# How does environmental performance affect financial performance? Evidence from Japanese manufacturing firms

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# How does environmental performance affect financial performance? Evidence from Japanese manufacturing firms*

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**Abstract**

This paper examines the effects of environmental performance on financial performance using the data of Japanese manufacturing firms from 2004 to 2008. As the environmental performance, our study considers the two different environmental issues of waste and greenhouse gas emissions in capturing the effects of corporate environmental management on financial performance. In addition, to clarify how each financial performance responds to a firm's effort in dealing with different environmental issues, we utilize many financial performance indices reflecting various market evaluations. Our estimation results show the different effects of each environmental performance on financial performances. For example, while an increase in waste emissions generally improves financial performance, their reduction ameliorates financial performance in dirty industries. In addition, while greenhouse gas reduction leads to an increase in return on equity, it does not have a significant effect on return on sales which reflects the evaluation in the goods market, and it leads to a decrease in the natural logarithm of Tobin's $q$, which indicates the value of intangible assets.

**Keywords:** Environmental Performance; Financial Performance; Japanese Manufacturing Firms; Waste Emissions; Greenhouse Gas Emissions

**JEL Classification:** D22; Q53; Q56

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## 1 Introduction

Does better environmental performance improve a firm's financial performance? Seeking to answer this question, many studies have been conducted from both the economic and business administration perspectives (see e.g. Porter and van der Linde, 1995; Hart and Ahuja, 1996; Russo and Fouts, 1997; Konar and Cohen, 2001; King and Lenox, 2002; Nakao et al., 2007).[1] Researches on the relationship between environmental and financial performance are not only meaningful in the sense of analyzing firm behavior, but also important from the social benefit perspective. In economic literature, environmental problems have traditionally been treated as inconsistencies between social and private benefits and have mainly been left to government intervention to solve them. However, if financial performance is positively related to environmental performance, firms have incentives to reduce their environmental damages. This means that environmental problems may be solved by the market mechanism without government intervention, leading to a preferable environment for both firms and the government. For this reason, analyzing the relationship between environmental and financial performance also has important policy implications.

In recent years, many stakeholders of firms such as governments, non-governmental organizations, local communities, consumers, trading partners, employees, investors, financial agencies and stockholders are conscious of corporate environmental management, especially in developed countries. This directly or indirectly influences the financial performance of firms. For example, if a firm violates an environmental regulation or causes an environmental accident, the firm not only has to pay fines and penalties, but may suffer from a loss of trust and reputation or a boycott of goods. Such risks have negative effects on the evaluation of a firm's future profits. On the other hand, a firm that actively addresses environmental issues might gain positive reputation among some stakeholders and may influence them to expect that the firm will succeed in reducing environmental risks and production costs in the long term. Therefore, firms have an incentive to address various environmental issues against the backdrop of various stakeholders' interests.

This paper demonstrates the relationship between environmental and financial performance, and moreover, considers the relationship between the characteristics of each environmental issue and the responses of various markets and stakeholders' behaviors behind them. In previous empirical studies, the relationships between environmental and financial performance are controversial. Cordeiro and Sarkis (1997), Sarkis and Cordeiro (2001), Wagner et al. (2002), and Rassier and Earnhart (2010) advocate a partially or completely negative relationship.[2] On the other hand, Hart and Ahuja (1996), Russo and Fouts (1997), Konar and Cohen (2001), and King and Lenox (2002) report a positive relationship. Some studies such as Hart (1995) and Ambec and Lanoie (2008) indicate the channels from which environmental

[1] Murphy (2002), Molina-Azorín et al. (2009), and Blanco et al. (2009) provide detailed surveys on the relationship between environmental and financial performance.

[2] Walley and Whitehead (1994) theoretically explain a negative relationship between environmental and financial performance.

performance affects financial performance. Specifically, Hart (1995) explains the relationship between the two performances by considering natural resources in the resource-based view. Ambec and Lanoie (2008) summarize the channels and suggest that better environmental performance can improve financial performance in both revenue (e.g. better access to certain markets; differentiating products; and selling pollution-control technologies) and cost aspects (e.g. risk management and relations with external stakeholders; costs of material, energy, and service; cost of capital; and cost of labor).

Meanwhile, most of the existing studies do not necessarily capture the characteristics of each environmental issue enough since they use a few indices as the proxy for environmental performance. In recent years, there have been many kinds of environmental issues such as global warming, acid rain, deforestation, ozone depletion, biodiversity, pollution of the environment by toxic chemical compounds, and waste issues. Each environmental issue has different characteristics such as the scope of pollution (e.g. local or global), length of time until damages emerge, severity of the damages, facilities for specifying the polluters, and existence of regulations and international treaties. These various characteristics suggest that different stakeholders may place emphasis on different environmental issues. Some stakeholders, for example a local community, may directly suffer from a firm's environmental pollution while others may not suffer from it but may have monetary relationship with the firm. Therefore, some stakeholders may think that global warming is a more important problem than any other environmental issue and others may think that the waste problem is the most crucial issue. These stakeholders' differentiated preferences for environmental issues may affect financial performance. Taking this into account, this paper therefore considers two different environmental issues, waste and greenhouse gas emissions, as environmental performance. Waste and greenhouse gas emissions are different in many points such as the scope of pollution and existence of regulations, and therefore they are related to different kinds of stakeholders who directly or indirectly influence the financial performance of firms through various markets. Employing the amount of waste and greenhouse gas emissions enables us to investigate the difference of the market evaluation on different kinds of environmental issues.

Previous studies using the amount of emissions as environmental performance are as follows. Hart and Ahuja (1996) show that a reduction in emissions of selected pollutants improves financial performance, such as return on sales (ROS), return on assets (ROA), and return on equity (ROE) for a sample of S&P 500 firms. Konar and Cohen (2001) also indicate that a decrease in toxic chemical emissions ameliorates Tobin's $q-1$ in the S&P 500 firms.[3] King and Lenox (2002) obtain the same conclusion using toxic chemicals emissions as environmental performance, and ROA and Tobin's $q$ as financial performance for a sample of publicly traded U.S. manufacturing firms. In contrast, Wagner et al. (2002) make an index for environmental performance based on $SO_2$, $NO_x$, and Chemical Oxygen Demand (COD) emissions, and use ROS, ROE, and return on capital employed (ROCE) as financial performance for a sample of firms in the European paper manufacturing industry. They show that worsened environmental

[3] Konar and Cohen (2001) also use the number of lawsuits as environmental performance.

performance improves ROCE and has no significant effect on ROS and ROE.[4]

As for financial performance, this paper pays attention to many indices such as ROE, ROA, return on investment (ROI), return on invested capital (ROIC), ROS, Tobin's $q-1$, and the natural logarithm of Tobin's $q$ in order to take into account each market's evaluation of corporate management dealing with different environmental issues. In existing research studies, financial performance is proxied by some indices such as ROA, ROE, and ROS by Hart and Ahuja (1996); ROA by Russo and Fouts (1997); Tobin's $q-1$ and the natural logarithm of Tobin's $q$ by Konar and Cohen (2001); ROS by Sarkis and Cordeiro (2001); ROA and Tobin's $q$ by King and Lenox (2002); ROCE, ROE, and ROS by Wagner et al. (2002); ROA, ROS, and Tobin's $q$ by Elsayed and Paton (2005); and ROA and Tobin's $q-1$ by Nakao et al. (2007). These studies provide mixed results on the relationship between environmental and financial performance, implying that there are various channels from which environmental performance affects financial performance. Given this, the important point is that there is a possibility that each financial performance is affected directly or indirectly by different stakeholders.

