The Impact of Environmental Regulation on Competitiveness in the European Cement Industry – Results of a Matched Plant Comparison Between Germany, Spain and the UK*

Ursula Triebswetter
and David Hitchens**

Introduction: Environmental regulation and competitiveness

Essentially, there are two opposite views on the impact of environmental legislation on competitiveness. The traditional view fears that private costs initiated through stringent environmental policy impair competitiveness and productivity (Palmer et al. 1995). Conversely some commentators have argued that environmental regulation spurs innovation in a number of ways and that there are "win-win" opportunities available through environmental regulation, where simultaneously pollution is reduced and productivity increased ("Porter hypothesis" or revisionist view, Porter and van der Linde 1995). The differences between the traditional and the revisionist views can only be measured in empirical studies.

In general terms, a negative impact on the output and employment of firms will be stronger the larger the rise in costs following compliance, the greater the differential cost penalty relative to domestic and foreign competitors, the more significant the compliance costs are in total costs, the greater the degree of price competition between firms and the greater the sensitivity of demand to price increases (OECD 1993). Empirical studies taking labour productivity as the main indicator of competitiveness and firm performance come to at least mixed findings concerning the relationship between environmental regulation and competitiveness (Stewart 1993; Gray and Shadbegian 1995; Repetto 1995; Boyd and McClelland 1999). Clear proof of the Porter hypothesis is scarcely found (one example would be Murty and Kumar 2001). One shortcoming found in all the studies is that no systematic search for the impact of the type of environmental abatement measure was undertaken. In most cases the impacts of end-of-pipe technologies were measured, but not those of process-integrated or clean technologies. It should also be noted that much of the evidence has been US based, with only little attention paid to the European case.

Therefore this research was designed to cover the impact of European environmental policy and to examine not only the effects of end-of-pipe technology, but also those of clean technology. The cement industry was chosen because the sector is known to bear significant costs of environmental compliance.[1] German data were contrasted with those in similar (matched) firms in the UK and Spain, where national clean air regulation in the area of dust, SO_2 and NO_x emissions is still less stringent (see Tables 1 and 2 for an overview of clean air regulation in the European Union, EU 15). Especially the German national dust and NOx emission limits both for new and existing plants are among the most stringent emission limit values in the EU. The German NOx limits are 500 mg/Nm3 for new installations and 800 mg/Nm3 for existing installations. In comparison, Spanish legislation is in many provinces still quite soft. In 1998 Spanish NOx emission limit values were still fixed between 2400 and 6000 mg/Nm3. However, there is tremendous regional variation in Spain with a tendency in the North of being more progressive than in the South. In the UK permits are given on a plant by plant basis. Any emission limit values are understood as benchmark values, i.e. they are among

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** Dr. Ursula Triebswetter is senior research fellow at the department of Environment, Regions and Transport, Ifo Institute, Munich.
Prof. Dr. David Hitchens holds a chair in economics at Queen's University Belfast, School of Management and Economics, Belfast.

[1] In Germany in the year 2000 average environmental investments amounted to about 3.3 percent of all investments in the cement industry. Average environmental investments in the German manufacturing industry only amount to 3 percent of all investments (Wackerbauer 2002).

Table 1

National dust emission limits for the production of cement within the European Union (EU 15), in mg/Nm^3, around 2000

	Data based on	New/modified or existing plant	Kiln stack	Clinker cooling	Cement grinding	Other point sources
Austria	Na[a]	new/modified	50	50	50	50
		existing	50	50	50	50
Belgium	P	new/modified	50	50	50	
		existing	50–150	50–400	50–150	50–300
Denmark	P	existing	50[b]	50[b]	50[b]	50[b]
Finland	P	new/modified	50	50	30–50	30–50
		existing	50[c]	50	30–50	30–50
France	Na	new/modified	50	100	50	30
		existing	50[d]	100[d]	50[e]	30
Germany	Na	new/modified	50	50	50	50
		existing	50	50	50	50
Greece	Na/R	new/modified	100	100	100	
		existing	150	150	150	
Ireland	Na	new/modified	50	100	75	50
		existing	50	100	75	50
Italy	Na/P	Existing	50	50	50	50
Luxembourg	P	Existing	30[f]			
Netherlands	P	Existing	15[f]	10[f]	10[f]	10[f]
Portugal	Na	new/modified	50	100	75	50
		existing	100	100	75	50
Spain	Na	new/modified		170/100[g] 100[h]	300/250[g] 75[h]	300/250[g] 50[h]
		existing	400/250[g] 100[h]	170/100[g] 100[h]	300/250[g] 75[h]	300/250[g] 50[h]
Sweden	P	Existing	50 (i)	50	50	20
United King dom	Na[j]	new/modified	40[k]	50[k]	40[k]	50[k]
		existing	[l]	[l]	[l]	[l]

