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**Environmental Information, Asymmetric
Information and Financial Markets:
A Game-Theoretic Approach**

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Περιβαλλοντική πληροφόρηση, Ασύμμετρη πληροφόρηση και Χρηματαγορές: Μία προσέγγιση μέσω της θεωρίας παιγνίων

Περίληψη:

Η εργασία εξετάζει το πρόβλημα της ασύμμετρης πληροφόρησης μεταξύ των επιχειρήσεων και των χρηματαγορών που χρηματοδοτούν υπό μορφή δανείων, επενδύσεων, ασφαλειών, τις επιχειρήσεις. Πηγή της ασύμμετρης πληροφόρησης είναι η έλλειψη βασικής περιβαλλοντικής πληροφόρησης, δηλαδή η χρηματαγορές δεν έχουν επαρκή πληροφόρηση για το τι ακριβώς πράττουν οι επιχειρήσεις όσον αφορά στο περιβάλλον. Κατά συνέπεια, οι χρηματαγορές μη έχοντας τη δυνατότητα να διακρίνουν μεταξύ περιβαλλοντικώς υπεύθυνων και μη εταιρειών, δεν μπορούν να προβούν σε αποτελεσματική κατανομή των πόρων τους (επενδύσεών τους). Στην εργασία χρησιμοποιείται ένα υπόδειγμα από την θεωρία παιγνίων ώστε, αφ' ενός, να γίνει περισσότερο κατανοητό το μέγεθος του προβλήματος και αφ' ετέρου να προτείνει ως μερική λύση ένα διεθνώς αποδεκτό σύστημα πιστοποίησης και ελέγχου.

Environmental Information, Asymmetric Information and Financial Markets: A Game-Theoretic Approach

Abstract:

This paper examines the problem of asymmetric information in financial markets due to a lack of essential environmental information. Literature indicates that asymmetric information generates various problems for the actors of financial markets such as incomplete information for investment decisions and lending procedures, misallocation of financial markets funds, the underestimating of stock price securities and poor environmental risk management choices. To this end, this paper develops a game-theoretic approach to both examine the problem of asymmetric information caused by the absence of accurate environmental information and indicates how a well organized, internationally agreed auditing accounting certification scheme could play a critical role in solving this problem.

Keywords: Financial markets, environmental accounting, information asymmetry, accounting audit schemes.

1. Introduction

Information is very important for an effective decision making process for economic, environmental and managerial decisions. O'Dwyer (2005) says that good information flows advance democratic values for actors in the global financial world. Blowfield (2005) considers that information provides the possibility for the accountability of modern firms in the increasingly competitive globalized economic world, while simultaneously giving the essential sources for improving the process of environmental management. Therefore, economic, managerial, accounting and environmental economic fields have looked closely at the role that such information could play. New Institutional Economics (NIE), for example, considers information as a basic parameter estimating the risks and opportunities of economic actors, while management theorists consider information as the base for answering the relevant managerial problems at the micro- and macro-level. Accountants deem information as a very important factor for firms' and financial markets' operations and thus, they focus on finding specific accounting and auditing certification systems to accurately record all essential information and assure its quality.

Environmental managers and accountants want reliable and accurate information to make their decisions to solve environmental problems. They use economic, managerial and accounting techniques in order to collect relevant information to manage present or potential environmental risks. Gale (2006) highlights the necessity of accurate information on the economic and environmental

performance of firms that may not only assist them in their operations, but also help the participants of financial markets to organize environmental risk management strategies, which can play a critical role in the proper functioning of financial markets. According to Lorraine et al. (2004), the disclosures of information in relation to the good or poor environmental performance of firms ultimately affects their share prices and financial position, while Lanorie et al. (1998) consider that new types of environmental information drive financial markets to revise their prospects about the revenues and production costs of a firm. However, de Beer and Friend (2006) find a positive relationship between 'good' environmental disclosures and the operating of the financial markets. To understand this relationship, authors have examined the ways in which environmental information affects the environmental and economic management performance of different participants of the financial markets such as the banking sector, insurance companies and stock exchanges (Tucker, 1997; Cormier and Magnan, 2007).

