Employment Effects of Ecological Innovations: An Empirical Analysis

Harabi, Najib

University of Applied Sciences, Northwestern Switzerland

December 2000

Series A: Discussion Paper 2000-07

Employment Effects of Ecological Innovations: An Empirical Analysis

Najib Harabi

December 2000

Solothurn University of Applied Sciences Northwestern Switzerland

Solothurn University of Applied Sciences Northwestern Switzerland offers at the School of Management majors in Economy such as Controlling, Human Resource Management, Marketing, and Information and Knowledge Management. In addition, it offers both a full-time and part time course of study in Information Systems.

It is well-known for its further education activities ranging from conferences, seminars, and examination preparation to full-fledged graduate studies. The institute offers graduate programs in Non-Profit Organisation, Logistics, Corporate Design Management, and Personnel Management.

Solothurn University of Applied Sciences Northwestern Switzerland is active in widely varied areas of economics research. The most noteworthy topics of research are in the areas of Industry, Innovation and Strategic Management, Human Resource Management, and Information and Knowledge Management. The results of this research are presented in our publication series and research seminars.

Publication Series

In this series, Solothurn University of Applied Sciences Northwestern Switzerland, publishes the results of this research, with the aim of ensuring that colleagues as well as the public are informed on research activities and their ensuing results. To place orders for these publications, please refer to the order form at the end of this brochure.

Abstract

Ecological innovations have increasingly been seen as a major response to environmental problems. An important question for both economic research and public policy is whether these innovations also increase employment or not (the question of a double dividend). The purpose of this paper is to investigate empirically the factors affecting direct employment changes due to eco-innovations at the firm level. This analysis has been conducted in the framework of estimating a labor demand function including eco-innovations, the firm's output changes (changes in sales), its labor costs changes and a set of control variables (e.g. firm-specific variables, industry and country dummies). Using data from around 1600 firms in five different countries (Germany, Great Britain, Italy, Holland and Switzerland) we have obtained the following empirical results: firms investing in relatively important (from the firm's perspective) labor cost saving product innovations that have not been subsidized by the state and pursuing a market driven business strategy that leads to increases of their sales in industries in which they have a market power also increase the likelihood of their achieving a positive long term direct employment effect. Firms that deviate - on average - from this ideal portrait do not have positive direct employment effects. (It should, however, be emphasized that neither the indirect microeconomic nor the overall macroeconomic effects of eco-innovations are the subject of this study.)

Author

Dr. Najib Harabi is currently Professor of Economics and Research Director at the School of Management of the University of Applied Sciences Solothurn Northwestern Switzerland. Previously he held teaching and research positions at the universities of Zurich and St. Gall. Dr. Harabi has been Visiting Scholar at Stanford University, the University of California at Berkeley, University Paris-Dauphine and the European Center for Economic Research in Mannheim, Germany. He has also served as Deputy Research Director at the Swiss National Science Foundation. He has published extensively in the area of Industrial Organization, especially on the economics of technological change. He is a member of numerous national and international professional organizations.

1. Contents

1 Introduction

The interaction between technological innovation and employment has been studied in theoretical and empirical economics at the micro, meso and macro level[1]. Although the results of this branch of applied economics are still preliminary, some lessons can nevertheless be drawn:

There is a consensus on the two-edged nature of technological change: It both destroys old jobs and creates new ones. To compare the balance of employment gains and employment losses of technological change is an empirically difficult undertaking, as numerous empirical studies in the recent past have shown.

An empirical analysis of the relationship between technological innovation and employment has to distinguish between the short term and long term effects of technological change. In the short run the net employment effect is not always clear. In the long run the job creation effects have outstripped the job destruction effects, albeit accompanied by a steady reduction in working hours throughout the 19th and 20th centuries.

There is furthermore sufficient empirical evidence that "compensation" is not automatic, painless or instantaneous. The new jobs may not match the old ones with respect to skill or to location ("structural" versus "frictional" unemployment). Researchers underline the complexity of the dynamic of structural change in an economy. A major component of this structural change in the economy is due to the skill bias of technological change: high-skilled workers tend to be the main beneficiaries of technological change. With respect to location the employment effects of technological change seem to vary from one region to another. In addition, the effects of technological change differ widely between manufacturing and service sectors.

In attempting to assess the employment creation and destruction effects of technological change economists distinguish conceptually between the direct and indirect effects. The direct effects are the new jobs in producing and delivering new products, processes and services. The indirect effects are consequences elsewhere. In analyzing the indirect effects "elsewhere" the national economy (national firms) is – as a unit of analysis – too narrow. The new context of globalization in which technological change now occurs is also relevant for the empirical analysis of the economic and employment consequences of this phenomenon. External demand has become a major component of demand for technological innovations. More generally, empirical studies have confirmed the crucial role played by the magnitude of demand effects in the overall effect of technological change on employment.

As a part of the overall discussion of the technological innovation/employment relationship the purpose of this paper is to investigate empirically the factors affecting direct employment changes due to ecological innovations (a subset of the overall technological change) at firm level. It uses cross section data from around 1600 firms in five different countries (Germany, Great Britain, Italy, Holland and Switzerland) gathered for the first time to analyze this relationship. The paper consists of three parts. Section 2 provides a theoretical guide. In section 3 the data, the econometric analysis and the empirical results are presented. Section 4 is a brief summary of the paper. While interpreting the results of this paper, the reader should keep in mind that neither the indirect microeconomic nor the overall macroeconomic effects mentioned above are the subject of this study.

---

[1] Recent surveys of this literature are listed in the references.