Na = National law; R=Regional law; P=Typical permit; in mg/Norm m^3.
[a] Daily averages and reference condition of 273 K, 101.3 kPa, dry gas and 10% O_2. – [b] Limits under discussion. Reference condition of 273 K, 101.3 kPa, dry gas and 10% O_2. – [c] Existing plant must meet 50 mg/Nm^3 by January 1, 2001. Monthly averages and reference condition of – [d] 10% O_2 and dry gas. – [e] Existing plant with emission <150 mg/Nm^3 must meet limit for new plant by 2001. – [f] Existing plant must meet limit for new plant by 2001. – [g] Daily average values. – [h] Current limits. – [i] Limits under discussion. – [j] Daily average value. A limit value of 90 mg/Nm^3, including start/stop and CO-trips, applies for monthly averages. – [k] IPC Guidance Note S2 3.01. – [l] Benchmark releases. Benchmark releases are, in particular, not applicable to existing plant but are a factor in considering appropriate limits.

Source: EIPPC Cement BREF (2000). Based on Cembureau report (1997) and information provided by experts of the Technical Working Group set up in order to support the production of the BREF.

the strictest in the industry, but are not applicable for existing plants.

Furthermore, the cement industry is a very energy-intensive industry. As a result waste (e.g. tyres, rubber, paper waste and sludge) has been used as a fuel in this industry for more than 10 years and to varying degrees in the Member States of the European Union. The burning of these alternative fuels is more widespread in Germany than in the UK and Spain. In all countries it made necessary additional maximum emission limits for heavy metals.

Research method, sample selection, main hypothesis and measurement of competitiveness impacts

Matched plant technique

The central aim of this research is to examine whether different levels of environmental strin-

Table 2

National SO_2 and NO_x emission limits for the production of cement within the European Union (EU 15), in mg/Nm^3, around 2000

	Data based on	New/modified or existing plant	SO_2 normal situation	SO_2 S-rich raw materials	NO_x	PCDD/Fs* ng TEQ/Nm^3
Austria	Na$^{a)}$	new/modified existing	200 200	400 400	500 1000	
Belgium	P	new/modified existing	1000 1000		1800 1800	
Denmark	P$^{a)}$	existing	5/250/450$^{b)}$	no limit	1200/2500/850$^{c)}$	no limit
Finland	P$^{d)}$	existing	150–400		1200–1800	
France	Na	new/modified existing	500 500(e)	1200/1800$^{f)}$ 1200/1800$^{e)f)}$	1200/1500/1800$^{g)}$ 1200/1500/1800$^{g)}$	
Germany	Na	new/modified existing	400 400	400 400	500 800	
Greece						
Ireland	Na	new/modified existing	400 400	700 700	1300 1300	n.a. n.a.
Italy	Na/P	new/modified existing	 600		 1800	10000$^{h)}$ 10000$^{h)}$
Luxembourg	P	existing	100$^{i)}$		800$^{j)}$	0.1$^{k)}$
Netherlands	P	existing	$^{l)}$		1300$^{j)}$	0.1
Portugal	Na	new/modified existing	 400		 1300	0.1 0.1
Spain	Na	new/modified existing	2400/6000$^{m)}$ 600$^{n)}$ 2400/6000$^{m)}$ 600$^{n)}$	2400/6000$^{m)}$ 1800$^{n)}$ 2400/6000$^{m)}$ 1800$^{n)}$	1300-1800$^{n)}$	
Sweden	P	existing	-	<200	<200	0.1
UK	Na$^{o)}$	new/modified existing	200$^{p)}$ $^{q)}$	 600-2500$^{r)}$	900$^{p)}$ 500-1200$^{q)s)}$	

Na = National law; R=Regional law; P=Typical permit; in mg/ Norm m^3.
* Polychlorinated dibenzo dioxins and furans (total emitted quantity in nano g/ Norm m^3).
$^{a)}$ Daily averages and reference condition of 273 K, 101.3 kPa, dry gas and 10% O_2. – $^{b)}$ 5 for semi-dry process, 250 for wet process and 450 for wet process with wet scrubber and heat recovery. Limits under discussion. – $^{c)}$ 1200 for semi-dry process, 2500 for wet process and 850 for wet process with wet scrubber and heat recovery. Limits under discussion. – $^{d)}$ Monthly averages, reference condition of 10% O_2 and dry gas. – $^{e)}$ Existing plant must meet limit for new plant by 2001. – $^{f)}$ 1200 mg/Nm^3 if ≥ 200 kg/h; 1800 mg/Nm^3 if < 200 kg/h. – $^{g)}$ 1200 mg/Nm^3 for dry process with heat recuperation, 1500 mg/Nm^3 for semi dry and semi wet processes, and 1800 mg/Nm^3 for wet and dry processes without heat recuperation. – $^{h)}$ General rule for any kind of industrial emission. – $^{i)}$ Half hour average. – $^{j)}$ Daily average value. $^{k)}$ 6 hour average. – $^{l)}$ 90 kg/h as daily average, maximum 375 tonne/year. – $^{m)}$ Current limits. – $^{n)}$ Limits under discussion. – $^{o)}$ IPC Guidance Note S2 3.01. – $^{p)}$ 'Benchmark releases'. – $^{q)}$ Benchmark releases are, in particular, not applicable to existing plant but are a factor in considering appropriate limits. – $^{r)}$ Limit values reflect the actual levels of releases. Daily averages and reference condition of dry gas and actual O_2 content. – $^{s)}$ Actual releases, daily averages, not all plants currently have limits.

