The influence of ISO 14001 certification on industrial waste generation: the case of Swedish manufacturing firms

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Abstract

Adoption of environmental management systems (EMS) and ISO 14001-certification of those systems constitutes one of the most important elements of sustainable industry management in recent years. Research on EMS is rather extensive, but with few exceptions, studies of the influence of EMS are relying heavily on firm representatives' perceived benefits. Moreover, previous studies tend to focus on the systems impact on firms' overall environmental performance, not identifying differences in different environmental aspects. This study aims to contribute knowledge about the influence of certified EMS on industrial waste generation based on objective industrial waste data derived from mandatory annual environmental reports. The study focuses on changes in waste generation over a period of 12 years and includes both ISO 14001-certified firms (66 firms) and non-certified firms (50 firms). Consideration is given to the improvement efforts in the firms before EMS adoption. Analysis has been carried out using statistical methods, for example *t*-test, for three different industrial waste parameters: hazardous waste, waste to landfill and the total amounts of waste. The results indicate that a certified EMS has a positive impact on hazardous waste reduction. No effect has been found regarding waste to landfill or the total amounts of waste.

1. Introduction

Industrial waste generation is one of the environmental aspects that have been in focus in environmental legislation and other environmental policy instruments all over the world for many years. This environmental area is also one of the most dominating areas when firms and other organizations have turned their attentions towards voluntary environmental agreements and standards (Arifin et al.,2009). One such voluntary standard that has spread rapidly over the world the last 10-15 years is the international standard ISO14001 containing specifications for the implementation of an environmental management system (EMS).

Such a system is a set of management processes and procedures that allows organizations to analyze, control and reduce the environmental impact of their operations and services to save costs, improve efficiency and oversight and to streamline regulatory compliance (Pawar and Rissetto, 2001). A more specific description of an EMS in accordance with ISO 14001 is given in Table 1, where the overarching system requirements in ISO 14001 are shown.

Table 1
Overarching requirements in the international environmental management standard ISO 14001.

Section	**Subsections**
General requirements	
Environmental policy	
Planning	Environmental aspects
	Legal and other requirements
	Objectives, targets and program(s)
Implementation and operation	Resources, roles, responsibility and authority
	Competence, training and awareness
	Communication
	Documentation
	Control of documents
	Operational control
	Emergency preparedness and response
Checking	Monitoring and measurement
	Evaluation of compliance
	Nonconformity, corrective action and preventive action
	Control of records
	Internal audit
Management review	

During the period from 1996, when it first became possible to certify to ISO 14001, until now, about 220 000 organizations worldwide have chosen to certify their EMS (ISO, 2011). Firms adopt and certify their EMS for a wide variety of reasons but some of the most common are to effectively and systematically ensure compliance, to develop more environmentally efficient processes and gain greater competitiveness (Poksinska et al., 2003, Rivera-Camino , 2001; Gupta & Piero, 2003).

One of the most important contributions of an EMS in accordance to ISO 14001 is that it potentially helps organizations to identify and actively work with their most significant environmental aspects. The generation of industrial waste is often one if those aspects having significant environmental impacts. Arifin et al. (2009) report that among 12 major environmental issues in business organizations, waste generation ranked first and most concerned by business when they adopt the standard.

The popularity of ISO 14001 has lead to extensive research focusing on the impacts of the certified EMSs on corporate environmental performance (Nawrocka and Parker, 2009). Numerous studies have been conducted to evaluate the impact of the EMS. Some of these studies reports positive environmental effects of the systems (e.g. Arimura et al., 2008; Potoski & Prakash, 2005; Schylander & Martinuzzi, 2008; Annandale et al., 2004) while other studies show that firms seems to be more or less unaffected of the systems (eg, Melnyk et al., 2003; Hamschmidt & Dyllick, 2001, Hertin et al., 2008, Zobel, 2010). In other words, research in this area has not been able to find a conclusive answer to the question as to whether EMSs are useful for improving corporate environmental performance.

Common for most of the previous studies focusing on the environmental impact of EMSs and ISO 14001 are that they often rely solely on subjective perceptions of firm representatives (Franchetti, 2011), which in some cases are problematic since these perceptions might not always have factual support (Hamschmidt & Dyllick, 2001; Freimann & Walther, 2001). In addition, a majority of previous studies are focused on the organizational impact of the systems rather than actual changes in separate environmental aspects (Zobel, 2010). There is most probably a need to complement these more qualitative studies with studies that are based on more objective actual environmental data, since it has been suggested that qualitative case studies or survey studies tend to show more positive effects of environmental management than the relatively few studies that are based on more objective measurements of changes in environmental performance (Ammenberg, 2003).