Although environmental information is essential for reducing the risks of financial markets, firms usually provide incomplete information since this is done in an unstandardized fashion, on a voluntary basis and as result of the absence of an auditing certification scheme. These practices provide a limited amount of low quality information to the different participants of the financial markets. The absence of formal and rigorous accounting methods for recording environmental information and of an auditing certification scheme may explain a variety of drawbacks, which impede financial markets to manage financial risks arising from poor environmental performance. One significant drawback is the asymmetric nature of information between firms and other participants of the financial markets such as stock exchanges, the banking sector, investors and insurance companies. Asymmetric information may be described as the study of decisions in transactions where one party has more or better information than the other. Even in the case where firms communicate such information through environmental reports, Schaltegger (1997: p. 89) indicates that those reports '*are characterized by an information asymmetry between providers and the recipients of ecological statements*'.

To understand this problem, this paper, through the use of a game-theoretic approach aims to explain the gap between the knowledge of financial markets' participants and firms' environmental information. This analysis indicates the ways in which environmental information affects the financial and environmental decisions of

financial participants and concludes that a well-organized and commonly agreed environmental certified auditing scheme could assure the quality of this information and bridge this knowledge gap.

The remainder of this paper is organized in three sections. The second section presents a literature review on environmental information of firms and financial markets, accounting and information asymmetry and, finally, environmental accounting regulations and auditing schemes. The third section presents the model, which analyzes the problem of information asymmetry in financial markets. Finally, the fourth section presents the conclusions of this paper.

2. Literature Review

2.1. Environmental Information

Over recent decades, environmental problems such as soil degradation, water resources' diminution and air quality reduction have increased dramatically. To deal with such problems, different governmental and non-governmental organizations have implemented policies and tools such as market-based instruments (e.g. environmental taxes, subsidies and tradable permits), '*command and control*' instruments and voluntary tools (e.g. environmental management systems). The aim of these policies is to stimulate or compel organizations responsible for environmental degradation to implement environmental management practices to mitigate their impacts. By introducing the principles of environmental management, firms and participants of financial markets adopt environmental management strategies to both eliminate their environmental impacts and enhance economic benefits. In fact, firms impact the physical environment through their everyday operations and the financial markets impact the physical environment either as businesses themselves or as motivators for reorganizing firms' strategies in a more environmentally friendly way.

The successful implementation of such environmental practices by firms and financial participants requires a range of safe and clear environmental information mainly provided by environmental management accounting methods. Relevant literature outlines a number of different environmental management accounting

methods that record such information utilizing different measurement units and accounting principles such as Life Cycle Costing, Environmental Management Accounting and environmental accounting methods based on the Generally Accepted Accounting Principles (GAAP) (Dorweiler and Yakhou, 2005).

Such information helps participants of financial market to avoid potential financial risks associated with the poor environmental performance of firms, while also playing an important role in preserving the environment by stimulating such firms to implement stricter environmental management practices (Curran and Moran, 2007; Nikolaou and Giannakopoulos, 2009). Even though there is a consensus on the importance of such information to financial markets for managing their risks, more analysis is needed in order to assess how this can be effectively achieved. Firstly, firms require particular financial products from financial markets in order to finance environmentally friendly technologies, environmental management strategies and other environmental practices (Boyd, 1997; Boyer and Laffont, 1997). Thus, firms may disclose accurate information about their environmental performance to facilitate the financial markets' decisions about such products. Secondly, financial markets are significantly concerned about firms' environmental performance in order to avoid potential financial risks.

2.2. Environmental Asymmetric Information

A. Generally on Asymmetric Information

The problem of asymmetric information is not new. Neo-Classical Economics have recognized that information is not perfect. George Akerlof who got the Nobel Prize in Economics in 2001 for his contribution to the study of asymmetric information, in his famous 1970 article '*The Market for Lemons*' succinctly described the problem of how low quality used cars (lemons) drive high quality used cars out of the market. New Institutional Economics explain why such an imperfection creates problems. Ronald Coase (1937) argued that there is transaction cost in acquiring information, negotiating, monitoring, signing and enforcing contracts. Oliver Williamson explained how transaction costs can create problems in the smooth function of the market. Bounded rationality and opportunism are the two basic behavioral assumptions stated by Williamson (1988). Bounded rationality means that

the human brain has limited capabilities and cannot calculate all possible contingencies in the future. Coupled with opportunism, '*self-interest seeking with guile*' as Williamson defines it, is the reason why information asymmetry creates problems.