2 Employment Effects of Eco-Innovations: Theoretical Background

One central question will guide our discussion of the literature: What can economic theory tell us about the likely effects of technological change on employment at the firm level? In order to answer this question, I will be looking at the body of theoretical and empirical literature dealing with the relationship between technological change and labor demand at the firm level.[2]

A simple model which shows how the effects of technological change work will be presented briefly[3]. It suggests that examining the production function relationship is fundamental to understanding the effects of technology on output. Write the production relationship[4] as:

$$VA = T\left[(AL)^{(\sigma-1)/\sigma} + (BK)^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)}$$

Where K = capital, L = Labor, VA =value added. T represents a neutral technology parameter, A is labor augmenting technology and B is capital augmenting technology. If a firm maximizes profit, then the labor demand equation is:

$\log L = \log VA - \sigma \log (W / P) + (\sigma - 1) \log A$

The elasticity of labor demand with respect to a change in labor augmenting technological progress is given by:

$$\frac{\delta \log L}{\delta \log A} = \left(\frac{\delta \log VA}{\delta \log P}\right)\left(\frac{\delta \log P}{\delta \log MC}\right)\left(\frac{\delta \log MC}{\delta \log A}\right) + (\sigma - 1)$$

Or more succinctly,

$$\frac{\delta \log L}{\delta \log A} = \eta_p \mu \theta + (\sigma - 1)$$

Where the effect of technical change on labor demand is now written as a function of four factors:

- The price elasticity of product demand (η)[5]. The greater the sensitivity of consumers to price changes the more likely it is that an innovation will raise employment. The higher the price elasticity is, the greater the increase in output generated by an innovation.

---

[2] For the theory see for instance HAMMERMESH (1993) and PETIT (1996). For a recent survey of the empirical literature see CHENNELLS & REENEN (1999). Earlier surveys were done by CYERT & MOVERY (1988) and WIT (1990).

[3] See ADAMS (1997), REENEN (1999) and. CHENNELLS & REENEN (1999).

[4] To simplify the presentation we work with a special case of translog production function in which a constant elasticity of substitution between the factors is assumed. (the translog allows for more general paterns of substitution and complementarity).

- The market-elasticity (a measure of market power, μ). If the firm has some degree of market power, not all of the reduction in cost will be passed on in the form of lower prices. This will blunt the output expansion effect and make positive employment effects less likely.

- The "size" of the innovation as measured by its effect on marginal cost (θ). Since it is difficult to know the effect of any given measure of innovation on marginal cost, it is very difficult to determine the quantitative effect of an innovation.

- The elasticity of substitution between capital and labour (σ). The easier it is to substitute the more likely it is there will be positive effects of labour augmenting technical change, since labour is now relatively cheaper than capital and the firm will substitute into labour. The opposite is true for capital augmenting technical change.

The interpretation of all these theoretical results can be made clear in the following benchmark case: When there is perfect competition (θ =1), and no substitution between labor and capital (e.g. if labor is the only factor of production σ = 0), then for a normalized innovation ($\theta =1$) the effect on labor demand will hinge on whether demand is elastic. If product demand is elastic ($\eta >1$), then employment will rise, if it is inelastic ($\eta >1$), then employment will fall.

Generalizations of this simple model has been made and led to the consideration of further possible effects[6]. Katsoulacos (1986), for instance, found out on theoretical grounds that product innovations tend to have stronger output expansion effects and therefore more likely to result in employment increases. On the other hand Dobbs et al (1987) suggest that economies of scale tend to magnify the positive employment effects. The simple model presented above and its various alternative formulations and extensions have been used as a theoretical basis for various empirical studies.

While trying to come up with model-based empirical results concerning the relationship between innovation and employment, economists have encountered many problems. The most important ones are as follows[7]:

- Identification problem
- Endogeneity problem
- Aggregation problem
- Measurement problems

The Identification Problem: Since innovations are not the only cause of employment changes and imply indirect effects, it is difficult to isolate (to identify) their specific contributions, especially if data on other (co-determining) factors are missing. Endogeneity problem: The so-called endogeneity problem is due to fact that the relationship between innovation and employment is not one-way. Firms' decisions on innovation and employment influence each

[5] We are assuming the elasticity between value added and output is unity.

[6] For a short discussion of the generalisations of the model see CHENNELS & REENEN (1999)

[7] For more details see CHENNELS & REENEN (1999) and LUDSEK & STEINER (1999)

other and have often been taken simultaneously[8]. The Aggregation problem: Innovating firms may create jobs, but the desired effects may be accompanied by destruction of jobs of their non-innovating competitors and industries, whose products are crowded out by the new products (indirect effects). The net effect is not always clear. It is much more difficult to evaluate indirect than direct effects. Though this problem is well-known, econometric studies usually deal most exclusively with direct effects.[9] The present study makes no exception. Measurement problems: Last but not least economists have encountered problems concerning the measurement of key variables of the technological change/employment relationship. How to measure the technology input, for instance, turned out to be a difficult empirical problem.

In spite of all these problems a number of empirical studies have been conducted[10]. Focusing on the firm level studies, there are a wide variety of results from different countries. Overall, there appear to be consistently positive effects of proxies for product innovations on the growth of employment. The results for process innovations are very mixed – although usually insignificant, several examples of positive effects exist.[11] In a French study, Grrenan and Guellac (1996) find that process innovations have a strong positive effect at the firm level, but this dilutes at the industry level. The story is reversed for product innovations. The employment effects of innovations depend critically on the type of innovations being produced. This result is confirmed by an analysis by Reenen (1997), probably the most important contribution to the empirical analysis of the employment effects of innovations conducted recently. He derives estimable labor demand equations from a CES production function, all variables are taken in differences. In order to account for timing problems, long lags of innovations (up to 10 years) are contained in his specifications. The estimations are based on a panel data set of UK manufacturing firms, matched with innovation count data drawn from the Science Policy Unit's (SPRU) innovation database. His results can be summarized as follows: Product innovations have large positive (significant) employment effects, while the impact of process innovations is insignificant. As for timing, effects of innovations peak after 6 years. The thorough dynamic modeling strategy delivers strong evidence for causality from technological change to employment change.

In light of these theoretical and empirical results we will investigate in the following sections the relationship between eco-innovations and employment changes at firm level in five different European countries.

---

[8] The only econometric solution to this problem is to develop instrumental variables. Unfortunately, such instruments are not easy to find (lack of data).

[9] The prevalence is caused by the complexity of computations of indirect and direct effects and missing data.

[10] E.g. ARVANITIS & HOLLENSTEIN (1998) for Switzerland; BROUWER ET AL. (1993) for Holland ; HANNES & STEINER (1994) for Austria; KÖNIG ET AL (1995), ENTORF & POHLMEIER (1991) and ROTTMANN & RUSCHINSKI (1996) for Germany.

