and compare profitability between firms as it eliminates the effects of financial and accounting decisions. In addition, the data on EBIDTA is readily available as it is usually indicated on firm's financial books.

ii) Total factor productivity (TFP)

Firm competitiveness can also be measured by Total Factor Productivity (TFP) (Franco & Marin, 2015; Wayne B Gray & Shadbegian, 1995; Greenstone, List, & Syverson, 2012; Lanoie et al., 2008; Mohnen & Van Leeuwen, 2015). TFP can be considered one of the most comprehensive synthetic measures of business performance since it describes how effectively inputs are transformed into economically valuable outputs (Franco & Marin, 2015). TFP captures technical change, but in practice it also reflects the efficiency change, economies of scale, variations in capacity utilization and measurement errors (Rubashkina et al., 2015). The advantage of using TFP as measure of firm competitiveness is that it provides a measure of disembodied technical change. However, it also captures any deviation from the neoclassical assumptions such as equalization of marginal costs with marginal revenues and perfect competition (Franco & Marin, 2015). TFP can be calculated by the differences between output and weighed average of three inputs: labor, materials and energy expenditures, and capital stock. The calculation assumes that the all the inputs were directly and efficiently used to produce outputs (Wayne B Gray & Shadbegian, 1995). Therefore, the relationship between TFP and the cost of environmental regulation was used to formulate the third hypothesis:

Hypothesis 3: Environmental regulations increases firm competitiveness by increasing productivity

TFP cannot be measured directly but through a residual which accounts for effects on total output not caused by inputs. This residual is captured by the Cobb-Douglas production function (Miller & Upadhyay, 2002) where TFP is captured by the variable A in the equation (2) below:

$$Y = AK^{\alpha}L^{\beta} \quad \ldots\ldots (2)$$

Where Y represents total output, K represents capital input, L represents labor input, and alpha and beta are the two inputs respective shares of output. However the above question has been modified by some scholars to include other inputs such as cost of materials and energy (Wayne B Gray & Shadbegian, 1995) to change equation (2) above to:

$$Y = AK^{\alpha}L^{\beta}H^{\gamma} \quad \ldots\ldots (3)$$

Where H is the total cost of materials and electricity and gamma beings its share of the output. By assuming and allowing for the possibility of constant returns to scale and restricting $\alpha = \beta = \gamma = 1$ and taking the natural logarithm of equation (3) yield the following:

$$\ln Y = \ln A + \alpha \ln K + \beta \ln L + \gamma \ln H \quad \ldots\ldots (4)$$

Equation (4) above can then be used to calculate TFP of firms and will therefore be adapted in this study.

3 METHODOLOGY

This chapter outlines how the research was conducted through research design, variables, target population, sample size, and instruments that were used for data collection, data analysis and mode of data presentation.

3.1 Research design

A research design is a detailed framework or plan that helps in guiding a researcher through the research process, allowing for a greater likelihood of achieving research objectives (Wilson, 2014). It entails the conditions for collection and analysis of data in a manner that aims to bring relevance to the research purpose. This thesis adopted a descriptive research design to conduct the study. Descriptive research was chosen because it helps to describe existing or past phenomena by describing the subject using observations (Wilson, 2014). In this case the observed relationship between environmental regulation, innovation and competitiveness at firm level. The study was quantitative in nature, employing mainly the use secondary data that were analyzed using a range of descriptive statistics.

3.2 Variables for the study

3.2.1 Environmental regulation

The dependent variable for the study was environmental regulation as proxy by a combination of environmental permits/taxes, inspection/control and fines. As explained in chapter 2, firms in Norway have to apply for environmental permits before commencing operations. Usually permits have no expiry data but are renewed time to time due to changes in production which results in application of new or changed permit. In addition, according to the pollution control act, authorities can change permit every 10 years without application from the company. The permit fee depends on the amount of NEA fees and the risk of pollution and vary from case to case. Since it was difficult to trace the changes in permits or lack of more information about the same, the study adopted the cost of one permit which was based on the permit fee of a given risk class as a measure of environmental permit. In addition, the study counted the number and calculated the total costs of inspections and fines within the study period. Inspections fees are based on risk class while fines vary from case to case depending on the violation.

3.2.2 Number of patents

The first independent variable for the study was number of patents filed by the firm during the study period. Patents filed included successful, pending and rejected patents, this was assumed to be a better measure of innovation at firm level than strict use of successful patents. In addition, only the number of patents filed in Norway was considered ignoring the other or similar patents filed in other countries either by the firm or its sister firms. The reason being that it is only possible to relate innovation activities due to a given environmental regulation within a given country rather than having the two from different nations. In addition, different countries have different environmental regulations, some strict while others are pollution havens. Studies have also suggested that inventors respond to environmental regulatory pressure in their own country, but not to foreign environmental regulations (Popp, 2005b). The other reason of choosing patents in this study was that patents data is readily available.

3.2.3 Profit margin

The second independent variable for the study was profitability at firm level, which was proxy by EBITDA as represented by equation (1). EBIDTA was considered as a good measure of profitability because it allows for the comparison of profitability between firms and industries due to its ability to eliminate the effects of financial and accounting decisions at firm or industry level. This therefore allowed the study to relate environmental regulations and profitability hence evaluation of firm competitiveness. In addition, the reason for using EBIDTA was that the data was readily available as the value is usually indicated on firm’s financial books.

3.2.4 Productivity

The third independent variable was productivity, calculated from equation (4) which was used for the calculation of the TFP. The adoption of this variable was based on the fact that TFP is able to capture firm and industrial efficiency, technical change, economies of scale, variations in capacity utilization and measurement. The above factors were considered to be the major factors that could be affected by the environmental regulation that could determine how competitive a firm is. The factors could also shed more lights on how the firm response to the regulation or how it relates to innovations, as innovations can also increase productivity. In this study, output, capital, labor and materials/electricity were proxies by sales, physical capital, salaries (excluding managers) and cost of operation respectively. The assumption was that due to smaller size of the SMEs, all the above input factors were directly and efficiently used for production purposes. However this may not be true in all cases but it might presents a better way of getting closer to the ideal scenario. The other reason for use of these proxies is that the data is readily available and are reflected on the financial books of account.

3.2.5 Firm size

Firm size was used as the first control variable for the study. Larger firms are likely to have greater absolute levels of pollution abatement expenditure, and are also more likely to have the resources necessary to meet the fixed costs, and bear the risks, involved with undertaking investments in innovation (Kneller & Manderson, 2012) or have higher patenting activity (Brunnermeier & Cohen, 2003). In addition, Kammerer (2009) argues that larger firms have better opportunities and abilities to reduce environmental impact due to their financial and human resources and that firm size has a positive effect on the firms' environmental activities. Firm size can also be used to reflect firm visibility, as a result, the larger the firm, the more susceptible it may be to public environmental scrutiny. In addition, more often than not, large firms are called upon to act as industry leaders (Henriques & Sadorsky, 1996). Lanoie et al. (2011) and Klemetsen et al. (2013) used the number of employees as a measure of firm size hence the adaptation of the same measure in this study.

3.2.6 Firm age

The second control variable for the study was firm age, calculated from the year of establishment to the year 2014, which was the last year this study took into account. Older firms may be more affected by environmental regulation than younger firms. This is because the older firms may pollute more than the younger, more efficient firms. In addition, older plants have been noted to have higher environmental abatement cost spending and therefore less productive than the younger plants (Wayne B. Gray & Shadbegian, 2003). Studies such as the ones conducted by Horbach (2008) and Wayne B. Gray and Shadbegian (2003) have controlled for this hence adoption of the same on this study.