Asymmetry of information would not be a problem if economic actors did not behave opportunistically. If the seller of a used car, to refer to Akerlof's example, disclosed the full information about the car there would be no problem of information asymmetry. However s/he has the incentive to overestimate the quality of the car in order to gain more from selling it. Similarly it is in the seller's interest to conceal negative information about the car and disclose only good information. The buyer knows that and cannot trust the seller even if the seller discloses the full information. This means the buyer will try to pay less even if the car is really good. The buyer who cannot distinguish between a good used car and a '*lemon*' will not be able to offer a differentiated price but the same (pooling) price for both. This means the seller of a good car does not have the incentive to sell it because s/he is not going to gain the full price but a lower pooling price as a '*lemon*'. So, Akerlof concludes that bad cars drive good cars out of the market thus reducing the quality of used cars sold in the market. The way to partially solve the problem was discussed by Michael Spence (1973). He argues that in order to have a separating (not pooling) equilibrium, that is, two differentiated prices, a higher price for the high quality item and a lower price for the lower quality one, the player with superior information (in Akerlof's example, the seller of the used car) should send a costly signal to the second player, the buyer, such as offering an insurance or, providing a costly third party credible certification verifying the quality of the car.

B. Conventional Accounting and Asymmetric Information

Financial markets need complete and accurate information about the financial structure and the daily operation of firms, which are measured either in financial or non-financial units (Hoque, 2005). Healy and Palepu (2001) highlight that, '*information and incentive problems impede the efficient allocation of resources in a capital market economy*' (p. 407). For this purpose, they notify that firms' disclosures facilitate investors and financial markets to make precise decisions. Appropriate information is available to financial markets through formal financial statements

(published by firms) and external accounting reports prepared by intermediates (e.g. auditors and economic analysts).

Financial statements and reports are prepared mainly on a mandatory basis following GAAP principles and International Accounting Standards (IASs). This practice has assisted the production of an internationally acceptable set of high quality financial reporting standards, which limits management's opportunistic discretion in deciding the information disclosed (Barth et al., 2008). Lam and Du (2004) also believe that mandatory disclosures practices have a low level of estimation risk in the economy. However, while, accounting standards endeavour to reduce costs of preparing financial statements and to provide a commonly acceptable language for managers and investors, nevertheless there are no provisions for non-financial disclosures.

Healy and Palepu (2001) maintain that when a clear accounting regulatory regime and auditing organization are not in place, managers have incentives to reveal or withhold information from investors. Thus, firms are expected to voluntarily disclose where a rigorous regulatory regime covering the preferences of stakeholders is not in place. However, this produces several dilemmas. Firstly, the revelation of such information entails disclosure costs (Verrecchia, 1983) and mainly, where managers disclose bad news (Suijs, 2005). Firms have strong incentives to disclose voluntary information when financial participants consider it very significant in determining the fair value of firms and, consequently, improving their benefits (or eliminating the risks) (Dye, 1985). Moreover, firms are discouraged by increased competition to communicate private information when they have financial losses (Wagenhofer, 1990). This type of information costs is known as proprietary costs. Comparing these types of costs, Skinner (1994) considers that firms voluntarily communicate information when disclosure costs are relatively low compared to proprietary costs.

C. Environmental Information and Asymmetric problem

Today, the majority of financial participants want to know how the level of environmental performance of firms associated with their financial performance (positive or negative) and the way in which these consequences are transferred to market contracts, which are signed between participants and firms. This consideration

focuses on the necessity of those participants to *'keep risky securities out of their investment portfolio or ask for higher risk premiums, whenever they consider a company to have high environmentally induced systematic financial risks'* (Schaltegger, 1997; p. 88). In this sense, financial market participants demand environmental information to better organize their financial risk management procedures.