This paper presents the results of a study based on industrial waste generation data derived from mandatory annual environmental reports from 116 manufacturing facilities in Sweden. The purpose of this study is to contribute knowledge about the influence of ISO 14001-certified EMSs on industrial waste generation. Following this introduction, the data set and the statistical methods used in the study are outlined in section 2. Results are presented in section 3 followed by section 4 where the results are discussed and conclusions are drawn.

2. Methodology

An approach aiming at studying the influence of certified EMSs on environmental performance needs to focus primarily on changes in environmental performance over time as EMS is a tool for continuous improvement and do not say anything about the level of performance (ISO, 2004; Schylander & Zobel, 2003). Furthermore, the studies must include not only firms with a certified EMS but also firms without systems or possible simpler non-certified systems for comparison. Finally, the improvements of firms that existed before the introduction of the EMS must be taken into account.

2.1 Research approach

In this study, we have chosen 2000 as the base year and we choose to study the change in industrial waste generation over three-year intervals over the period 1994-2006, i.e. six years prior to certification and 6 years after certification. The three year intervals were chosen primarily in order to limit the amount of data. Fig. 1 shows a schematic illustration of the time periods that forms the basis for statistical analysis. The basis for analysis has not been the improvements as such, but rather the change in the rate of improvement before and after ISO 14001 certification and the corresponding periods for non-certified companies. Before analysis, the parameters have been normalized to each firm's production rate, in order to be able to study changes in environmental performance independent of the level of production.

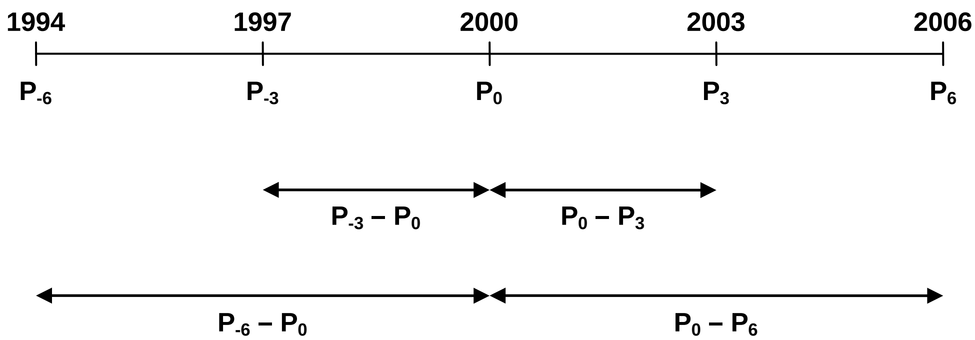

Figure 1. Schematic picture of the time periods over which the change in performance has been measured in certified and non-certified firms (P_{-6} = environmental performance in 1994, six years before the base year 2000; P_{-3} = environmental performance in 1997, three years before the base year 2000; P_0 = environmental performance in the base year 2000; P_3 = environmental performance in 2003, three years after the base year 2000; P_6 = environmental performance in 2006, six years after the base year 2000)

The change in the rate of improvement has been calculated for three different waste categories: hazardous waste, waste to landfill and the total amounts of waste. The shorter period 1997-2003 has the advantage that the production most probably has not changed so much during the period and it is therefore easier to follow changes in performance. In addition, it was easier to find waste data from the years 1997, 2000 and 2003. However it is a disadvantage that changes are most likely smaller than for the longer period 1994-2006. The major disadvantage with the longer period is that waste data from 1994 was hard to find, which made the statistical analysis more difficult. The parameters that have been the subject of analysis are therefore the following if the designations from Fig. 1 are used:

$$\textit{Change in rate of improvement (short)} = ((P_0 - P_3)/ P_0)*100 – ((P_{-3} - P_0)/ P_{-3})*100$$

$$\textit{Change in rate of improvement (long)} = ((P_0 – P_6)/ P_0)*100 – ((P_{-6} - P_0)/ P_{-6})*100$$

2.2 Collection of data

To gain access to environmental data that are reported by limited elements of subjectivity, mandatory yearly environmental reports from firms with regulatory environmental permits have been used. Environmental reports have been collected from both ISO 14001 certified firms and non-certified firms. We have chosen to study manufacturing firms (NACE code 15-37) where we can expect to find significant amounts of industrial waste as well as a number of different waste categories. A list of such firms, created by information from all 21 County Administrative Boards in Sweden, showed that the total number of such firms was 2331. The list was supplemented with information on ISO 14001 certification from all certification bodies in Sweden.

