

THE EFFECTS OF ENVIRONMENTAL MANAGEMENT SYSTEMS ON SWEDISH MANUFACTURING FIRMS' ENVIRONMENTAL PERFORMANCE

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Abstract

The corporate environmental management tool that undoubtedly has become the most popular in recent years is environmental management systems (EMS) based on ISO 14001. With few exceptions, studies on effects of EMS are relying on firm representatives' perceived benefits, which is problematic since they often have reason to give a positive image of their employer. This study therefore aims to contribute knowledge about the environmental effects of environmental management system based on more objective environmental data. The study focuses on changes in performance 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 improvement efforts in the firms before EMS adoption. Analysis has been carried out using statistical methods, e.g. *t*-test, for six different areas: air emissions, water emissions, resource use, energy use, waste and overall environmental performance. The analysis shows that there was no statistically significant difference concerning the change in the rate of improvement between certified firms and non-certified firms in any of the six areas.

Keywords: Environmental management systems, ISO 14001, corporate environmental performance

Introduction

In the early 1990s, environmental work in the private industrial sector becomes less driven by compliance and more based on internal strategy. A development begins where environmental and sustainability issues becomes of greater and greater strategic importance to firms (Lent & Wells, 1994; Meisner Rosen, 2001), and approaches in terms of concepts, methods or tools to systematically improve corporate environmental performance are created. The tool that undoubtedly has become the most popular in recent years for firms to effectively and systematically ensure compliance, to develop more environmentally efficient processes and gain greater competitiveness, is environmental management system (EMS) (Poksinska et al., 2003, Rivera-Camino , 2001; Gupta & Piero, 2003). Many of the implemented EMSs are based on the international standard ISO 14001. During the period from 1996, when it became possible

to certify against ISO 14001, until now about 129 000 organizations worldwide have chosen to certify against ISO 14001 (Corporate Risk Management, 2009).

Numerous studies have been conducted to evaluate the impact of the EMSs. Some of these argue that the systems lead to real improvements (e.g. Annandale et al., 2004; Arimura et al., 2008; Potoski & Prakash, 2005; Schylander & Martinuzzi, 2008) while others are more hesitant in their conclusions (e.g. Andrews et al., 2003; Hamschmidt & Dyllick, 2001; Hertin et al., 2008; Melnyk et al., 2003). With few exceptions, most of the studies are either case studies including one or a few firms or studies in which questionnaires were sent out to a larger number of firms. Common for these studies is that they rely on how firm representatives are experiencing the benefits of the systems. Often, the person engaged in case studies or answering questionnaires are the firm's environmental manager. The problem with answers or statements made by the environmental manager is that they must be seen as subjective perceptions (Freimann & Walther, 2001). The results may well be different if more objective data are collected, or if other people with other responsibilities within firms were used as respondents (Hamschmidt & Dyllick, 2001). Another disturbing factor is that the environmental managers are often specialists in communication with stakeholders on environmental issues. They are used to painting a positive picture regarding the firm's environmental activities when they get questions from journalists, researchers or students. In addition, they often communicate their own social role within the firm as positive, so they will probably not give out any information that may harm the firm or themselves as environmental experts. This may well lead to perceptions that have no factual support (Freimann & Walther, 2001).

Since it has been shown that qualitative case studies or survey studies tend to show more positive effects of EMSs than the relatively few studies that are based on more objective measurements of changes in environmental performance (Ammenberg, 2003), further studies should be quantitative and as far as possible use more objective environmental data. Qualitative studies such as case studies are generally useful for studying phenomena that are early in development but the possibility of generalizing from the results is limited. In the situation we now find ourselves in when standardized EMSs have existed for about 15 years, the possibility to generalize is of utmost importance. Therefore, this study aims at studying the environmental effects of EMS measured by means of quantitative environmental data.

Method

A number of previously used approaches to study the effects of EMSs have been shown to be associated with weaknesses that strongly affect the results (Schylander & Zobel, 2003; Nawrocka & Parker, 2009). Therefore, the methodology of new studies must be well thought out. It 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. Furthermore, the studies must include not only firms with an EMS but also ones without systems for comparison. Finally, the improvements of firms that existed before the introduction of the EMS must be taken into account.