Firms provide such kind of information through a range of means such as formal financial statements, annual reports, environmental reports and internet sites. Current environmental disclosures are based either on the mandatory regulatory regime or on self-regulatory initiatives of firms. The former practice relies on the idea that it is better to disclose environmental information through financial statements based on current accounting regulation (Berhelot et al., 2003) since these could be more credible due to the utilization of advance financial auditing standards (Neu et al., 1998; Bewley, 2005). Based on those views, governments and independent regulatory accounting agencies issue accounting regulations such as the Security and Exchange Commissions (SEC) and the Accounting Standards Associations (ASA). For example, in the United States, the SEC issues certain report standards to record general contingent liabilities, including environmental issues (for instance, SFAS No. 5). Additionally, SFAS No.19 assists the estimation of restoration and abandonment costs as well as residual salvage values. Similarly, the American Institute of Certified Accountants (AICPA) introduced SOP 96-1 Environmental Remediation Liabilities (ERL), in which companies are required to publicly communicate their remediation liabilities. In the same vein, several European organizations have issued environmental accounting standards such as the European Commission (EC, 2001).

However, how complete such standards are is a result of the awareness and the knowledge of such organizations regarding the value of environmental information from financial markets, accounting and auditing bodies. In most cases, the requirements of financial markets for environmental information exceed the present state of information as upheld by the current accounting regulatory regime. In order to overcome this regulatory drawback or cover the complete absence of relevant regulations, some firms prepare environmental information on a voluntary basis. Actually, voluntary disclosures are a common practice by the majority of firms to face current unregulated (or partially regulated) environmental accounting standards and consequently, they develop a variety of self-regulated norms essential to communicate

such information. Authors attempt to explain this voluntary practice of firms mainly based on epistemological and ontological scientific assumptions and specific features of firms. Relevant theories are proposed to explain such voluntary disclosure practices such as the stakeholder theory, the political economy theory, the legitimacy theory, the agency theory and the social contract theory (Cooper and Owen, 2007). In the meantime, several studies examine the effect of different determinants on firms' disclosure choices: company size, industrial sector, location of environmental information in annual report, content of themes and firm profitability (Gao et al., 2005).

However, this practice gives rise to two problems namely a lack of information and asymmetric information (Synnestvedt, 2001). The former problem refers to the idea that there are few incentives for a firm to disclose private environmental information as well as lack of specific expertise to record such information. The latter problem, which impeded financial markets in the organization of their environmental risk management, is asymmetric information among firms' environmental disclosures and the demand from third parties for such disclosures.

2.3. Environmental Auditing

The low quality of environmental disclosures is also a result of a lack of a generally accepted environmental audit certification scheme to verify and assure the quality of this disclosed information. Several authors have proposed a range of auditing schemes in order to facilitate firms in disclosing such information. Some authors maintain that environmental information should be disclosed under the General Accounting Accepted Principles (GAAP) within formal financial statements (Nikolaou, 2007). This practice has an advantage due to the fact that firms gain credibility and improve the quality of disclosures in order to exploit the benefits of present financial audit schemes (Neu et al., 1998). Following such practices, firms might not disclose some kinds of information, essential for organizations to manage their environmental risks such as non-financial and bad environmental information. Other authors state that strict accounting requirements are necessary for reliable and accurate environmental information. In this sense, governmental organizations and financial market associations (e.g. SEC) provide some useful environmental accounting requirements. In this case, financial participants miss the chance to utilize

non-financial environmental information and information that covers a broad range of environmental issues. Today, most authors look for a formal environmental auditing scheme which can audit how accurate and complete relevant information can facilitate firms to manage their environmental risks (Dixon et al., 2004).

Present environmental auditing practices can be classified in two main categories, namely, as internal and external. Dittenhofer (1995) highlights internal auditing as the procedure that determines the level of firms' compliance with regulations and the way to find a range of environmental aspects which firms could improve. To this end, the majority of such environmental auditing provides general norms for examining the performance of firms in environmental issues. Conversely, he describes external environmental auditing as the procedure of independent agencies to assure that the economic and environmental performance of firms is as they disclosed in formal financial reports. Power (1997) comments, that external environmental auditing from financial auditors limits the reliability of disclosed information due to auditors' limited knowledge, skills and experience of environmental issues.

