Standardization, R&D and Export Activities: Empirical Evidence at Firm Level

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Standardization as a Technology Monitoring Strategy: Empirical Evidence from the World's most Technology-intensive Companies

ABSTRACT:

In 1998 the Massachusetts Institute of Technology (MIT, Cambridge) and the Fraunhofer Institute for Systems and Innovation Research (ISI, Karlsruhe) in collaboration with the National Institute of Science and Technology Policy (NISTEP, Tokyo), conducted a survey on the "Strategic Management of Technology" in general in over 200 companies.[1] Besides intramural R&D, there is a growing tendency to acquire technology from external sources. This creates a need for intensive technology monitoring, which can be undertaken also by participating in standardization bodies. The aim of the paper is to analyse the relevance of this strategy among other mechanisms to monitor technology and the determining factors for its use, differentiated by companies from Europe, Japan and the United States.

[1] For a general overview of the main results of the survey compare Edler, Jakob/ Meyer-Krahmer, Frieder/ Reger, Guido: Managing Technology in the Top R&D Spending Companies Worldwide: Results of a Global Study. In: Engineering Management Journal - Special Issue on 'Managing High Technology Research Organizations', Vol. 13, No. 1, March 2001 (forthcoming).

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1. Introduction

The relationship between R&D activities or innovation and export performance has already been analysed both at the macroeconomic level (Fagerberg 1988, Greenhalgh 1990, Wakelin 1998b), and at the microeconomic company level (Brouwer and Kleinknecht 1993, Wakelin 1998a, Ebling and Janz 1999). However, the role of technical standards as one indicator of a country's or a company's technological capacity has not yet been well analysed. In this paper, we concentrate on voluntary standards published by standards development organisations like the British Standardisation Institute (BSI) in the UK or the German Institute for Standardization (DIN) in Germany. Obligatory regulating standards issued by governmental institutions or industry standards informally elaborated by one or more companies in consortia are neglected. Hence, the former have a regulatory character, and the latter are generally protected by some intellectual property rights, being very similar to proprietary innovations. In contrast to innovations, technical standards are very ambiguous from the theoretical point of view, because besides their competitiveness-enhancing effects due to quality improvements and allowing economies of scale, they foster lock-ins into inferior technologies especially in times of short development phases and product cycles. Furthermore, incompatibilities with the standards of other companies and countries make (foreign) trade – both the export and the import of goods – more difficult. Consequently, the empirical analyses of the impact of standards on trade performance of Swann et al. (1996) for the UK and also Blind and Jungmittag (2000) for Germany support these ambiguous effects, because they show positive, but mostly insignificant results.

A microeconomic analysis will be performed in order to elucidate both company's driving factors for participating in standardisation processes and the impacts of joining standardisation processes on R&D activities and export performances. Blind (1999) has already determined the R&D and patent intensity and export activity as the major driving forces for standardisation at standardisation development organisations at a sectoral level. In a first step, these results will be verified in the following section on the basis of the company-specific

data[1] using a Probit model. In further steps we shall examine to which extent the export activities and the R&D involvement depend on company- and branch-specific characteristics and attitudes towards standardisation.

The remainder of the paper is set out as follows. Section 2 outlines the special characteristics of standardisation and innovation at firm level, and summarises both the empirical studies of the impact of innovation, respectively R&D, on export behaviour and the small empirical work about the determinants of standardisation activities. Section 3 presents the data set and gives some descriptive statistics. Section 4 considers the model specifications in order to explain the participation in standardisation processes. In a second model, section 5 explains the export performance of the firms by R&D behaviour, standardisation effort and other variables. Finally, in a third model, an elucidation of the determinants of the R&D activity itself will be attempted. The paper concludes with a summary of the results and some recommendations for future strategies of standardisation development organisations.

2. Firm Behaviour

The decisions about joining a standardisation process and therefore of committing resources is made on the firms' level as well as the determination of resources for R&D and innovation (cf. for the latter Wakelin 1998a). However, in contrast to the benefits of innovations which primarily the firm can appropriate by reduced production costs, penetrating new markets and exploiting monopoly rents, new standards published and distributed by standard development organisations are at first glance a public good.[2] Despite the general possibility for everybody to buy a standard for a reasonable price, only the core of companies which have the relevant technological know-how can use the new technical specification effectively and efficiently.[3] Therefore, the participants in the standardisation process may have advantages compared to outsiders, due to their early involvement in the development of the standard and the accompanying

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1 The company survey was performed by the Technical University of Dresden. See Blum et al. (2000).