Research approach

In this study, we have chosen year 2000 as the base year and we studied the change in environmental performance over three-year intervals over the period 1994-2006, i.e. six years prior to certification and six years after certification. Figure 1 shows a schematic illustration of the time periods that form 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 firms. Before analysis, the parameters have been normalized to each firm's production rate.

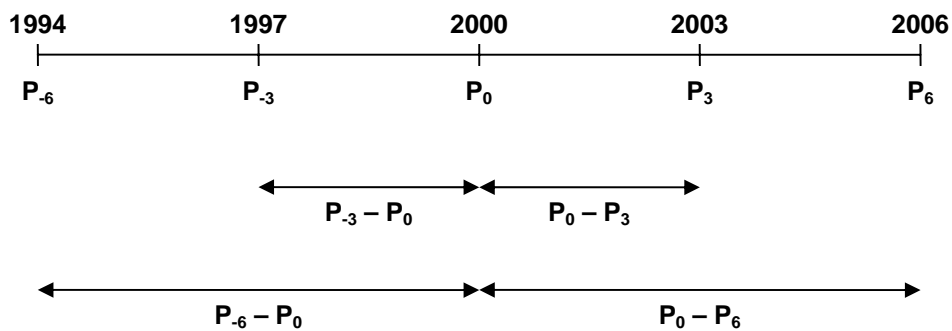


Fig. 1 Schematic picture of the time periods over which the change in performance has been measured in certified and non-certified firms (P_{-6} = environmental performance in 1994, P_{-3} = environmental performance in 1997, P_0 = environmental performance in the base year 2000, P_3 = environmental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

The change in the rate of improvement, measured in percent, has been calculated for a number of environmental parameters over a short period of time, i.e. the period between 1997 and 2003, and a long period of time, i.e. the period between 1994 and 2006. The parameters that have been the subject of analysis are therefore the following if the designations from Figure 1 are used:

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

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

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. 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 relatively complex environmental impact as well an impact that can be considered significant, which increases the possibility to find statistically verifiable differences. 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 a 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 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' different local and regional environmental monitoring agencies. Documents were received for 217 of the 260 firms (83%). All 217 firms were not included in the study for various reasons, e.g. that not enough necessary documents could be found, the firm had closed down or 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 1. We see from the table that we may suspect that the average values of firm size are different, which is also confirmed by a *t*-test. The difference in size is statistically significant at the 0.05 level of significance. This fact should be taken into account when interpreting the study results.

Table 1 Summary statistics over the samples of certified firms and non-certified firms

Parameters	Certified firms	Non certified firms
Count*	56	48
Average	328.625	69.1042
Standard deviation	646.711	99.2421
Coeff. of variation	196.793%	143.612%
Minimum	11.0	2.0
Maximum	4694.0	545.0
Range	4683.0	543.0
Std. skewness	17.9473	8.40338
Std. kurtosis	59.714	15.4402

* 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.

Statistical methods

The method we have chosen for comparison of certified and non-certified firms are *t*-test using the computer program Statgraphics Centurion XV. The *t*-test is one of the most common statistical methods used to compare two different samples. 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. Variances were tested using an F test, which is a commonly used test to compare variances between groups. When extreme values are present, Grubb's test has been used for identification of outliers.

Results

Since we wanted to perform a comparative statistical analysis of the change of the rate of improvement in environmental performance between certified firms and non-certified firms, we set the following null hypothesis and alternative hypothesis which were tested for the periods 1997-2003 and 1994-2006:

H₀ = the change of the environmental performance improvement rate for ISO 14001-certified firms do not differ significantly from the corresponding change for non-certified firms

H_{ALT} = the change of the environmental performance improvement rate for ISO 14001-certified firms differ significantly from the corresponding change for non-certified firms

The change in the rate of improvement has been studied in six different areas: 1) air emissions, 2) water emissions, 3) resource use, 4) energy use, 5) waste, and 6) overall environmental performance. The results in each area are reported in subsections below. The main reason for the division in different areas is to potentially be able to show if EMSs have different impact on different environmental aspects.