3.3 Sampling and sample size

The study targeted manufacturing SMEs firms operating in Norway that had 0-50 employees. Initially, sampling was done by first compiling the list of all the manufacturing firms in Norway. A total of 4109 firms met the selection criteria out of which 351 firms were randomly selected (95% confidence level and +/-5 confidence interval) for a survey. The survey was designed to capture the measurement of environmental regulations through PACE cost and environmental permits/taxes. Innovation through number of patents, R&D expenditure and number of product and process innovations. Competitiveness through profit margins and to capture variables used to calculate productivity (equation 4). However, only two responses were received after two reminders hence there was need to change the sampling method.

Thereafter, the author mainly used secondary data from different official websites. The new selection criteria was that a firm had to operate in the manufacturing sector, have 0-50 employees, registered with the Norwegian environmental authority and its financial and other data available on the relevant official websites. The researcher then adopted a stratified sampling technique where firms were grouped into homogenous subgroups that were distinct hence giving precise information on the whole population when the strata are grouped together. Firms were grouped according to the manufacturing sector in which they operate. Through this, the study was able to obtain data on manufacturing SMEs grouped by subsectors spread across Norway between 2010 and 2014 period. The selection of the 2010 - 2014 period was based on data availability and the reasoning that during surveys, it could have been easier for managers to recall firm activities and expenditure during these years than many years back. In addition, Klemetsen et al. (2013) had studied firms in Norway between 1993 and 2010 hence the need to be different.

3.4 Data collection

An effort to use triangulation method for data collection through means of primary and secondary data of firms was not successful due to survey failure as explained above. Data on environmental regulation was obtained from the Norwegian environmental agency (Miljødirektoratet) website[2]. The data included organizational number, cost of

[2] http://www.norskeutslipp.no/en/Lists/Virksomheter-med-utslippstillatelser/?SectorID=90

registration/environmental permit, firms' risk level classification, number and amount paid for each control/inspection, and environmental fines paid by the firms. Data on innovation was collected from Patents Norway website (Patentstyret)[3] and from the World International Property Organization (WIPO)[4], which included only patents filed in Norway by the firms. Attempt to obtain R&D data from Statistic Norway as an additional measure of innovation was futile.

Data on firm size, firm age, competitiveness and confirmation of organizational number were collected from the Proff website[5], the official website that provides accounting and performance information of Norwegian businesses. The number of employees and the difference between the year of establishment and the year 2014, were collected to represent firm size and age respectively. Organizational number was also reconfirmed to reconcile it with that which was obtained from Norwegian environmental agency website. This was done as a control check as it was realized that over time, some firms had changed names or had missing organizational numbers hence the need for data quality control. Data on competitiveness included EBITDA which was used as a proxy to profitability, sales, capital, salaries and operation cost which were later used to calculate TPF. Apart from the organization number, firm size and age, all the other data sets above were collected for five (5) years that is between 2010 and 2014 period, so as to achieve the lag of 3 - 5 years.

3.5 Data analysis

Data analysis was done using Statistical Package for Social Sciences version 22.0 (SPPS V22) for windows. Three analysis models were employed during data analysis representing 3, 4 and 5 year lags. Descriptive statistics, frequencies, correlation and regression analysis were used to perform the statistical analysis. The results from the statistical analysis was then used to summarize the findings and outline the study recommendations. Data and findings were presented using descriptive statistics, frequency tables, percentages, graphs and charts. Odd ratio of 95% or 99% confidence interval and 5% or 1% level of precision were used for data interpretation.

[3] https://search.patentstyret.no/
[4] http://www.wipo.int/patentscope/en/
[5] http://www.proff.no/

3.6 Reliability and validity of the study

The researcher used various strategies to ensure that the study methodology and data attained reliability and validity. The study adopted methodology that has been tested by many studies on PH, using only variables and data sources that has been used by similar studies. The data for measuring variables was obtained from the official national and international websites, hence the data is considered reliable and authentic. The study period was the same for all the firms hence it is expected that all firms were subjected to the same type of environmental policies and economic factors that determined profitability and productivity. This control ensured that there was a uniform platform hence helped in reducing some of the exogenous factors that might affect the study. The 3, 4, and 5 years lags also gave similar results hence validation of the methods. The major threat to reliability and validity of the study were the sampling method and inadequate data sources. Sampling depended on data availability and not following a statistical approach which could reduce the study reliability and validity. In addition, measurement of variables such as regulations, innovation and use of proxy and assumption for profitability and productivity could have been insufficient. Improving the reliability and validity of the study could be achieved through use of a triangulation methodological approach, use of more than one data sources per variable and more controls to reduce indigenous and exogenous effects.

3.7 Limitation of the study

Due to constraints in obtaining primary data from SMEs by way of survey, the study relied solely on the use of secondary data which might be inadequate in such studies for bringing out the best clear picture of the situation. It would be prudent to also obtain primary data from these SMEs especially on variables that cannot be measured by the available secondary data. Such data enrichment could involve the measure of environmental regulation using PACE and measure of innovation through R&D expenditure, product and process innovations. Lack of these may negatively affect the results as they could have given a better in-depth view of the situation. In addition, the study relied on assumptions and proxies to calculate profitability and competitiveness. These are likely to introduce errors to the results and therefore the most accurate scenario might not have been realized. Finally, there are some many endogenous and exogenous factors that might affect innovation, profitability and productivity. These factors could not be measured by the study hence it is difficult to conclusively conclude that the study findings are the true representation of the situation.

4 RESULTS

The cost of environmental regulations and total number of patents were lagged 3-5 years while a 3-5 year average was used for profitability and productivity. Assumption was that firms take time or longer periods to innovate or meet regulations. Due to difficulties in statistical analysis using results of log function of larger numbers, natural log (ln) values were used for productivity values. Two firms had negative capital values resulting in infinite productivity values hence are omitted from the results. All the lags yielded similar significant results with three and four year lags yielding close results while five year lag yielded more significant results (Appendix 1-2). Hence the results presented and discussed in this chapter are based on the five year lags.

4.1 Industrial operations

A total of 70 manufacturing firms, spread across various industries met the selection criteria for the study. The number was arrived at after excluding start-ups from the list as they were thought to be affected by newness or were considered to be unstable. As a result, the study considered only firms established more than 3 years before the beginning of the study period. The frequency and percentages are indicated in the Table 1 below.

Table 1: Frequency table of firms in the study

Industry	Frequency	Percent (%)
Chemicals	3	4.29
Chemical/Electrolyte	12	17.14
Feeds	2	2.86
Food	24	34.29
Metals	9	12.86
Mining	11	15.71
Oil and gas	1	1.43
Plastics/glass	4	5.71
Textile	4	5.71
Total	**70**	**100.00**

Food industry had the majority of the firms (34.29%) and the least being oil and gas (1.43%). The data spread across the nine industries was considered sufficient to be able to eliminate the effects of homogeneity thereby giving a clear picture of the relationship between environmental regulations, innovations and competitiveness at firm level of manufacturing SMEs.

4.2 Cost of environmental regulations across industries

The cost of environmental regulations (000) varies across and within industries as indicated in Figure 3 below. All the industries had a median environmental regulations cost below Kr 75,000/= apart from chemical and oil/gas industries.