2 In the case of privately owned de facto standards caused by network externalities, the R&D decision will change towards a socially ineffective speed up of R&D. Cf. Kristiansen (1998).

3 Therefore, Antonelli (1994) goes even further and characterizes standards as non-pure private goods.

process of knowledge exchange and creation. Salop and Scheffman (1987, 1992) underline this argument in the way that the establishment of product standards may be a strategy by which firms could disadvantage rivals by raising their costs. Secondly, only the companies, which are in the same branch or are using the same technology may benefit in general from a new standard. Consequently, the theoretical approaches of Farrell and Saloner (1985) dealing with innovation and standardisation use game theoretical models with only two companies. Therefore, despite the explicit technological spill-overs of standards, which justify an analysis at branch (see Blind 1999a) or even at macroeconomic level (Jungmittag et al. 1999), the single company is a suitable unit of analysis, especially when considering the relationships between innovation, standardisation and export behaviour.

Concerning the firms' performance in R&D and its impact on standardisation, two contradictory trains of thought have to be considered. Firstly and obviously, the standardisation process is a continuation of the development phase of internal R&D. Therefore, companies which are actively involved in R&D are also more likely to participate in standardisation processes in order to continue their previous activities and to reach marketable products or process technologies compatible with those of other companies (Farrell and Saloner 1985). However, the involvement in standardisation processes is accompanied by the danger that the other participants could use the own disclosed and unprotected technological knowledge for their purposes.[4] Therefore, R&D-intensive companies may be more reluctant to join standardisation processes. On the other hand, particularly companies with low R&D efforts may compensate this by entering standardisation clubs of R&D-intensive firms and in profiting from the technology transfer there. This view is supported by the analysis of Love and Roper (1999) about the substitute relationship between own R&D and technology transfer. In general, the companies' R&D intensity may be therefore ambivalent for the likelihood of joining standardisation processes.

Including the link to exports, the participation in standardisation processes at national level facilitate influence also on the standardisation at European or international level. Therefore, exporting companies are more likely to participate

4 Compare Blind (1999b) for a cross-sectoral study about the impact of patent protection on standardisation.

in standardisation. On the other hand, companies actively involved in standardisation should be more successful in exporting their goods and services due to their influence on the product specification of supranational standards.

The majority of empirical studies considering the determinants of standardisation are based on product classes (Link 1983, Lecraw 1984) or standardisation processes (Weiss and Sirbu 1990). Puzzling results came to light concerning the relationship between R&D intensity and standardisation. Whereas Link (1983:398) finds a positive impact of the R&D intensity on the probability that a voluntary standards process will be initiated, Lecraw (1984:513) discovers a negative influence of the R&D intensity on standard usage due to very short product cycles making standards quickly obsolete and strong incentives to differentiate the own R&D-intensive product against those of the competitors'. Lecraw (1984:519) admits that his analysis "cannot be used to determine the motivation for the higher use of standards" in different industries. The same is true for his analysis of the impact of standards on price differences between Canada and the US.

However, there are firm level studies which have examined the relationship between innovation and exports. Both the studies, which have used R&D expenditure as an indicator for innovation (like Hirsch and Bijaoui 1995), and the studies of Wakelin (1998a) for a sample of UK firms, and Ebling and Janz (1999) for a sample of German service companies, which are based on surveys, found significant implications of innovation activities on export behaviour.

The study presented here allows to combine both R&D-specific incentives and export strategic motives in order to explain first of all firms' likelihood to join standardisation processes. In a second step, the probability to export will be explained by both R&D or innovation variables and standardisation activities. Finally, R&D behaviour will be taken as an endogenous variable to be explained by export performance and standardisation.

3. The Data and Descriptive Statistics

The empirical analysis presented here aims firstly to assess the importance of different determinants of standardisation activities, in particular the role of R&D and export behaviour. The data set used in this paper is a microeconomic data set of 417 German firms which answered a questionnaire of the Technical University of Dresden sent out to over 2000 firms in 1998 (Blum et al. 2000). Only firms in ten manufacturing sectors were chosen.