Source: EIPPC Cement BREF (2000). Based on Cembureau report (1997) and information provided by experts of the Technical Working Group set up in order to support the production of the BREF.

gency have an impact on competitiveness. For a robust testing of the potential effects of environmental regulation on competitiveness in the cement industry the need for a detailed compilation of empirical data was recognised. The matched plant comparison was selected as research method; it is an interview-based sample survey technique which is comparable to a benchmarking exercise (e.g. Hitchens et al. 1990 and 1993; Mason et al. 1994; for an extension to questions of environmental economics, see Hitchens et al. 1998, 2000, 2001). It systematically compares supply-side features of the firm after controlling for size, ownership and product type. While no formal model is used for the specification of a production function, the technique has yielded robust measurements of the importance of a range of factors influencing relative competitiveness in a variety of industries across the EU.

The technique allows access to sometimes confidential data on environmental costs and economic performance. This is particularly important since the focus of the study was on the cost and environmental effects of clean technology solutions which are not covered in the census data. Between May 1999 and April 2000 18 interviews were undertaken in dry process cement plants in Germany, Spain and the UK. Access to additional information on

Table 3

Overview about pollution reduction techniques for the cement industry and its environmental and economic effects

	Kiln systems applicability	Reduction efficiency	Reported emissions		Reported costs[c)g)]	
			mg/m^3 [a)]	kg/tonne[b)]	Investment	Operating
NO_x Reduction techniques						
Flame cooling	All	0–50%	400–	0.8–	0.0–0.2	0.0-0.5
Low-NO_x burner	All	0–30%			0.15–0.8	0
Staged combustion (MSC)	Precalciner	10–50%	<500–1000	<1.0–2.0	0.1–2	0
	Preheater				1–4	0
Selective non-catalytic reduction (SNCR)	Preheater and Precalciner	10–85%	200–800	0.4–1.6	0.5–1.5	0.3–0.5
Selective catalytic reduction (SCR) – data from pilot plants only	Possibly all	85–95%	100–200	0.2-0.4	ca. 2.5[d)] 3.5–4.5[e)]	0.2–0.4[d)] No info.[e)]
SO_2 reduction techniques						
Absorbent addition	All	60-80%	400	0.8	0.2–0.3	0.1–0.4
Dry scrubber	Dry	up to 90%	<400	<0.8	11	1.4–1.6
Wet scrubber	All	>90%t	<200	<0.4	6–10	0.5–1
Activated carbon	Dry	up to 95%	<50	<0.1	15[f)]	no info.
Dust reduction techniques						
Electrostatic precipitators	All kiln systems clinker coolers cement mills		5–50 5–50 5–50	0.01–0.1 0.01–0.1 0.01–0.1	2.1–4.6 0.8–1.2 0.8–1.2	0.1–0.2 0.09–0.18 0.09–0.18
Fabric filters	All kiln systems clinker coolers cement mills		5–50 5–50 5–50	0.01–0.1 0.01–0.1 0.01–0.1	2.1–4.3 1.0–1.4 0.3–0.5	0.15–0.35 0.1–0.15 0.03–0.04
Fugitive dust abatement	All plants		–	–	–	–

[a)] Normally referring to daily averages, dry gas, 273 K, 101.3 kPa and 10% O_2. – [b)] kg/tonne clinker: based on 2000 m^3/tonne of clinker. – [c)] For No_x and SO_2: investment cost in 10^6 Euros and operating cost in Euros/tonne of clinker, normally referring to a kiln capacity of 3000 tonne clinker/day and initial emission up to 2000 mg NO_x/m^3. – [d)] costs estimated by Ökopol for a full scale installation (kiln capacities from 1000 to 5000 tonnes of clinker/day and initial emissions from 1300 to 2000 mg NO_x/m^3), operating costs ca. 25% lower than for SNCR. – [e)] Costs estimated by Cembureau for a full scale installation. – [f)] This cost also includes an SNCR process, referring to a kiln capacity of 2000 tonne of clinker/day and initial emission of 50-600 mg SO_2/m^3. – [g)] For dust: investment cost in 10^6 euros and operating cost in euros per tonne of clinker for reducing the emission to 10-50 mg/m^3, normally referring to a kiln capacity of 3000 tonne clinker per day and initial emission up to 500 g dust/m^3

Source: EIPPC Cement BREF (2000).

profitability, which was necessary for the estimation of competitiveness effects in the cement industry, was made possible during later interviews with headquarter offices in November 2000.