The absence of comprehensible international standards of environmental auditing leads many different governmental and non-governmental organizations to produce specific environmental reporting standards with specific environmental and ethical codes such as AccountAbility 1000 (AA1000) and the Global Reporting Initiative (GRI). This variety of auditing standards is also met in Gray's (2000) review work, which classifies environmental auditing schemes in two categories: those compiled and used by external participants (e.g. supplier audits, consumer audits, image audits) and correspondingly, those that are produced and used by internal participants. However, Watson and MacKay (2003) point to the absence of internationally agreed reporting standards as well as an international (or national) auditing certification scheme making environmental auditing a complicated and difficult procedure.

3. The model

Similar to the example of used cars is the problem of asymmetric information in the financial markets with respect to environmental information disclosures by firms. We have two players. Firms that demand funding (buyers of money) and want

to attract investments and financial institutions (e.g. banking and insurance companies, investors) that want to make investments in firms. In the ideal case of symmetric information, financial institutions would offer funding (loans, insurance premiums, buying stocks) at the level where they would maximize their profits, that is where marginal cost equals marginal revenue. This means that firms with higher levels of environmental performance would get higher investment than firms with lower levels of environmental performance, assuming that an environmentally responsible firm has higher chances of being successful reducing environmental costs such as potential fines and penalties from the government and regulation agencies, costs of managing pollution or other kinds of environmental accidents and/or decreased sales due to boycotting by customers who will not purchase its products and services.

In other words, the higher the environmental responsibility and performance of a company, the less the chances of environmental accidents, pollution and fines that is, the lower the environmental cost of their operations. Financial institutions fund firms based on many factors (financial performance, for instance) including environmental performance. As mentioned above, the more a firm is environmentally responsible the less the chances of accidents and fines, so the less the chances that the financial institution's investment will fail (lose its value in total or in part). So, based on the information which in the ideal scenario is perfectly symmetric or, even if asymmetric, firms' disclosures are trustworthy, financial institutions will allocate their resources in an optimal way maximizing their profits by maximizing the level of return of the investments on the firms given the known probabilities of failure or accident- that is the risk which is common knowledge.

Given asymmetric information and the incentive for firms to be self-laudatory in their reports (Holder-Webb et al. 2009) there is misallocation of resources and a decrease of the total social welfare. An environmentally responsible (ER) firm that incurs the cost of ER action may not get the appropriate amount of funding (highest investment value) because of inadequate information at the financial institution level, and a non-ER firm that does not incur a cost for ER action may get higher investment than optimal. This scheme distorts the incentive for good firms to really invest in environmentally responsible activity much like owners of good used cars are not willing to sell them. Just as bad cars drive good cars out of the market, non-ER firms do the same to ER firms.

In order to elaborate on the aforementioned discussion and to better illustrate the problem of inefficiency as a result of the asymmetry of information between firms and financial markets, a simple game-theoretic model is used (Chymis et al., 2007). We suppose we have 2 players, firms (f) that demand investments and financial institutions (fn) that offer investments. The firms can engage in ER activity or not. The problem is how financial institutions can trust firms' claims that they have taken ER actions, given that firms have incentives to claim they are ER even though they are not in order to increase the value of any possible investment.

It is assumed that when a firm has taken an ER action it means it has already estimated and evaluated potential environmental risk associated with its activities and has taken action in limiting this risk to the maximum possible point thus organizing a risk management strategy. If this information can pass to the financial institution it means the financial institution will not need to re-estimate and re-evaluate the potential environmental risk from the specific firm's activities thus liberating resources to be invested in this or other ER firms. Otherwise the financial institution has to incur the costs of searching for relevant information, and redesigning a risk management strategy, that is, of doing the firm's homework (evaluation and estimation of potential environmental risk and design of an environmental risk management strategy). Because financial institutions are held accountable for environmental accidents if firms are not ER, in this case it is the financial institutions that have to replace firms in environmental responsibility.

In case of an accident (e.g. environmental problem, unexpected pollution, other environmentally harmful effects from the operation of the firm etc.) there is a cost of remedy that has to be taken otherwise fines may be levied or the market (customers and markets in general) may punish the firm and the financial institution. The chances for an accident as well as the remedy costs vary from industry to industry. It is different for a heavily polluting industry (chemicals, oil, pharmaceuticals,) than the software industry for example (Chymis, 2007; Waddock and Graves, 2000; Griffin and Mahon 1997).

The objective is to examine the conditions under which this game has a separating or a pooling equilibrium, that is, if the financial institutions can identify ER and non-ER firms and offer a separating investment or not and thus offer a pooling investment.