As already discussed, there are a number of different explanations for participation in standardisation. The definitions of the main company-specific quantitative variables in the data set are given below:

Export intensity: $Exp_{ij} = X_{ij}/TT_{ij}$;

Import intensity: $Imp_{ij} = Im_{ij}/TT_{ij}$;

Competition intensity: $Comp_{ij}$ = Number of competitors (low = 1; medium = 2, high = 3);

R&D intensity: $R\&D_{ij} = 100*R\&D_{ij}/TT_{ij}$;

Size: $Size_{ij} = \log TT_{ij}$;

Labour intensity: Lab_{ij} = Number of $Employees_{ij}/TT_{ij}$,;

where X stands for exports in DM (German Marks), Im for imports in DM, TT for total turnover in DM, R&D for expenditure for R&D in DM. The subscript i is for the firm and j for the sector.

Some descriptive statistics for the variables are presented below in Table 1 for the two separate classifications of standardisers and non-standardisers.[5] The most obvious differences between the two classes are the variations in the export intensity, the R&D intensity and labour intensity. Whereas the higher export in-

5 Due to missing variables, the number of observations are not identical.

tensity of standardisers was expected due to the theoretical considerations, the lower R&D intensity of companies joining the standardisation process supports the train of thought which assumes a substitutive relationship between the own R&D effort and the participation in standardisation processes and the reluctance of R&D-intensive companies to disclose their knowledge in standardisation processes. The labour intensity of standardising companies is surprising, and not explainable at first glance, significantly higher compared to the non-standardisers.

Table 1: Descriptive statistics: Means (standard deviations) [number of observations]

	Standardisers	Non-Standardisers
Export intensity	0,15 (0,24) [204]	0,12 (0,21) [207]
Import intensity	0,02 (0,06) [205]	0,02 (0,05) [207]
Competition intensity	2,58 (0,51) [176]	2,61 (0,48) [183]
R&D intensity	2,71 (3,63) [205]	3,36 (5,75) [209]
Log size	19,43 (2,38) [149]	17,95 (1,49) [165]
Labour intensity	0,0001539 (0,00075) [146]	0,000006 (0,000016) [159]
Standardisation department	0,38 (0,49) [205]	0,14 (0,36) [204]

4. Explanatory Factors for Participation in the Standardisation Process at Company's Level

The influence of various variables on the decision for or against active participation in the standardisation process can be determined by means of a Probit model.[6] In general, the response of all 417 companies in Germany are taken into account in the model. By contrast to the simple representation of descriptive statistics, in a multivariate analysis – like the regression model – other company characteristics and attitudes also are simultaneously considered. Thus spurious correlations, i.e. apparent influences of a variable on the standardisation decision, can be discovered which originate from the fact that the actual causal variable has not been considered. The observation of the significance of export intensity for the standardisation decision corresponds to the comparison between two companies which only differ in their export activities, but are otherwise completely alike. The influence of the other factors can therefore be separated.

6 In the Probit model based on a filter question in the questionnaire it is simply assumed, that the variable in question – in this case the decision about cooperation in a standardisation committee – can only assume two values: no or 0 and yes or 1.

The decision of company i from branch j to participate actively in standardisation is a function of different factors. On the one hand, this decision is co-determined by company-specific characteristics Z_{ij}, such as size and labour intensity. Further, standardisation is to be seen in context with the research and development activities of a company, so that on the one hand the R&D intensity and on the other hand the anticipated advantages or disadvantages for own R&D ($R\&DAdv^{exp}$) resulting from the participation in the standardisation process can be seen as an explanation.[7] Finally, the influence of standards on foreign trade originates from the strategic decisions in particular of those companies which are involved in export. Therefore, the actual export activities as well as the anticipated advantages ($ExpAdv^{exp}$) resulting from participation in standardisation processes – especially when national norms are adopted as European and international standards – are supposed explanatory factors for export success.[8] After all, the general attitude towards the benefits of standards for the economic development of one's own company ($EcDC^{exp}$) and own branch ($EcDB^{exp}$) is a decisive factor for collaboration in the standardisation process.[9] In addition, sector-specific characteristics S_j, expressed as dummy variables with mechanical engineering as base, and the framework conditions for the total economy (= constant α) explain the company-specific standardisation decisions:

$$Std_{ij} = f\left(Z_{ij}; R\&D_{ij}; R\&DAdv_{ij}^{exp}; Exp_{ij}; ExpAdv_{ij}^{exp}; EcDB_{ij}^{exp}; EcDC_{ij}^{exp}; S_j; \alpha\right) \quad (1)$$