Sample selection and classification according to environmental criteria

The size distribution and the environmental performance of sample plants should be representative of the industry in each country. To control for this factor the size distribution and the environmental performance of the sample was cross-checked with national statistics.

From the eight plants visited in Germany six were located in West Germany and two in East Germany. The latter plants were visited in order to consider the special situation in East Germany, where after the German reunification cement plants have been rapidly modernised with high capacity dry kilns. From the five Spanish plants three were located in Andalusia, one close to Madrid and one in Catalunia. The five UK plants were located throughout the country.

Sample plants were matched by size and environmental category. It was possible to gain access to detailed data on the emission situation of sample plants visited in Germany, Spain and the UK. This had an impact on the analytical approach insofar as a concise classification of the cement sample according to environmental parameters was possible. Within this framework it was possible to ask the question whether the top environmental performers were economically any different from their counterparts with a lower environmental performance. As a background for the interviews a recently published list of best available technologies (BAT) for the cement industry was used (EIPPC Cement BREF,

Table 4

Number of cement plants in different environmental categories and size classes* in the sample

Environmental category	Germany		Spain		UK	
	No. of plants	Size class	No. of plants	Size class	No. of plants	Size class
Group 1:						
Low emissions and medium number of env. measures	1	Small	0	–	1	Large
Low emissions and high number of env. measures	1	Large	0	–	0	–
Group 2:						
Medium emissions and low number of BATs	0	–	0	–	1	Large
Medium emissions and medium number of BATs	1	Medium**	1	Small	1	Medium
Medium emissions and high number of BATs	5	4 Medium***, 1 Large	0	–	0	–
Group 3:						
High emissions and low number of BATs	0	–	2	2 Large	0	–
High emissions and medium number of BATs	0	–	2	2 Medium	2	1 Large, 1 Medium
Total number of plants	8		5		5	

* Size classes are defined as follows: small size: < 600,000 tonnes of cement per year; medium size: 600,000 – 1,000,000 tonnes of cement per year; large size: > 1,000,000 tonnes of cement per year. – ** This plant has remarkably lower emissions than the average of all medium-sized plants. – *** One of these plants has remarkably lower emissions than the average of all medium-sized plants. These two marked medium-sized plants required a further differentiation of group 2 later on and were analysed in a group called group 2a, whereas the other three medium-sized plants are called group 2b. For ease of illustration group 2b also includes the remaining large plant of group 2 with average emissions.

2000; see Table 3 for an overview of abatement technologies and their expected effects). This list was developed as a reference document for the European cement industry within the framework of the Council Directive 96/61/EC on integrated prevention and pollution control (IPPC). During the interviews it was asked which of the possible technologies for NO_x, SO_2 and dust abatement were implemented in sample plants and what were their exact economic and environmental effects.

Both clean technology measures and end-of-pipe technologies were examined. With respect to the total number of environmental initiatives, it became evident that German sample plants clearly undertook more activities than their counterparts in the other sample countries. The analysis of emission data revealed that, on average and as expected, German plants had the lowest dust and NO_x emissions. Lowest SO_2 emissions were found in the Spanish sample. The number and type of clean air initiatives (process-integrated or end-of-pipe) together with the actual emission levels served as a classification model for the environmental quality of sample plants. A total of 18 cement sample plants were divided in three groups of different environmental quality (see Table 4). As expected, German plants fell into the groups with higher environmental quality (two plants in group 1 and six in group 2). Four of the five Spanish plants were classified as group 3 performers. In the UK sample plants were to almost even parts both group 2 and 3 performers.[2]

The number of individually matched pairs is shown in Table 5. A full set of comparisons was possible between Germany and Spain; due to the lack of small sample plants in the UK no comparison of small British and German plants was possible.

Main hypothesis and measurement of competitiveness impacts

The main hypothesis was that the proportional cost of environmental compliance relative to turnover

[2] Two of the medium-sized plants in the German group 2 have remarkably lower emissions than the average of all medium-sized plants. These two medium-sized plants required a further differentiation of group 2 later on and were analysed in a group called group 2a, whereas the other three medium-sized plants are called group 2b. For ease of illustration group 2b also includes the remaining large plant of group 2 with average emissions (see results presented in Tables 7 and 8).

incurred by the firms is likely to be a negative function of the productivity level. This is supposed to hold because firms with the capability of achieving high productivity will also find it easiest to implement environmental initiatives and high environmental performance without the penalty of reduced output and employment (Hitchens et al. 1998, 2000, 2001). To this end it was measured through which abatement initiatives cement plants in Europe have adjusted to varying levels of environmental regulation, why they were put in place (legislation vs market driven measures), at what costs and how their competitiveness was affected. Information on the impact of environmental measures on overall profitability was obtained. Moreover, general competitive advantages and disadvantages were put in relation to the impact resulting from environmental regulation.

