The Impact of Clean Production on Employment in Europe – An Analysis using Surveys and Case Studies (IMPRESS)

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Abstract

While the impact of innovations on employment has been analysed empirically in several studies, only few studies have specifically analysed innovations which are environmentally beneficial. In this study, we have carried out case studies and analysed data from more than 1500 firms that have introduced environmental innovations recently in five European countries (Germany, United Kingdom, Italy, Netherlands, Switzerland). The data stem from identical telephone interviews carried out simultaneously in these countries. The interviews were especially designed for analysing the relationship between environmental innovation and employment on the firm-level. On the basis of an econometric model we find that different factors lead to positive and negative employment effects in the wake of environmental innovations.

Product and service innovations create more jobs in contrast to process innovations. Employment changes only occur in the wake of major innovations. While environmentally motivated innovations tend not to have employment effects, cost reductions envisaged by eco-innovations reduce employment. If the innovation is motivated by market share considerations, employment may increase as well decrease. We detect skill biased technological change of eco-innovations, because the share of highly qualified employees has a positive impact on employment increases, while it is insignificant for employment decreases. Employment is especially created in small firms. A positive correlation between sales expectations and employment is in broad conformity with the innovation literature.

Therefore environmental innovations have a small but positive effect on employment on the firm level. Thus, environmental support programmes do not counteract labour market policy. However**,** it should not be expected that the ecological modernisation of firms can provide substantial contributions to overcome mass unemployment. A further shift from end-of-pipe technologies to cleaner production, especially towards product and service innovations, would be beneficial for the environment and creates jobs. This synergy should be considered in political programmes whether they are borne by environmental, labour market or innovation policy. Some potential still exists for shifting subsidies from end-of-pipe solutions to cleaner products and services.

1. Introduction

The impact of innovations on employment has been analysed empirically in several studies over the past years. The studies have tested the hypotheses that:

> Product innovations have a positive impact on employment since they create new demand. Negative indirect effects occur if sales of other products decrease (substitution effect) or if prices increase due to the new product (income effect).
>
> Process innovations increase the productivity of firms and have a negative direct impact on employment since they are normally labour-saving investments. A negative direct effect can be compensated by positive indirect effects, if the sales of a firm increase due to lower prices.

The fear that technical progress in general and process innovations in particular kill jobs has not been confirmed by the empirical data. Although the results of individual studies varie, the tendency is that innovation has a positive effect on employment and more jobs are created by product than by process innovations. Nevertheless individual studies found negative employment effects of process innovations.

In the political debate, increasing attention is drawn to the question of how ecological transformation towards cleaner production affects the economic performance of industries, especially concerning employment. Views about the direction of these impacts are highly controversial. A popular hypothesis is that lower inputs of natural resources in the production process due to improved eco-efficiency require higher labour inputs and thus lead to positive employment effects. This view is expressed in the slogan: „Make kilowatt-hours unemployed, not people“. However, this position is contradicted by observations over the past decades that innovation improves both energy and labour productivity and therefore replaces labour. Further, it is often argued that environmental protection measures are a cost burden for domestic firms and thus weaken their competitiveness on international markets.

Within the empirical literature on employment impacts of innovation, only few studies have specifically analysed innovations which are environmentally beneficial. All studies found that employment impacts of environmental innovations were positive but very small. In a German survey, 84 to 91 percent of the firms stated that environmental innovations have no notable effect on firm-level employment (numbers differ slightly across categories of innovations). When there were employment changes, the positive ones outnumbered the negative ones.

In IMPRESS, we analyse the direct employment effect of environmentally beneficial innovations on the firm level on the basis of 1594 telephone interviews with industry and service firms. They were realised in five European countries (Germany, United Kingdom, Italy, Netherlands, Switzerland). The data bank created on the basis of the interviews is unique concerning the possibility of econometric analysis of the relationship between environmental innovation and employment.

2. Conceptual approach

In IMPRESS, five case studies and and international telephone survey were carried out. The role of the case studies was to improve our qualitative understanding between innovation, environment and employment. The role of the survey was a quantification of these relationships. The executive summary focuses on the survey in order to comminicate the quantitative results of the project. However, the case studies were extremely helpful for the design of the survey questionnaire.

2.1. Definitions

We use the following definition of environmental innovation or eco-innovation. Environmental innovations consist of new or modified processes, techniques, practices, systems and products to avoid or reduce environmental harms. Environmental innovations may be developed with or without the explicit aim of reducing environmental harm. They may be motivated by the usual business goals such as reducing costs or enhancing product quality. Many environmental innovations combine an environmental benefit with a benefit for the company or user.

For environmentally friendly technologies we use the following categories:

Eco-innovations are divided into cleaner technology (product and process-integrated changes) and end-of-pipe-technology (pollution control technologies that prevent the direct release of harmful substances into the environmental media air, water and soil).

Recycling can not easily be subsumed under the categories cleaner and end-of-pipe technology. Process-internal recycling can be understood as cleaner technology while process-external recycling is an end-of-pipe technology. To avoid any confusion, it is reasonable to treat recycling as a separate category.

Finally, we have introduced the area of logistics, product delivery and distribution systems as a separate innovation category. Although they can be interpreted as specific kinds of process innovations, we have added them explicitly. This was motivated by the fact that the importance of product

delivery, transport and distribution has increased over the past years, and not all firms may understand these activities as process innovations.

To summarise, we asked for six different categories of eco-innovations in our survey: Product integrated measures (goods and services), process integrated measures, end-of-pipe measures (pollution control), recycling, organisational measures and logistics.