[11] E.g. BLANCHOVER & BURGESS (1997) for UK and Australian plants; BLECHINGER ET AL. (1998) for Dutch firms and REGEV (1998) for Israeli firms.

3 An Empirical Investigation of Selected European Firms

3.1 Data

In this paper we analyze data from the European project IMPRESS (acronym for: "The Impact of Cleaner Production on Employment – A Study using Case Studies and Surveys"[12]. The project was run from October 1998 to January 2001. Between March and July 2000, 1594 telephone interviews with industry and service firms were realized 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 like mining, agriculture or public administration have not been included in the sample.

In Germany, an additional stratification for the firms located in East or West Germany has been introduced, in Italy, the firms were differentiated between the North and the rest of the country, while in Switzerland, a differentiation between the region of the three major language groups German, French and Italian took place.

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. The number of small and large firms and the number of firms interviewed per sector is reported in Table 1 in the appendix. The descriptive results reported are not weighted by the probability of the firm to be included in the sample which varies by country. Therefore the descriptive analysis is not representative for all eco-innovators in the five countries.

The data set was especially designed to measure the effects of eco-innovations on employment on 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, see for example Pfeiffer (1999). In addition, besides the differentiation between direct and indirect effects, the data sets allows to draw conclusions on the employment effects of relevant policy variables such as subsidies and environmental regulations.

[12] See for detailed information the project homepage http://www.impress.zew.de

3.2 Econometric Analysis

3.2.1 Econometric Specification

The dependent variable (Y1) is the long term (more than one year) employment effect of eco-innovations at firm level. It is represented here as a dummy variable that takes the value 1, if this effect is positive and 0 if it is either constant or negative. (For a short description of all dependent and independent variables see the List of Variables in the Appendix.)

According to our theoretical model there are four groups of independent variables: The size of the innovation, the market power of the innovating firm, the price elasticity of product demand and the substitution possibilities of capital for labor within a firm. In addition, as shown in many empirical studies (see COHEN 1995) for a recent survey of the empirical literature), the innovation behavior is different across firms, industries and countries. We therefore need to control for these differences.

The size of innovation is represented here by two variables: one tries to catch the quantitative importance of an eco-innovation and it is measured by its share of the firm's total innovation expenditures (I_SHARE). The other one captures the qualitative nature of innovation by distinguishing among the following different categories of innovations: product, service, distribution system, process, organizational method, recycling system and pollution control (end-of-pipe).Table 2 summarizes the relative importance of these 7 different categories of eco-innovations for the firms surveyed. By way of a factor-analytic procedure we were able to reduce these 7 categories to 3 principal components (see Table 3): The first component – here called ORGANIZATIONAL INNOVATION -- receives high loadings from new organizational methods, service innovation and new distribution systems. The second component – here called PROCESS INNOVATION – loads highly on process innovations and pollution control. Finally, the third component, PRODUCT INNOVATION, loads almost exclusively on this type of innovation.

The market power of innovating firms cannot be measured directly in our survey (for instance, through their market share). An indirect qualitative measure for it can be derived from a question concerning the most important factor of competition between a firm and its competitors. These factors are the following: price, quality, environmentally friendly features, innovative products or services, corporate image (Table 4). We assume that a positive response (dummy=1) to these questions implies the existence of competition between firms operating in a specific product market using one of the 5 factors mentioned. Otherwise (dummy=0) we assume that there is a form of market power that is based on one of the five factors. Again, through factor analysis we were able to reduce these 5 forms of competition to 3 subgroups (Table 5).These synthetic variables are called here, according to the factor loadings they received, PRICE COMPETITION, CORPORATE IMAGE COMPETITION and INNOVATION COMPETITION.

Since the price elasticity of product demand cannot be computed directly from our database, it is captured indirectly through the following two variables: The estimated price changes due to innovation (PRICEC) and the estimated quantity demand changes due to innovation (SALESC). These variables have been derived directly from the questionnaire (Questions 22 and 23).

The substitution effects due to eco-innovation in general and the substitution possibilities of capital for labor in particular are captured by survey questions concerning "increase or decrease of energy costs" (ECOSTC), "increase or decrease of material costs" (MCOSTC), "increase or decrease of waste disposal costs" (WCOSTC) and "increase or decrease of labor costs" (LCOSTC). The latter is a proxy for changes in wages and other wage related costs.

Firm specific variables include first the "firm size", measured by the number of employees (the variable SIZE1 takes the value of 1 if the number of employees is less than 50 and 0 otherwise.) and secondly indicators for firm-specific innovation strategies, measured by questionnaire-items related to the reasons for introducing eco-innovations by firms. These reasons were listed as follows: comply with environmental regulations; secure existing markets; increase market share; reduce costs; improve the firm's image; respond to a competitor's innovation and achieve an accreditation. (For their relative importance for the firms surveyed, see Table 6.) These reasons were reduced to three subgroups of firm-specific strategies and may be called, according to the factor loadings they received, as follows: MARKET STRATEGY, ENVIRONMENTAL STRATEGY and COST REDUCTION STRATEGY (see Table 8).

Industry and country specific differences have been taken care of by industry and country dummies. Since government support for innovation is different across industries and countries, we explicitly asked a question regarding state subsidy or grants for eco-innovations (see our variable "I_SUBSID").

3.2.2 Econometric Issues

A significant problem is related to the "noise" in the data used. This is mostly due to the fact that almost all variables were originally "yes/no" responses to qualitative questions. The variables have the measurement properties of categorical data. To be useful in the econometric analysis, these responses have to be converted into dummy variables. Since our dependent variable (y1) is of such a nature (y1=1, if the response to the question concerning the long term (more than one year) employment effect of eco-innovations is positive and y1=0, if it is either constant or negative), we have to use a logit procedure as a basis of our parameter estimates. Another econometric problem is that the values of our endogenous variable are highly asymmetrically distributed: We have far more "0s" than "1s".