Table 5

Number of individually matched pairs in the cement sample*

Size	Germany : Germany	Germany : Spain	Germany : UK
Small	–	1 : 1	–
Medium	2 : 3	5 : 2	5 : 2
Large	1 : 1	2 : 2	2 : 2
Total	3 : 4	8 : 5	7 : 4

* First number always refers to plants in higher environmental category than second number.

Factors influencing competitiveness in the European cement industry

Cement is a binding agent and important building material. It consists mainly of calcium (normally limestone), silica, alumina and iron ore. It is made by quarrying, crushing and grinding raw materials, burning them in huge rotary kilns at high temperatures and finely grinding the resulting clinker with gypsum into an extremely fine, usually grey, powder. There is a wide variety of cements, but each type is standardised to agreed norms. Cement quality standards are relatively easy to meet and the product is internationally competitive. While there are about 250 cement plants in the EU, there has been much consolidation of the industry through merger and acquisition since the 1970s. Technology of kilns has changed to the dry technology with cyclone preheaters. This has gone along with an increase in capacity and greatly improved energy efficiency. Today, the minimum optimal size (MOS) for a kiln is considered to be 3,000 tonnes per day (Wagner and Vassilopoulos 2000). Up to this size the unit costs decrease, if capacity is fully utilised. Concentration of production in the industry is high. The market share of the three largest manufacturers in Germany, Spain and the UK is 48 percent, 56 percent and 94 percent respectively (Dresdner-Kleinwort-Benson Research 1998).

Cement is a heavy, low unit price product and transport costs are an important factor for the producer's customer base (Dumez and Jeunemaître 2000). Most cement is delivered by road and in Western Europe transport costs usually limit supply to a radius of 200 km. Cheap rail freight and low production costs have led to imports from Eastern Europe and elsewhere by sea. Transport by water is cheap and, once handling charges are paid, distance matters little. Cement prices at ports are often lower than inland (the difference can be as much as 20 percent). Quantity-wise imports from South East Asia to the EU still play a minor role[3], but they influence the prevailing prices and can induce national cement manufacturers to offer considerable price discounts. The prices for these cement imports were said to be about EUR 10 cheaper than the prices at national European ports[4]. Despite this threat from imports, customer need for just-in-time deliveries of cement of uniform quality limits competition (see Hitchens et al. 2002).

Sample description according to economic and environmental criteria

Within the countries under consideration for this case study the German cement industry is the largest producer in terms of number of plants, employees and total production (see Table 6 below). Spain takes the top ranking with respect to labour productivity measured as annual output per employee.

Since about 70 percent of variable costs in cement production are incurred by energy and electricity costs, this factor receives greatest attention for cost

[3] Imports from Asia (South East Asia, Saudi Arabia, Turkey and Lebanon) to Belgium and the Netherlands in the first 10 months of 2000 amounted to 600,000 tonnes cement. Prices were about 20 percent below market price. Information by Cembureau, Brussels.
[4] Interviews in November and December 2000 with chief executives of participating cement companies.

Table 6

Comparison of German, Spanish and UK cement industry according to economic and environmental criteria

Most recent year available	Country		
	Germany 1999	Spain 1997	UK 1998
No. of plants	66	43	22
Employees	11,372	5.464	5,000
Production cement (1,000 t)	36,000	27,933	12,409
Tonnes of cement/employee	3,105	5,112	2,482
Energy consumption (kcal/kg clinker)	715	844	1,000
Electricity (kWh/t cement)	108	106	112
Import of cement (1,000 t)	4,466	3,044	1,300
Export of cement (1,000 t)	2,929	5,572	600
Import – Export	1,537	–2,528	700

Sources: Bundesverband der Deutschen Zementindustrie e.V. (1998 and 2000); British Cement Association (1998) and Oficemen (1997).

reduction (see Chacko and Shenoy 1997). This is also important from an environmental perspective since CO_2 emissions can be reduced. Germany shows the lowest energy consumption in the sample. Electricity consumption has been increasing from 80 kWh/tonne cement in 1960 to 110 kWh/tonne cement in 1990 in the West German cement industry (see Wagner and Vassilopoulos 2000). In the sample for Germany an average of 108 kWh/tonne was measured at the end of the 1990s. Included among the reasons for the increase in electricity consumption are a higher use of electricity for environmental equipment, finer grinding of cement, particularly of composite cement, and a more automatic process. Since cement milling requires the largest share of electricity, special efforts are taken to improve the cement mills. In the sample there are no big variations concerning electricity consumption. From the sample countries Spain is the only country which exports more than it imports.