$e(s, k)$: Expected value of investment which is an increasing function of s , the expected sum of investment and k , other market factors affecting the reliability of the firm such as financial performance indicators and other general market and economic conditions.

c^{er} : Cost of per unit environmentally responsible activity, or ER action, by firm. Apparently, an environmentally responsible firm has to take a series of actions. We have firms that are more or less environmentally responsible. In order to model the environmentally responsible activity we consider this activity per unit, that is, one specific ER action.

c^{re} : Cost of per unit re-evaluation, re-estimation of environmental risk by financial market. This corresponds to per unit cost of ER activity.

u : Cost of remedy measures taken in case of unexpected event (e.g. environmental accident)

p_a^{er} : Probability that an accident occurs when environmentally responsible action has been taken

p_a^n : Probability that an accident occurs when environmentally responsible action has not been taken

p_l^{er} : Probability of loss of expected investment value (firm goes bankrupt) when environmentally responsible action has been taken¹

p_l^n : Probability of loss of expected investment value (firm goes bankrupt) when environmentally responsible action has not been taken.

We assume that $p_a^n > p_a^{er}$ the probability that an unexpected event, which will incur remedy cost u , is higher when a firm has taken an ER action than the corresponding probability if the firm has not taken the ER action. Similarly, we assume that $p_l^n > p_l^{er}$ the probability that the value of the investment is lost when the firm has taken an ER action is higher than the corresponding probability if the firm has not taken the ER action.

Note that our model is a cost benefit analysis based strictly on the costs of engaging or not in an environmentally responsible action. We do not include in the

¹ In reality this may be more complicated with different probabilities on different percentages of investment that can be lost. This can be described by an integral containing all possible probabilities for all possible percentages of loss. Without loss of generality and for simplicity reasons we express the integral with a probability of losing the whole investment (firm goes bankrupt).

model any societal value on environment per se other than that indirectly incorporated in the term p_l , that is, the probability of loss of investment. This probability indirectly incorporates any societal value on the environment. This value reflects on the monetary value of the investment by the financial market to the firm.

3.1. ER action by Firms

A firm is going to take an ER action if doing so is less costly than not doing so. This happens when:

$$c^{er} + p_a^{er}u + p_l^{er}e(s,k) \leq p_a^n u + p_l^n e(s,k) \quad (1)$$

or if

$$c^{er} \leq u(p_a^n - p_a^{er}) + e(s,k)(p_l^n - p_l^{er}) \equiv c^f \quad (2)$$

The left hand side of equation (1) shows the per unit expected cost to a firm of taking an ER action and the right hand side, the expected cost of not doing so. Equation (2) shows that the firm will take the ER action if the cost of this action does not exceed a maximum value for the firm c^f . Every time c^f increases it means it is efficient for the firm to take the ER action. The higher the c^f is, the higher the number of firms taking ER actions. This maximum cost increases in e , s , u , p_a^n , p_l^n . It decreases in p_a^{er} , and p_l^{er} . In plain words, the incidence of ER actions will increase if the expected value of the investment, the amount of investment, the cost of remedy measures in case of accident, and the probabilities of an accident or loss of investment when an ER action has not been taken, increase. Firms will have a decreased incentive to take an ER action if the probability of an accident and of losing the investment (bankruptcy) when ER action has been taken increases.

So, as investment value increases a firm has incentive to engage in ER action. Whether all firms engage in ER action depends on firm specific costs as well as industry specific costs. We could expect large firms in heavy pollutant industries that have a lot to lose from not engaging in ER activities will most probably take ER actions. Indeed research has shown that industry and firm size affects the level of environmental performance (Chymis 2007, Waddock and Graves 2000, Griffin and Mahon 1997).

Clearly we see the incentive for a firm to be environmentally responsible because of the expected value of the investment from the financial institution will be

higher as well as because of other factors such as higher probability of accident and even loss of the investment value. For any given c^f , there will be firms that take an ER action when $c^{er} \leq c^f$ and firms that do not when $c^{er} > c^f$.