The year 2000 was chosen as the base year because it was the year that the most certified manufacturing firms with permit got an ISO 14001 certificate. A total of 130 such firms could be found. A comparative sample was created by a random sample of 130 firms taken out of the total population of non-certified manufacturing firms with a permit. Environmental reports for the years 1994, 1997, 2000, 2003 and 2006 were collected from the firms' local and regional environmental agencies. Documents were received for 217 of the 260 firms (83%). All 217 firms were not included in the study for various reasons, for example, that not enough necessary documents could be found, the firm has closed down or there was poor document quality. After the removal of non-usable firms, 66 certified firms and 50 non-certified firms remained.

Summary statistics of the two samples are illustrated in Table 2. Average firm size is greater for the certified firms (*t*-test, $P<0.05$). This fact should be taken into account when interpreting the results of the study, since the data from the two groups of firms might be biased concerning firm size. Unfortunately, this was unavoidable because firm size was not available in the original lists of firms that we received from the County Administrative Boards. The size of the firms in the random sample was identified after the sample was drawn.

Table 2
Summary statistics over the samples of certified and non-certified firms.

Parameters	Certified firms	Non-certified firms
Count*	56	48
Average firm size (emp.)	329	69.1
Standard deviation	647	99.2
Stnd. skewness	17.9	8.40
Stnd. kurtosis	59.7	15.4

* The number of firms in the table is less than 66 and 50 since information concerning the number of employees was not available for all firms.

2.3. Statistical methods

Certified and non-certified firms were compared using the *t*-test, which is one of the most commonly used methods for comparing two samples (Box et al., 2005). It should be noted that for the *t*-test to have full validity, assumptions about normally distributed data and equal variances must apply. Therefore, the sample distribution has been tested using the parameters standardized skewness and standardized kurtosis (Thode, 2002). Variances were tested using an F-test, which is a commonly used test to compare variances between groups (Lomax, 2007). When extreme values are present, Grubb's test (Barnett and Lewis, 1994) has been used for identification of outliers.

3. Results

We wanted to perform a comparative statistical analysis of the change of the rate of improvement regarding industrial waste generation between certified and non-certified firms. The following null hypothesis and alternative hypothesis were set and tested for the periods 1997-2003 and 1994-2006:

> H_0 *= the change of waste generation rate for ISO 14001-certified firms do not differ significantly from the corresponding change for non-certified firms*
>
> H_{ALT} *= the change of waste generation rate for ISO 14001-cerfified firms differ significantly from the corresponding change for non-certified firms*

The data collected from the environmental reports allowed us to study three different waste parameters: hazardous waste, waste to landfill and the total amounts of waste.

It should be noted that waste to landfill in a sense is counted twice in this study, both as an individual parameter and as a portion of the total amount of waste. However, this problem is limited since waste to landfill is often a small portion of the total waste production.

An increase in waste going to reuse, recycling, composting or incineration has not been used for analysis mainly for two reasons. Firstly, these types of wastes are seldom reported by the firms in their environmental report and the small amount of data would limit the explanation power of the statistical analysis. Secondly, it is not obvious how changes in generation of these waste types should be interpreted. An increase can be counted as an improvement (if waste to landfill concurrently is reduced) or as deterioration (if the total amount of waste increases).

3.1. Time period 1997-2003

Despite some difficulties in interpreting environmental reports relating to the disposal of waste and quantities of waste we have been able to use data from about two thirds of the certified firms as well as the non-certified firms when it comes to hazardous waste. Summary statistics of both firm groups are shown in Table 3. We see from the table that the observations are likely to be normally distributed since the values of standardized skewness and standardized kurtosis are well within the range -2 to +2. Furthermore, we see that the average change in hazardous waste generation improvement is 17 % for the certified firms and 39 % for non-certified firms. After removal of four outliers in the certified group and one outliner in the non-certified group using Grubb's test, a *t*-test gives the values $t=-0.773$ and $P=0.442$, which means we are not close to being able to say that there is a significant difference between the groups. An F-test indicates significant difference between variances.

Table 3
Summary statistics on the change in generation of hazardous waste in the period 1997-2003.

Parameters	Certified firms	Non-certified firms
Count	46	37
Average change (%)	16.7	39.4
Standard deviation	97.3	167
Stnd. skewness	1.24	0.537
Stnd. kurtosis	0.661	-0.800

Only about a third of the firms in the sample reports data concerning waste to landfill. Despite the relatively low number of observations, we do not seem to have any problem with normality, since the values of skewness and kurtosis do not give us any reason to doubt that the observations are normally distributed (see Table 4). The average change in hazardous waste generation improvement is almost --10% for the certified firms while the non-certified seem to improve their handling of waste to landfill by 12%. However, the *t*-test that was carried out after three outliers were removed (two from the sample of certified firms and one from the sample of non-certified firms) do not support that any differences would exist between the groups of firms (t=-1,12, $P=0.272$). The null hypothesis therefore appears to be valid. An F-test shows that there is no significant difference in the size of the variances, which does not give us any reason to doubt the results.