The results of the Probit estimate are presented in Table 2. This model is able to explain a significant share of the companies' motives to join standardisation processes. The most decisive factor for participation in the standardisation process is the company size. The larger a company is, the greater the likelihood that it will participate actively in the standardisation process. The endowment with personnel and financial resources, which is underlined by the positive coefficient of a standardisation department, is crucial for joining standardisation processes, which is similar to the size-dependent innovation activities of companies.

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7 The answer to the question of the impact of (non-)participation on the own R&D costs reaches on a 5-point-scale from very negative (-2) to very positive (+2).

8 The answer to the question of the cost adavantages for the own company due to the conversion of national standards into European or international standards reaches from none over temporar to lasting on a 3-point scale.

9 These answers vary from total rejection to total support on a 5-point-scale.

On the other hand, the R&D intensity is a significantly negative explanatory factor.[10] This means that companies with low R&D activities are more likely to participate actively in the standardisation process. As already argued, the explanation for this can be that the participation in the standardisation process compensates for the own low R&D activities, which is supported by the empirical results of Love and Roper (1999: 52).

On the other hand, the export intensity is a positive explanatory factor for the collaboration in the standardisation process in the company-based assessment. However, the import intensities are not significant and slightly negative. This supports the theory that the involvement in standardisation processes is one instrument in companies' export strategies, but not a marketing tool in the international procurement of raw materials and intermediate goods.

Finally, neither the labour intensity nor the competition intensity are significant in explaining participation in standardisation processes. The latter results makes obvious that standardisation is not differently used in high or low competitive environments. The inclusion of sector dummies also makes clear that companies' participation in standardisation is indifferent to sectors.

The qualitative explanatory factors, which refer to the cost advantages for R&D, have the expected influences. Thus the companies which expect cost savings for own R&D by participating in the standardisation, or which fear cost disadvantages from non-participation, are more likely to engage actively in standardisation processes. The same applies for the companies which realise high cost advantages or low cost disadvantages from the adoption of national standards in European and international standards. It is surprising, however, that companies which rate standards as beneficial for the economic development of their own branch are more inclined to standardise, while this does not apply to companies which rate standards as beneficial for the economic development of their own company.

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[10] In order to integrate the sectoral degree of innovation, in one other model the patent intensities of the sectors were included as dummies. However, no signficant sector impact was found.

On the whole, it can be concluded that above all the export intensity of a company is a crucial factor for the participation in the standardisation process. The microeconometric investigation makes clear that large companies are more likely to be active in standardisation than small ones. These are two fundamental findings which must be taken into consideration in formulating the concluding recommendations. Further, the perception to what extent the participation in the standardisation process influences own R&D costs and whether the adoption of national standards in European and international standards brings advantages for one's own company, is an important starting point for future strategic orientation of the standards organisations.

Table 2: Regression Results of a Probit Estimation to explain Participation in Standardisation[11]

Explained Variable: Collaboration in the Standardisation Process	Coefficient	t-value
R&D intensity	-0,049*	-1.673
Competition intensity	0.280	1.087
Company size (log.)	0.363***	4.721
Labour intensity	-6843,501	-0.535
Export intensity	1.249*	1.891
Import intensity	-1.252	-0.564
Standardisation dept.	0.614	1.638
Influence on R&D costs (participation)	0.017**	2.392
Influence on R&D costs (non-participation)	-0.051***	-3.776
Cost advantages from adoption of national standards in European or international standards	0.016***	3.086
Cost disadvantages from adoption of national standards in European or international standards	-0.010**	-2.219
Influence on the economic development of the own branch	0.021***	3.295
Influence on the economic development of the own company	-0.008	-1.400
Aero- and astronautics	0.119	0.160
Chemical industry without pharmaceuticals	-0.020	-0.039
Electrical engineering	0.083	0.165
Manufacture of rubber and synthetic goods	0.419	0.637
Construction, building	-0.167	-0.307
Vehicle construction	-0.803	-1.094
Manufacture of metal goods	-0.183	-0.350
Radio, television and communications engineering	-0.904	-1.314
Manufacture of pharmaceutical goods	-0.044	-0.075
Other	0.857	1.479
Constant	-14.814***	-3.859
Log likelihood	-75.955	
Pseudo R^2	0.41	
Number of observations	186	