3.3 Empirical Results

The results of the regression analysis are summarized in Table 9 and can be interpreted as follows:

The size of innovation as measured by the variable I_SHARE (the share of eco-innovation expenditures as a percentage of firm's total innovation expenditures) has a positive effect on the firm's probability to increase long term employment. This effect is statistically significant. In addition, as expected, product innovations seem to have a positive impact, while process innovations seem to have a negative impact on long term employment. Both effects are statistically significant. However, the impact of organizational innovation on employment is not statistically significant.

The market power of the innovating firm: The impact of competition in product markets on the long term employment of firms operating in those markets depends on the means used for competition: while innovation-based and corporate image based competition seems to have a positive effect, price competition seems to have the opposite effect. Only the last effect is, however, statistically significant. This does not seem to confirm our theoretical expectation that market power lessens the positive employment effect of innovations.

The price elasticity of product demand: Eco-innovations that led to increases in output and sales could also increase long term employment. This impact is statistically significant. On the other hand, changes of prices due to innovations affect long term employment negatively.

Of all substitution effects that are caused by the introduction of an eco-innovation only labor cost changes - as a proxy for changes in wages and other wage related costs - seem to have a statistically significant positive effect on the long term employment of innovating firms. The other effects, such as energy cost changes, material cost changes and waste disposal cost changes appear to be not important.

Firm specific variables: While firm size does not seem to affect long term employment due to eco-innovations, firm-specific strategies do. Eco-innovating firms that pursue a clear market driven strategy such as securing existing markets or increasing market share also increase their long term employment. On the other hand, firm strategies that consist of innovating in order to comply with environmental regulations or to improve the firm's image do not seem to have the same systematic effect on long term employment.

Industry and country specific differences: The long term employment effect of eco-innovations varies not only across firms but also across industries and countries, as shown in Table 8. After controlling for these differences and other important variables, our econometric analysis suggests another striking result: State intervention in form of subsidies or grants for developing or purchasing eco-innovations appear to have a statistically significant negative impact on the long term employment of the firms in our five country-sample. At least in this respect state policy does not appear to be effective.

4 Conclusions and policy implications

I conclude the paper with a brief summary of the results, some reflections on them and a few brief observations on the implications they carry for firm strategy and public policy towards environmental innovations.

The purpose of this paper was to investigate empirically the factors affecting direct employment changes due to eco-innovations at the firm level. Using data from around 1600 firms in five different countries (Germany, Great Britain, Italy, Holland and Switzerland) we have obtained the following empirical results: firms investing in relatively important (from the firm's perspective) labor cost saving product innovations that have not been subsidized by the state and pursuing a market-driven business strategy that leads to increases of their sales in industries in which they have considerable market power also increase the likelihood of their achieving a positive long term direct employment effect. Firms that deviate - on average - from this ideal portrait do not have positive direct employment effects. It should, however, be emphasized that neither the indirect microeconomic nor the overall macroeconomic effects of eco-innovations were the subject of this study. The analysis of such effects would entail the settlement of too many theoretical, empirical and data problems to be handled in the framework of this research project.

From the perspective of the existing body of theoretical and empirical literature on the relationship between innovation and employment, some of which has been presented above, the following comments about the empirical results of this study can be made:

- Not surprising is the result that an eco-innovation in general, measured by its share of a firm's total innovation expenditures (input indicator), does have a significant impact on firms' long term employment.
- The results concerning the employment effect of product and process innovations confirm by and large the results of other studies (see the survey by Chennells/Reenen, 1999). However, it is surprising that organizational eco-innovations do not have any significant impact on firms' long term employment.
- From a theoretical (neo-classical) viewpoint is it quite surprising that price-based competition among firms does not have a positive impact on long term employment. This result instead confirms a Schumpeterian perspective suggesting that imperfect competition (market power) helps firms to innovate and create jobs.
- The results that employment effects of innovations vary across firms, industries and countries concur with other empirical innovation studies. In this respect it is worth noticing that firms pursuing different strategies achieve different outcomes concerning employment. Firms with a clear market-driven strategy (innovation in order to secure existing markets or to increase market share) are more successful than those that are aiming at just improving their corporate image.
- From an economic policy view point the result is striking that state subsidy and grants for eco-innovation do not have - on average - a positive impact on job creation in firms.

These results have clear implications for both corporate strategy and economic policy.

5 References

ARVANITIS S., HOLLENSTEIN H. (1998)
"Arbeitsqualifikation, Beschäftigung und Innovationsaktivitäten: Erste empirische Ergebnisse einer ökonomischen Analyse anhand von Unternehmensdaten". Paper presented at the Conference "Bildung und Arbeit", 24-26 September 1998, Zurich: University of Zurich.

BLANCHOVER D., BURGESS (1997)
New technology and jobs: comparative evidence from a two country study", Economics of Innovation and New Technology, 6 (1/2).

BLECHINGER D., KLEINKNECHT A., LICHT G., PFEIFFER F. (1998)
"The Impact of Innovation on Employment in Europe – An Analysis using CIS Data. ZEW Dokumentation Nr. 98-02, Mannheim: ZEW.

BROUWER E., KLEINKNECHT A., REIJNEN O. N. (1993)
"Employment Growth and Innovation at the Firm Level, An Empirical study, Journal of Evolutionary Economics, 3, pp. 153-160.

CHENNELLS L., REENEN J. V. (1999)
Technological change and the structure of employment and wages: A survey of the micro-econometric evidence, London: Institute for fiscal studies.

COHEN W. M. (1995)
"Empirical Studies of Innovative Activity", in: Stoneman, P. (ed.), Handbook of The Economics of Innovation and Technological Change, Oxford: Blackwell.

CYERT R. M., MOWERY D.C. (EDS.) (1988)
The Impact of Technological Change on Employment and Economic Growth, Cambridge, Mass: Ballinger.

ENTORF H., POHLMEIER W. (1991)
" Employment, innovation and export activities", in Florens, J. et al. (eds.), Microeconometrics: surveys and applications, Oxford: Basil Blackwell.

FLORENS, J. ET AL. (EDS.) (1991)
Microeconometrics: surveys and applications, Oxford: Basil Blackwell.

FREEMAN C., SOETE L.(1997)
"The Information Society and Employment " (Ch.17), in: The Economics of Industrial Innovation. London: Pinter.