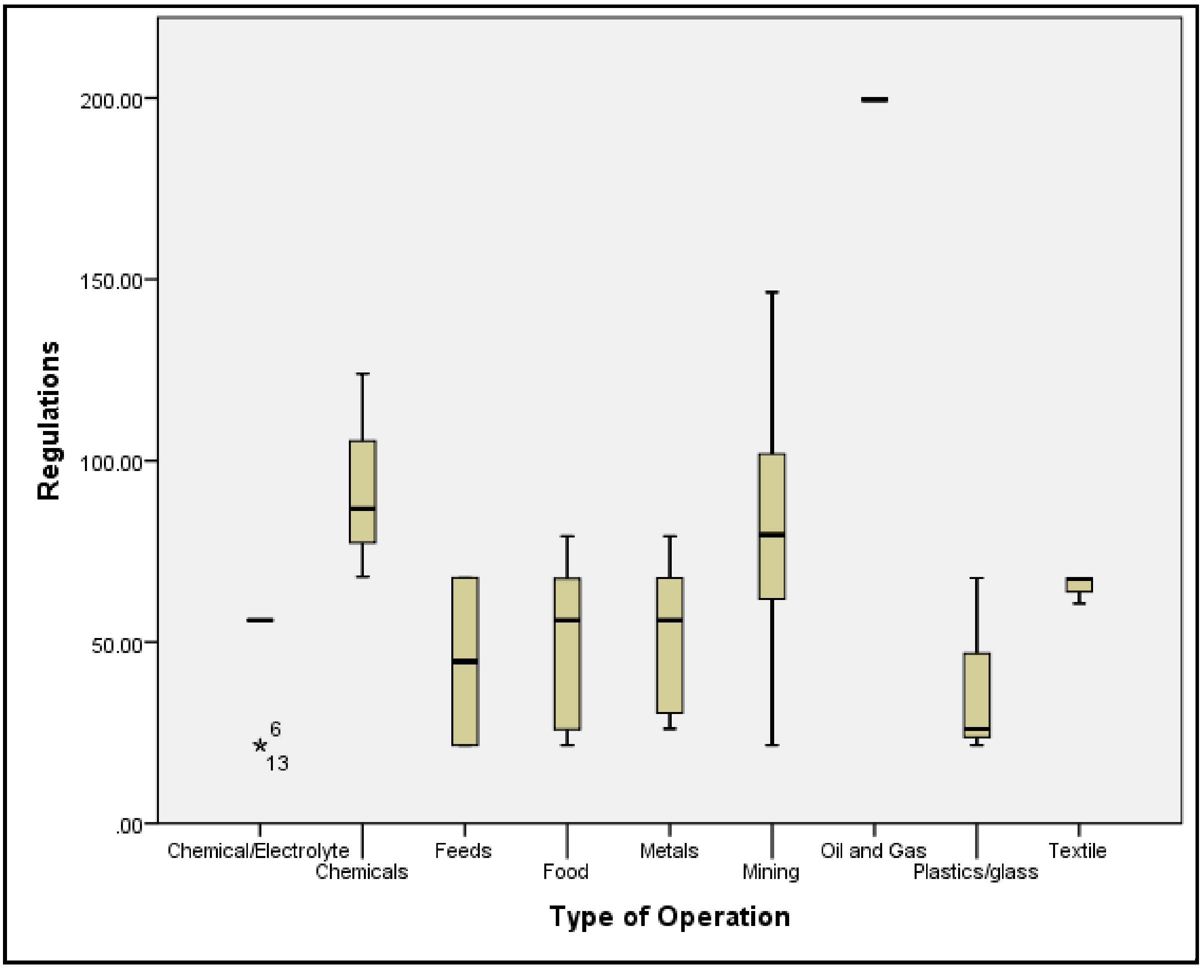

Figure 3: Cost of environmental regulations across the industries

Mining industries had the greatest cost variance while chemical/electrolyte had some outliers' values due to fines paid or lack of controls/inspections during the study periods. Despite the above, it seems that there is some similarities and closeness of the firms in this study in relation to the cost of the regulations. However, despite the above closeness, there was need for an in-depth look at the industries to determine how the cost of regulations is related to innovations, profitability and productivity. Therefore, the next step was to have an industrial view by looking at how various industries responded to regulations so as to be able to identify which industries if any, met the PH. This was achieved through graphs that related the cost of environmental regulations to the number of patents filed, profitability and productivity.

4.3 Environmental regulations verses innovations across the industries

As a first step, the author began the analysis by graphing the cost of environmental regulations and patents application to depict the innovation reactions of firms and industries towards the enforcement of environmental policies. A plot of average cost of regulations and average patents filed per industry (Figure 4) shows that in the five year period (2010-2014), patents were filed in all the industries except in metals, textile and, oil and gas industries. However, there is no indication whether these patents were environmental patents in reaction to the environmental policy. It can also be observed from the patents figures that only few firms filed for patents. This is an indication that in such studies, patents alone may not be an adequate proxy or measure of innovation activities, hence additional variables are required to measure innovation activities in SMEs.

The results shows a negative correlations between the cost of environmental regulations and number of filed patents across all the industries. The highest number of patents were filed in the plastic/glass industry which also had the lowest average cost of regulations. Oil and gas industry had the highest cost of regulations and filed no patent. The results across the industry therefore suggest that none of the industry followed the PH which postulates that an increase in the cost of regulations should encourage firms to be innovative through filing in patents. However the non-filing of the patents could be due to other reasons and not a pointer of lack of innovations activities in these SMEs.

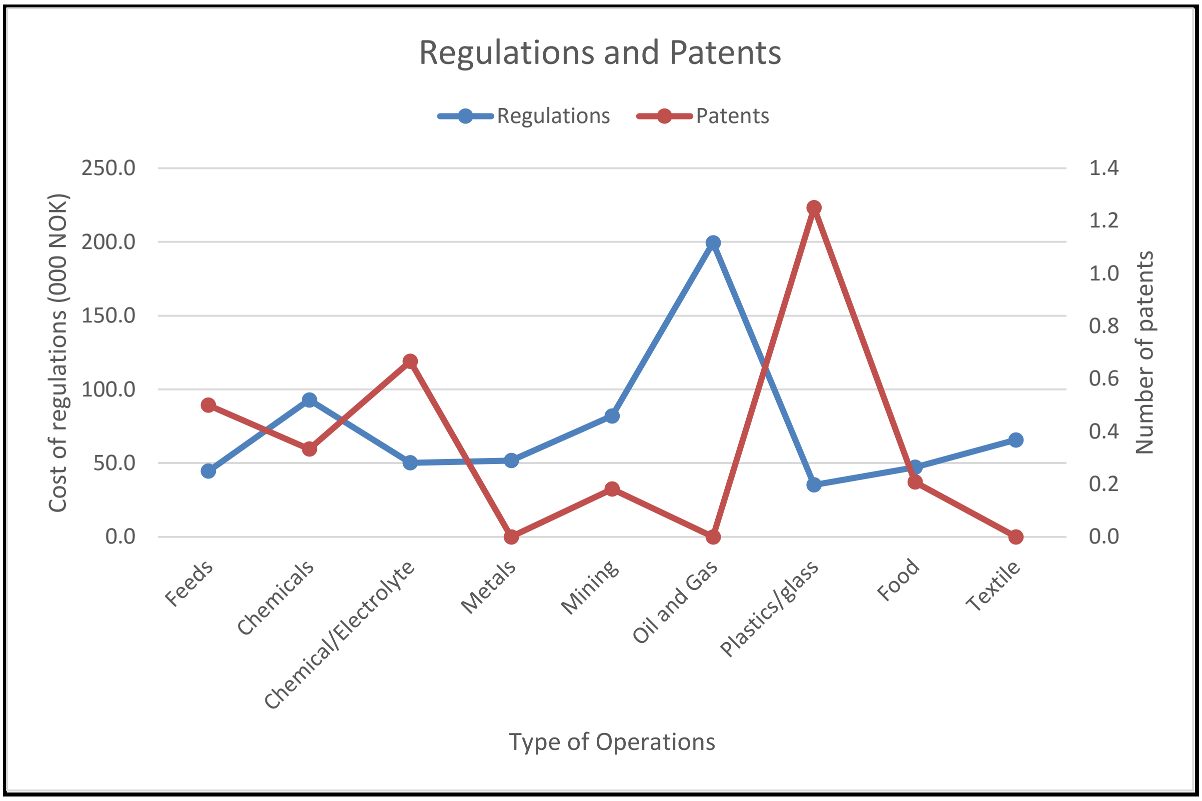

Figure 4: The cost of environemtal regulations verses innovation across the industries