There are two possible cases. One is a pooling equilibrium in which –*ceteris paribus*– there is one amount of investment offered by the financial institutions regardless if the firm has taken the ER action or not and a separating equilibrium where the financial institution –*ceteris paribus*– offers a higher investment for firms that have taken the ER action and a lower one for those that have not. The second case requires that there is no asymmetry of information and that financial institutions know which firm is ER and which is not. We discuss in the next section what the financial institutions do.

In the case of the separating equilibrium the higher amount of investment s increases through the parameter e (value of the investment) the cost of not taking the ER action for firms. We denote the new maximum non-ER action cost \bar{c}^f where we observe firms taking the ER action. Now, we can expect that more firms will have $c^{er} \leq \bar{c}^f$ but not necessarily all firms. This means that even in the case of a separating equilibrium not all firms will take the ER action. However the incentive for a firm to take the ER action is now higher once the firm will receive a higher investment from the financial institutions.

3.2. Re-evaluation by Financial Institutions

Financial institutions have to decide whether to incur costs of re-evaluation and re-estimation of environmental risk from firm’s activities. If firms have taken the ER action financial institutions can get firms’ evaluation without any extra costs of designing a separate risk management strategy for their own. The question is whether to trust firms’ reports or not, just like the case of the used cars where the buyer has the choice to either trust the report of the seller about the condition of the car or not to trust and incur costs to take the car to a mechanic and get the precise condition of the car. Financial institutions have to either believe or not the announcements and reports from firms and base their risk management strategy purely on firm’s reports without any further costly investigation.

The financial institution has not full information about whether the firm has taken the ER action. Suppose q , where $0 \leq q \leq 1$ is the perceived probability that the

firm has taken the ER action. If $q = 1$, then the financial institution knows with certainty that the firm has taken the ER action; if $q = 0$ the financial institution knows with certainty the firm has not taken the ER action. Financial institutions will not take the action of re-estimating and redesigning an environmental risk strategy when the cost of not re-estimating is less than the cost of re-estimation. This is true if:

$$q(p_a^{er}u + p_l^{er}e(s,k)) + (1-q)(p_a^n u + p_l^n e(s,k)) \leq c^{re} + p_a^{er}u + p_l^{er}e(s,k) \quad (3)$$

or if

$$c^{re} \geq [u(p_a^n - p_a^{er}) + e(s,k)(p_l^n - p_l^{er})](1-q) \equiv c^{fn}. \quad (4)$$

The left hand side of equation (3) expresses the expected cost to the financial institution from not re-evaluating the risk management strategy, based on the probability that the firm has taken the ER action (q) and the probability that the firm has not taken the ER action ($1-q$). The right hand side of the same equation represents the expected cost of re-estimation. Without loss of generality we assume that after the action of re-estimation, the probabilities for an unexpected event or for a loss of the investment are the same as after the firm takes the ER action. Simplifying (3) we get equation (4) which shows that it is inefficient for the financial institution to re-estimate if the expected cost of re-estimation is greater than a maximum condition c^{fn} . This is similar to the condition for the firm c^f , however in this case the condition is a function of, q , the perceived probability that the firm has taken the ER action.

We see that as long as $q < 1$, that is, if financial institutions cannot know with certainty that a specific firm has taken the ER action, financial institutions will offer a pooled investment. The inefficiency is clear: Even when a firm has taken the ER action and there is no need for the financial institution to re-evaluate and redesign an environmental risk strategy, $c^{fn} = 0$ and $c^{re} > 0$, due to asymmetry of information we have $q < 1$, $c^{fn} > 0$ and $c^{re} < c^{fn}$ for some financial institutions, which means that some financial institutions will incur cost c^{re} although they should not because it is pure waste.

The question is whether financial institutions can know with certainty which firms have taken an ER action and which have not, so we can have a separating equilibrium solution to the problem of asymmetric information.

3.3. Solution through a third party auditing certification system

We mentioned previously that the solution to the asymmetric information as proposed by Michael Spence (1973) is a costly signal sent by player 1 (firms) to player 2 (financial institutions). The solution is the existence of a separating equilibrium. This can happen when the firm which participates in the certification program (this can be an internationally agreed environmental auditing scheme) gets an official certification that indeed has taken the claimed ER action.