Air emissions

When analyzing the changes concerning air emissions, all emission parameters were merged into one parameter by calculating the mean for the percentage change for all air emissions. Typical air emissions are solvents (VOCs), dust, nitrogen oxides (NO_x) and sulfur dioxide (SO₂), but several other parameters were presented in the reports as well. Air emissions that are linked to energy use have not been included here if the energy use are reported since there is often a linear relationship between energy use and the related air emissions. However, if air emissions related to energy use are specified and energy use is not, the air emissions are included. Parameters that are only expressed as concentrations, e.g. mg/l or mg/m³, have not been normalized to the rate of production since these values are independent of how much is produced. If a parameter is expressed by the sign < (less than) before the value, half the value has been used to calculate the change.

1997-2003. About half of the firms have parameters so that they can be included in this analysis (see Table 2). In Table 2 we see the summary statistics regarding air emissions from the two groups of firms. In the table we see that all values of skewness and kurtosis are well within the range -2 to +2, which means we can consider the observations as normally distributed. Furthermore, we see that the mean rate of improvement is reduced by 43 % for the certified firm, while it increases by about 6 % for the non-certified firms. After outliers in both samples were removed using Grubbs's test, a *t*-test gives the values *t* = -1.50148 and *P* = 0.13885. Since the P-value is larger than $\alpha = 0.05$, we can not reject the null hypothesis, but the relatively low P-value still indicate that the non-certified firms perform better than the certified firms. It should be noted that an F-test indicates

that there is a statistical significant difference between variances, which we should keep in mind when interpreting the results.

1994-2006. Fewer firms reported reliable data for air emissions during the period 1994-2006 compared with 1997-2003 (see Table 2). The values for skewness and kurtosis allow us to consider the observations as normally distributed. In Table 2 we see that the mean rate of improvement is reduced by 26 % for the certified firms, while it increases by 15 % for the non-certified firms. A *t*-test without outliers, identified by Grubb's test, gives the values $t=-1.49557$ and $P=0.142244$, The P-value is larger than $\alpha = 0.05$, meaning that we can not reject the null hypothesis. However, the P-value indicates that we have almost the same situation as for the shorter time period. An F-test provides information that there is no statistically significant difference between variances, which means that we can be fairly certain that the *t*-test has full validity.

Table 2 Summary statistics on the change in the rate of improvement concerning air emissions between the periods 1997-2000 and 2000-2003 and the periods 1994-2000 and 2000-2006

Parameters	Certified firms 1997-2003	Non-certified firms 1997-2003	Certified firms 1994-2006	Non-certified firms 1994-2006
Count	35	23	29	15
Average	-43.0951	6.01174	-26.0703	14.9593
Standard deviation	146.857	66.7815	82.703	92.9675
Coeff. of variation	-340.773%	1110.85%	-317.23%	621.468%
Minimum	-382.03	-112.11	-224.97	-102.33
Maximum	334.39	156.7	95.7	167.67
Range	716.42	268.81	320.67	270.0
Std. skewness	0.312825	0.335931	-1.78054	0.40293
Std. kurtosis	1.26509	-0.0707545	0.112581	-0.841671

Water emissions

Analysis of water parameters have been made in the same manner as for air emissions. Common types of emissions include heavy metals, BOD, suspended solids, nitrogen and phosphorus, but several other emission types are reported. As far as it has been possible, total emissions over the whole year are used in the analysis, but when this has not been possible concentrations has been used instead.

1997-2003. As with air emissions, about half of the participating firms have reported some type of emissions to water. In Table 3 we see the summary statistics regarding water emissions from the two groups of firms. In the table we see that one of the values of kurtosis is out of range but the value is relatively close to +2 and we can therefore regard the observations as normally distributed. The average improvement rate for the certified firms decreases by 5 %, while it increases by 13 % for the non-certified firms. All outliers in both samples have been identified by Grubb's test and after removal of outliers a *t*-test gives the values $t=-0.772269$ and $P=0.443386$. The P-value is

significantly larger than $\alpha=0.05$, and we can therefore not reject the null hypothesis. An F-test indicates that there is no significant difference between the variances.