GRENAN D., GUELLAC D.(1997)
"Technological innovation and employment reallocation", Paris: INSEE mimeo.

HAMERMESH D. S. (1993)
Labor Demand, Princeton: Princeton University Press.

HANNES L., STEINER V. (1994)
" Innovation and Employment at the Firm Level" . Working Paper. Austrian Institute of Economic Research, Vienna: WIFO.

INSTITUTE FOR PROSPECTIVE TECHNOLOGICAL STUDIES IPTS (1997)
Environment and Employment. Sevilla: IPTS.

KÖNIG H., BUSCHER H., LICHT H. (1995)
„ Employment, investment and innovation at the Firm Level" , in: The OCDE jobs study: evidence and explanations, Paris: OECD.

MATZNER E., WAGNER M. (1988)
The Employment Impact of New Technology, Averbury: Aldershot.

OECD (1994)
The OECD Jobs Study, Evidence and Explanations, Part I and Part II, Paris: OECD

PETIT P. (1996)
" Employment and Technical Change" (Ch.10), in Handbook of the Economics of Innovation and Technological Change, edited by Stoneman, London: Basil Blackwell.

PFEIFFER, F., (1999)
Human Capital and innovation in eastern and western Germany. In: M. Fritsch, H. Brezinski: Innovation and technological change in Eastern Europe. Edward Elgar, Cheltenham, pp., 142–166.

PINATA M. ET AL. (1995)
The Dynamics of Innovation and Employment: An International Comparison. Seminaire d'Experts sur la Technologie, la Productivite et l' Emploi: Analyses macro-economiques et sectorielles. Paris: OECD.

REGEV H. (1998)
" Innovation, skill labor, technology and performance in Israeli industrial firms" , Economics of Innovation and New Technology, 6 (1/2).

ROTTMANN H., RUSCHINSKI M. (1996)
" Beschäftigungswirkungen des technischen Fortschritts" Working Paper ifo Institute No.30, Munich: ifo.

STONEMAN, P. (ED.) (1995)
Handbook of The Economics of Innovation and Technological Change, Oxford: Blackwell.

WIT G. R. DE (1990)
A Review of the literature on technological change and employment. Background Report 2. Macro-Economic and Sectoral Analysis of Future Employment and Training Perspectives in the New Information Technologies in the European Community, mimeo Merit, Maastricht, November.

6 Appendix

6.1 List of The Variables

Short description	Variables	Source
Dependent Variable		
Long term employment effect of Eco-Innovation	if i_employ=1 then y1=1; else y1=0;	Q33
Independent Variables		
A-Variables: firm-specific		
Firms Size: Number of employees	Size1 = less than 50 Size2 = 50-99 Size3 = 100-249 Size4 = 250-499 Size5 = over 500	Q48
Percentage of total employees with higher education	Hi_qual	Q50

Firm strategy: reasons for eco-iInnovation:
• Comply with environ. Regulations
• Secure existing markets
• Increase market share
• Reduce costs
• Improve firm's image
• Respond to a competitor's innovation
• Achieve an accreditation
• No one of this
	if r_reg=1 then dummy=1; else dummy=0;
	if r_secure=1 then dummy=1; else dummy=0;
	if r_incr=1 then dummy=1; else dummy=0;
	if r_cost=1 then dummy=1; else dummy=0;
	if r_image=1 then dummy=1; else dummy=0;
	if r_resp=1 then dummy=1; else dummy=0;
	if r_accr=1 then dummy=1; else dummy=0;
		Q21

Major factors used for competition:
• Price
• Quality
• Environ. friendly features
• Innovative products or services
• Corporate image
	if c_imp=1 then price=1; else price=0;
	if c_imp=2 then quality=1; else quality=0;
	if c_imp=3 then environ=1; else environ=0;
	if c_imp=4 then innov=1; else innov=0;
	if c_imp=5 then image=1; else image=0;
		Q44

Estimated price changes due to innovation	if i_prices=2 or i_prices=3 or i_prices=4 then priceC=0; else priceC=1;	Q23
Estimated quantity demand changes due to innovation	if i_sales=2 or i_sales=3 or i_sales=4 then salesC=0; else salesC=1;	Q22

Substitution effects due to innovation:
• Increase or decrease of energy costs
• Increase or decrease of material costs
• Increase or decrease of waste disposal costs
• Increase or decrease of labour costs
	if i_ecost=2 or i_ecost=3 or i_ecost=4 then ecostC=0; else ecostC=1;
	if i_mcost=2 or i_mcost=3 or i_mcost=4 then mcostC=0; else mcostC=1;
	if i_wcost=2 or i_wcost=3 or i_wcost=4 then wcostC=0; else wcostC=1;
	if i_lcost=2 or i_lcost=3 or i_lcost=4 then lcostC=0; else lcostC=1;
		Q24-Q27

B-Variables: industry-specific		

Industry-dummies	if sector=1 then br1=1; else br1=0;
	..
	..
	if sector=8
	then br8=1;
	else br8=0;	

Policy variables in industry: • State subsidy or grants	i_subsid	Q18
C-Variables: innovation–specific		
Quantitative importance of Innovation: % of total innovation expenditures	i_share	Q20

Qualitative nature of innovation:
• Product
• Service
• Distribution system
• Process
• Organizational method
• Recycling system
• Pollution control (end-of-pipe)
	if i_prod=1 then dummy=1; else dummy=0;
	if i_serv=1 then dummy=1; else dummy=0;
	if i_dist=1 then dummy=1; else dummy=0;
	if i_proc=1 then dummy=1; else dummy=0;
	if i_org=1 then dummy=1; else dummy=0;
	if i_recy=1 then dummy=1; else dummy=0;
	if i_poll=1 then dummy=1; else dummy=0;
		Q14

D-Variables: country-dummies	if country=1 then count1=1;
	else count1=0;
	..
	..
	if country=5 then count5=1;
	else count5=0;	