This paper focuses on the Japanese manufacturing sector using the data of 268 firms from 2004 to 2008. Since the manufacturing sector is generally considered to have a closer relationship with environmental issues, we consider that manufacturing firms have stronger incentives to actively or voluntarily deal with environmental issues through various means. In practice, active environmental management such as over-compliance with regulations, publication of Corporate Social Responsibility (CSR) reports, and other voluntary approaches are introduced in many Japanese firms. With regard to previous studies using Japanese firm-level data, Nakao et al. (2007) uses the environmental score from the Nikkei Environmental Management Survey as environmental performance and shows that better environmental performance improves financial performance such as ROA and Tobin's $q-1$ in the Japanese manufacturing sector. Nagayama and Takeda (2007), Yamaguchi (2008), and Takeda and Tomozawa (2008) also investigate the effects of new environmental information (e.g. release of environmental management ranking) on stock prices by using an event study methodology. Furthermore, Cole et al. (2006) analyze the determinants of environmental performance of firms in Japan and find that globalization has positive impacts on environmental management.

Finally, our contributions to literature are as follows. First, in order to capture the characteristics of different environmental issues, we pay attention to both waste and greenhouse gas emissions as environmental performance. Second, to clarify how various financial performances are influenced by different environmental issues, we use seven financial performance indices such as ROE, ROA, ROI, ROIC, ROS, Tobin's $q-1$, and the natural logarithm of Tobin's $q$, and examine the behaviors of various stakeholders. Third, to the best of our knowledge, this paper is the first in attempting to utilize the amount of emissions as environmental

[4] As the proxy for environmental performance, some previous studies use integrated indices provided by independent organizations such as rating companies, instead of the amount of emissions. For example, Russo and Fouts (1997), Butz and Plattner (2000), Salama (2005), and Elsayed and Paton (2005) utilize environmental ranking as environmental performance.

performance instead of environmental scores from studies using Japanese firm-level data.

The remainder of this paper is organized as follows. Section 2 discusses the estimation methodology and data. Section 3 presents empirical results. Section 4 concludes the paper.

## 2 Estimation methodology and data

The main purpose of this study is to examine the effects of environmental performance on financial performance. Following previous research studies, some other determinants that may have effects on financial performance are also included in the estimation equation as explanatory variables in addition to environmental performance. Our basic specification is expressed as follows:

$$\begin{aligned} Financial\ performance_{it} = \beta_0 &+ \beta_1 Size_{it} + \beta_2 Growth_{it} + R\&D_{it} \\ &+ \beta_4 Advertisement_{it} + \beta_5 Capital\ intensity_{it} + \beta_6 Leverage_{it} \\ &+ \beta_7 Waste_{it} + \beta_8 Greenhouse\ gas_{it} + \mu_i + \varepsilon_{it} \qquad (1) \end{aligned}$$

where $i$ denotes the firm; $t$ indicates the period; and $\mu$ is the firm-specific fixed effect. Financial performance is ROE, ROA, ROI, ROIC, ROS, Tobin's $q-1$, or the natural logarithm of Tobin's $q$. We use these dependent variables because each of them reflects the behavior and evaluation of various stakeholders with different interests. ROE includes the stockholders' evaluation and performance of the goods market. ROA, ROI, and ROIC reflect not only the equity capital contributed by stockholders but also borrowed capital provided by creditors and investors. ROS indicates the market evaluation by consumers and trading partners. Tobin's $q - 1$ and the natural logarithm of Tobin's $q$ are interpreted as the intangible assets value of the firms.[5] Then, as for explanatory variables, *Size* represents the firm size; *Growth* is the firm growth. *R&D* is the research and development intensity; *Advertisement* is the advertisement intensity; *Capital intensity* is defined as the sales and operating revenue divided by stockholders' equity; and *Leverage* is the financial leverage, defined as the sum of liabilities and net assets divided by total stockholders' equity. The detailed definitions of each variable are provided in Table A1 of the Appendix. The rationale underlying our selection of these variables is based on previous preeminent studies such as Russo and Fouts (1997), Konar and Cohen (2001), King and Lenox (2002), and Nakao et al. (2007).

As the proxies for environmental performance, we take waste and greenhouse gas emissions into account. *Waste* and *Greenhouse gas* are defined as waste and greenhouse gas emissions divided by sales and operating revenue, respectively. We pay attention to these two factors

[5] Based on Konar and Cohen (2001), the concept of Tobin's $q$ can be briefly explained as follows. The market value of the firm ($MV$) can be expressed as the summation of the firm values from the tangible assets ($V_T$) and from the intangible assets ($V_I$). Since Tobin's $q$ is defined as $MV/V_T$, from a simple calculation, Tobin's $q - 1$ is equal to $V_I/V_T$. Therefore, Tobin's $q - 1$ is interpreted as the intangible assets value of the firms, such as patents, brand name, and so on. Following Hirsch and Seaks (1993) and Konar and Cohen (2001), we use Tobin's $q - 1$ and the natural logarithm of Tobin's $q$ as the dependent variable. Hirsch and Seaks (1993) compare the two specifications with respect to Tobin's $q$ using Box-Cox transformations and show that the semi-log specification has higher log-likelihood values than the linear specification.

because they reflect different kinds of environmental problems. In Japan, waste emissions are regulated by various laws. Many environmental pollution issues emerged during the high economic growth period of the 1950s through 1970s. Given that these issues aroused national discussion on environmental problems, various environmental laws and regulations were formulated such as the Basic Law for Environmental Pollution Control in 1967, which was succeeded by the Environment Basic Law in 1993 and the Basic Act on Establishing a Sound Material-Cycle Society in 2000. On the other hand, greenhouse gas emissions have only been paid attention to in relatively recent years since the address of global warming issues, which lead to the formulation of the Law Concerning the Promotion of the Measures to Cope with Global Warming in 1998. However, this law does not explicitly address the reduction in greenhouse gas emissions of individual firms. More regulations on greenhouse gas emissions may be imposed in the future due to this insufficiency, individual firms need to deal with this uncertainty. In particular, waste and greenhouse gases have different characteristics as environmental issues, such as the scope of pollution and existence of regulations.