Sample results: Measuring the impact of environmental regulation on competitiveness

In this section the results on the impact of environmental legislation on competitiveness in the selected sample of cement plants in Germany, Spain and the UK are presented. To this end data on output and input measurements of competitive performance were linked with the environmental performance on a matched pairs basis. The environmental performance is already captured in the classification of plants as group 1, 2 or 3 performers (emission levels and numbers of environmental initiatives were the decisive criteria for the classification). As output indicators of competitive performance data on productivity, capacity utilisation, production costs, sales and prices were used. Input measurements of competitive performance mainly consisted of age of kiln, skills and investment levels. Furthermore, environmental and economic performance were put in relation to the level of compliance costs measured as environmental investment. Finally, the influence of other company characteristics like ownership and the use of alternative fuels on the relationship between competitiveness and environmental performance was examined.

Output indicators of competitiveness and environmental performance

The German plants with low emissions and many pollution abatement measures classified as group 1, and 2 performers showed in some respects a better economic performance than their national and/or foreign counterparts with less favourable environmental performance, but not in all aspects. Productivity and environmental performance were not always positively correlated. Table 7 indicates that the small German plant in group 1 has a higher productivity than the small counterpart in group 2 in Spain. Within Germany the large plant in group 1 also shows a higher productivity level than an equally large plant in group 2b. The same is true for large plants in the German/British comparison. However, amongst the medium-sized plants the German plants in group 1 and group 2a never reach the productivity level of their counterparts in group 2b within Germany. Moreover, all medium-sized German plants are with 8,700 tonnes of output per employee and year less productive than their Spanish and UK counterparts of the same size with higher emissions (9,100 and 11,300, respectively).

Productivity is closely related – among other factors like labour intensity – to capacity utilisation. The rate of capacity utilisation in the German plants has

Table 7

Average productivity in tonnes of cement per employee and year[a)] in the sample

Env. category	Germany Average of group 1 and 2a	Germany Average of group 2b	Germany Average of group 1 and 2 (total)	Spain Average of group 2 and 3	Germany Average of group 1 and 2 (total)	UK Average of group 2 and 3
Small plants	-	-	6,500	5,000	-	-
Medium plants	6,500*	10,200**	8,700	9,100	8,700	11,300
Large plants	9,600	9,000	9,300	12,600	9,300	13,500
Total number of matches	3	4	8	5	7	4

[a)] Figures are calculated as the output per employee in the kiln and cement area incl. maintenance; figures are rounded to the next hundred.
* Average of group 1 and 2a. The latter are medium-sized plants with remarkably lower emissions than the average of the total group 2.
** Average of remaining three medium-sized plants of group 2 called group 2b. For ease of illustration group 2b also includes the remaining large plant of group 2 with average emissions.

on average been lower than in the Spanish or British plants due to market reasons and not because of environmental legislation. Large Spanish plants show the highest degree of capacity utilisation; this would also explain their high productivity. Within Germany the large East German plants show the lowest degree of capacity utilisation. This would be because the construction boom after German reunification has slowed down. Furthermore, production costs, price per tonne and sales per head do not give the German plants an economic advantage over the plants in group 2 and 3 of the other sample countries. Still, costly secondary measures which really bring emissions down, have only been introduced in the German industry on a broad basis. Simultaneously, the measures do not seem to exert a significant impact on profitability. During additional interviews with headquarter chief executives of multinational cement companies it was said that German plants have always been profitable despite their environmental investments.

Input indicators of competitiveness and environmental performance

It was also hypothesised that modern plants can attain better environmental performance because the newest technology also embodies best environmental technology. It was shown for all sample countries that new kilns have a high environmental performance and lead to high productivity levels. In Germany also relatively old kilns can reach a favourable environmental performance. This is most likely due to the national approach to environmental standards. Therefore also old kilns are maintained at a high standard.

Moreover, 80 percent of German plants had expert systems in place. In Spain and the UK it was only 60 percent of sample plants. In the interviews the importance of skills related to the use of expert systems were stressed by the German plants. The operators in the control room underwent a special training in which steadiness both of process efficiency and emissions was taught. However, the assumed positive impact of skills (here measured indirectly in the use of expert systems) on environmental performance can be demonstrated only for small and large German plants and in the international comparison between Germany and UK for medium- sized plants. All German plants tended to have higher investments in the past and plan higher future investment than their foreign counterparts. In addition to total annual investment over the last five years also detailed data for all environmental investments undertaken during the last 10 years were asked.[5] As far as data are available there is a trend that German plants incur the highest compliance costs measured as capital costs of environmental measures.

All German plants in group 1 and 2 have on average invested more in environmental initiatives than their Spanish and British counterparts with higher emissions (see Table 8). Environmental investments in the large new German plants can-

[5] Data were scarce for general primary measures. However, investments for NO_x primary (process-integrated) measures and secondary (end-of-pipe) measures for the reduction of NO_x, SO_x and dust emissions were well recorded. Since secondary measures and also NO_x primary measures are much more expensive than general primary measures, they reasonably reflect the additional burden created by environmental regulation and can be regarded as a proxy of total compliance costs. Most of these environmental measures were undertaken during the last five to ten years; they were converted into prices of 1998 and evaluated in relation to sales in 1998.