2.2. Direct and indirect employment effects

We assume a two-stage decision process of the firm. It decides at a first stage on the resources to invest in innovation and, depending on the outcoume, determine at a second stage the profit-maximising volume of labour input. Our study concerns the second-stage profit-maximizing decision for a given successful innovation. The employment impacts may be split into direct and indirect effects. The direct employment effects are defined as effects that are directly related to the new product or process. Indirect employment effects occur elsewhere in the same firm (the case of a multi-product or multi-process firm where these indirect effects are related to other products and processes) or occur in other firms. Indirect effects can be:

substitution effects (like reduction in employment in old processes and products following the introduction of an eco-innovation),

income or compensatory effects (they stem from an increase or decrease in value added related to the production and use of an eco-innovation. They can occur in the innovating firm (changes in sales due to the costs of eco-innovation) or elsewhere.

2.3. Hypotheses

We have formulated hypotheses concerning direct and indirect employment effects as described in Table 1. The hypotheses are in broad conformity with hypotheses in former studies on the general employment effects of innovations. We have, however, introduced two peculiarities of eco-innovation:

Environmentally friendly products usually do not create substantially new demand. An example is the introduction of low-noise lawn-mowers. They led to more employment in the production of these devices, which are however at least partly compensated by respective losses in the sale of noisy lawn-mowers. Thus it can be assumed that substitution effects of cleaner products are generally higher compared to other product innovations. Positive employment effects of cleaner products can occur if they create more value per unit. For example, the production of organic food is normally more costly than for conventional food which is met by a higher consumer willingness to pay for these products. Further, additional employment can be created in R&D-

departments temporarily. Total employment effects of cleaner products can however be expected to be lower compared to other innovations.

Environmentally friendly process innovations do not necessarily increase the productivity of a firm. They may even reduce productivity and require increasing labour inputs per unit. Thus environmental process innovations can have a positive direct employment effect. These effects can be compensated by negative indirect effects, i.e. a loss of sales and competitiveness (especially if environmental standards are different across countries). This peculiarity of environmental process innovations can be explained by the fact that they are often not motivated by cost reduction and increasing sales, but also compliance with regulation. This can be assumed especially for end-of-pipe technologies. For example, a new filter or recycling process may be installed due to regulation. In contrast, economic innovation goals like increased productivity and cost reduction (costs of energy, waste, disposal, material or labour) can be especially assumed for process integrated innovations and innovations in logistics.

Table 1: Hypotheses on direct and indirect employment effects of eco-innovations

Types of integrated measures	**Direct employment effects**	**Indirect employment effects**
Product integrated measures (goods and services)	Tendency positive, employment due to new product or service	Tendency negative, size depends i.a. on the degree of complementarity of old and new products/services
Process integrated measures, logistics	Increasing productivity but negative employment effect, substitution effect of technical progress	Tendency positive (compensatory effect, increasing competitiveness)
End-of-pipe processes, recycling measures	Tendency positive, due to implementation and operation of new technology. Increasing productivity is not the main innovation goal (other motivations such as compliance with regulation dominate)	Tendency negative (compensatory effect, loss of competitiveness)
Organisational measures (e.g. eco-audits)	Positive employment effect due to implementation of the organisational measure	Unknown, depends on concrete measures within environmental programme of the firm

Product integrated innovations, eco-friendly services

Product innovations in integrated environmental protection lead to positive direct employment effects, which can however be partly or entirely offset by their crowding out of previous products. Our study is the first one looking specifically at the effects of environmental innovations in the service sector, too. Our working hypothesis is that the effects are similar to those of product integrated measures.

Process integrated measures, logistics

Our hypothesis is that the employment effects of process integrated environmental measures are in terms of their employment effects comparable to the cost-saving technological progress by other process innovations. In addition to the ecological effects, increasing productivity of the production process is sometimes the main reason for the innovation. As competitiveness improves, the indirect effects inside the firm tend to be positive. Negative indirect effects outside the firm may occur in other sectors due to reductions of waste, transport, energy and material use (job losses for supplying firms in waste, energy, transport and production sector). The same is assumed for environmental logistics innovations which often include measures for reducing transport.

End-of-pipe processes, recycling

End-of-pipe and recycling measures tend to have positive direct employment effects. They create new steps and links in the value chain and thus have a potential for additional employment. They are normally accompanied by additional investments which do not necessarily increase the productivity of the firm. The indirect employment effects tend to have the opposite effect. The effects are thus the opposite of the hypothesised effects of integrated process innovation.

Organisational measures

Organisational measures are initially accompanied by additional expenditure and work processes (e.g. undergoing an eco-audit procedure), which create positive direct employment effects, while the indirect effects depend on the concrete measures which are implemented within the environmental programme of a firm.

It should be noted that our firm survey mainly measures direct effects within the firm. Thus empirical evidence drawn from our study focuses on our corresponding hypotheses on direct effects. However, some questions have been included in the questionnaire which allow interpretations concerning the relevance of indirect effects. For example, we asked for the effects of environmental innovations on prices. Substantial price effects can be used as an indicator that indirect income effects may be significant.

3. Empirical evidence

3.1. Description of the data

Between March and July 2000, 1594 telephone interviews with industry and service firms were carried out in five European countries (401 from Germany, 384 from Italy, 201 from Switzerland, 400 from the United Kingdom, 208 from the Netherlands). The addresses for the telephone interviews were drawn from a stratified sample with the dimensions small firms (between 50 and 199 employees) and large firms (200 or more employees) and 8 sectors according to the NACE codes D-K. These NACE codes are industry, manufacturing and services. Firms active in other sectors such as mining, agriculture or public administration have not been included in the sample.