Our study focuses especially on the sign and significance of each environmental performance on various financial performances, which is influenced by various stakeholders' behaviors. If environmentally-friendly management has positive (negative) effects on financial performance, the sign of environmental performance can be negative (positive). In addition, if environmentally-friendly management is not related to financial performance, the coefficient is not significant.

Our sample is drawn from three data sources. The data of waste and greenhouse gas emissions come from the Corporate Social Responsibility Database released by Toyo Keizai (2006, 2007, 2008, 2009). Since Toyo Keizai (2006) started to conduct questionnaire surveys on waste and greenhouse gas emissions, we use all available data in the initiation of this study. Furthermore, because the Toyo Keizai conducts multi-year questions in its survey, we utilize the results of the survey conducted at the most recent time.[6] Next, stock prices come from the "Kabuka" (Stock prices) CD-ROM 2010 provided by Toyo Keizai (2010). Finally, all other data are taken from the NEEDS (Nikkei Economic Electronic Databank System) released by Nikkei Digital Media (2010). Based on all available data of manufacturing firms from these three data sources, our sample consists of an unbalanced panel data, which includes 268 Japanese manufacturing firms from 2004 to 2008. Descriptive statistics of each variable are reported in Table A2 of the Appendix.

As the estimation method, we use the fixed effect (FE) model because our sample consists of five-year unbalanced panel data. The FE estimation allows us to control unobserved firm-specific fixed effects that may affect financial performance and, therefore, deals with the endogeneity issues resulting from unobserved firm-specific effects. Although we also conduct the pooled ordinary least squares (OLS) and the random effects (RE) estimation, econometric

[6] Specifically, the data from 2004 comes from Toyo Keizai (2006); data from 2005 comes from Toyo Keizai (2007); data from 2006 comes from Toyo Keizai (2008); and data from 2007 and 2008 comes from Toyo Keizai (2009).

tests indicate that the FE estimation is preferable to other estimations.[7] Our analysis proceeds as follows. First, we report the estimation results using the full sample. Second, in capturing the relationship between the dirtiness of industries and environmental performance, we divide the full sample into 'clean' and 'dirty' industries since environmental performance is associated with the inherent dirtiness of an industry. Every firm in our sample in the manufacturing sector is classified into one of sixteen industries, listed in detail as shown in Table A3 of the Appendix. This classification criterion follows Mani and Wheeler (1998).[8] Finally, to assess the role of firm growth in the relationship between financial performance and environmental performance, we conduct the estimation, adding the interaction terms between environmental performance and firm growth.[9]

# 3 Estimation results

## 3.1 Case of the full sample

Table 1 presents the estimation results using the full sample. Since ROE shows how much of a profit the firms make using the equity capital invested by the stockholders, it is one of the comprehensive indices of firm performance. In column (1) in which the dependent variable is ROE, the effect of waste emissions on ROE is significantly positive, suggesting that an increase in waste emissions improves financial performance. This result holds except for the case in column (5) where ROS is used as the dependent variable. Since waste emissions are regulated by several laws such as the Waste Management and Public Cleansing Law in Japan, most firms usually operate by abiding to these regulations. Therefore, stakeholders such as stockholders, investors, and financial institutions may highly value firms that legitimately increase waste emissions. In addition, if environmental regulation-abiding firms are forced to further reduce waste emissions, they have to bear the additional costs generated by corporate environmental management. As a result, this leads to a decrease in their profits in the future. In columns (6) and (7), the results show that the effects of waste emissions on Tobin's $q-1$ and the natural logarithm of Tobin's $q$ are also positive, suggesting that an increase in waste emissions improves the evaluation of a firm's intangible assets.

[Table 1 here]

In contrast, greenhouse gas emissions have a significant negative impact on ROE, implying that stockholders take the long-run firm performance into account because ROE does not include debt but reflects equity capital. Specifically, due to the fact that greenhouse gas emissions may be regulated in the future, firms that seek to reduce them voluntarily in order

[7] The results of the pooled OLS and RE estimations can be provided upon request.

[8] Cole et al. (2006) examine the relationship between globalization and environmental management using Japanese firm data. They also follow the criterion of 'clean' and 'dirty' suggested by Mani and Wheeler (1998).

[9] Konar and Cohen (2001) analyze the relationship between environmental performance on financial performance, taking into account the interaction terms between advertisement and firm growth, and between R&D and firm growth.

to mitigate future regulation risks obtain higher evaluations from stockholders. In addition, in the sense that global warming issues broadly affect human beings, it is related to a wider range of stakeholders unlike waste problems. Therefore, stockholders may expect that firms addressing global warming issues will proactively improve their corporate reputation and image in the future. However, it is noteworthy that the effects of greenhouse gases on ROA, ROI, ROIC, and ROS in columns (2) to (5) are insignificant. These results may be attributed to the facts that ROA, ROI, and ROIC include the value of debt as well as equity capital, and that ROS reflects the evaluation in the goods markets. In addition, although the coefficient of greenhouse gases on Tobin's $q - 1$ is not significant in column (6), its effect on the natural logarithm of Tobin's $q$ is significantly positive, suggesting that greenhouse gas emissions increase the value of intangible assets.

Furthermore, both waste and greenhouse gas emissions do not have a significant impact on ROS. Unlike other accounting-based financial performance, ROS does not include the capital structure in its calculation. Therefore, our results indicate that goods markets reflecting the evaluation by consumers and trading partners do not pay attention to a firms' efforts to reduce waste and greenhouse gas emissions. This result shows that stakeholders who do not have monetary relationships with firms seem to disregard environmental management as far as the firms operate by abiding to laws and regulations. While this result is not in line with that of Sarkis and Cordeiro (2001) who indicate negative impacts of pollution prevention and end-of-pipe efficiencies on ROS, it is similar to that of Wagner et al. (2002). Therefore, from Table 1, it is evident that the reactions and responses of capital markets to the environmental performance of firms are different for each environmental issue. As for other explanatory variables, the coefficients generally have expected signs. However, the effects of R&D on financial performance are significantly negative in most cases. Although this result seems to be somewhat counter-intuitive, previous studies such as King and Lenox (2002) also report the negative relationship between R&D and financial performance.

### 3.2 Cases of clean and dirty industries

We investigate the effects of environmental performance on financial performance, dividing our sample of the manufacturing industry into the two subsets of clean and dirty industries. This analysis allows us to examine the relationships between the dirtiness of an industry and its environmental performance. Following the classification criterion suggested by Mani and Wheeler (1998), we report the estimation results in the cases of clean and dirty industries separately. The detailed classification of clean and dirty industries is reported in Table A3 of the Appendix. Table 2 presents the results in the case of clean industries. The sign and significance of the coefficients of waste and greenhouse gas emissions are similar to those in the case of the full sample in Table 1, and the impacts of waste are qualitatively larger than those in the case of the full sample. This is partly because the number of firms which are classified into clean industries in our sample is larger than that of dirty industries.