Table 8

Environmental investment in primary NO_x measures and secondary measures for NO_x, SO_x and dust reduction as percent of sales* in the sample

Env. Category	Germany	Germany	Germany	Spain	Germany	UK
	Average of group 1 and 2a	Average of group 2b	Average of group 1 and 2 (total)	Average of group 2 and 3	Average of group 1 and 2 (total)	Average of group 2 and 3
Small plants	–	–	n.a.	5.4	–	–
Medium plants	4**	8***	6.4	1.6	6.4	6
Large plants	new plant	new plant	New plants	0.8	new plants	14.1
Total number of matches	3	4	8	5	7	4

* The investments under concern were undertaken between 1988 and 1998, were converted into prices of 1998 and put into relation of sales in 1998.
**Average of group 1 and 2a. The latter are medium-sized plants with remarkably lower emissions than the average of the total group 2.
*** Average of remaining three medium-sized plants of group 2 called group 2b. For ease of illustration group 2b also includes the remaining large plant of group 2 with average emissions.

not be separated from total investment. Large British plants had a need for environmental upgrading and show quite high investment levels. From this analysis it is also clear that Spanish plants have invested least and have the weakest environmental performance with four of the five sample plants being classified as group 3. In the UK compliance costs rise with plant size.

All but one German plant of group 1 and 2 use more alternative fuels than their national or international counterparts in group 2 and 3. One large German plant in group 1 covers at the moment 25 percent of its energy consumption by means of alternative fuels, whereas its national counterpart in group 2 already uses 50 percent of alternative fuels. The use of alternative fuels is motivated by cost reducing reasons and was started in Germany already in the mid 1980s. Investment can be several million Euros, but operating costs are reduced because of lower energy costs. Plants achieve a reasonable payback and report a positive impact on profitability. Thus, there is a high potential to offset the additional costs of environmental compliance. In Box 1 examples of savings through alternative fuels are presented for selected German and British plants. All sample plants using alternative fuels have obtained the necessary permits for it in times of increasing environmental investment. A prerequisite for the use of alternative fuels, however, is the implementation of stricter environmental standards, especially for heavy metals.

Concerning ownership, multinationals in Spain and the UK showed a less favourable environmental performance than multinationals located in Germany. The Spanish plant with the lowest emissions was owned by a German multinational. Although this plant was the “best” in terms of emissions in Spain, it did not emit as little as its German sister plant. Many primary measures were in place in that Spanish plant, but fewer secondary pollution reduction techniques than in a comparable German plant. The implication is that multinational companies can benefit from softer legislation in foreign countries.

Drivers and effects of air pollution abatement efforts in the cement industry

The impact of clean air regulation on competitiveness of the cement industry depends – among other things like the economic position of a firm – on the nature of the corresponding environmental initiatives, i.e. whether they are end-of-pipe measures that increase costs or whether they are clean technology solutions that can decrease both emissions and costs. Interviews with the cement plant managers were aimed at identifying the individual effects of abatement technologies at plant level. Plant managers were asked which of the currently known best available technologies (BATs) according to the EIPPC Cement BREF were already implemented in the cement works. The motivation for each initiative was examined and as far as the data allowed it, its timing and investment costs were recorded and potential changes arising for the business. These changes included any impact on operating and capital costs, environmental performance, employment and training needs, payback

Box

Examples of costs savings through the use of alternative fuels in Germany and the UK

Because of its high energy costs, the cement industry has been searching for alternative fuels. Among the types of alternative fuels most frequently used are used tyres, rubber, paper waste and paper sludge, waste woods, waste oils, sewage sludge, plastics and spent solvents. The change from primary to secondary (alternative) fugitive materials is technically relatively easy, although the use of alternative fuels triggers more stringent environmental standards. This has been found in all the German cement sample plants which were already fairly stringently regulated before they introduced alternative fuels. Still, the cost reduction through alternative fuels is sufficiently large to be offsetting the compliance costs for clean air standards in the cement industry. The German waste market is such that if a company uses tyres, it receives about 30 Euros per tonne from the supplier. Moreover it saves 75 Euros per tonne of coal which would have been needed instead of the tyres. This leads to an enormous annual saving of fuel costs depending on the amount of fuel substitution. Some German companies planned to substitute up to 75 percent of their fuel by secondary materials until the year 2001. Individual examples of cost savings in the German sample are as follows:

A large German plant obtains on average 37.5 Euros per tonne of alternative fuel. About 2 tonnes of alternative fuels are needed to reach the same heat value as produced by a tonne of coal which costs about 50 Euros per tonne. Consequently per tonne of replaced coal the plant saves 125 Euros (2 x 37.5 + 50). Altogether the plant can save energy costs amounting to 7.5 percent of its annual turnover. The plant was modernised and incurred the highest compliance costs in the sample. It was planned to reduce energy costs down to zero through the increased use of alternative fuels.