The firms contacted have been asked first if they have introduced at least one eco-innovation during the last three years. If this was not the case, the interview was terminated. Therefore, the data basis only contains firms that identified themselves as eco-innovators and the analysis concentrates on the behaviour of firms with respect to employment changes provided they have introduced an environmentally related innovation. In addition, we only have cross-section data and therefore neither an analysis of causal effects or of the impact of time is possible. Also individual fixed effects can not be taken account of. The time structure is only captured indirectly by asking about the employment impact during the last three years and by asking about the expected demand effects. These limitations of the data seem to be minor, however, because we do not estimate employment change equations or labour demand, but only impacts on the sign of the employment change.

The data set was especially designed to measure the effects of eco-innovations on employment at the firm level. Therefore, it has some unique variables that are not included in other data sets. For example, it directly asks about the employment effects induced by the innovation in contrast to the general employment change which is frequently used as an indirect indicator for it. In addition, besides the differentiation between direct and indirect effects, the data set allows to draw conclusions on the employment effects of relevant policy variables such as subsidies and environmental regulations.

3.2. Descriptive results

Figure 1 shows all environmentally beneficial innovations according to our definition which have been introduced by the firms in the last 3 years (column ‘Mentioned’; multiple answers were possible). The figure also shows the innovation which has been cited as the most environmentally beneficial one (´Most beneficial´, here also multiple categories were given by some firms). The

most environmentally beneficial innovation is the one the entire questionnaire is referred to. Therefore, if the firm has introduced more than one innovation, the respondent had to choose the one that had the highest positive impact on the environment for the interview. Besides the innovation types process and product integrated environmental innovations, also recycling and pollution control (end-of-pipe technologies) also have been frequently introduced. Changes in the distribution system (logistics) and in organisation methods are not widespread.

Figure 1: Environmentally beneficial innovation

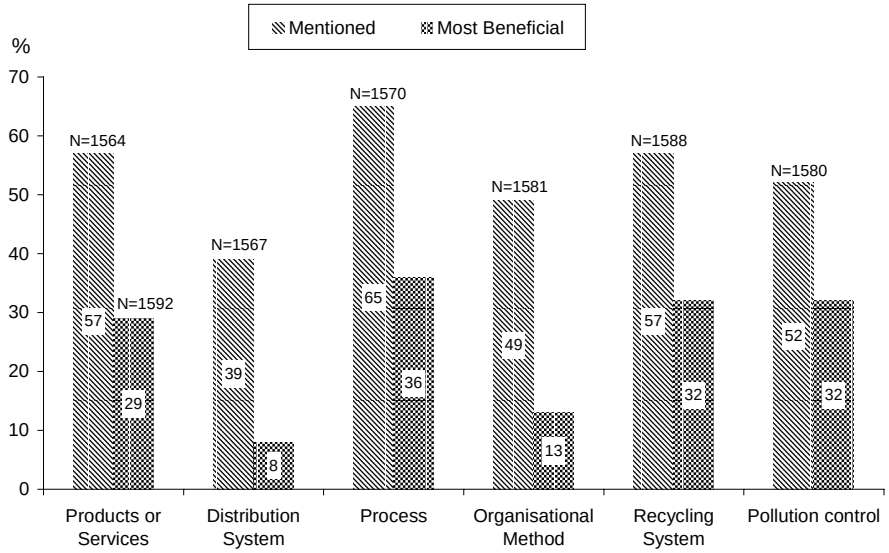


Figure 2 shows important reasons for introducing the eco-innovation by innovation type (multiple answers were possible). The three most cited reasons for introducing the innovation are to improve the firm's image, to comply with environmental regulation and to reduce costs. This is particularly noticeable for process integrated innovations, recycling innovations and when end-of-pipe (pollution control) technologies were introduced. Increasing market share plays only a minor role for introducing eco-innovations but is particularly important for integrated technologies (product, service and process integrated).

Figure 2: Important reasons for introducing the innovation

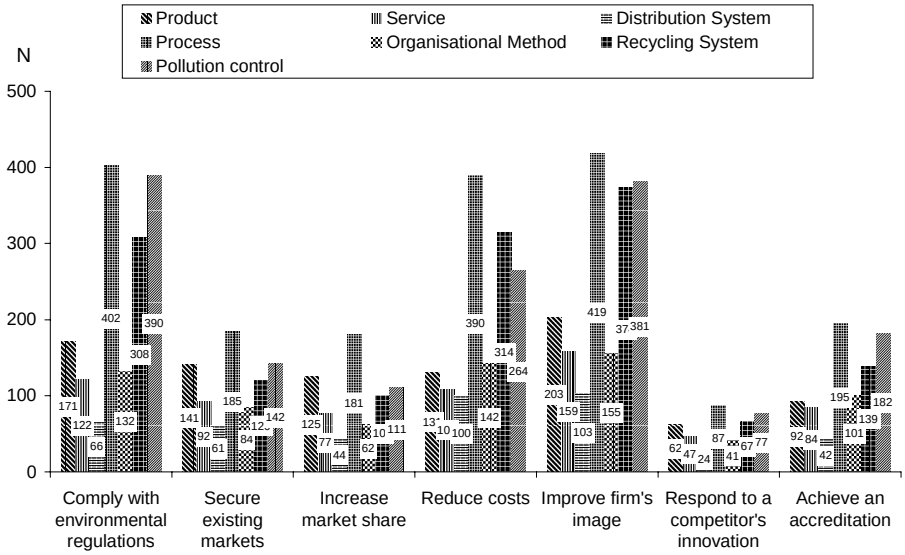


Figure 3 shows the effects of the environmental innovation on employment. Overall 88 % of the firms had no notable effect on employment due to the specific innovation (see left column). In 9 % of the cases the number of long-term employees increased due to the innovation, in 3 % of the cases it decreased. This shows that there is only a weak but positive relation between the introduction of environmental innovations and employment.