[Table 2 here]

Table 3 illustrates the results when our sample is reduced to the firms in dirty industries. In this case, waste has a significant negative impact on ROA, ROI, and ROIC. This outcome may result from the facts that the cost to dispose waste is higher in dirty industries due to more severe regulations, and that firms in dirty industries often confront both more risks of failure to comply with the laws and regulations, and lawsuits. In addition, other stakeholders rather than environmental regulators (e.g. local residents) may penalize these firms severely (e.g. boycott of goods). Given these reasons, the firms in dirty industries that seek to reduce waste emissions have higher financial performance. As for greenhouse gas emissions, its effects on ROE, ROA, ROI, and ROIC are significantly positive, suggesting that markets value firms that emit more greenhouse gases. Since greenhouse gas emissions are not regulated by laws in Japan, firms which have greater production and emit more greenhouse gases can be highly valued. These results may imply that the problems of greenhouse gas emissions are different from that of waste laying which are regulated strictly by laws and regulations, and most stakeholders seem to worry about an increase in cost as a result of seeking to reduce greenhouse gas emissions.

[Table 3 here]

In sum, while waste emissions have positive impact on most financial performances in the case of the full sample and clean industries, they have negative impact on several financial performances in the case of dirty industries. In this case, better environmental management of waste emissions increases financial performance resulting from cost reductions in the future, improvement in abilities to comply with laws, and reduction in lawsuit risks. On the other hand, the signs and significances of the effects of greenhouse gas emissions varies depending on financial performance indices and the sample. Although a reduction in greenhouse gases leads to an increase in ROE in the case of the full sample and clean industries, it causes a decrease in the natural logarithm of Tobin's $q$ in the case of the full sample and clean industries, and a decrease in most financial performances in the case of dirty industries. The estimation results provide mixed relationships between environmental and financial performance, implying that the evaluation of each environmental performance is different among various financial performances. This result can be accounted for by the responses of stakeholders having different interests in varying markets.

### 3.3 Interaction between environmental performance and firm growth

To capture the role of firm growth in the relationship between environmental performance and financial performance, we add two interaction terms between firm growth and environmental performance, waste and greenhouse gases. Table 4 reports the results in the case of the full sample with these two interaction terms. In columns (1) and (6) where the dependent variables are ROE and ROS, the interaction terms between waste and firm growth have significantly negative impact. This outcome means that the partial effect of waste on financial performance is decreasing as firm growth rises. However, the interaction terms between greenhouse gases and firm growth have insignificant impact in all columns (1) to (7).

[Table 4 here]

Next, as the estimation procedure above, we divide the full sample into clean and dirty industries. Table 5 presents the estimation results in the case of clean industries. In all columns except for column (5), the interaction terms between waste and firm growth have significant negative impact on financial performance. In contrast, in all columns (1) to (7), the interaction terms between greenhouse gas emissions and firm growth have significant positive impact on financial performance. Although the coefficient of waste is not significant, the null hypothesis that both coefficients of waste and its interaction term with firm growth are simultaneously zero is rejected at 1% significance level in the F test in all the cases except for the case where ROS is used as the dependent variable in column (5). Also, although the coefficient of greenhouse gas emissions is not significant, we can reject the null hypothesis that both coefficients of greenhouse gases and its interaction term with firm growth are simultaneously zero at 5% significance level in the F test in all columns (1) to (7). In order to comprehensively demonstrate these results in more detail, we illustrate the figures regarding the partial effects of waste and greenhouse gases on $\ln(q)$ in column (7) in Figures 1 and 2. As firm growth increases, the partial effect of waste decreases, but the partial effect of greenhouse gases increases. The threshold level of firm growth separating the negative and positive effects of environmental performance on $\ln(q)$ is $-0.1080$ and $-0.0679$ in the case of waste and greenhouse gases, respectively.[10] In the case of waste emissions in Figure 1, its partial effect is negative if firm growth is positive. This outcome may result from the fact that since waste emissions are regulated by laws, firms with high growth rates can afford to follow the regulations and make efforts to reduce waste laying. In contrast, in the case of greenhouse gas emissions in Figure 2, its partial effect is positive if firm growth is positive. One possible explanation is that since greenhouse gas emissions are not explicitly regulated, the markets highly value firms that prioritize an increase in production over a reduction in greenhouse gas emissions when these firms are growing rapidly.

[Table 5 here]

[Figure 1 here]

[Figure 2 here]

Table 6 shows the results in the case of dirty industries taking the two interaction terms into account. Although the two interaction terms do not have significant effects in columns

[10] In this analysis, the number of observations such that firm growth is below the threshold is 68 and 84 out of 505 observations in the case of waste and greenhouse gas, respectively.

(1) to (4), in columns (5) to (7) where ROS is used as the dependent variable, Tobin's $q-1$, or the natural logarithm of Tobin's $q$, the coefficients of the two interaction terms are significant and have the same signs as the case of Table 5.

[Table 6 here]

# 4 Conclusion

This paper examines the relationship between environmental and financial performance using the data of Japanese manufacturing firms from 2004 to 2008. Since environmental issues have been diverse in recent years, each stakeholder may have different preferences for each environmental issue. Given this, this study employs seven financial performance indices reflecting each market evaluation in order to clarify how each market evaluates corporate management when dealing with different environmental issues. Furthermore, in order to test the hypothesis that each stakeholder may emphasize different environmental issues, we utilize the amount of waste and greenhouse gas emissions as the proxies for environmental performance. To the best of our knowledge, this paper is the first in attempting to use emissions of waste and greenhouse gases instead of environmental management scores from studies using Japanese firm-level data.

Our estimation results show that the responses of financial performance are different depending on each environmental issue, the results of which are attributed to varying stakeholder preferences. For example, while the effect of waste emissions on financial performance is generally positive, waste emissions have a negative impact in dirty industries. One possible explanation for this result is that the cost to dispose waste is higher in dirty industries due to more strict regulations, and/or firms in dirty industries often confront both more risks of failure to comply with laws, and lawsuits. In addition, while greenhouse gas reduction increases ROE which reflects the long-run financial performance, it does not have a significant effect on ROS which shows the short-run financial performance. In other words, stockholders take the long-run firm performance into account, but consumers and trading partners do not care about corporate environmental management in the short-run.

Our results have some policy implications for the relationship between firms and the government. Although environmental problems have mainly been left to government intervention to solve them, if firms have incentives to reduce their environmental damages, the market mechanism could provide some clues to deal with environmental issues. Furthermore, when the market mechanism alone cannot solve environmental issues, the government should formulate appropriate regulations and laws to complement it.