Another large German plant uses 17 percent of alternative fuels and obtains 10 Euros per tonne. Price for brown coal costs usually lies around 25 Euros per tonne. The plant can save energy costs amounting to 1.7 percent of its annual sales.

A large British plant used 20,000 tonnes of tyres and obtained revenues of 18 Euros per tonne. Coal would costs the plant 57 Euros per tonne. It was reported that savings through alternative fuels sum up to 93 Euros per tonne of replaced coal and to 2.5 percent of turnover.

times, maintenance, process efficiency, and impact on capacity, output and profitability.

The more strictly regulated German firms have on average implemented more abatement measures than their counterparts in Spain and the UK and have done this in the majority of cases with economically and/or environmentally more beneficial effects. It has to be stressed that German plants – perhaps because of stringent regulation – have voluntarily implemented other cost reducing measures to a much wider and deeper extent than cement plants in countries with softer regulation.

Legislation-driven measures

Concerning the purely legislation-driven measures selective non-catalytic reduction (SNCR), staged combustion and absorbent addition which are undertaken only in the German sample and nowhere else, no loss in competitiveness of German plants was detected. Although these investments increase operating costs (see Table 3 above), sample plants remained profitable. With regard to SNCR and absorbent addition those plants with the highest investment costs achieved the largest reduction in emissions. All plants using these secondary abatement techniques, also used alternative fuels and could at least partly compensate the increase in production costs due to secondary measures with a decrease in energy costs (see also below). Although German plants were forced to invest in low NO_x burners early on, no negative impact on competitiveness was reported. German firms invested earlier in bag filter replacements and reduced emissions more effectively than cement plants in Spain and the UK. This is also the case for noise measures.

Cost or process-driven measures

The environmentally most favourable performing German plants have voluntarily invested in electro filters and could achieve more profitable solutions for their business than the plants in Spain and the UK which undertook the investment because of legislative pressure. Moreover, German plants with particular energy initiatives have reduced their energy consumption more than plants in the other countries, doing it also for cost-reducing reasons. Also their share of energy costs in total production costs is lowest in the entire sample. German plants spent more on expert systems and achieved more beneficial results both with respect to economic and environmental consequences of this measure than plants in other countries investing also for process-efficiency reasons. Almost all German plants have been using alternative fuels since the mid-1980s and thus were able to reduce their energy costs substantially. Only in exceptional cases did emissions go down. This initiative was not used frequently in the other sample countries at the time of the study. With respect to process-optimisation measures there is no particular advantage for German firms.

Competitive advantages and disadvantages

Only one cement plant in Germany clearly mentioned the ability to fulfil strict environmental standards as a competitive advantage. Several other German plants stated low energy costs and modernity of plant as most important competitive features. Indirectly, however, these aspects are connected to favourable environmental performance. In Spain and the UK low distance to raw material, low transport costs and consistency of product quality were the most frequently stated competitive advantages. With respect to competitive disadvantages German cement plants stressed that environmental requirements were high. But the top environmental performers did not complain about environmental costs, only one large German plant felt that it was suffering from a competitive disadvantage because of environmental costs. Simultaneously this plant stated problems related to infrastructure and plant design as more important. In Spain and the UK current environmental requirements and costs were hardly mentioned at all.

Summary and conclusions

Cement is a commodity of mass production and hence cost competitiveness is decisive for business success. Therefore the impact of additional costs caused by environmental regulation is an important issue for the industry, especially for Germany where regulation is more stringent than in the other sample countries. It was shown that the German cement industry already uses costly pollution abatement techniques which are not frequently used elsewhere. However, the analysis of the interview data collected in German cement factories shows hardly an impact on the competitiveness of German plants and proves that dry technology cement plants operating up to a high environmental standard are economically viable.[6]

A number of factors were identified that affect the ease and take-up of best available technologies. These factors will be important for those EU countries that will in the future be more strictly regulated via the implementation of the IPPC-Directive and do not want to loose their level of competitiveness. Modernity, technology, size, skills and form of ownership are among these facilitating factors. Furthermore, those plants which already have secondary abatement measures in place (in particular in Germany) were favoured by an above-average use of cost-reducing primary measures and the use of alternative fuels. Time for planning investments is important not only because current investment is long-lived but also because the plants that already lag behind require more time to fulfil environmental standards. But even these plants should state their plans of how and when they will achieve BAT-associated emission levels. However, implementation and sequencing of environmental improvements should also consider the possibility of minimizing total environmental costs through the use of primary measures and alternative fuels.

[6] This finding is also confirmed for plants in Sweden and Austria visited by the main author in 1999 and 2000, where environmental regulation is at least partially even more stringent than in Germany.

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