[11] The asterisks represent the levels of significance: *** < 0.01, ** < 0.05, * <0.10.

5. Collaboration in the Standardisation Process and other Explanatory Factors for Export Activities in Companies

After it becomes clear by means of the Probit estimate of the standardisation activity that exporting companies are more inclined to engage in standardisation, the question arises whether the participation in standardisation increases the propensity to export. Besides the active collaboration in standardisation, the actively utilised stock of standards is also taken as a further indicator for the influence of standards on export behaviour.

A number of empirical investigations already exist on the influence of innovation activities on the exports of a company, which for the most part show a positive correlation.[12] Therefore, the R&D intensity[13] is taken as a company-specific innovation variable and the patent intensity of the branch as a sector-specific innovation variable (Inno) in addition to the collaboration in the standardisation process (Std).

Derived from the classical foreign trade theories, the relative allocations of capital and labour and the resulting relative factor prices are a determinant for specialisations and export flows. As this information is not available on a company level, the labour costs (LabC), normed by the gross output, are taken as an indicator for the relative allocation with labour and the average wage (AvWag) as an indicator for the quality of the human capital in the branch. Further, the labour intensity (LabInt) is available as an exogenous variable for each company. As Germany is (comparatively) low in labour supply and high in qualified human resources, it is expected that the labour costs per turnover and the labour intensity will have a negative effect on the export probability, and the average wage a positive one.[14]

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12 Cf. e.g. Wakelin (1998a) and Ebling and Janz (1999).

13 Cf. Hirsch and Bijaoui (1985) on this explanatory factor.

14 Cf. on this Ebling and Janz (1999), p.7, among others.

As the opening up of export markets initially involves relatively high fixed costs, it can be concluded out of this that the larger a company, the more easily the financial means can be raised or the risk taken.[15]

Finally, the intensity of competition (CompInt) is an influential factor for the export activities of an enterprise.[16] On the one hand it is argued that enterprises in highly competitive (domestic) markets are inclined to look for opportunities in export markets (Brouwer and Kleinknecht 1993). On the other hand, companies in markets with low competition have an increased chance to invest their (thus won) profit margins in opening up export markets. After all, with companies which show a high quotient of imports in total turnover, it can conversely be assumed that they have less problems in export activities because of their international business contacts and experience.

The following formula attempts to explain the export behaviour of enterprises:[17]

$$Exp_{ij} = f\left(Std_{ij}; R\&D_{ij}; Inno_j; LabInt_{ij}; LabC_j; AvWag_j; Size_{ij}; CompInt_{ij}; Imp_{ij}\right) \quad (2)$$

The Probit estimate makes clear that the active participation in standardisation has neither positive nor negative impacts on the export behaviour of the enterprises questioned. On the contrary, in particular the company-specific R&D intensity and the innovation intensity of the branch as a whole are crystallising out as the driving forces for the export activities of the company. Against expectation, companies in branches with high average wages export rather less, while the tendency to export increases with rising labour costs. With increasing company size, the export probability grows slightly, even if not significantly, but

15 Equally, companies which already have part of the concern or employees abroad find it easier to be successful in export markets. On the other hand, these organisational connections can lead to products and services being produced on the spot and exports are then superfluous. Because of too many missing values, these variables cannot be considered in the Probit model.