An official and perfectly credible certification is the costly signal the environmentally responsible firm sends to the financial institutions. Given the assumption the internationally agreed auditing scheme is credible the financial institution can know with certainty which firm is ER and which it is not. So, q , the perceived probability, now becomes certainty and takes the value of 1 or 0 and nothing in between. The financial institution can now offer a separated investment. Higher in the case of an ER firm and up to the amount of c^{re} , the cost of re-evaluating and reorganizing an environmental risk management strategy. Lower in the case of a non ER firm because the financial institution needs to take the cost of re-evaluation and organization anew of a risk management strategy on behalf of the firm.

We see that from the financial institutions' point of view the problem of asymmetric information gets solved once a credible auditing certification system is in place. However from the point of view of the firms this is not clear yet and we need to elaborate on that. Does every environmentally responsible firm want to participate in the certification program? We assume that non ER firms will not participate because once they have not taken the ER action they do not want to pay the extra cost to be certified they have not taken the ER action. From equation 2 we understand that if $c^{er} > c^f$ firms will not take the ER action and do not have any incentive to participate in the auditing certification program which entails a cost c^c .

The interesting question is if all firms which are ER firms will enter the auditing certification program. The firm knows that if it takes the ER action and if it gets the certification it will receive a higher investment from the financial market, but this will happen only when the sum of the cost of the ER action plus the cost of the participation to the auditing certification scheme is less than the maximum non-ER

cost, or $c^{er} + c^c \leq \bar{c}^f$ (recall that \bar{c}^f is the maximum non-ER action cost due to the higher investment the firm will receive from the financial institution).

If we combine the two conditions, one for taking the ER action ($c^{er} \leq c^f$) and the other of participating in the auditing certification program ($c^{er} + c^c \leq \bar{c}^f$) we get a new condition $c^c \leq \bar{c}^f - c^f$. Firms will participate in the auditing certification program if this condition is satisfied, namely, if the per unit ER activity cost of getting the certification from the generally agreed auditing scheme is less than the per unit ER activity change of moving from a pooling to a separating equilibrium. In other words the condition says that the per unit ER activity cost should not exceed the change in the maximum non-ER action cost, change that takes place due to the financial institution's higher investment to the ER firm. We need to note here a final plausible case. That is when $c^{er} > c^f$ and c^c is small enough (it satisfies the condition $c^c \leq \bar{c}^f - c^f$) so that $c^{er} + c^c \leq \bar{c}^f$. This means there may be firms which under the case of a pooling investment they wouldn't engage in the ER action but, under the prospect of the separating investment they would engage in the ER action given that adding the cost of certification would still satisfy the last condition.

Consequently we can conclude that the implementation of a generally agreed auditing regime will solve the asymmetric information problem but not completely. It depends on the cost of this auditing scheme. Still there will be firms that the above condition will not be satisfied and the higher the cost of the auditing program, the more firms will not participate even though they engage in ER activity.

4. Conclusions

We saw that a generally agreed international environmental certification auditing scheme can be a solution to the asymmetric information problem. However, it is not going to solve it completely (i.e. perfectly) because its implementation is costly. Our model shows that the cost of per unit implementation of the program should be less than the extra amount of investment the financial institution will offer to the firm.

Empirical research is needed to estimate the cost of the implementation of such a program. It is true that if this cost gets split among all firms that want to participate it may be relatively low. In our model we talked about the per unit

environmentally responsible activity. This means that the corresponding cost of verification for one ER action is really low. Of course, a firm which participates in the program will be certified for a series of activities. We can imagine a check list which includes many boxes to be ticked. It is not impossible that the whole auditing program is less costly than what the current situation in the financial markets is.

The fact that asymmetric information is highly costly is manifested in the financial markets with the series of programs that have been in place in order to decrease the asymmetry such as the ISO, GRI, GAAP, EMAS etc. However, as we mentioned in the first part of the paper, the problem has not been solved in a satisfactory way and financial markets still operate inefficiently due to the persistence of information asymmetry.

This study demonstrates the need of a generally agreed international environmental accounting certification auditing scheme. According to the literature we propose that the scheme should take into consideration the industry and the size of the firms. Mining, Petroleum, Chemicals, Pharmaceuticals, Food, Machinery, Utilities are industries that by their nature pollute more than industries such as Retail, Software, Telecommunications, Banks and Financial Services. The international auditing scheme should be designed based on the industry characteristics.

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