4.4 Environmental regulations verses profitability across the industries

Figure 5 shows a plot of average cost of regulations and average profits for the five year study period (2010 – 2014). The profit values from oil and gas industry were removed from the plot as it was only one firm that made a huge loss hence considered an outlier. The results indicate that apart from feeds, chemical and food industries, all the other industries recorded minimal profits (below 1 million NOK) with mining recording the greatest loss of about 2 million NOK.

The results shows a positive correlations for feeds, chemicals, chemical/electrolyte, plastic/glass and food industries which might suggest a PH like relationship. The other industries had negative or undetermined correlation with the cost of regulations. Chemical industry had the highest cost of both regulations and profitability while mining had a higher cost of regulations and the lowest profits, a pointer to the difference on how firms and industries can be in terms of reacting to the environmental policies.

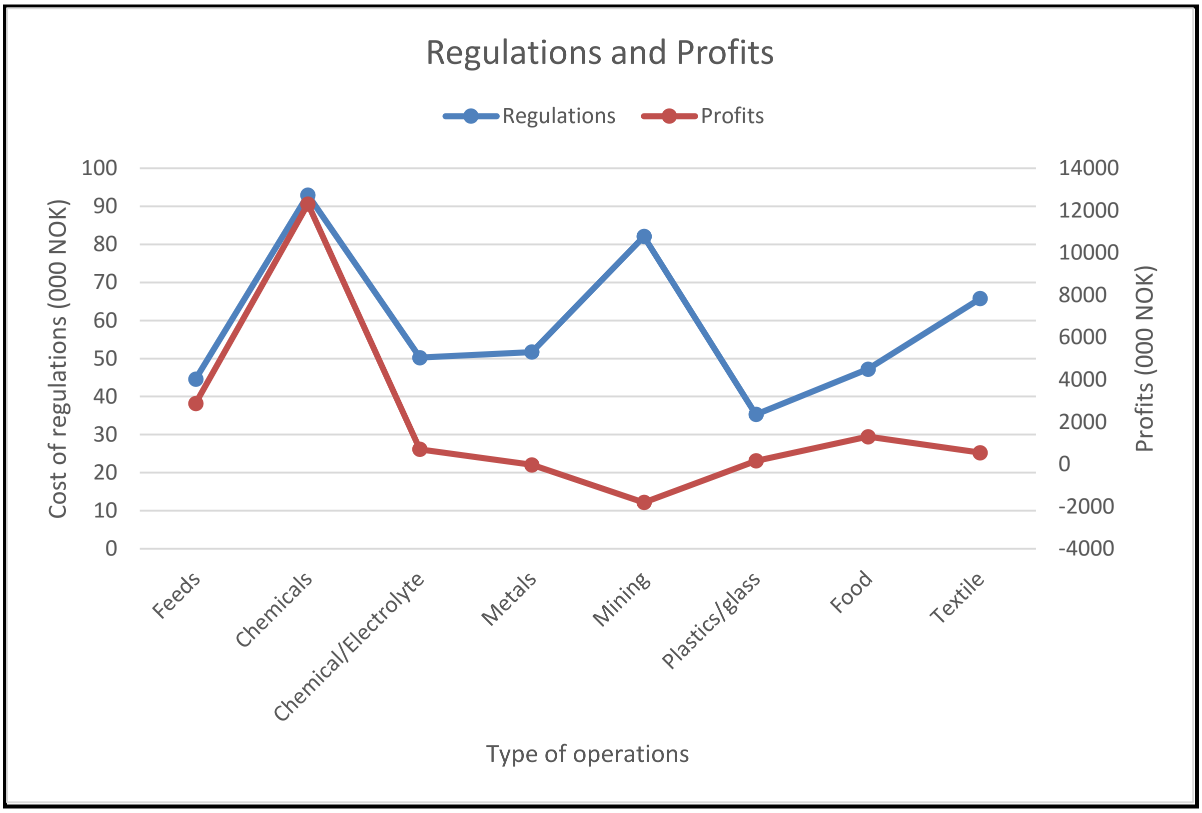

Figure 5: The cost of environmental regulations verses profitability across the industries

4.5 Environmental regulations verses productivity across the industries

Since the natural log (ln) of big values gives yields values that are zero or close to zero, the natural log of productivity values was used for the plot. A plot of the average cost of environmental regulations and average industrial productivity (Figure 6) indicates that productivity across the industries was similar falling between -15 to -20 values except for oil and gas industry.

The results indicated a negative correlations across all industries with oil and gas having the highest cost of regulations and the least productivity hence these industries do not follow the PH. It can also be observed that industries that had the highest patents filed (plastic/glass and chemical/electrolyte) had also the highest productivity while oil and gas industries did not file any patent and had also the lowest productivity. This might indicate that filing of patents might have contributed to increased productivity which may support the PH in these industries.

However, it can also be observed that chemical industry which had the highest profits had one of the lowest productivity hence not follow the PH.