1994-2006. The material collected in this study gives us relatively few useful observations of water emissions for the period 1994-2006. We see from Table 3 that the distribution fits well with normal distribution. The mean change in improvement rate for both certified firms and non-certified firms is positive (about 10 % for the certified companies, and about 5 % for the non-certified companies) and they are close to each other. After the removal of outliers in both samples using Grubb's test a *t*-test gives the values $t=0.184966$ and $P=0.854215$, which makes us fairly confident that we can not reject the null hypothesis. However, the validity of the *t*-test is questionable since an F-test indicates that there is a statistically significant difference between the variances.

Table 3 Summary statistics on the change in the rate of improvement concerning water emissions between the periods 1997-2000 and 2000-2003 and the periods 1994-2000 and 2000-2006

Parameters	Certified firms 1997-2003	Non-certified firms 1997-2003	Certified firms 1994-2006	Non-certified firms 1994-2006
Count	30	25	27	14
Average	-5.438	13.0568	10.2867	4.52143
Standard deviation	80.5191	97.1457	66.0492	134.707
Coeff. of variation	-1480.68%	744.024%	642.086%	2979.29%
Minimum	-156.76	-208.49	-83.63	-215.77
Maximum	207.56	295.38	153.73	261.2
Range	364.32	503.87	237.36	476.97
Std. skewness	1.5275	1.34426	1.081	0.304908
Std. kurtosis	1.85939	2.51316	-0.640442	-0.218033

Resource use

The change in resource use has been difficult to measure by using environmental reports, because resources rarely are reported. However, three parameters are relatively often included in the reports: chemical use, water use and the use of fuels (mainly diesel oil) for internal transports. The mean value of the change in improvement rates for these three parameters have been calculated and used in the analysis within the area of resource use. It is not obvious that an increase in chemical use always is worse from an environmental perspective, because it is often the properties of the chemical and not its amount that will determine its environmental impact. However, in this study we have disregarded this and made the assumption that a reduction of the amount of chemical use in general is environmentally sound.

1997-2003. About half of the firms in the samples report information concerning one or more of the three types of resources that are used here. Summary statistics regarding resource use for the two groups of firms are illustrated in Table 4. We see from the table that we can consider the observations from the non-certified firms as normally distributed. The same applies to the certified firms, although one of the values for

kurtosis is outside the valid range. We see that the mean rate of improvement is increasing by 11 % for the certified firms and the corresponding value for the non-certified firms are 1 %. Grubb's test was used to remove outliers in both samples. After the removal of outliers a *t*-test gives the values $t=0.707141$ and $P=0.482636$, which does not give us any reason to reject the null hypothesis. An F-test indicates that there is no significant difference between the variances.

1994-2006. Only about a third of the firms in the samples reports one or more parameters within the recourse use area over the period 1994-2006. The values of skewness and kurtosis do not give us any reason to doubt that the observations are normally distributed. The mean value for the improvement rate increases a few percent for both the certified firms and the non-certified firms. Despite the small count of observations, a *t*-test has been carried out after outliers were removed from the sample of certified firms using Grubb's test. The *t*-test gives the values $t=-0.0986028$ and $P=0.92205$. The null hypothesis therefore appears to be valid. An F-test shows that there is no significant difference in the size of the variances.

Table 4 Summary statistics on the change in the rate of improvement concerning recourse use between the periods 1997-2000 and 2000-2003 and the periods 1994-2000 and 2000-2006

Parameters	Certified firms 1997-2003	Non-certified firms 1997-2003	Certified firms 1994-2006	Non-certified firms 1994-2006
Count	31	23	20	15
Average	11.1758	1.28478	3.524	5.28933
Standard deviation	49.7625	52.2406	50.1653	55.3244
Coeff. of variation	445.27%	4066.11%	1423.53%	1045.96%
Minimum	-142.08	-105.59	-79.95	-89.55
Maximum	137.17	119.22	113.68	119.22
Range	279.25	224.81	193.63	208.77
Std. skewness	-0.893607	-0.00145396	0.882206	0.533179
Std. kurtosis	2.82283	0.204296	-0.263639	-0.144877

Energy use

When analyzing the change in the rate of improvement in the energy use area three different parameters have been used: electricity, fossil fuel and total energy. The values that have been the subject of analysis is a merger of the three parameters where the mean of the percentage changes for the three parameters have been calculated. The parameter fossil fuel use often consists only of consumption of fuel oil but sometimes include other fossil fuels such as oil, LPG and natural gas. In such cases the energy content of the various fuels have been calculated and the sum of the energy content used for analysis. Parameters that are related to renewable energy sources are not included as separate parameters because an increase in the use of renewable energy can often be counted as an improvement.