Table 4
Summary statistics on the change in generation of waste to landfill in the period 1997-2003.

Parameters	Certified firms	Non-certified firms
Count	17	14
Average change (%)	-9.50	12.4
Standard deviation	41.3	67.0
Stnd. skewness	-1.10	0.0913
Stnd. kurtosis	-0.0834	-0.805

A small number of non-certified firms (6 firms) reported reliable data concerning the total amounts of waste in the period (see Table 5), which makes a comparison between the groups somewhat problematic. However, we can see in Table 5 that the observations in the two samples can be regarded as normally distributed despite the low number of observations. Furthermore, we see that the mean value of the change in the rate of improvement indicates a slight decrease for certified firms (7%) and what might be a larger reduction for the non-certified firms (34 %). We might suspect that the certified firms perform better but a *t*-test do not confirm this (*t=1,49*, *P=0,150*). An F-test indicates that variances could be considered equal.

Table 5
Summary statistics on the change in generation of total amount of waste in the period 1997-2003.

Parameters	Certified firms	Non-certified firms
Count	18	6
Average change (%)	-6.89	-34.3
Standard deviation	33.8	52.8
Stnd. skewness	0.179	-0.0469
Stnd. kurtosis	-0.212	-0.847

3.2. Time period 1994-2006

The quality of the waste-related data described in the environmental reports from 1994 is much worse than it is in recent years. This fact results in that significantly less observations are available to use for analysis for the period 1994-2006 than for the shorter period. Concerning waste to landfill and total amounts of waste, data from 1994 is so rare that it is not possible to conduct meaningful statistical analyses for the 12 year period.

The quality of the reports also influence the usable number of hazardous waste observations, but here we have enough data for a comparison (see Table 6). Again we have no problem with the distribution of data, although it was necessary to remove four outliers from the observations from the certified firms. The mean value of the change in the rate of improvement for the certified companies is 37 % while the non-certified seems to perform much worse in the period after year 2000 than they did the previous period. A *t*-test helps us to reject the null hypothesis (*t = 2.15, P= 0,0365*) and we can be fairly certain that there is a difference between the two groups of firms. However, we should be somewhat careful when we interpret these results since an F-test shows that the variances are most likely not equal.

Table 6
Summary statistics on the change in generation of hazardous waste in the period 1994-2006.

Parameters	Certified firms	Non-certified firms
Count	36	15
Average change (%)	37.3	-98.7
Standard deviation	166	282
Stnd. skewness	1.24	-0.308
Stnd. kurtosis	0.722	0.677

4. Discussion and conclusions

To summarize the results of our study, we have found some evidence that firms choosing to adopt an EMS and certify according to ISO 14001 might improve their environmental performance concerning hazardous waste at a faster rate than firms choosing not to certify. We were not able to find any significant differences comparing the development over three year intervals before and after ISO 14001 certification, but over a slightly longer interval of six years we can conclude that certified firms performed better. In contrast, we were not able to find any significant differences concerning waste to landfill or the total amount of waste. A possible reason for the divergent results could be that the certified firms simply do not consider that waste to landfill or other waste types are significant environmental aspect and therefore do not actively work with improvements in this area. Instead, firms might have chosen to focus on other areas, for example hazardous waste or other environmental issues that in the current public debate is considered to be more important environmental aspects, such as energy use or emissions of carbon dioxide.

However, we should be somewhat careful in our conclusions since the used data set gives us some problems. Our data is nicely normality distributed and it is clear that the distribution of the data does not influence the statistical methods used. In contrast, the variances in the waste data both from the ISO 14001-cerfied firms and the non-certified firms are large hindering us from seeing clearer differences. In addition, when it comes to the comparison between the two groups of firms regarding hazardous waste an F-test indicate significant differences between variances which influence the validity of the *t*-test. Nevertheless, we have been able to limit the variation to some extent by identifying and removing outliers in the data set. The large variances are somewhat surprising considering that the data is derived from mandatory environmental reports. One factor influencing the variances might be the methods and approaches used by the firms to measure their waste generation. It is obvious when studying the reports that most firms do not measure the amounts of waste themselves. Instead they rely on data from contracted waste handling firms.

On the other hand, there is every reason to believe that the approach taken in this study to try to exclude the effects of factors other than the introduction of EMSs is accurate.

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