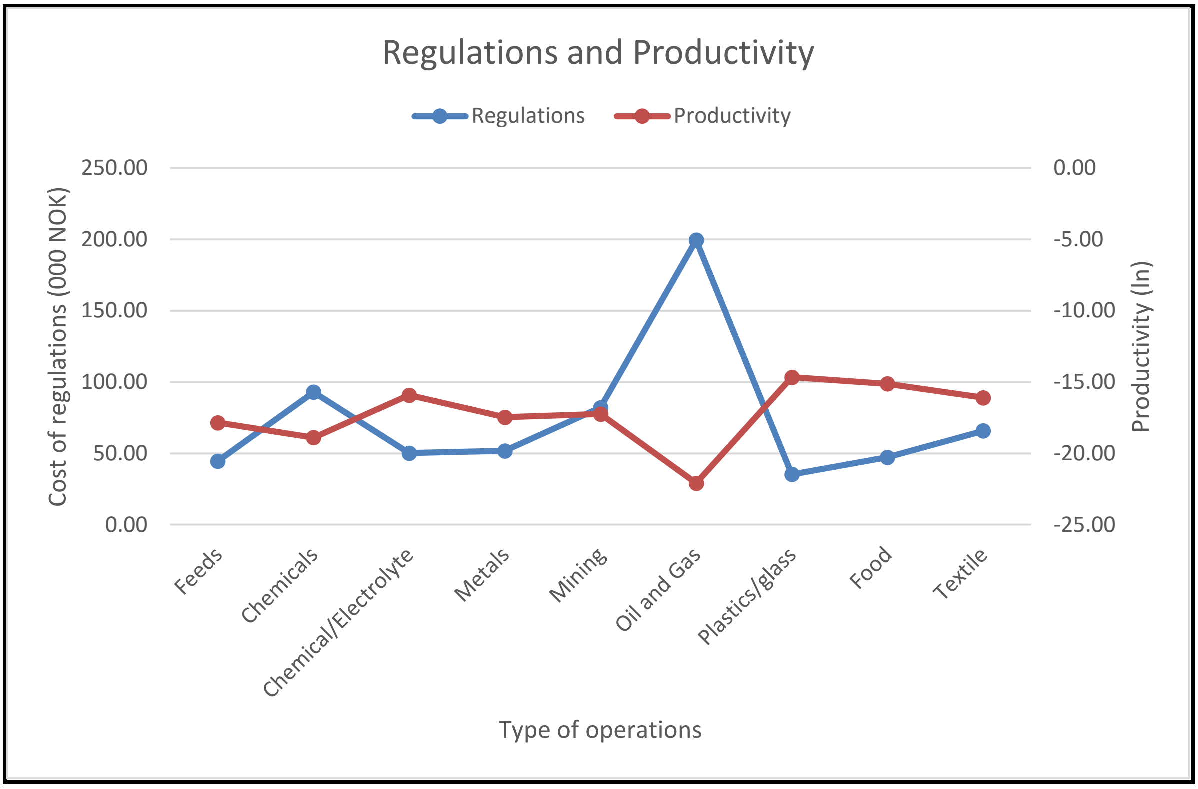

Figure 6: The cost of environmental regulations verses productivity across the industries

4.6 Descriptive statistics

Apart from industrial view above, it was also important to have a holistic view of SMEs through the use of statistics to determine how they react to environmental regulations. Descriptive statistics of dependent variable (environmental regulations), independent variables (innovations, profitability and productivity) and control variables were run to determine the data spread, mean and deviations (Table 2). The analysis lagged environmental regulations cost and number of patents for 5 years but used 5 years average values for profitability and productivity. The assumption was that it might take a firm more time to meet a specific environmental regulation or come up with an innovation while profitability and productivity are year specific.

The total number of the firms for each variable was 70 except for productivity which had two firms removed due to infinite results caused by negative values for capital. From the standard deviations values, it seems that firms are similar in terms of all variables except in terms of profitability.

Table 2: Descriptive statistics

Descriptive Statistics					
	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Regulations	70	21.50	199.50	58.23	32.30
Patents	70	0.00	6.00	0.32	1.12
Profits	70	-121864.80	30082.40	-809.83	16834.43
Productivity	68	-22.09	-5.79	-16.52	2.37
Firm Age	70	5.00	115.00	25.71	20.82
Firm Size	70	0.00	50.00	23.26	14.57
Valid N (listwise)	68				

4.7 Correlation analysis

Table 3 below displays the correlations between variables with each other and indicates values for Pearson correlations, Sig. (2-tailed) and number of samples (N) in each variable. The results shows that environmental regulations is negatively and significantly correlated to profits and productivity (-0.498 and -0.497 respectively), negatively correlated to patents and firm age (-0.039 and -0.102) and, positively correlated to firm size (0.119). The negative but significant values for profits and productivity therefore indicates that the cost of environmental makes a significant reduction in SMEs profitability and productivity. This is the exact opposite of the PH which postulates a significant increase in profitability and productivity due to the enforcement of environmental regulations. There is also a weakly negative correlation with patents indicating that regulations does not spur innovation in these SMEs. In addition the negative and positive correlation with firm age and firm size respectively is an expected case. The older firms are expected to be more polluting hence high cost of regulations due to older equipment and technology, and bigger firms are expected to be emit more pollution due to increased size.

Patents application was weakly and negatively correlated to regulations, profits and productivity (-0.039, -0.166 and -0.140 respectively) and weakly but positively correlated to firm size and firm age (0.048 and 0.063 respectively). The results shows that innovations through patents filing does not increase profitability and productivity hence does not meet the PH. Therefore in these SMEs, innovations has not been able to surpass the cost of regulations by triggering increased competitiveness through increased productivity by eliminating production wastages. The weakly positive correlation with firm age and size is an indication that a firm size and age may not be a factor when it comes to SMEs innovations activities.

Table 3: Correlations analysis

Correlations							
		Regulations	Patents	Profits	Productivity	Firm Age	Firm Size
Regulations	Pearson Correlation	1	-.039	-.498**	-.497**	-.102	.119
	Sig. (2-tailed)		.746	.000	.000	.399	.328
	N	70	70	70	68	70	70
Patents	Pearson Correlation	-.039	1	-.166	-.140	.048	.063
	Sig. (2-tailed)	.746		.169	.256	.694	.603
	N	70	70	70	68	70	70
Profits	Pearson Correlation	-.498**	-.166	1	.321**	.134	.032
	Sig. (2-tailed)	.000	.169		.008	.269	.795
	N	70	70	70	68	70	70
Productivity	Pearson Correlation	-.497**	-.140	.321**	1	-.128	-.421**
	Sig. (2-tailed)	.000	.256	.008		.297	.000
	N	68	68	68	68	68	68
Firm Age	Pearson Correlation	-.102	.048	.134	-.128	1	.110
	Sig. (2-tailed)	.399	.694	.269	.297		.365
	N	70	70	70	68	70	70
Firm Size	Pearson Correlation	.119	.063	.032	-.421**	.110	1
	Sig. (2-tailed)	.328	.603	.795	.000	.365	
	N	70	70	70	68	70	70
**. Correlation is significant at the 0.01 level (2-tailed).							

Firms profits was negatively and significantly correlated to regulations (-0.498), positively and significantly correlated to productivity (0.321), negatively correlated to patents (-0.166) and, positively correlated to firm age and firm size (0.134 and 0.032 respectively). The positive and significant correlations between profitability and productivity indicates that in these SMEs, the two variables are closely related and a factor for one another. Therefore increased production means increased profits and increased profits is an indicator of earlier efficient and higher production. The weak positive correlations with firm age and size stipulates that firm size and age do not significantly influence firm profitability.

Firm productivity was negative and significantly correlated to regulations and firm size (-0.497 and -0.421 respectively), positively and significantly correlated to profits (0.321) and negatively correlated to patents and firm age (-0.140 and -0.128 respectively). The negative but significant correlation with firm size could be an indication that smaller firms are better coordinated, efficient and well managed resulting in an increased and efficient productivity. However, the process of calculating productivity cannot be ruled out to have contributed to the observed results. In addition, the weakly negative correlation with firm age is an expected results as older firm may be less efficient in production due to older equipment and technology.

4.8 Regression analysis

Table 4 below shows a model summary of the effect of environmental regulations on firm's patents filing, profits and productivity (independent variables), and controlling for firm age and firm size (control variables). The summary shows that R = 0.640, which is the correlation of observed and predicted values of the dependent variable regulations. R square in the summary is 0.409, and represents the overall proportions of variance in regulations, involving independent and control variables as factors that may explain regulations.

Table 4: Regression model summary

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.640[a]	.409	.362	25.858
a. Predictors: (Constant), Firm Size, Profits, Firm Age, Patents, Productivity				

The results above indicates that the proportion of variance in the cost of environmental regulations that can be explained by the independent and control variables (patents, profits, productivity, firm age and firm size) is 41% (0.409). Though the larger percentage (59%) of the variability in the cost of environmental regulations cannot be explained by the model variables. It can be observed that the cost of environmental regulation has a quite strong association with firms' innovations and competitiveness, a factor that should spur these SMEs firms toward PH.