## Appendix: Data definitions and sources

[Table A1 here]

[Table A2 here]

[Table A3 here]

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Table A1: Data definitions and sources

| Variable | Description | Source |
|---|---|---|
| ROE | Return on equity is defined as income for the term divided by total stockholders' equity (average of 2 terms). | Nikkei Digital Media (2010) |
| ROA | Return on assets is defined by the following ratio. The numerator is the sum of operating profit, interest revenue/discount fee/interest on securities, and dividend revenue. The denominator is the sum of liabilities and net assets (average of 2 terms). | Nikkei Digital Media (2010) |
| ROI | Return on investment is defined by the following ratio. The numerator is the same as that in the case of ROA. The denominator is {total assets – (total current assets - total current liabilities)}. | Nikkei Digital Media (2010) |
| ROIC | Return on invested capital is defined by the following ratio. The numerator is the same as that in the case of ROA. The denominator is {total stockholders' equity + short-term borrowings + CPS + long-term borrowings within 1 year + corporate bonds due within 1 year and CBS + deposits from employees + corporate bonds and CBS + long-term borrowings + discounted notes receivable – (cash and equivalents + securities + business-account loans and investment securities)}. | Nikkei Digital Media (2010) |
| ROS | Return on sales is defined as income for the term divided by sales and operating revenue. | Nikkei Digital Media (2010) |
| $q-1$ | This variable is Tobin's $q-1$. Tobin's $q$ is defined as (total debt + stock prices * the number of stocks) / total assets. | Nikkei Digital Media (2010) and Toyo Keizai (2010) |
| $\ln(q)$ | This variable is the natural logarithm of Tobin's $q$. | Nikkei Digital Media (2010) and Toyo Keizai (2010) |

Table A1 (Continued): Data definitions and sources

| Variable | Description | Source |
|---|---|---|
| Size | Firm size is the natural logarithm of sales and operating revenue (in the unit of million Japanese Yen). | Nikkei Digital Media (2010) |
| Growth | Firm growth is the growth rate in sales and operating revenue. | Nikkei Digital Media (2010) |
| R&D | Research and development intensity is defined as research and development expenses divided by sales and operating revenue. | Nikkei Digital Media (2010) |
| Advertisement | Advertisement intensity is defined as advertisement expenses divided by sales and operating revenue. | Nikkei Digital Media (2010) |
| Capital intensity | Capital intensity is defined as sales and operating revenue divided by stockholders' equity. | Nikkei Digital Media (2010) |
| Leverage | Financial leverage is defined as the sum of liabilities and net assets (average of 2 terms) is divided by total stockholders' equity. | Nikkei Digital Media (2010) |
| Waste | This variable is defined as waste emissions (in the unit of tons) divided by sales and operating revenue (in the unit of million Japanese Yen). | Nikkei Digital Media (2010) and Toyo Keizai (2006, 2007, 2008, 2009) |
| Greenhouse gas | This variable is defined as greenhouse gas emissions (in the unit of tons of $CO_2$ equivalents) divided by sales and operating revenue (in the unit of million Japanese Yen). | Nikkei Digital Media (2010) and Toyo Keizai (2006, 2007, 2008, 2009) |

Table A2: Descriptive statistics

| Variables | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|
| ROE | 0.0423 | 0.1001 | -0.9432 | 0.3069 |
| ROA | 0.0557 | 0.0415 | -0.0761 | 0.2133 |
| ROI | 0.0740 | 0.0658 | -0.0915 | 0.4349 |
| ROIC | 0.0969 | 0.0828 | -0.1106 | 0.6952 |
| ROS | 0.0377 | 0.1381 | -1.7789 | 0.7633 |
| $q-1$ | 0.4021 | 0.6021 | -0.6350 | 4.6476 |
| $\ln(q)$ | 0.2642 | 0.3713 | -1.0078 | 1.7312 |
| Size | 11.8980 | 1.4937 | 7.9288 | 16.3070 |
| Growth | 0.2445 | 4.4049 | -0.9297 | 91.9909 |
| R&D | 0.0498 | 0.0546 | 0.0001 | 0.4047 |
| Advertisement | 0.0134 | 0.0203 | 0.0000 | 0.1348 |
| Capital intensity | 1.9535 | 1.3862 | 0.0570 | 10.5098 |
| Leverage | 2.1291 | 1.0471 | 1.0700 | 11.3700 |
| Waste | 0.1717 | 0.6809 | 0 | 13.7018 |
| Greenhouse gas | 8.4367 | 92.4203 | 0 | 2190.8570 |

Table A3: Detailed classification in manufacturing sector

| Clean | Dirty |
|---|---|
| Food and beverages | Paper and pulp |
| Textiles | Chemicals and chemical products |
| Refined petroleum products | Pharmaceutical products |
| Machinery | Rubber and plastics products |
| Electrical machinery | Clay and glass |
| Motor vehicle, other transport equipment | Iron and steel |
| Precision instruments | Non-ferrous metals |
| Other manufacturing | Metal products |

Table 1: Environmental performance and financial performance （full sample）

| | (1) ROE | (2) ROA | (3) ROI | (4) ROIC | (5) ROS | (6) $q-1$ | (7) $\ln(q)$ |
|---|---|---|---|---|---|---|---|
| Size | 0.2718*** | 0.0717*** | 0.0941*** | 0.1380*** | 0.0127 | 0.6473*** | 0.4873*** |
| | (0.0534) | (0.0193) | (0.0263) | (0.0354) | (0.0596) | (0.1967) | (0.1337) |
| Growth | 0.0015 | 0.0004*** | 0.0003** | 0.0003 | 0.0026 | 0.0013 | 0.0007 |
| | (0.0009) | (0.0001) | (0.0002) | (0.0002) | (0.0020) | (0.0014) | (0.0011) |
| R&D | -0.8852*** | -0.3423** | -0.4970** | -0.5565** | -2.6629 | -5.6743*** | -3.5828*** |
| | (0.2985) | (0.1444) | (0.2315) | (0.2532) | (2.4085) | (1.5722) | (0.8158) |
| Advertisement | 0.1605 | -0.0674 | -0.0244 | 0.1699 | -10.9601* | -3.7458 | -2.6903 |
| | (0.8485) | (0.3190) | (0.4500) | (0.5711) | (6.2352) | (3.4406) | (2.3814) |
| Capital intensity | -0.1879*** | -0.0107** | -0.0088 | -0.0267** | -0.0427*** | 0.0916 | 0.0298 |
| | (0.0205) | (0.0048) | (0.0063) | (0.0131) | (0.0145) | (0.0639) | (0.0346) |
| Leverage | 0.0999*** | 0.0065 | 0.0032 | 0.0252 | 0.0073 | -0.2755** | -0.1230** |
| | (0.0302) | (0.0085) | (0.0113) | (0.0215) | (0.0235) | (0.1083) | (0.0604) |
| Waste | 0.0473** | 0.0155** | 0.0198* | 0.0280** | -0.0564 | 0.1640** | 0.1174** |
| | (0.0224) | (0.0078) | (0.0104) | (0.0137) | (0.0681) | (0.0680) | (0.0478) |
| Greenhouse gas | -0.0001*** | 0.0000 | 0.0000 | 0.0000 | -0.0001 | 0.0001 | 0.0001** |
| | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0001) | (0.0000) | (0.0000) |
| Constant | -3.0019*** | -0.7750*** | -1.0134*** | -1.5257*** | 0.2437 | -6.5914*** | -5.1390*** |
| | (0.6467) | (0.2369) | (0.3237) | (0.4344) | (0.7796) | (2.4254) | (1.6444) |
| $R^2$ | 0.53 | 0.19 | 0.15 | 0.15 | 0.29 | 0.14 | 0.18 |
| No. of firms | 268 | 268 | 268 | 268 | 268 | 268 | 268 |
| Observations | 751 | 751 | 751 | 751 | 751 | 749 | 749 |

Notes:

1. The asterisks ***, **, and * are 1%, 5%, and 10% of significance levels, respectively.
2. The numbers in parentheses are the heteroskedasticity-robust standard errors.