16 The answers on the number of competitors are on 3-point scale ranging from one, over some to many.

17 In contrast to the first approach, the variable export behaviour takes only two values, with yes = 1 and no = 0.

decreases again in very large companies which probably produce directly „on the spot" in the export markets. Finally, companies with few competitors export clearly more than those with very many competitors, so that the former can leverage their market dominating position also successfully into export activities. The same applies for companies which fall back especially on imports. On the one hand, the growing world-wide specialisation, as well as the increasingly important intra-industry trade, allow the procurement of cheap and high-quality intermediate products abroad and thus strengthen own competitiveness. On the other hand, companies like these are more integrated in international markets, so that their sales efforts abroad are more successful.

In addition to the Probit model, a Tobit model was estimated in order to analyse the influence of the exogenous variables on their export intensity. In general, the results of the Tobit estimation confirm the signs of the coefficients of the Probit estimation. However, the R&D intensity does not explain the export intensity, whereas it was significant for the overall export decision. On the other hand, the export intensities increase with the company size.

Table 3: Regression Results of Probit and Tobit Estimation to explain Export Behaviour

Explained Variable: Export Behaviour	Probit estimation		Tobit estimation	
	Coefficient	t-value	Coefficient	t-value
R&D intensity	0.058***	2.819	0.039	0.762
Innovation intensity of the branch[18]	8.78e+07***	2.864	1.50e+07**	2.295
Labour intensity	-82639.27	-1.479	-11658.94	-0.817
Labour costs of the branch	3.862*	1.741	1.553***	2.952
Average wage of the branch	-3.38e-05**	-2.468	-2.69e-06	-0.956
Company size (log.)	1.335	1.564	0.370*	1.756
(Company size (log.))^2	-0.037*	-1.652	-0.009*	-1.840
Competition intensity	-2.671***	-2.671	-0.219***	-4.473
Import intensity	172.275***	3.083	2.330***	6.919
Active collaboration in standardisation	0.001	0.511	0.001	1.078
Constant	-10.314	-1.232	-3.293	-1.564
Log likelihood	-94.258		-114.744	
Pseudo R^2	0.48		0.31	
Number of observations	261		261	

What do these results mean for standardisation? The most important result of this part of the study is the great significance of R&D and innovations for the export success of companies. For this reason, in the following analysis we shall examine to what extent standardisation affects the R&D behaviour of companies, besides other explanatory factors.

6. Collaboration in the Standardisation Process, Export Activities and Other Explanatory Factors for the R&D Activities of Companies

Seeing as participation in standardisation cannot be proved to have a direct influence on the export behaviour of a company, we shall examine to what extent (besides other factors) the active collaboration in standardisation (Std) can explain R&D activity or the lack of it, which once again, as shown, are crucial for success in exporting. Additionally, the actively utilised stock of standards (StdStock) may be used as a substitute for own R&D or may be an indicator for the company's knowledge base which is able to support its R&D efforts. There-

[18] Innovation intensity is defined as quotient between the number of German patent applications at the German patent office and production value of the industry branch (OECD 1997).

fore, both the collaboration in standardisation and the active use of standards have ambiguous impacts on a company's decision to perform R&D. As well, not only the export but also the import intensity will be included as explanatory factors for involvement in R&D. For, on the one hand, the strong links to international markets increase the pressure to innovate. On the other hand, high technology can be procured in foreign markets, imported and used to complement or substitute own R&D.

Like export behaviour, active involvement in R&D is also accompanied by high fixed costs. For this reason it should be easier for larger companies to amortise this pool of costs by fixed cost degression. Furthermore, human capital is a crucial pre-condition to conducting successful R&D. The average wage of the branches (AvWag) is therefore included as an additional explanation. After all, companies in highly competitive markets (CompInt) are forced to innovate, therefore these companies will tend to conduct more R&D.

In order to determine the influence of the individual explanatory factors on the R&D decision, the following Probit regression model equation is used:[19]

$$R\&D_y = f\left(Std_y; StdStock_y; Inno_j; Exp_y; Imp_y AvWag_j; Size_y; CompInt_y\right) \qquad (3)$$

The R&D commitment of the companies questioned can only be explained to a very limited degree by the selected indicators. The export and import intensity of a firm alone significantly increase the probability of R&D activities. Companies which have strong links to the international markets through their procurement and sales activities, have not only better pre-requisites, but also more pressure to conduct R&D actively. Neither the collaboration in the standardisation process nor the actively utilised stock of standards exhibit significant coefficients.[20] Whereas R&D may be a substitute for the participation in standardisa-

[19] In contrast to the other two approaches, the variable R&D behaviour takes only two values, with yes = 1 and no = 0.