The regression coefficients of the dependent variable, environmental regulations is shown in Table 5 below. Taking into account that in the model, the unit of measure for the environmental regulation and profits was thousands, and productivity was by natural log function. The results shows that when all the other variables are kept constant there will be a reduction in the cost of environmental regulation by Kr 29, 917 (-29.917). In as much as this results is not significant (p=0.220), the reduced value of the environmental regulation could be a needed relieve for the SMEs which may be financially constrained.

Table 5: Regression coefficients

Coefficients[a]						
Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
		B	**Std. Error**	**Beta**		
1	(Constant)	-29.917	24.170		-1.238	.220
	Patents	-4.536	2.831	-.160	-1.602	.114
	Profits	-.001	.000	-.388	-3.598	.001
	Productivity	-5.642	1.599	-.414	-3.527	.001
	Firm Age	-.100	.157	-.064	-.640	.524
	Firm Size	-.059	.244	-.026	-.240	.811
a. Dependent Variable: Regulations						

The results also shows that filing of one patent by the firm could reduce the cost of environmental regulation by Kr 4,536 (-4.536) though the values are not significant (p=0.114). This results is the opposite of the PH where innovations is hypothesized to increase in response to enforcement of the environmental policies. An increase in profits by 1,000 NOK, would results in reduction in environmental regulation by Kr 1 (-0.001) and the value is significant (p=0.001). The results shows that profitability has minimal negative effect on the cost of environmental regulations hence does not support the PH. This could mean that firm's profitability is dictated by other variables and not necessary the cost of environmental regulations. As a result, these firms may not see the need to innovate to overcome the regulations as their profitability is assured no matter the cost of regulation.

A unitary increase in the natural log function of firm's productivity results in a reduction in the cost of environmental regulation by Kr 5, 642 (-5.642) and the value is significant ($p=0.001$). This results is contrary to the PH that suggest an increased productivity with increased cost of regulations due to reduction of production inefficiencies. A year increase in firm age and unit increase in firm size results in a reduction in the cost of regulations by Kr 100 and Kr 59 respectively with insignificant p values ($p = 0.524$ and $p = 0.811$ respectively). The results shows that when it comes to these SMEs, the age and size of the firm does not influence the cost of environmental regulations. This is contrary to the study done by Becker et al. (2013), that found that pollution abatement operating cost (POAC) intensity increased with firm size. However, as noted earlier, the other variables in the model only accounts for 41% variability in the cost of environmental regulations hence the larger share of the cost of environmental regulation is influenced by other variables that may have not been captured by this study.

5 DISCUSSIONS

The results in chapter 4 above shows that the firms were drawn from nine various industries, a required element that is needed to avoid homogeneity which could affect the results. This also means that the firms are faced with very different regulations requirements as pollutants vary across the industries. The industrial diversity was also considered useful in bringing in more insights and dimensions into the study. The study data can therefore be considered as an adequate representation of the manufacturing SMEs in Norway. In addition, the study can be considered sufficient in reflecting on how manufacturing SMEs reacts to the enforcement of the environmental policies. The results indicate that food industry with 34% (Table 1) was over represented in the study and may slightly affect the results. However the effect is expected to be minimal as the difference in percentage composition with the other industries is minimal.

All the industries had a median environmental regulations cost below Kr 75,000/= apart from chemical and oil/gas industries (Figure 3). The industrial operations that stood out in terms of high propensity for serious environmental violations and regulations were chemical, mining, and oil and gas. This is expected results as these industries are considered to be more polluting hence have high cost of regulation than the rest. In addition, due to high pollution level, these industries are also faced with higher controls/inspections and fines than the others. Despite the above, it seems that there is some similarities and closeness of the firms in this study in relation to the cost of the regulations. This was also confirmed by the risk level classification which showed that majority of the firms had risk level of 3 or 4 hence less polluting. However, the large difference between industries and firms is an indication of firm's relationship with regulation authority (NEA) and its environmental behavior. In addition, the difference could be because some firms are dirtier, or involve manufacturing processes with high potential environmental damage, and as a consequence have a larger cost of environmental regulations.

The industrial view analysis of how the cost of environmental regulations related to innovations (patent), profitability and productivity across the industries gave mixed results. Firstly, a plot of the cost of environmental regulations verses innovation (patents) yielded a negative correlations (Figure 4). Highest number of patents were filed in plastic/glass industry and none in oil and gas industry, industries that had the lowest and highest average cost of environmental regulations respectively. The study results therefore indicates that these SMEs do not conform to the PH. However, non-filing of the patents is an expected results is such studies as patents are seldom filed by firms. Some of the reasons that might attribute to this are, that applications for patents is very costly and therefore some firms may opt not to go for it. It could also be that some firms may want to keep their innovations secret and therefore would prefer trade secrets as opposed to filing in patents (Popp, 2005a). Another reason is that patent application by SMEs are generally low as they lack the financial, human and organizational resources to undertake major research and development that might result in profitable patents. Therefore, due to the above reasons, the results could also be an indication that in such studies, patents alone may not be an adequate proxy or measure of innovation activities, hence additional or multiple variables are required to measure innovation activities in SMEs.

Secondly, a plot of environmental regulations and profitability (Figure 5) showed a positive correlations for feeds, chemicals, chemical/electrolyte, plastic/glass and food industries which might suggest a PH like relationship. The other industries had negative or undetermined correlation with the cost of regulations hence do not confirm to PH. The above difference could be related and determined by industrial, firm or managerial aspects. Industrial factors could be related to the ease of meeting the regulations or the formulation of the industrial policies. The difference in correlations above could also offer insight into these SMEs characteristics and the behaviour and attitudes of their managers. Some of the reasons for the above mixed results could be that while feeds, chemicals, chemical/electrolyte, plastic/glass and food industries view environmental regulations as an opportunity, the other industries view it as a cost. Hence, the different attitudes adopted by these SMEs determines their PH results. Firms and industries that view environmental regulations as an opportunity tends to conform to the PH relationship hence the observed increase in profits with increase cost of environmental regulations. On the other hand, firms that view environmental regulations as a cost do not confirm to the PH hence the cost of environmental regulations eats slightly into their profit margins. In addition, the different correlations could suggest that the firms that conformed to PH relationships have come up with innovative ways to reduce wastages and increase efficiency which resulted in increased profit margins. On the other hand though, firms that did not conform to the PH had not innovated. Such firms and their managers had not tried to come up with innovative ways that would overcome the recurring cost of the environmental regulations thereby realizing increased profitability. However, firm profitability could be a result of many internal and external factors that cannot be fully or solely explained by the cost of the regulations. Profitability could also be based on the kind of industrial product or market hence these factors should be considered when discussing such results.

Thirdly, a plot of environmental regulations and productivity indicates a negative correlations across all industries (Figure 6), hence all the industry did not confirm to the PH. The results also indicated that industries that had the highest patents (innovations) had also the highest productivity and vice versa. This is a confirmation of the PH and the study concept that postulates an increased productivity as a result of innovations that are expected to reduce wastages and increase efficiency thereby increasing firm's productivity. Therefore, it can be considered that plastic/glass and chemical/electrolyte industries have realized the above relationship. However, since the cost of environmental regulation is so small compared to the other cost of production, it is not expected to affect firm's productivity that much. This might be the reason for the observed low productivity values and correlations. It should also be noted that the calculation of productivity employed equations and proxies that could have affected the results.

Apart from having the above discussed industrial view results, statistical analysis results (Table 2, 3, 4 and 5) gave holistic view and feedbacks on the proposed hypotheses as discussed below.

Hypothesis 1: Environmental regulation increases the chances of firm innovation activities through increased patents filing.