Table 2: Environmental performance and economic performance (clean industries)

| | (1) ROE | (2) ROA | (3) ROI | (4) ROIC | (5) ROS | (6) $q-1$ | (7) $\ln(q)$ |
|---|---|---|---|---|---|---|---|
| Size | 0.3434*** | 0.1158*** | 0.1514*** | 0.2151*** | -0.0794 | 1.0123*** | 0.7877*** |
| | (0.0526) | (0.0199) | (0.0293) | (0.0414) | (0.0927) | (0.2491) | (0.1562) |
| Growth | 0.0006* | 0.0005*** | 0.0007*** | 0.0009*** | -0.0003 | 0.0036 | 0.0027 |
| | (0.0003) | (0.0002) | (0.0003) | (0.0003) | (0.0007) | (0.0028) | (0.0022) |
| R&D | -1.1654*** | -0.3446 | -0.4593 | -0.5318 | -4.7747 | -7.4529*** | -4.5591*** |
| | (0.4128) | (0.2172) | (0.3025) | (0.3736) | (3.1800) | (2.5888) | (1.3625) |
| Advertisement | -0.4935 | -0.1881 | -0.0648 | 0.0822 | -13.1404** | -4.9042 | -3.5417 |
| | (0.9355) | (0.3815) | (0.5429) | (0.6897) | (6.3889) | (4.9691) | (3.2008) |
| Capital intensity | -0.1975*** | -0.0136*** | -0.0129** | -0.0329** | -0.0250 | 0.0759 | 0.0095 |
| | (0.0220) | (0.0047) | (0.0059) | (0.0145) | (0.0184) | (0.0700) | (0.0368) |
| Leverage | 0.1201*** | 0.0180* | 0.0186 | 0.0481* | -0.0207 | -0.1858 | -0.0461 |
| | (0.0365) | (0.0094) | (0.0116) | (0.0250) | (0.0321) | (0.1186) | (0.0668) |
| Waste | 0.1318*** | 0.0547*** | 0.0698*** | 0.0955*** | -0.1037 | 0.4749** | 0.3655*** |
| | (0.0421) | (0.0173) | (0.0241) | (0.0322) | (0.1144) | (0.1874) | (0.1274) |
| Greenhouse gas | -0.0001*** | 0.0000 | 0.0000 | 0.0000 | -0.0001 | 0.0001 | 0.0001*** |
| | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0001) | (0.0000) |
| Constant | -3.8770*** | -1.3368*** | -1.7498*** | -2.5134*** | 1.4818 | -11.1912*** | -8.9252*** |
| | (0.6491) | (0.2476) | (0.3649) | (0.5152) | (1.2470) | (3.0828) | (1.9311) |
| $R^2$ | 0.58 | 0.29 | 0.25 | 0.22 | 0.38 | 0.18 | 0.25 |
| No. of firms | 182 | 182 | 182 | 182 | 182 | 182 | 182 |
| Observations | 506 | 506 | 506 | 506 | 506 | 505 | 505 |

Notes:

1. The asterisks ***, **, and * are 1%, 5%, and 10% of significance levels, respectively.
2. The numbers in parentheses are the heteroskedasticity-robust standard errors.

Table 3: Environmental performance and economic performance (dirty industries)

| | (1) ROE | (2) ROA | (3) ROI | (4) ROIC | (5) ROS | (6) $q-1$ | (7) $\ln(q)$ |
|---|---|---|---|---|---|---|---|
| Size | 0.2953*** | 0.0740*** | 0.0970** | 0.1431*** | 0.1323** | 0.4671 | 0.2909 |
| | (0.0627) | (0.0273) | (0.0426) | (0.0466) | (0.0549) | (0.2951) | (0.1853) |
| Growth | 0.0034*** | 0.0005*** | 0.0002 | 0.0001 | 0.0070*** | 0.0032* | 0.0018** |
| | (0.0003) | (0.0002) | (0.0003) | (0.0003) | (0.0003) | (0.0016) | (0.0009) |
| R&D | 0.1331 | -0.1162 | -0.3362 | -0.2577 | 0.2386 | -0.0738 | 0.1719 |
| | (0.5347) | (0.2679) | (0.4929) | (0.4821) | (0.4714) | (2.5033) | (1.2041) |
| Advertisement | -1.2326 | -1.1772 | -2.7144** | -2.8571** | -0.8658 | -8.1834 | -5.8256 |
| | (1.4683) | (0.7275) | (1.1479) | (1.2076) | (1.0627) | (7.6799) | (4.0442) |
| Capital intensity | -0.1709*** | -0.0203 | -0.0199 | -0.0396 | -0.0879*** | 0.0418 | 0.0406 |
| | (0.0352) | (0.0160) | (0.0260) | (0.0287) | (0.0315) | (0.1965) | (0.1270) |
| Leverage | 0.0357 | -0.0222 | -0.0365 | -0.0355 | 0.0319 | -0.4912* | -0.3132** |
| | (0.0281) | (0.0140) | (0.0273) | (0.0258) | (0.0219) | (0.2544) | (0.1309) |
| Waste | -0.0180 | -0.0127* | -0.0301*** | -0.0318*** | 0.0050 | 0.0375 | 0.0218 |
| | (0.0155) | (0.0073) | (0.0115) | (0.0120) | (0.0154) | (0.0829) | (0.0461) |
| Greenhouse gas | 0.0020** | 0.0010** | 0.0021*** | 0.0024*** | -0.0015 | -0.0024 | -0.0016 |
| | (0.0010) | (0.0005) | (0.0008) | (0.0008) | (0.0010) | (0.0054) | (0.0031) |
| Constant | -3.2205*** | -0.7116** | -0.8974* | -1.3942** | -1.4217** | -4.0367 | -2.5052 |
| | (0.7524) | (0.3240) | (0.5090) | (0.5463) | (0.6510) | (3.4939) | (2.1442) |
| $R^2$ | 0.49 | 0.20 | 0.14 | 0.20 | 0.59 | 0.15 | 0.17 |
| No. of firms | 86 | 86 | 86 | 86 | 86 | 86 | 86 |
| Observations | 245 | 245 | 245 | 245 | 245 | 244 | 244 |

Notes:

1. The asterisks ***, **, and * are 1%, 5%, and 10% of significance levels, respectively.
2. The numbers in parentheses are the heteroskedasticity-robust standard errors.