1997-2003. Compared with the previously analyzed areas significantly more firms (about two thirds) reports of one or more of the parameters we use in the area of energy use. In Table 5 we can see the summary statistics regarding energy use for the two groups of firms. One of the values of skewness is near the range limit of +2, but we should still be able to consider the distribution as normally distributed. The mean for the change in improvement rate is 1 % for the certified firms while the corresponding mean for the non-certified firms is – 22 %. As before, however, variances are large. Testing of the hypothesis by a *t*-test, after removal of outliers using Grubb's test, gives the values $t=1.6593$ and $P=0.10166$. Thus, we can not reject the null hypothesis, although the relatively low P-value allows us to suspect that the certified firms are doing better in this area. It should be noted that the *t*-test is not fully valid in this case as an F-test indicates that there is a statistical difference between the variances.

1994-2006. A relatively small number of non-certified firms reported energy-related parameters in 1994 (see Table 5), which makes a comparison between the groups difficult. We see in Table 5 that the observations in the two samples can be regarded as normally distributed. Furthermore, we see that the mean of the change in the rate of improvement indicates a slight decrease for both certified firms (6 %) and non-certified firms (12 %). A *t*-test, after the outliers have identified and removed using Grubb's test in both firm samples, gives the values $t=0,344847$ and $P=0,731549$, and we are therefore not close to rejecting the null hypothesis. The results, however, is questionable since an F-test indicates that variances are most likely not equal.

Table 5 Summary statistics on the change in the rate of improvement concerning energy use between the periods 1997-2000 and 2000-2003 and the periods 1994-2000 and 2000-2006

Parameters	Certified firms 1997-2003	Non-certified firms 1997-2003	Certified firms 1994-2006	Non-certified firms 1994-2006
Count	43	27	40	16
Average	-1.12953	-21.8456	-5.858	-11.6806
Standard deviation	36.4078	67.9712	49.3409	73.483
Coeff. of variation	-3223.26%	-311.144%	-842.282%	-629.102%
Minimum	-64.78	-187.11	-133.77	-157.42
Maximum	89.94	123.88	120.09	76.37
Range	154.72	310.99	253.86	233.79
Std. skewness	2.10266	-1.17428	-0.969695	-1.54335
Std. kurtosis	1.1184	0.954961	1.44716	0.058214

Waste

Waste-related parameters have been handled in a similar way as energy-related parameters. The parameters hazardous waste, waste to landfill and the total amounts of waste have been used for analysis. The values that have been the subject of analysis is the combination of these three parameters where the mean of the percentage change for the three parameters have been calculated. An increase in waste going to reuse, recycling,

composting or incineration is often counted as an improvement and can therefore not be used directly in our analysis.

1997-2003. Despite problems in interpreting environmental reports concerning the disposal of waste and quantities of waste, the number of observations that we have been able to use for the analysis are greater than for the other areas. Summary statistics regarding waste from both groups of firms are shown in Table 6. We see from the table that the observations are likely to be normally distributed. Furthermore, we see that the mean of the change in rate of improvement is 15 % for the certified firms and 34 % for non-certified firms. After removal of outliers using Grubb's test, a *t*-test gives the values $t=-0.735643$ and $P=0.463883$, which means we are not close to reject the null hypothesis. An F-test indicates significant difference between variances.

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 significantly less observations available to use for analysis for the period 1994-2006 than for the shorter period (see Table 6). The values for skewness for the sample of certified firms are outside the limit of +2, which means we have a small problem with the distribution of data. The mean of the change in the rate of improvement for the certified firms that are 36 % while the non-certified firms shows a reduction of 16 %. Grubb's test shows a number of outliers in both samples and all these have been removed before a *t*-test gives the values $t=1.60704$ and $P=0.113988$. The P-value is less than $\alpha=0.05$ and therefore we can not reject the null hypothesis, but we may suspect that the certified firms has a greater positive change in its rate of improvement in the waste area compared to the non-certified firms in the period from 1994 to 2006. The *t*-test should be valid as an F-test does not show any significant differences between variances.