Regarding the distribution of employment effects by innovation type, it becomes apparent that product innovations and service innovations have a sizeable above-average positive employment effect (18 % and 20 %). It is further interesting that the employment effect of recycling innovations is positive in almost all cases. Innovations in logistics have the highest shares of negative employment changes.

Figure 3: Effect of innovation on employment

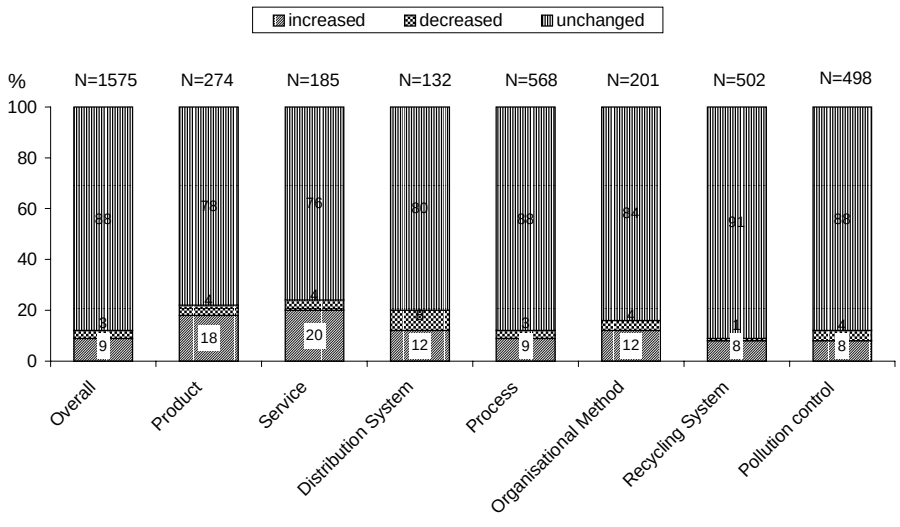


Figure 4 shows which proportions of the establishment's total innovation expenditures over the past three years were spent on environmental innovation. For the majority of establishments (51 %), less than 5 % were spent on the eco-innovation. Distributing the results by innovation types, it is remarkable that an above-average number of firms had a relatively higher investment share for product, service and process integrated innovations. Innovations with a high share in total innovation costs also induce employment changes more often. While in firms where employment was unchanged by the innovation only 14% reported an innovation share above 50% of total innovation expenditures, the share was 42% for firms reporting employment increases and 16% for firms reporting employment decreases.

Figure 4: Proportion of innovation expenditures

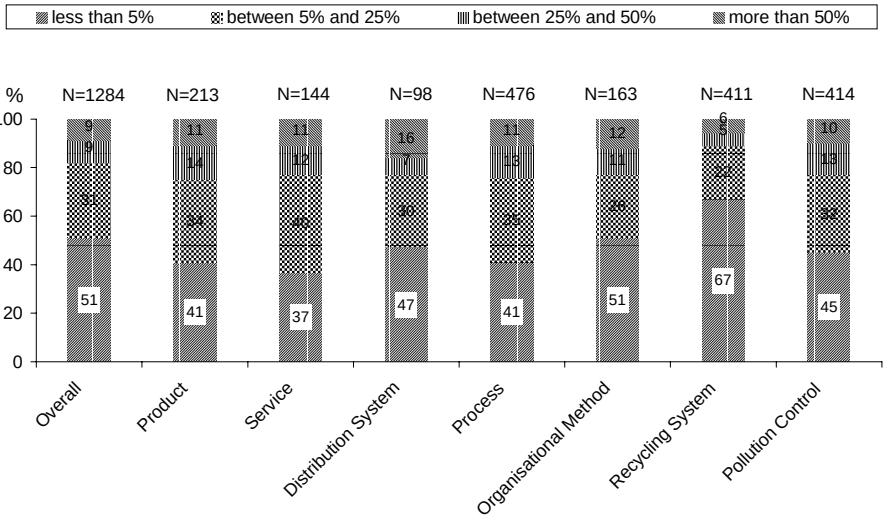
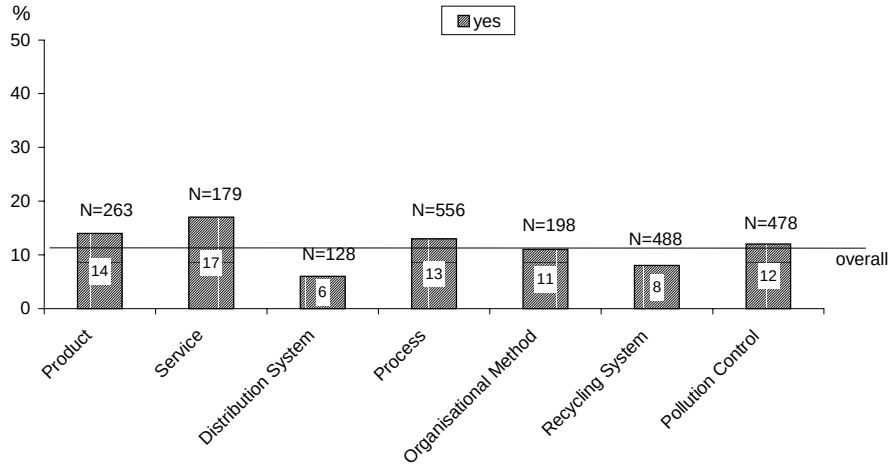


Figure 5 gives an answer to the question whether there is a correlation between receiving subsidies or grants for introducing the innovation and the innovation type. Multiple answers were possible. On average, only 11 % of firms received a subsidy or grant. For product and service innovations, the number of firms is above average. Since exactly these innovations are the ones with the strongest positive employment effect, the overall allocation of subsidies within environmental technology support programmes in the five countries involved can be characterised as employment-friendly. This also can be seen from the fact that 21% of the firms indicating employment increase due to the innovations received subsidies, while this was the case for only 7% of the firms that reduced employment. The share was 9% for the firms that did not change employment.