Table 4: Environmental performance and economic performance with interaction terms (full sample)

| | (1) ROE | (2) ROA | (3) ROI | (4) ROIC | (5) ROS | (6) $q-1$ | (7) $\ln(q)$ |
|---|---|---|---|---|---|---|---|
| Size | 0.2721*** | 0.0721*** | 0.0942*** | 0.1384*** | 0.0389 | 0.6628*** | 0.4943*** |
| | (0.0497) | (0.0185) | (0.0258) | (0.0346) | (0.0555) | (0.1902) | (0.1294) |
| Growth | 0.0041*** | 0.0009** | 0.0007 | 0.0008 | 0.0080*** | 0.0039 | 0.0024 |
| | (0.0008) | (0.0004) | (0.0005) | (0.0007) | (0.0024) | (0.0035) | (0.0025) |
| R&D | -0.8684*** | -0.3348** | -0.4930** | -0.5490** | -2.3021 | -5.4644*** | -3.4856*** |
| | (0.2924) | (0.1439) | (0.2344) | (0.2539) | (2.4876) | (1.5835) | (0.8156) |
| Advertisement | 0.2484 | -0.0078 | 0.0033 | 0.2306 | -7.5980** | -1.7760 | -1.7905 |
| | (0.6423) | (0.2689) | (0.3999) | (0.5054) | (3.8553) | (3.6734) | (2.7634) |
| Capital intensity | -0.1885*** | -0.0109** | -0.0089 | -0.0268** | -0.0454*** | 0.0902 | 0.0291 |
| | (0.0204) | (0.0048) | (0.0062) | (0.0131) | (0.0142) | (0.0639) | (0.0346) |
| Leverage | 0.1000*** | 0.0066 | 0.0033 | 0.0253 | 0.0107 | -0.2736** | -0.1221** |
| | (0.0301) | (0.0085) | (0.0114) | (0.0215) | (0.0233) | (0.1086) | (0.0606) |
| Waste | 0.0375 | 0.0142 | 0.0185 | 0.0270* | -0.0340 | 0.1796** | 0.1226** |
| | (0.0241) | (0.0088) | (0.0120) | (0.0157) | (0.0562) | (0.0745) | (0.0544) |
| Waste * Growth | -0.0197*** | -0.0039 | -0.0029 | -0.0035 | -0.0581*** | -0.0299 | -0.0169 |
| | (0.0059) | (0.0024) | (0.0035) | (0.0044) | (0.0202) | (0.0245) | (0.0181) |
| Greenhouse gas | -0.0001** | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001** |
| | (0.0001) | (0.0000) | (0.0000) | (0.0000) | (0.0002) | (0.0001) | (0.0001) |
| Greenhouse gas * Growth | 0.0001 | 0.0001 | 0.0000 | 0.0001 | 0.0026 | 0.0015 | 0.0007 |
| | (0.0003) | (0.0001) | (0.0002) | (0.0002) | (0.0018) | (0.0012) | (0.0008) |
| Constant | -3.0058*** | -0.7808*** | -1.0157*** | -1.5317*** | -0.1375 | -6.8174*** | -5.2412*** |
| | (0.5990) | (0.2269) | (0.3174) | (0.4246) | (0.7345) | (2.3472) | (1.5912) |
| $R^2$ | 0.54 | 0.19 | 0.15 | 0.15 | 0.35 | 0.14 | 0.18 |
| No. of firms | 268 | 268 | 268 | 268 | 268 | 268 | 268 |
| Observations | 751 | 751 | 751 | 751 | 751 | 749 | 749 |

Notes:

1. The asterisks ***, **, and * are 1%, 5%, and 10% of significance levels, respectively.
2. The numbers in parentheses are the heteroskedasticity-robust standard errors.

Table 5: Environmental performance and economic performance with interaction terms (clean industries)

| | (1) ROE | (2) ROA | (3) ROI | (4) ROIC | (5) ROS | (6) $q-1$ | (7) $\ln(q)$ |
|---|---|---|---|---|---|---|---|
| Size | 0.3719*** | 0.1287*** | 0.1700*** | 0.2394*** | -0.0152 | 1.1597*** | 0.8870*** |
| | (0.0461) | (0.0154) | (0.0242) | (0.0350) | (0.0817) | (0.2272) | (0.1349) |
| Growth | 0.0566*** | 0.0235*** | 0.0338*** | 0.0437*** | 0.0265 | 0.2514*** | 0.1766*** |
| | (0.0140) | (0.0052) | (0.0075) | (0.0097) | (0.0226) | (0.0582) | (0.0351) |
| R&D | -1.2827*** | -0.3883* | -0.5219* | -0.6119* | -4.6392 | -7.8924*** | -4.8831*** |
| | (0.3731) | (0.2079) | (0.2910) | (0.3584) | (3.1209) | (2.5630) | (1.3586) |
| Advertisement | 1.4051 | 0.7028* | 1.2308** | 1.7755*** | -7.3535** | 5.3902 | 3.2840 |
| | (0.9804) | (0.3582) | (0.5239) | (0.6691) | (3.4230) | (5.0819) | (3.3405) |
| Capital intensity | -0.2023*** | -0.0156*** | -0.0159*** | -0.0368*** | -0.0315* | 0.0531 | -0.0062 |
| | (0.0209) | (0.0046) | (0.0060) | (0.0142) | (0.0174) | (0.0708) | (0.0383) |
| Leverage | 0.1277*** | 0.0213** | 0.0234** | 0.0544** | -0.0094 | -0.1487 | -0.0207 |
| | (0.0352) | (0.0090) | (0.0113) | (0.0243) | (0.0310) | (0.1169) | (0.0660) |
| Waste | -0.0170 | -0.0049 | -0.0159 | -0.0150 | -0.1112 | -0.1570 | -0.0830 |
| | (0.0411) | (0.0161) | (0.0224) | (0.0300) | (0.0908) | (0.1784) | (0.1065) |
| Waste * Growth | -0.2461*** | -0.1015*** | -0.1464*** | -0.1893*** | -0.1454 | -1.0982*** | -0.7683*** |
| | (0.0611) | (0.0226) | (0.0324) | (0.0418) | (0.0987) | (0.2535) | (0.1530) |
| Greenhouse gas | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0003 | 0.0003 |
| | (0.0001) | (0.0000) | (0.0000) | (0.0001) | (0.0003) | (0.0004) | (0.0002) |
| Greenhouse gas * Growth | 0.0010* | 0.0005*** | 0.0007*** | 0.0009*** | 0.0045** | 0.0059** | 0.0038*** |
| | (0.0006) | (0.0002) | (0.0003) | (0.0003) | (0.0022) | (0.0023) | (0.0015) |
| Constant | -4.2287*** | -1.4972*** | -1.9826*** | -2.8170*** | 0.6125 | -13.0391*** | -10.1645*** |
| | (0.5671) | (0.1913) | (0.3001) | (0.4350) | (1.0932) | (2.8062) | (1.6655) |
| $R^2$ | 0.62 | 0.37 | 0.33 | 0.28 | 0.46 | 0.22 | 0.30 |
| No. of firms | 182 | 182 | 182 | 182 | 182 | 182 | 182 |
| Observations | 506 | 506 | 506 | 506 | 506 | 505 | 505 |

Notes:

1. The asterisks ***, **, and * are 1%, 5%, and 10% of significance levels, respectively.
2. The numbers in parentheses are the heteroskedasticity-robust standard errors.