Hypothesis 1 was not validated by the study with regression analysis giving insignificant results and correlations analysis also giving negative and insignificants results between the two variables. The result is in agreement with other studies such as Adam B. Jaffe and Palmer (1997) that found little evidence that patents were related to regulatory compliance cost, Franco and Marin (2015) who found that upstream regulations negatively affected innovation and productivity. The invalidated hypothesis could be interpreted to mean that environmental laws are not currently well formulated to spur innovation activities in these SMEs (M. E. Porter & Van der Linde, 1995). This is a situation that can be overcome by bringing together government, policy makers and all other stakeholders in the formulation, review and implementation of the environmental polices so that there is a dual effect where the environment and the interest of the industries are protected by such policies.

It could also be possible that the management in these SMEs might have also played a role in the results obtained. This could be related to the behavior and attitude of the managers and their interpretations of environmental regulations, as either a threat or opportunity (Sharma, 2000) . A likely scenario is that the managers of these SMEs only view the regulations as a threat and a cost to be met and therefore they do not inspire innovation in their firms. They merely comply with environmental regulation but they do not see any advantages to be gained in developing green competencies through innovations (Rugman & Verbeke, 1998). As a result, these firms are comfortable with just meeting the cost of the environmental regulations but do nothing about it even though it minimally eats it into the firm's profit, or even if there are available ways in the firms than can actually be used to overpass the regulations standards and costs. It can therefore be suggested that these SMEs do not invest in firm-level improvements to enhance their green performance beyond compliance with the environmental regulation (Rugman & Verbeke, 1998).

The managers of these SMEs could also be viewed as either resistant to change, that is only concerned with preserving their private benefits of control over the firm (Aghion et al., 1997) or are risk averse (Sharma, 2000). They do not innovate for the fear that innovations may add complexity to their firm processes and therefore increase the risk both to the firm and to the manager (Sharma, 2000) or under-invest in opportunities as they put more weight on bad outcomes than on good ones (Ambec & Barla, 2006). Lack of innovations by the SMEs could also be related to the limited resources for R&D or they may only have few employees with no structure for R&D. Lack of such units and resources may greatly reduce the chances of coming up with innovations as there are no resources and employees assigned to R&D. Therefore, in as much as environmental regulations may induce R&D, innovations may not be achieved due failure to compose a R&D sector, allocate resources to R&D or in dealing with the uncertainty in research (Hart, 2004). It could also be that these firms prefer to wait for R&D spillovers to save on cost and avoid the risk of uncertain nature of R&D (Popp, 2005b).

Hypothesis 2: Environmental regulations increases firm competitiveness by increasing profitability.

Hypothesis 2 was not validated by the study though the regression analysis produced significant results and correlation analysis also gave negative yet significant correlations between the two variables. However the negative effect of the cost of environmental regulations on profitability is very minimal as showed by the value of unstandardized coefficients (Table 5). The result is in agreement with studies done by Alpay et al. (2002), that found that pollution regulations had little impact on profitability. Generally, a profit maximizing firms will innovate at finite intervals to maximize the net present value of the firm's profit flows (Aghion et al., 1997). However this is not the case in this study where we observe slight decrease in profits due to environmental regulations. The invalidation of the hypothesis could be seen as a revelation into the nature of these SMEs and their management. It could be that these SMEs and their managers are more concerned with minimizing efforts toward profitability as they may be more interested in running their firms quietly without interrupting their habits hence maintenance of the status quo (Aghion et al., 1997). Due to few employees and limited time, it could also be that the managers of these SMEs, whose limited time and attention is split between short term financial returns and reduction of long-term environmental cost, choose to spend more time and attention on the former over the latter (Sinclair-Desgagné, 1999). Therefore the cost of environmental regulations becomes a recurring cost to the firm rather than being eliminated to boost profit margins.

It could also mean that these SMEs view the cost of environmental regulation as a minimal external cost which they have no incentives to minimize (Adam B. Jaffe et al., 2005). As such they do nothing or very little to eliminate such costs even though such costs eats into their profits. The results could also be an indication of the presence of market failure that is not corrected by the enforcement of the environmental regulation. Hence, these SMEs which are assumed to be profit maximizers are unable to realize profitability that is induced by the environmental regulations (Ambec et al., 2013).

Hypothesis 3: Environmental regulation increases firm competitiveness by increasing productivity

Hypothesis 3 was invalidated by the study though regression analysis was significant and correlations analysis showed a negative yet significant correlations between the two variables. The results is in agreement with studies done by Wayne B. Gray and Shadbegian (2003) who found that PACE significantly lowered productivity, Becker (2011) who found that for an average manufacturing plant, there was no statistically significant effect on productivity due to environmental compliance cost, Alpay et al. (2002) who found that pollution regulations had negative impact on productivity, Lanoie et al. (2008) who found that the contemporary impact of environmental regulation was negative, and Greenstone et al. (2012) who found that, stricter air quality regulations were associated with a roughly 2.6 percent decline in TFP.

The invalidation of this hypothesis could be interpreted by arguing that the enforcement of the environmental regulations has failed to eliminate the production inefficiencies in these SMEs. This could indicate that the environmental policies has failed to push these SMEs to adopt greener efficient technology or reconsider and re-engineer their existing production routes to realize an increased productivity through realization of incremental innovations (Sinclair-Desgagné, 1999). The failure to adopt efficient technologies or alter the production processes could be because such alterations may be costly to the firm or that these SMEs might be too resistant to change. The invalid hypothesis could also be due to their size and nature, these SMEs might be using the rule of thumbs to make and implement decisions and choices, procedures that over time have dominated the decision making processes (Sinclair-Desgagné, 1999) hence resistance. The results therefore suggest that in these SMEs, environmental regulation has failed to identify and eliminate the production inefficiencies and regulatory disincentives that have prevented improvements in productivity (Murty et al., 2006).

The results could also be an indication that the environmental regulation has failed to eliminate the existence of market failure through market competitiveness based on green technology and products. Market competitiveness has failed to introduce urgency in decision-making processes of these SMEs. Therefore, there is no reduction in slack that is the amount of free-cash available to the managers. As a result of the above, these SMEs lack a disciplinary device to foster technology adaptation and growth that could greatly increase productivity and environment (Aghion et al., 1997). In addition, it could be that these SMEs' market competitiveness does not require them to produce at acclaimed environmental standards (Rege, 2000) or have not reached a Pareto-improving equilibrium (Constantatos & Herrmann, 2011).

Another reason for the observed results could be due to coordination and organizational failure at these SMEs. Since SMEs are small in size, it is expected that they may not experience coordination problems due to the fact that communication may not a big problem. However, due to lack of environmental policies and plans in most SMEs as opposed to MNEs, there may be lack of proper communications and habits that may results in systematic errors and losses that could lower the productivity and competitiveness (Sinclair-Desgagné, 1999). As a result, the environmental regulation has failed to create competitiveness of these SMEs by failing to solve the coordination problems among these SMEs (André et al., 2009). It could also be argued that organizational failure has not been resolved by the enforcement of these environmental regulations. Since these SMEs are in the manufacturing industry, they are expected to be the most polluting but also the most productive (Ambec & Barla, 2002). However, productivity is the manager's private information and therefore the firm must offer rents for information on high productivity. It therefore seems that the environmental regulations have failed to disrupt production by making the managers rent and polluting technologies less attractive. Therefore, it can be concluded that environmental regulations has failed to create external pressure to help these SMEs overcome organizational inertia (Ambec & Barla, 2002).