Table 6 Summary statistics on the change in the rate of improvement concerning waste between the periods 1997-2000 and 2000-2003 and the periods 1994-2000 and 2000-2006

Parameters	Certified firms 1997-2003	Non-certified firms 1997-2003	Certified firms 1994-2006	Non-certified firms 1994-2006
Count	47	44	37	18
Average	15.4834	33.942	36.01	-15.6283
Standard deviation	81.6751	149.926	119.881	92.4407
Coeff. of variation	527.501%	441.711%	332.911%	-591.494%
Minimum	-187.4	-234.58	-206,8	-161.76
Maximum	239.86	406.29	379.23	143.76
Range	427.26	640.87	586.03	305.52
Std. skewness	1.47186	0.429576	2.42191	-0.570159
Std. kurtosis	1.55671	-0.460511	1.81584	-0.715463

Overall environmental performance

In order to get a measure of the studied firms' overall environmental performance, all reported parameters in each firm have been merged into one parameter by calculating the mean of the percentage change for all reported parameters. Although we here use the

term overall environmental performance, it is the only the performance that has its origin inside the gates of the firms that are included. Two key areas such as transport and the firms' products are not included because data in these areas are not available in the environmental reports.

1997-2003. In the analysis of overall environmental performance observations from a relatively large number of firms have been used. In Table 7 we see the summary statistics regarding overall environmental performance of both groups of firms. Even though a number of outliers have been removed using Grubb's test, we still have a value of skewness for the certified firms which are outside the lower limit of -2, giving us some problems with normality. In Table 7 we see that the means of the two groups differ somewhat. The certified firms show a negative change in the rate of improvement of 11 % while the non-certified firms show a positive change of 25 %. After removing outliers using Grubb's test, a *t*-test provides values of $t=-1.98456$ and $P=0.0501092$. The P-value is not less than $\alpha=0.05$, but it is very close. The difference in mean is not statistically significant at the 95 % confidence level but you can still determine that it is likely that the improvement rate increases more in the non-certified firms than in the certified firms. The *t*-test is most likely valid regarding the assumption of equal variances as an F-test indicates that it is unlikely that the variances are different.

1994-2006. As before, the number of usable observations is much less for the longer time period. We see in Table 7 that we can be fairly sure that both distributions are relatively close to normal distribution. The mean for the change in the rate of improvement in the two samples are 19 % for the certified firms and 5 % for the non-certified firms, which is an almost inverted result compared with the corresponding analysis for the period 1997-2003. Also for the longer period Grubb's test shows that the data from both groups of firms contains a number of outliers that have been removed before a *t*-test gives values of $t=1.20939$ and $P=0.230527$, which means that we can not reject the null hypothesis. An F-test indicates that variances can most likely be considered equal in this case.

Table 7 Summary statistics on the change in the rate of improvement concerning overall environmental performance between the periods 1997-2000 and 2000-2003 and the periods 1994-2000 and 2000-2006

Parameters	Certified firms 1997-2003	Non-certified firms 1997-2003	Certified firms 1994-2006	ALLA EJ CERT 6 UU
Count	52	44	46	27
Average	-10.5785	24.9243	18.8539	-4.77889
Standard deviation	93.0846	79.983	72.6266	92.8015
Coeff. of variation	-879.944%	320.903%	385.207%	-1941.91%
Minimum	-274.31	-140.27	-101.22	-185.9
Maximum	148.31	228.49	209.33	192.37
Range	422.62	368.76	310.55	378.27
Std. skewness	-2.68434	1.2102	1.82632	-0.247598
Std. kurtosis	1.6582	0.0351416	0.702382	-0.316505

Discussion

We have in this study not in any of the analyzed areas been able to find any statistical significant differences between ISO 14001-certified and non-certified firms at 95 % confidence level. However, in some areas we can at least suspect that differences exist.