6.2 Tables

Table 1: Description of the sample

	Number of Firms	Share
Small	1203	75.47
Large	391	24.53
Industry/Manufacturing (NACE-Codes D-F)	906	56.84
Hereby: Manufacturing	736	46.17
Electricity, Gas and Water	33	2.07
Construction	137	8.59
Service (NACE-Codes G-K)	688	43.16
Hereby: Wholesale/Retail-Trade	263	16.50
Hotels and Restaurants	37	2.32
Transport, Storage and Communication	156	9.79
Financial Intermediation	61	3.83
Real Estate, Renting and Business Activity	171	10.73

Table 2: Categories of Eco-Innovations

Categories of Eco-Innovations	Share of firms stating each category of Eco-Innovations (in %)
Product	17 %
Service	12 %
Distribution System	8 %
Process	36 %
Organizational method	13 %
Recycling system	32 %
Pollution control	32 %

Table 3: Factor Analysis of Categories of Eco-Innovations

Categories of Eco-Innovations	Rotated factor loadings			
	Factor 1: ORGANIZATIONAL INNOVATION	Factor 2: PROCESS INNOVATION	Factor 3: PRODUCT INNOVATION	Uniqueness
Product	-0.03394	-0.09957	0.79583	
Service	0.52413	-0.03220	0.35038	
Distribution System	0.71807	-0.06868	0.06579	
Process	-0.07929	0.61351	0.01315	
Organisation Method	0.69002	0.02722	-0.28051	
Recycling System	-0.11052	-0.62261	-0.50499	
Pollution Control	-0.02441	0.67917	-025896	

Table 4: Factors of Competition

Factors of Competition	Share of firms stating the importance of each factor of competition (in %)
Price	35 %
Quality	41 %
Environmentally friendly features	3 %
Innovative products and services	6 %
Corporate image	8 %

Table 5: Factor Analysis of Factors of Competition

Factors of competition	Rotated factor loadings			
	Factor 1: PRICE COMPETITION	Factor 2: CORPORATE IMAGE COMPETITION	Factor 3: INNOVATION COMPETITION	Uniqueness
Price	0.91046	-0.23879	-0.27131	
Quality	-0.88707	-0.26994	-0.31380	
Environmentally friendly features	0.00534	0.12197	0.25814	
Innovative products or services	-0.00527	-0.17316	0.93785	
Corporate Image	-0.00128	0.97426	0.03233	

Table 6: Reasons for Introducing Eco-Innovations

Reasons	Share of firms stating the importance of the Different reasons for introducing eco-innovations (in %)
Comply with environmental regulations	66 %
Secure existing markets	32 %
Increase market share	27 %
Reduce costs	58 %
Improve the firm's image	71 %
Respond to a competitor's innovation	15 %
Achieve an accreditation	30 %

Table 7: Analysis of Reasons for Eco-Innovations

Reasons for Eco-Innovations	Rotated factor loadings			
	Factor 1: MARKET STRATEGY	Factor 2: ENVIRONMENTAL STRATEGY	Factor 3: COST REDUCTION STRATEGY	Uniqueness
Comply with environmental regulations	-0.13090	0.77675	-0.10949	
Secure existing markets	0.84786	0.10865	-0.04809	
Increase Market Share	0.86306	0.01789	0.01730	
Reduce Costs	0.03064	-0.01255	0.98417	
Improve Firm's Image	0.20047	0.60314	0.03820	
Respond to a competitor's innovation	0.54069	0.32544	0.17236	
Achieve an accreditation	0.23559	**0.62691**	0.05848	

Table 8: Descriptive Statistics of Model-Variables

Variable Label	N	Mean	Std Dev	Minimum	Maximum
y1	1594	0.0922208	0.2894282	0	1.0000000
priceC	1594	0.1122961	0.3158295	0	1.0000000
salesC	1594	0.2013802	0.4011573	0	1.0000000
comp1	1594	7.577934E-17	1.0000000	-1.0562924	1.2384847
comp2	1594	6.131301E-16	1.0000000	-0.6876244	3.3830798
comp3	1594	1.121367E-16	1.0000000	-0.3736654	3.7242417
I_SHARE	1284	1.7531153	0.9437564	1.0000000	4.0000000
innovty1	1591	2.075998E-16	1.0000000	-0.8579669	4.4633396
innovty2	1591	-7.41009E-16	1.0000000	-1.9069414	2.0003029
innovty3	1591	1.529959E-17	1.0000000	-2.1137574	2.9072070
ecostC	1594	0.1737767	0.3790362	0	1.0000000
mcostC	1594	0.1913425	0.3934815	0	1.0000000
wcostC	1594	0.2026349	0.4020888	0	1.0000000
lcostC	1594	0.2158093	0.4115117	0	1.0000000
goal1	1579	6.270405E-16	1.0000000	0.9519553	2.4833215
goal2	1579	-5.27338E-18	1.0000000	-2.1190611	1.7946973
goal3	1579	6.609307E-17	1.0000000	-1.5798322	1.4695321
I_SUBSID	1521	1.8948060	0.3069041	1.0000000	2.0000000
size1	1594	0.2427854	0.4289010	0	1.0000000
br1	1594	0.4617315	0.4986898	0	1.0000000
br3	1594	0.0859473	0.2803742	0	1.0000000
br4	1594	0.1649937	0.3712914	0	1.0000000
br6	1594	0.0978670	0.2972280	0	1.0000000
br7	1594	0.0382685	0.1919040	0	1.0000000
count1	1594	0.2509410	0.43369070	0	1.0000000
count3	1594	0.1260979	0.3320638	0	1.0000000
count4	1594	0.1304893	0..3369467	0	1.0000000

Labels:

comp1 = 'PRICE COMPETITION'
comp2 = 'CORPORATE IMAGE COMPETITION'
comp3 = 'INNOVATION COMPETITION'
innovty1 = 'ORGANISATIONAL INNOVATION'
innovty2 = 'PROCESS INNOVATION'
innovty3 = 'PRODUCT INNOVATION'
goal1 = 'MARKET STRATEGY'
goal2 = 'ENVIRONMENTAL STRATEGY'
goal3 = 'COST REDUCTION STRATEGY'
priceC = 'product price changes'
salesC = 'sales changes'
ecostC = 'energy costs changes'
mcostC = 'material costs changes'
wcostC = 'waste disposal cost changes'
lcostC = 'labour costs changes'
Size1 = 'less than 50 employess'
I-Share = '% of total firm's innovation expenditure'
I-subsid = 'state subsidy or grants'
br 1 = manufacturing
br 2 = electricity
br 3 = construction
br 4 = wholesale, retail, trade
br 5 = hotels and restaurants
br 6 = transport, storage and communication
br 7 = financial intermediation
br 8 = real estate, renting, business activity

count 1= UK
count 2=Germany
count 3=Switzerland
count 4=Netherlands
count 5=Italy