The results and discussions above points to the invalidation of all the three study hypotheses. The invalidation of all the study hypotheses returns a negative response to the research question that is environmental regulations negatively affects firm's innovations activities and competitiveness. The invalidation of the study hypotheses could suggest that manufacturing SMEs in Norway do belong to the economy paradigm and not the PH paradigm of environmental regulations on firm's strategies and performance. That is to say that they are comfortable with just meeting the requirement and cost of the regulations but do not see it as an opportunity and a challenge to innovate and increase competitiveness through increased profitability and productivity. The results therefore suggests that there is urgent need to encourage these SMEs towards PH. In order to encourage these SMEs to confirm to the PH, it requires the efforts of the Norwegian government, policy makers, NEA, SMEs managers and other stakeholders in review or formulating well-structured environmental laws that encourages PH. It would also require the government, NEA and Innovation Norway to do more in advocacy, incentives and interventions on matters environment and innovations so that there is change in attitude, behavior and organization structure of these SMEs so that PH is realized.

6 CONCLUSION

The study did not validated its hypotheses thereby returning a negative response to the research question that is environmental regulations negatively affects firm's innovations activities and competitiveness. There are a number of reasons why the effects of environmental regulations was negative or difficult to detect in this study. First, the data used in the study were limited in their ability to measure the relative stringency of environmental regulations, innovations, profitability and productivity, making it difficult to use such measures in regression analysis of the effects of environmental regulations on firms' innovations and competitiveness. Secondly, since the cost of environmental regulation is a relatively small fraction of the total cost of production, environmental regulations cannot be expected to be the major significant determinant of competitiveness in most industries. Thirdly, the difficulty in obtaining data from SMEs could have resulted in the negative results as the data might have been inadequate or the use of proxies may have not resulted in the best quality data.

Despite the above challenges, the study contributes to the PH by testing it on SMEs, an important area that has been neglected by most studies. Secondly it looked at the lagged effect of the regulations that offered more insights into the PH than previous studies. In conclusion, the results from this study suggest that these SMEs belong to the economy paradigm and not the PH paradigm of environmental regulations on firm's strategies and performance. Therefore, they merely comply with regulations but don't see the need to innovate. However the present analysis does not allow the author to conclude that this is the actual case as the results may be different or vary depending on the data sources, industry and country. Therefore the author recommends further studies and an urgent need for interventions to encourage SMEs in Norway towards the realization of PH. This calls for the government, policy makers, NEA, Innovations Norway, SMEs managers and other stakeholders to come up with well-structured laws that encourages PH. More also needs to be done on advocacy, incentives and interventions on matters environment and innovations to realize change in attitude, behavior and organization structure of these SMEs but also subsidies that could aid in the realization of PH.

6.1 Future research

The future results on PH should focus on SMEs as they constitute the majority of the firms of any industry in any country and because they are crucial actors for the adoption and the diffusion of innovation. Such studies should be helpful in understanding how SMEs reacts to environmental regulations thereby contributing to better understanding of PH. Firstly, due to data availability issues, such studies should focus more on obtaining more and richer data sets and longer time series to measure a given variable as opposed to using just one data set or 3-5 years period. This is expected to yield more significant results as well as a clearer picture and a better understanding of the situation. Secondly, adding an international dimension can greatly increase the variations both across policies and across outcomes thereby providing a richer sample and insight. Thirdly, a more industry focus studies on SMEs should be done. These studies should focus on a detailed analysis of the impact of particular classes of regulations or new regulation and develop hypothesis that could be then tested on other firms or industries using the data from these in-depth studies as control. Finally there should be model studies and projections by looking at how the global pollution levels, global warming, economic and market factors would affect the PH at firm and industrial levels.

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APPENDIX

Appendix 1-A: Correlations analysis (3 year lags and averages)

Correlations

		Regulations_3	Patents_3	Profits_3	Productivity_3	FirmAge	FirmSize
Regulations_3	Pearson Correlation	1	-.019	-.279*	-.394**	-.064	.105
	Sig. (2-tailed)		.878	.020	.001	.600	.387
	N	70	70	70	68	70	70
Patents_3	Pearson Correlation	-.019	1	-.158	-.156	.037	.060
	Sig. (2-tailed)	.878		.191	.203	.763	.622
	N	70	70	70	68	70	70
Profits_3	Pearson Correlation	-.279*	-.158	1	.320**	.187	-.002
	Sig. (2-tailed)	.020	.191		.008	.122	.988
	N	70	70	70	68	70	70
Productivity_3	Pearson Correlation	-.394**	-.156	.320**	1	-.109	-.378**
	Sig. (2-tailed)	.001	.203	.008		.377	.001
	N	68	68	68	68	68	68
FirmAge	Pearson Correlation	-.064	.037	.187	-.109	1	.110
	Sig. (2-tailed)	.600	.763	.122	.377		.365
	N	70	70	70	68	70	70
FirmSize	Pearson Correlation	.105	.060	-.002	-.378**	.110	1
	Sig. (2-tailed)	.387	.622	.988	.001	.365	
	N	70	70	70	68	70	70

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Appendix 1-B: Correlations analysis (4 year lags and averages)

Correlations

		Regulations_4	Patents_4	Profits_4	Production_4	FirmAge	FirmSize
Regulations_4	Pearson Correlation	1	-.019	-.279*	-.380**	-.064	.105
	Sig. (2-tailed)		.878	.019	.001	.600	.387
	N	70	70	70	69	70	70
Patents_4	Pearson Correlation	-.019	1	-.163	-.135	.037	.060
	Sig. (2-tailed)	.878		.178	.270	.763	.622
	N	70	70	70	69	70	70
Profits_4	Pearson Correlation	-.279*	-.163	1	.306*	.121	.046
	Sig. (2-tailed)	.019	.178		.010	.317	.703
	N	70	70	70	69	70	70
Production_4	Pearson Correlation	-.380**	-.135	.306*	1	-.158	-.427**
	Sig. (2-tailed)	.001	.270	.010		.194	.000
	N	69	69	69	69	69	69
FirmAge	Pearson Correlation	-.064	.037	.121	-.158	1	.110
	Sig. (2-tailed)	.600	.763	.317	.194		.365
	N	70	70	70	69	70	70
FirmSize	Pearson Correlation	.105	.060	.046	-.427**	.110	1
	Sig. (2-tailed)	.387	.622	.703	.000	.365	
	N	70	70	70	69	70	70

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Appendix 2-A: Regression analysis (3 year lags and averages)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.451[a]	.203	.139	25.25114

a. Predictors: (Constant), FirmSize, Profits_3, Patents_3, FirmAge, Productivity_3

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-19.068	25.706		-.742	.461
	Patents_3	-2.654	2.771	-.111	-.958	.342
	Profits_3	.000	.000	-.166	-1.330	.188
	Productivity_3	-4.924	1.669	-.391	-2.950	.004
	FirmAge	-.077	.155	-.058	-.496	.621
	FirmSize	-.133	.233	-.071	-.570	.570

a. Dependent Variable: Regulations_3

Appendix 2-B: Regression analysis (4 year lags and averages)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.436[a]	.190	.126	25.56353

a. Predictors: (Constant), FirmSize, Profits_4, FirmAge, Patents_4, Productivity_4

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-3.459	21.585		-.160	.873
	Patents_4	-2.340	2.799	-.097	-.836	.406
	Profits_4	.000	.000	-.175	-1.401	.166
	Productivity_4	-3.918	1.454	-.368	-2.695	.009
	FirmAge	-.089	.155	-.067	-.575	.568
	FirmSize	-.082	.240	-.044	-.340	.735

a. Dependent Variable: Regulations_4