Figure 5: Was subsidy/grant received (by innovation type)



The following Figures show the effects of the environmental innovations on sales, prices and costs. They therefore allow us to make tendency statements about the indirect innovation effects. As can be seen in Figure 6, the innovations had no effect on sales and prices for more than 83 % of the establishments. For 16 % of the establishments, sales increased. Prices increased in 9 % of the firms but in most cases by less than 5 %. Prices decreased also in 9 % of the firms. Since 82 % of the firms state no price effect and for the rest neither negative nor positive effects dominate, it can be concluded that indirect income effects stemming from the innovation can be neglected on the firm level.

Figure 6: Effects of innovations on sales and prices

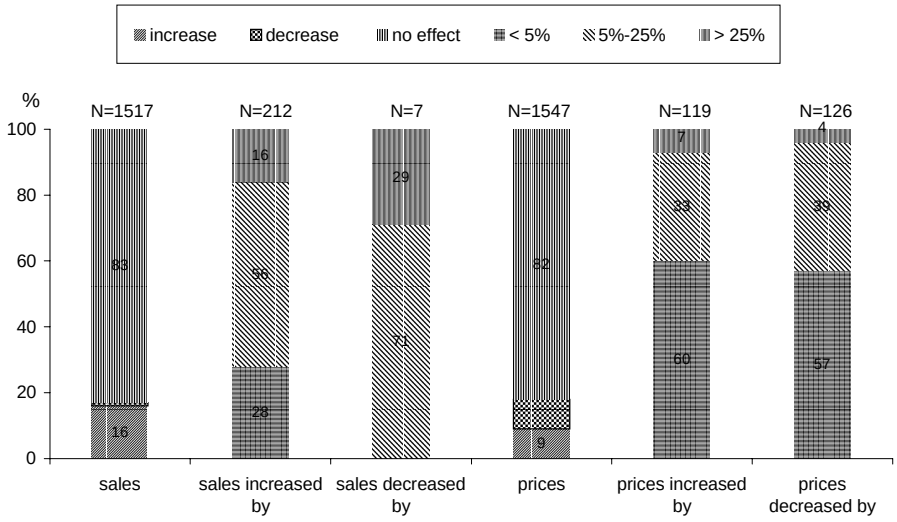


Figure 7 shows that energy costs decreased in more firms than the other costs listed here. 34 % of the firms could decrease their energy costs due to the innovation. This result is in line with the high share of process innovations (see Figure 1) and the motive of cost reduction (see Figure 2). The level of decrease of energy costs is also relatively high: for 52 % of the firms, energy costs decreased by more than 5 %. Material costs were unaffected for 58 % of the firms. In those cases with changes in material costs, the number and level of decrease were a bit higher than in the cases of increase. While substantial decreases of energy costs indicate negative indirect employment effects for the energy supplying industry, no similar effect can be found for materials.

Figure 7: Effects of innovations on energy and material costs

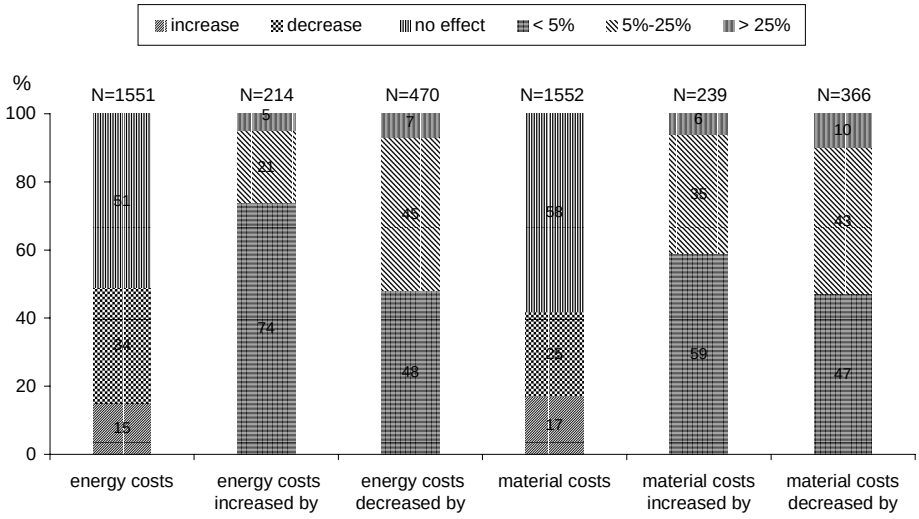
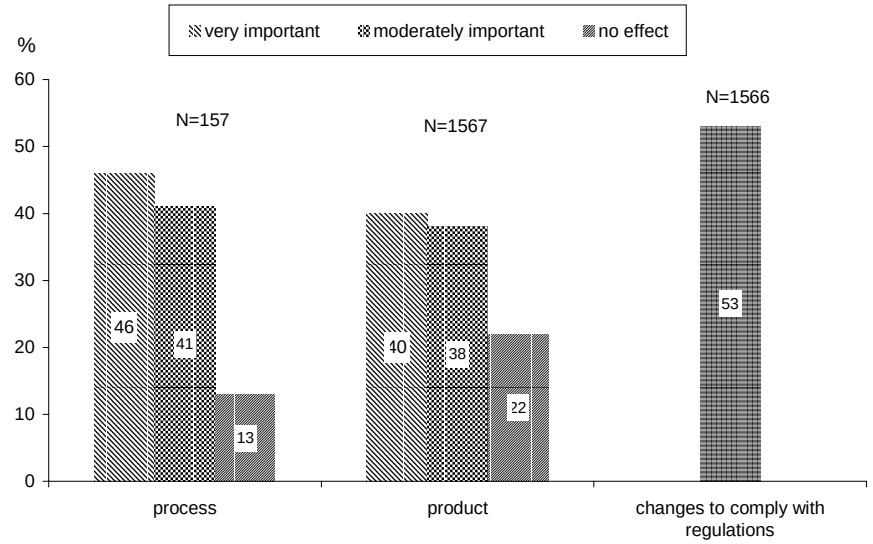