Table 9: Analysis of Parameter Estimates (Logit-Model)

Variable	DF	Estimate	standard Error	Chi-Square	Pr>ChiSq
Intercept	1	-2.61137	0.65974	15.6673	<.0001
priceC	1	-0.05815	0.31685	0.0337	0.8544
salesC	1	1.01885	0.25233	16.3039	<.0001
comp1	1	-0.16539	0.11433	2.0928	0.1480
comp2	1	0.03119	0.10192	0.0937	0.7596
comp3	1	0.08132	0.10527	0.5967	0.4398
I_SHARE	1	0.41554	0.11315	13.4869	0.0002
innovty1	1	0.07416	0.10698	0.4806	0.4882
innovty2	1	-0.17632	0.12264	2.0671	0.1505
innovty3	1	0.21958	0.11051	3.9482	0.0469
ecostC	1	0.26395	0.28691	0.8464	0.3576
mcostC	1	0.23261	0.26332	0.7804	0.3770
wcostC	1	-0.11820	0.28971	0.1665	0.6833
lcostC	1	1.32142	0.25422	27.0196	<.0001
goal1	1	0.36402	0.11487	10.0417	0.0015
goal2	1	0.10549	0.11101	0.9032	0.3419
goal3	1	0.01037	0.11592	0.0080	0.9287
I_SUBSID	1	-0.52835	0.28825	3.3597	0.0668
size1	1	0.30528	1.02741	0.0883	0.7664
br1	1	-0.36849	0.32204	1.3092	0.2525
br3	1	-0.54362	0.46975	1.3392	0.2472
br4	1	-0.21139	0.39280	0.2896	0.5905
br6	1	-0.28908	0.42424	0.4643	0.4956
br7	1	1.12044	0.53593	4.3708	0.0366
count1	1	-1.13351	1.06877	1.1248	0.2889
count3	1	-0.58204	0.39719	2.1474	0.1428
count4	1	0.0031960	0.32464	0.0001	0.9921

Publications to date:

In Series A 'Discussion Papers' of Solothurn University of Applied Sciences Northwestern Switzerland, the following publications have appeared:

No. 98-01 THOMAS M. SCHWARB (July 1998)
«Ich verpfeife meine Firma»... Einführung in das Phänomen «Whistle-Blowing».

No. 98-02 MATHIAS BINSWANGER (December 1998)
Stock Market Booms and Real Economic Activity: Is this Time different?

No. 98-03 GÜNTER SCHINDLER (December 1998)
Unscharfe Klassifikation durch kontextbasierte Datenbankanfragen.

No. 99-01 MATHIAS BINSWAGER (January 1999)
Co-Evolution Between the Real and Financial Sectors:
The Optimistic «New Growth Theory» View versus the Pessimistic «Keynesian View».

No. 99-02 MATHIAS BINSWANGER (June 1999)
Die verschiedenen Rollen des Finanzsektors in der wirtschaftlichen Entwicklung.

No. 99-03 LORENZ M. HILTY (June 1999)
Individuenbasierte Verkehrssimulation in Java.

No. 99-04 ALBERT VOLLMER (June 1999)
Mobile Arbeit in der Schweiz – Telearbeit und Desksharing.

No. 99-05 NAJIB HARABI (July 1999)
The Impact of Vertical R&D Cooperation on Firm Innovation: an Empirical Investigation.

No. 99-06 MAIKE FRANZEN (July 1999)
Konstruktives Lernen mit dem E-Book. Entwicklung einer Lernumgebung für konstruktives Lernen.

No. 99-07 MATHIAS BINSWANGER (December 1999)
Technological Progress and Sustainable Development: Different Perspectives on the Rebound Effect.

No. 2000-01 LORENZ M. HILTY, THOMAS RUDDY, DANIEL SCHULTHESS (January 2000)
Resource Intensity and Dematerialization Potential of Information Society Technologies.

No. 2000-02 LORENZ M. HILTY, ALBERT VOLLMER, DANIEL SCHULTHESS, THOMAS RUDDY (February 2000)
Lifestyles, Mobility and the Challenge of Sustainability: A Survey of the Literature.

No. 2000-03 LORENZ M. HILTY, THOMAS RUDDY (May 2000)
The Information Society and Sustainable Development.

No. 2000-04 ROLF MEYER, NAJIB HARABI (June 2000)
Frauen Power unter der Lupe. Geschlechtsspezifische Unterschiede der Jungunternehmerinnen und -unternehmer. Ergebnisse einer empirischen Untersuchung.

No. 2000-05 ROLF MEYER, MARION ALT, KERSTIN HÜFFMEYER, NAJIB HARABI (June 2000)
Selbständigerwerbende und ihre jungen Unternehmen – 9 Fallbeispiele.

No. 2000-06 NAJIB HARABI, ROLF SCHOCH, FRANK HESPELER (August 2000)
Einführung und Verbreitung von Electronic Commerce. Wo steht die Schweiz heute im internationalen Vergleich? Ergebnisse einer empirischen Untersuchung.

No. 2000-07 NAJIB HARABI (December 2000)
Employment Effects of Eco-Innovations: An Empirical Analysis.

No. 2001-01 ROLF MEYER, NAJIB HARABI, RUEDI NIEDERER (January 2001)
Der Einfluss der Beratung, Weiterbildung und des Beziehungsnetzes auf den Erfolg junger Unternehmen.