The area where the analysis is closest to show statistically significant differences between the two groups of firms is overall environmental performance. Here we get results that are surprising, while at the same time they are divergent and difficult to explain. For the period 1997-2003, it is likely that the non-certified firms have a greater positive change in the rate of improvement than the certified firms. Surprisingly, the trend is the opposite for the period 1994-2006. Why the results are divergent for the two time periods is difficult to explain. One possible explanation would be that it takes longer than three years before the effects of the EMSs becomes visible as suggested in previous studies (MEPI, 2001). A possible, but not very probable explanation of why the non-certified firms seem to increase their rate of improvement more during the shorter period would be that the companies that choose to certify have to spend much time on the system itself before you start to see effects of the system.

With regard to air emissions, we can suspect that the non-certified firms are increasing their rate of improvement more than the certified firms in both the short and the longer period. Also these results are difficult to explain. A possible reason could be that the certified firms simply do not consider that air emissions are a significant environmental aspect and therefore do not actively work with improvements in this area. Instead, firms might have chosen to focus on other areas that in the current public debate is considered to be more important environmental aspects, such as energy use or CO₂-emissions

One area that shows tendencies to results that are more in line with what one would expect is energy use. For the longer time period, we can not find any differences, but for the short time period, our analysis shows possible positive effects of EMSs. To derive a probable reason for this is obviously not easy but the same reasoning as above regarding the prioritized environmental aspects could be used as explanatory manner. Similar results as in the energy area we get from analysis of waste parameters, with the difference that in this case we might suspect differences for the longer time period. To find an explanation as to why EMSs would reduce energy use in the short term but reduce waste in the long term is very difficult.

Comparison with previous research

Several other studies have claimed to study the relationship between EMS and overall environmental performance by using objective environmental data. However, it is really only one study in which a sufficient number of different types of parameters have been studied that it is right to claim a focus on overall performance. Generally it was found in this so called MEPI-study that ISO 14001-certified firms in several European countries did not perform better than non-certified firms (Hertin et al., 2001). Statistically significant differences could only be found in one case. In addition, the researchers also

found that the certified firms in several cases appeared to perform worse than firms without EMS. Even though different approaches and methods were used in our study and the MEPI-study, the results can be considered to be relatively consistent.

For individual parameters, it is not so easy to find relevant studies to compare with. However, a couple has been found with a focus on emissions to air and water. The first is a relatively small statistical study within pulp and paper industry in Quebec, Canada. This study focused on the effects of EMS on emissions of BOD and suspended solids into water and the total discharge of waste water (Barla, 2007). The results of the Canadian study shows that ISO 14001-certification does not appear to have any effect on the amount of suspended substances or effluents. In contrast, the emissions of BOD declined slightly in the certified firms. The study also shows that the effects of the EMS vary greatly between different firms. Since our study could not find any positive effects of EMSs on water parameters as well as great variation between firms, we may say that the correlation between the two studies is good. The results from another North American study differs more from our results. In this study, emissions data from about 4,000 firms in the United States, of which 4 % were ISO 14001-certified, were used for analysis. In the study, the change in various emissions to air and water during the period 1995 to 2001 in ISO 14001-certified firms and non-certified firms were compared (Potoski & Prakash, 2005). The results showed that the certified firms generally reduced their emissions faster than the non-certified firms. It should be noted the improvement rate prior to the adoption of the EMS were not taken into account, making it difficult to ensure that the higher reduction rate in the certified firms actually depended on the certified systems.

Limitations of approach and methods used

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 that can affect environmental performance is accurate. More subjective studies in which firm representatives are asked about their experiences concerning the benefits of the systems are not needed. However, it is far from obvious that the way we have chosen to quantify environmental performance is optimal. When different parameters have been merged into one, it is the mean of the change in improvement rate that have been analyzed without any assessment made of each parameter for its potential environmental impacts. Such an assumption that all parameters have equal influence is of course a rough approximation. One option would be to either make your own subjective weighting of the parameters or use any of the valuation models developed in the field of LCA (Life Cycle Assessment).

It is also not optimal to rely on parameters that are reported in environmental reports when trying to seek changes in environmental performance, because it is not possible to affect which parameters that are reported. The parameters included in the reports are not comprehensive but represents only what the firm and its monitoring agency have agreed upon. In addition, environmental reports often contain only the parameters associated with environmental impacts that originate inside the gates of the facility. Parameters with

its environmental impact outside the facility such as products or transports are rarely reported.

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