Figure 8 gives an answer to the question how important are environmental regulations for processes and products and whether concrete changes were made in the last three years in order to comply with these regulations. It becomes apparent that environmental regulations seem to be important for both product and process innovations. Concrete changes in order to comply with the regulations were made in about half of the eco-innovative firms.

Figure 8: Importance of environmental regulations for processes and products and changes to comply with regulations



Finally we asked some general questions which are not related to the specific innovation, e.g. concerning the competitive situation of the firm and general employment trend. Price and quality are clearly the dominating competition factors, see Figure 9. By a wide margin, they are followed by innovative products or services, corporate image and environmentally friendly features. Environmentally friendly features are mentioned by only 3 % of the firms as the most important factor. This is surprising because the answering firms are exclusively those which introduced environmental innovations in the last three years. It can be concluded that environmental innovations are only developed voluntarily by firms if they face no substantial negative impacts on more important competition factors, especially on costs and quality.

Figure 9: Important competition factors

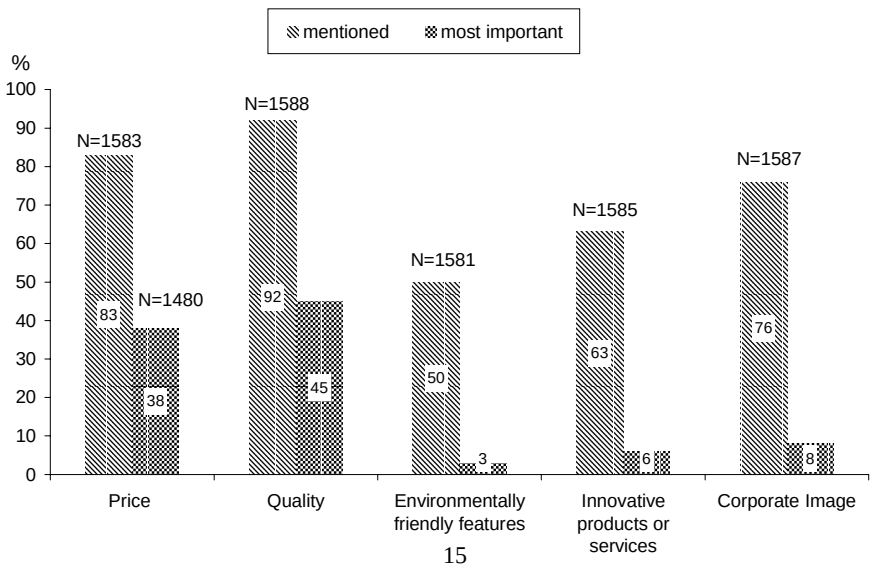
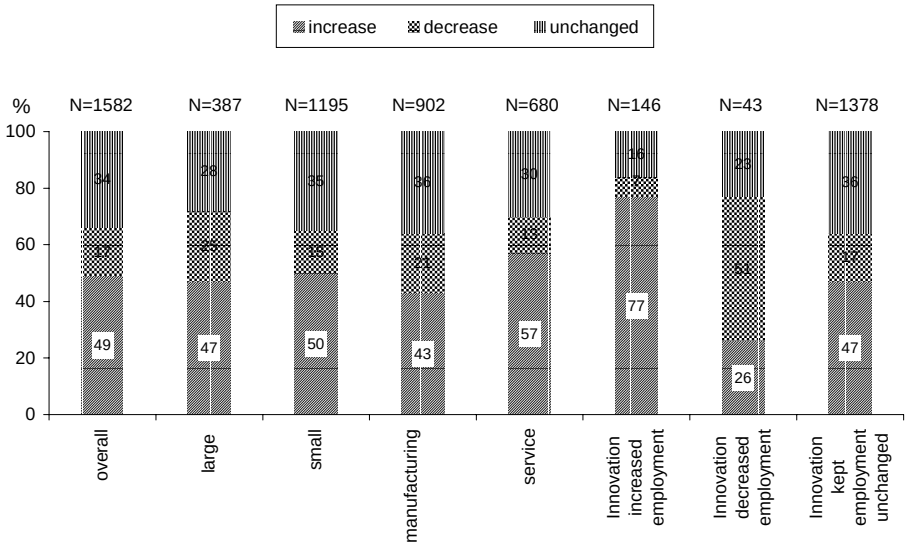


Figure 10 shows the overall employment changes of the firms introducing environmental innovations. For the majority, employment increased in the last three years (49 %; see left column). Figure 16 shows that large and small firms increased employment almost to the same extent, while the employment shift to the tertiary sector is represented by a more frequent increase in service than in manufacturing firms. The last three columns of the figure present evidence for the measurement error if the general employment change is taken as a proxy for changes in employment induced by innovations. This measurement error only can be avoided in panel studies. In addition, the difference between total employment change and employment change attributed to the innovation shows that the people who were interviewed were able to differentiate between general employment changes in the firm and changes induced by the eco-innovation.