Nr. 2001-02 NAJIB HARABI (January 2001)
Introduction and Diffusion of Electronic Commerce –
What is Switzerland's position in an international comparison? Results of an empirical study

Nr. 2001-03 NAJIB HARABI, HESPELER FRANK (February 2001)
Electronic Commerce in der Schweiz: Lehren aus Einzelfallstudien

In Series B 'Reprints' of Solothurn University of Applied Sciences Northwestern Switzerland, the following publications have appeared:

No. 98-01 NAJIB HARABI (October 1998)
Channels of R&D spillovers: An Investigation of Swiss Firms.
Reprinted from: Technovation, 17 (11/12) (1997) 627–635.

No. 98-02 MAX ZUBERBÜHLER (October 1998)
Virtualität – der zukünftige Wettbewerbsvorteil.
Reprinted from: io Management, 67 (1998), 18–23.

No. 98-03 NAJIB HARABI (October 1998)
Les facteurs déterminants de la R&D.
Reprinted from: Revue française de gestion, n° 114, 1997, p. 39–51.

No. 98-04 NAJIB HARABI (December 1998)
Innovation through Vertical Relations between Firms, Suppliers and Customers: a Study of German Firms.
Reprinted from: Industry and Innovation, Volume 5, Number 2, pp. 157–178.

No. 99-01 CHRISTOPH MINNIG, RUEDI NIEDERER, THOMAS SCHWARB (January 1999)
Imagestudie Erziehungsdepartement des Kantons Solothurn. Schlussbericht.

No. 99-02 NAJIB HARABI (January 1999)
Der Beitrag von Profit- und Nonprofit-Organisationen zum technischen Forstschritt: Ergebnisse aus der Schweiz.
Reprinted from: Wagner, R. (1997). Festschrift zum 60. Geburtstag von Antonin Wagner. Zürich: Turicum.

No. 99-03 LORENZ M. HILTY, KLAUS TOCHTERMANN, JÖRG VON STEINAECKER (July 1999)
The Information Society and the Environment – A Survey of European Activities.
Reprinted from: Proc. 1st International Environmental Management Systems Conference, Vienna/Austria 1998.

No. 99-04 THOMAS M. SCHWARB (August 1999)
Das Arbeitszeugnis als Instrument der Personalpraxis.
Reprinted from the dokumenation at the conference „Arbeitszeugnis" at Solothurn University of Applied Sciences Northwestern Switzerland, Olten.

No. 99-05 THOMAS M. SCHWARB, ALBERT VOLLMER (December 1999)
Telearbeit
Reprinter from: Schwarb Th. M. (ed.) (1999) Erfolgsfaktor Human Resource Management, Zürich:

Weka.

No. 2000-01 NAJIB HARABI, ROLF MEYER (February 2000)
Die neuen Selbständigen
A Study by order of NEFU (Netzwerk für Einfrau-Unternehmerinnen) Switzerland.

No. 2000-02 RUEDI NIEDERER, STEFANIE GREIWE, CHRISTOPH MINNIG, THOMAS SCHWARB (March 2000)
Projektmanagement – Praxis und Ausbildung.
A Study by order of Universities of Applied Sciences and SwissPM.

No. 2000-03 THOMAS SCHWARB, STEFANIE GREIWE, CHRISTOPH MINNIG, RUEDI NIEDERER (March 2000)
Olten ist eigentlich schön, aber ...
A Study of Attraktivity and Image of Olten by order of the Project Olten Plus.

No 2000-04 THOMAS SCHWARB, ALBERT VOLLMER, RUEDI NIEDERER (March 2000)
TA-Studie „Mobile Arbeitsformen: Verbreitung und Potenzial von Telearbeit und Desksharing"
A Study by order of Swiss Science and Technology Council and Commission for Technology and Innovation.

No. 2000-05 THOMAS SCHWARB, STEPHANIE GREIWE, CHRISTOPH MINNIG, RUEDI NIEDERER (NOVEMBER 2000)
Olten ist eigentlich schön, aber...
A Study of the Attractiveness of Olten as a Residential and Industrial Location and of the Image of Olten under Contract from the Project Olten Plus (POP).

No. 2000-06 THOMAS SCHWARB, STEPHANIE GREIWE, CHRISTOPH MINNIG (NOVEMBER 2000)
Ich gehe nach Olten einkaufen, wenn ...
A Study of Shopping in Olten under Contract from the Project Olten Plus (POP).

No. 2000-07 THOMAS SCHWARB, STEPHANIE GREIWE (January 2001)
Zofingen unter der Lupe.
Study of the Situation of Shopping in Zofingen.

In Series C 'Guest Lectures' of Solothurn University of Applied Sciences Northwestern Switzerland, the following publications have appeared:

No. 99-01 PATRIK DUCREY, BARBARA HÜBSCHER (July 1999)
Aktuelle Probleme der Wettbewerbspolitik
Lectured at University of Applied Sciences Solothurn Northwestern Switzerland on May 31st 1999.

No. 2000-01 ANDY STURM (April 2000)
Grundlagen der schweizerischen Geldpolitik
Lectured at University of Applied Sciences Solothurn Northwestern Switzerland on April 14th 2000.

No. 2000-02 PATRICIA SCHULTZ (September 2000)
Von Männern und Frauen in Arbeitswelt und Privatleben
Lectured at University of Applied Sciences Solothurn Northwestern Switzerland on February 22nd 2000.

No. 2000-03 NILS GOLDSCHMIDT (September 2000)
Auf dem Weg zu einem kommunitaristischen Wohlfahrtsstaat. Ethische und ökonomische Anmerkungen zu einem nicht ganz neuen Leitbild
Lectured at University of Applied Sciences Solothurn Northwestern Switzerland on March 3rd 2000.

No. 2000-04 ELISABETH JORIS (September 2000)
History and Herstory
Lectured at University of Applied Sciences Solothurn Northwestern Switzerland on November 30th 1999.

Orders

Price per copy:	Discussion Papers (Series A):............SFr. 20.-
	Reprints (Series B):...........................SFr. 20.-
	Guest Lectures (Series C): ....SFr. 20.-
Send orders to:	Fachhochschule Solothurn Nordwestschweiz -Sekretariat Weiterbildung- Postfach CH-4601 Olten Telephone: ++41 +848 821 011 Telefax: ++41 +62 296 65 01 e-Mail: ccc@fhso.ch