Table 6: Environmental performance and economic performance with interaction terms (dirty industries)

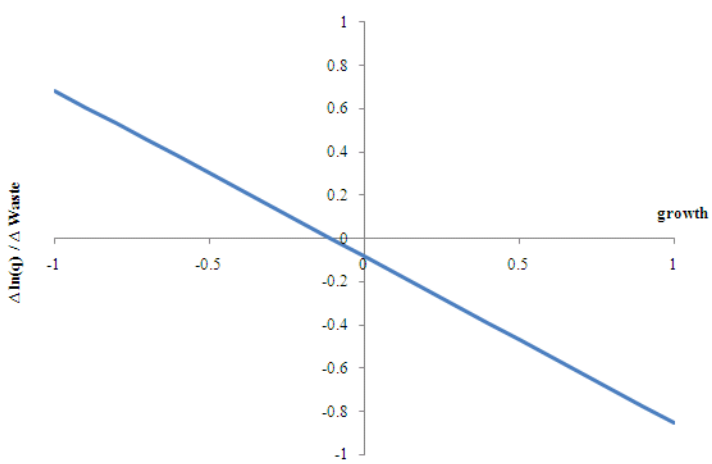
| | (1) ROE | (2) ROA | (3) ROI | (4) ROIC | (5) ROS | (6) $q-1$ | (7) $\ln(q)$ |
|---|---|---|---|---|---|---|---|
| Size | 0.2969*** | 0.0746*** | 0.0983** | 0.1445*** | 0.1290** | 0.4722 | 0.2909 |
| | (0.0633) | (0.0277) | (0.0433) | (0.0475) | (0.0553) | (0.2966) | (0.1867) |
| Growth | 0.0034*** | 0.0006** | 0.0000 | -0.0001 | 0.0085*** | 0.0097** | 0.0060** |
| | (0.0006) | (0.0003) | (0.0005) | (0.0005) | (0.0005) | (0.0037) | (0.0023) |
| R&D | 0.1551 | -0.1067 | -0.3337 | -0.2575 | 0.2997 | 0.3692 | 0.4252 |
| | (0.5425) | (0.2723) | (0.5014) | (0.4899) | (0.4747) | (2.4130) | (1.1759) |
| Advertisement | -1.0512 | -1.0947 | -2.7334** | -2.9070** | -0.0692 | -3.3693 | -2.9709 |
| | (1.5733) | (0.7685) | (1.2400) | (1.2846) | (1.0277) | (8.4823) | (4.1361) |
| Capital intensity | -0.1680*** | -0.0191 | -0.0192 | -0.0391 | -0.0823*** | 0.0919 | 0.0683 |
| | (0.0359) | (0.0165) | (0.0274) | (0.0297) | (0.0314) | (0.2063) | (0.1312) |
| Leverage | 0.0274 | -0.0255 | -0.0392 | -0.0377 | 0.0215 | -0.6099** | -0.3766** |
| | (0.0311) | (0.0156) | (0.0319) | (0.0298) | (0.0219) | (0.2895) | (0.1495) |
| Waste | -0.0224 | -0.0147** | -0.0303*** | -0.0314*** | -0.0097 | -0.0620 | -0.0359 |
| | (0.0153) | (0.0073) | (0.0113) | (0.0120) | (0.0119) | (0.0971) | (0.0591) |
| Waste * Growth | -0.0113 | -0.0056 | 0.0053 | 0.0084 | -0.0798*** | -0.4252* | -0.2596* |
| | (0.0267) | (0.0118) | (0.0223) | (0.0219) | (0.0202) | (0.2294) | (0.1364) |
| Greenhouse gas | 0.0035** | 0.0016** | 0.0026** | 0.0028** | 0.0003 | 0.0178 | 0.0091 |
| | (0.0014) | (0.0007) | (0.0012) | (0.0013) | (0.0012) | (0.0132) | (0.0075) |
| Greenhouse gas * Growth | 0.0008 | 0.0003 | 0.0001 | -0.0000 | 0.0023*** | 0.0164* | 0.0094* |
| | (0.0010) | (0.0004) | (0.0009) | (0.0008) | (0.0007) | (0.0087) | (0.0050) |
| Constant | -3.2382*** | -0.7181** | -0.9105* | -1.4086** | -1.3895** | -4.1068 | -2.5149 |
| | (0.7598) | (0.3282) | (0.5150) | (0.5542) | (0.6551) | (3.4793) | (2.1464) |
| $R^2$ | 0.50 | 0.21 | 0.14 | 0.20 | 0.61 | 0.17 | 0.19 |
| No. of firms | 86 | 86 | 86 | 86 | 86 | 86 | 86 |
| Observations | 245 | 245 | 245 | 245 | 245 | 244 | 244 |

Notes:

1. The asterisks ***, **, and * are 1%, 5%, and 10% of significance levels, respectively.

2. The numbers in parentheses are the heteroskedasticity-robust standard errors.

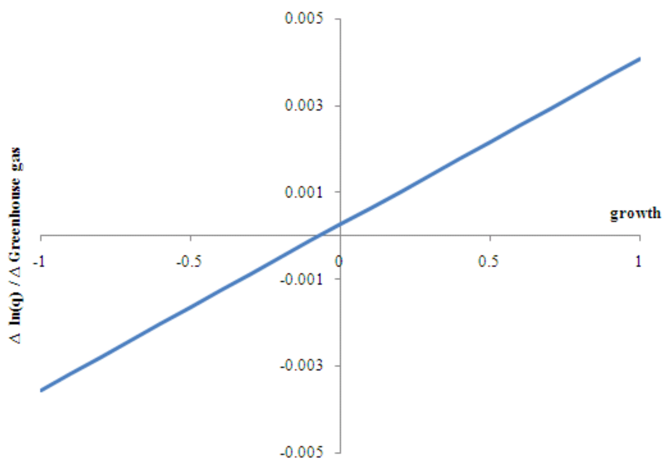
Figure 1: The partial effect of waste on $\ln(q)$




Notes:

1. This figure is illustrated based on the result of column (7), Table 5.

Figure 2: The partial effect of greenhouse gas on $\ln(q)$




Notes:

1. This figure is illustrated based on the result of column (7), Table 5.