Figure 10: Change in overall employment



3.3. First conclusions

We can conclude from the descriptive analysis that environmentally beneficial innovations generally have a small but positive effect on employment on the firm level. Overall 88 % of the firms state that eco-innovations are neutral, 9 % state a positive and only 3 % a negative impact. For environmental product and service innovations, 18 to 20 % state positive effects. These results give first evidence to the hypothesis that more jobs are created by environmentally friendly product and service innovations than by process innovations. Other factors like size of innovation or regulatory pressure can strengthen both positive and negative effects.

The three most cited reasons for introducing the innovation are to improve the firm's image, to comply with environmental regulation and to reduce costs. This is particularly noticeable for process integrated innovations, recycling innovations and when end-of-pipe (pollution control) technologies were introduced. Increasing market share plays only a minor role for introducing eco-innovations but is particularly important for integrated technologies (product, service and process integrated). On the other hand, price and quality are clearly the most important competition factors for eco-innovating firms. It can be concluded that environmental innovations are only developed voluntarily by firms if they expect no substantial negative impacts on these "hard" competition factors. In the innovation process of a firm, environmental aspects are clearly dominated by economic factors or by restrictions due to regulation.

While the data mainly refer to hypotheses on direct effects, at least some general conclusions can be drawn concerning the indirect effects. Income effects due to price changes seems to be negligible, while substantial decreases of energy and waste disposal costs may lead to significant negative indirect employment effects in the energy and waste disposal sector.

4. Econometric Analysis

The goal of the econometric analysis is to quantify several explanatory variables (like the impact of the category of innovation, the innovation goals, and the size of the innovation) and suitable control variables on the probability that the eco-innovation has a positive or negative employment effect on the firm level. The dependent variable is the answer to the question "By long-term employment we mean employment in the firm for more than one year. Has this innovation increased, decreased, or had no noticeable effect on the number of long-term employees in your establishment?".

The dependent variable has three values (increase, decrease and unchanged) that are unordered. As we have argued in the introduction, the determinants of a positive employment impact, no employment change and of a negative employment impact may be completely different. Therefore, we need an estimation method that allows for differences between the employment changes of firms. We therefore chose a multinomial logit regression, because this estimation techniques detects the differences between the determinants for the three values of the dependent variable. The regression thus explains the different reasons for an employment increase or decrease relative to unchanged employment.

The explanatory variables included in the model are directly linked to the considerations in section 2. Independent variables are:

Categories of eco-innovation (see IMPRESS hypotheses)

eco-innovation goals (since it can be expected that cost reduction targets have a negative impact, while targets to increase market share should have a positive influence on employment) and

size of innovation (since employment changes only occur when the turn-over costs are more than compensated by the change).

Control variables are:

the firm size,

whether the effects can be partly explained by subsidies which have been received for the innovation,

sales expectations (it can be expected that firms with optimistic expectations are more inclined to increase employment already before demand actually increases, this is also called demand pull hypothesis of innovations),

whether products or processes have been changed due to environmental regulation (indicator for strictness of environmental regulation),

competition factors as a proxy for market characteristics (since firms competing on the basis of costs probably choose a different employment behaviour than firms competing on innovative products or environmental performance) and

the share of workers with unversity or college degree. This may indicate if skills and innovations are complements, i.e. there is skill biased technological change (see for example Van Reenen, 1997).

The list of relevant variables for our econometric model is shown in Table 2.

Table 2: Relevant variables and indicators

Dependent variables:
Increase of employment due to eco-innovation
Decrease of employment due to eco-innovation
Independent variables:
Category of eco-innovation
Eco-innovation goals
Share of expenditures for eco-innovation on total innovation expenditures
Control variables:
Firm size
Share of employees with college or university degree
Subsidies or grants for innovation received
Positive sales expectations
Changes of product or processes to comply with environmental regulations
Competition factors
Country

The eco-innovation categories, eco-innovation goals, and competition factors are captured by item lists that potentially are correlated and therefore the variables may be collinear. In order to correct for that, a factor analysis was carried out that reduces the number of dimensions to the uncorrelated ones.

The multinomial logit model shows which variables have a stronger impact on firms with a change in employment in comparison to firms without employment changes in the wake of environmentally beneficial innovations. It produces the following significant correlations (see Table 3).

Table 3: Regression results of multinomial logit regression

	Prob. that employment increased		Prob. that employment decreased	
	Coeff.	z	Coeff.	z
Product innovation	.632*	2.349	.536	1.004
Service innovation	.658*	2.205	.432	0.601
Process innovation	-.116	-0.444	.282	0.562
Organisational method innovation	.187	0.548	.051	0.078
Recycling system innovation	-.007	-0.026	-2.361*	-2.180
End-of-pipe innovation	-.055	-0.204	1.593**	3.006
Reason to innovate: Market share	.577**	4.823	.976**	3.801
Reason to innovate: Environment	.008	0.066	-.650**	-2.718
Reason to innovate: Cost reduction	.046	0.385	.692**	2.613
"Hard" competition factors	.094	0.809	-.595	-1.570
"Soft" competition factors	-.105	-0.814	-.503*	-2.119
Large firm	-.832*	-2.369	.666	1.281
Share of environm. on total innov expenditures	.899**	3.501	1.217*	2.465
Share of total employees with college or university degree	.015**	3.075	.003	0.276
Subsidies or grants for innovation received	.327	1.070	-1.080	-1.205
Sales expectations positive	1.144**	3.191	-.393	-0.751
Change - comply with environ. Regulations	.753**	2.995	1.345**	2.673
Germany	.941*	2.290	1.231+	1.862
Switzerland	.462	0.907	.737	0.913
The Netherlands	.800+	1.680	-1.185	-1.143
Italy	.404	0.970	-.560	-0.738
Constant	-4.942**	-9.051	-6.269**	-6.496
Number of observations	1015			
Log likelihood	-353			
Pseudo R^2	0.2253			

Source: IMPRESS Questionnaire, April 2000, Remarks: Significancy levels are as follows: + < 0.1, * < 0.05, ** < 0.01

5. Results and policy conclusions

Firstly, several factors are significant for positive employmment impacts. With respect to the reference category (logistics innovations[1]), product and service innovations have a positive effect, while all other innovation categories are not significant. This is in line with the general literature on innovation and employment. Indirect substitution effects of product and service innovations on the firm level appeared to be lower than we expected. To control for this substitution effect, the question "Did this innovation replace some of the product/service sales of your establishment?" was used. While we expected substitution effects in nearly all cases, only 43 % of the product innovators and 27 % of the service innovators answered "yes". It seems that ecological products and services have created their own market niches being supplements to conventional goods and services. However, it can be assumed that for most of the innovations mentioned by the firms, as for example "new cleaning techniques" or "transport reduction measures", negative indirect substitution effects occur in other firms.

Small firms report more employment increases than large firms. This result is in line with other empirical studies on the general relation between innovation and employment, too. Firms with high shares of employees with college or university degrees have a higher probability to increase employment in the wake of innovations. This may be an indication that also environmentally-oriented innovations are skill-biased. Positive sales expectations are highly significant for increasing employment. Firms in Germany, the Netherlands and Italy have a higher probability to report a positive employment effect than firms in the UK, the reference country.

Secondly, some other factors have been identified correlating significantly with an increasing probability of job losses. End-of-pipe-processes have a positive, recycling innovations a negative correlation with the probability that the innovation has a negative impact on employment. This result is quite surprising since we expected the same direction of employment effects for both kinds of innovations. However, already the descriptive analysis has shown that employment effects of recycling innovations are positive in almost all cases. An explanation for the difference between end-of-pipe technologies and recycling measures may be the maturity of regulation. While end-of-pipe regulations have existed, in many cases, for twenty or thirty years, political measures concerning recycling have been mainly implemented during the nineties. Thus, new end-of-pipe innovations often replace existing older technologies, while other

[1] Innovations in logistics have been used as reference category because they have a small share of the total sample and appeared to be not significant in the econometric analysis. The relative high number of cases with negative employment effects in the descriptive analysis turned out to be a spurious correlation int the econometric test.

environmental process innovations, especially in the area of recycling, have lower substitution effects. We have addressed this substitution effect by the following two questions in the questionnaire „Did the introduction of this process innovation replace, at least in part, a previous production process in your establishment?“ and „Did the introduction of this process innovation replace, at least in part, end-of-pipe pollution control equipment?“ 38 % of end-of-pipe innovators answered the first question with “yes“, compared to 19 % of recycling innovators. And 34 % of end-of-pipe innovators agreed on the second question, compared to 13 % of recycling innovators. These numbers indicate that substitution effects are substantially different across different types of environmental process innovations. This may explain the better performance of recycling innovations in terms of employment.

When environmental goals motivate the innovation, it is less probable that the innovation has a negative employment effect. On the other hand, cost reduction as motivation for the innovation increases the probability that the firm reduces employment. In contrast, innovations aiming at cost reduction have only negative effects on employment. It can be expected that firms invest in improved labour-saving technologies, especially in areas where the technologies have already reached a certain maturity (mainly end-of-pipe technologies). If the firm is not under the pressure of strong cost competition, “soft“ factors like environmental aspects become more important. This decreases the probability of job losses.

Further, three factors have been identified which can affect employment in both directions. Market share as an innovation goal, innovation size and strictness of environmental regulation are significant for either positive or negative employment changes. Market-oriented strategies focusing on the development of environmentally beneficial innovations impose chances but also risks on firms. Environmental products and services are often marketed on small niches and thus bear risks of profitability. Other innovation goals like complying with environmental regulations still dominate. Concerning innovation size, the result confirms the hypothesis that fixed turn-over costs lead to changes in employment only if there is a major re-organization in the wake of the innovation. A critical innovation size must be reached before employment changes are measurable in person/years by surveys as carried out within our project. Also environmental regulation can lead to both positive or negative employment effects, depending on the concrete innovation actitivities being undertaken due to the regulatory pressure.

Finally, it is remarkable that subsidies or grants for the innovation do not have any employment impact. This means that the allocation of subsidies for environmental technologies and innovations in the respective countries is neutral concerning employment and thus does not counteract labour market policy. However, employment could be stimulated by shifting more money from end-of-pipe measures to integrated measures, especially products and services. But even an

employment-oriented allocation of subsidies for environmental programmes will only induce minor employment changes.

To sum up the results of the econometric analysis, basic hypotheses about the general relationship between innovation and employment have been confirmed. Product and service innovations create more jobs than process innovations. Employment changes only occur in the wake of major innovations. This is confirmed by the significant impact of the share of innovations expenditures variable for employment increases as well as employment decreases. We also detect signs of skill-biased technological change of eco-innovations, because the share of highly qualified employees has a positive impact on employment increases, while it is insignificant for employment decreases. Significant impacts of the control variable size show that employment is especially created in small firms. A positive correlation between sales expectations and employment is in broad conformity with the innovation literature.

Beyond these general insights, some specific conclusions can be drawn for a coordinated environmental, innovation and labour market policy. Generally, eco-innovations have a small but positive effect on employment on the firm level. Thus environmental support programmes do not counteract labour market policy. However it should not be expected that ecological modernisation of industries gives substantial contributions to overcome mass unemployment. A further shift from end-of-pipe technologies to cleaner production, especially towards product and service innovations, would be beneficial for the environment and would create jobs. This synergy should be considered in political programmes whether they are borne by environmental, labour market or innovation policy. Some potential still exists for shifting subsidies from end-of-pipe solutions to cleaner products and services.