[20] However, in contrast to the negative impacts of governmental regulations on macroeconomic growth (Berger 1998), involvement in standardisation does not negatively affect R&D activities.

tion, the latter and an actively used stock of standards are not sufficient to make own R&D redundant. Therefore, the results indicate that participation in standardisation and an actively used stock of standards are both complements and substitutes for own R&D efforts. Finally, the average wage as indicator of the quality of the employed human capital emerges as the anticipated positive explanatory factor for R&D only in two branches.

The performed Tobit estimation to explain not the R&D decision, but the R&D intensity has compared to the Probit estimation an even smaller informative value. The coefficients of the export and import intensities loses their significance. On the other hand, the competition intensity companies are confronted with have a negative impact on their R&D intensity. If we assume in the long run that companies performing R&D are also more innovative, then they may be able to change their market conditions from perfect competition with a large number of competitors to monopolistic competition with a much smaller number of suppliers of similar goods. However, in the short run analysis, the degree of competition is an exogenous variable. The results suggest that lower competition leaves the companies more freedom to devote resources to R&D. These considerations confirm Schumpter's hypothesis that companies need a certain degree of market-power to perform successfully R&D (Schumpeter 1934), which could not be empirically verified by Scherer (1965) for companies in the United States.

Table 4: Regression Results of Probit and Tobit Estimation to explain R&D Behaviour

Explained variable: R&D behaviour	Probit Estimation		Tobit Estimation	
	Coefficient	t-value	Coefficient	t-value
Company size (log.)	-0,006	-0,110	0.114	0.552
Competition intensity	-0,219	-1,077	-1.489*	-1.869
Export intensity	0,953*	1,857	0.897	0.526
Import intensity	3,935**	2,160	9.153	1.576
Stock of standards (actively utilised)	-0,0005	-0,013	-0.051	-0.324
Active collaboration in standardisation	0,002	0,785	-0.004	-0.533
Average wage in the manufacturing of metal goods	0,425	1,045	1.531	0.884
Average wage in the construction industry or others	0,514	1,441	1.724	1.114
Average wage in the mechanical engineering industry	0,391	0,991	3.995**	2.396
Average wage in the electrical engineering industry	0,919**	2,110	5.133***	3.034
Average wage in the vehicle construction industry	0,632	1,441	3.088	1.631
Average wage in the radio, television and communications industry	0,498	1,040	6.744***	3.229
Average wage in aero- and astronautics industry	-0,970	-1,331	0.047	0.014
Average wage in the chemical industry without pharmaceuticals	0,440	1,027	4.811***	2.786
Average wage in producing pharmaceuticals	0,960*	1,866	4.780**	2.299
Constant	0,616	0,649	1.466	0.356
Log likelihood	-128,078		-669,430	
Pseudo R^2	0,085		0,025	
Number of observations	258		258	

7. Conclusions

What can be deduced for the future standardisation strategies of both standards development organisations and companies from these results? It became clear that export activities explain the probability of a participation in standardisation

positively, and the R&D intensity negatively. This last aspect is to be regarded favourably, as companies with no or low R&D activities can participate in the R&D results of the other collaborators by working together in the standardisation process. Standardisation can therefore also be regarded as a channel for technology transfer from the R&D-intensive companies to those less engaged in R&D. However, the involvement in standardisation does not substitute own R&D efforts.

On the other side, the participation in standardisation cannot exert a positive influence on either the probability for export or R&D activities. Concerning the latter, the results indicate that participation in standardisation or using actively a large stock of standards is an activity neither complementary nor substitutive with own R&D efforts. Nevertheless, the answers to the questions about the influence of participation or non-participation on the R&D costs make clear that companies which see a positive correlation between standardisation and R&D, are also actively engaged in standardisation. The same applies for the enterprises which realise cost and competitive advantages, when national standards are adopted in European and international ones. From this a number of strategic aspects for designing the future standardisation process become obvious. As regards R&D, it must be made clear that standardisation can have a positive influence on the knowledge base in companies, in particular in those with low R&D capacities. On the other hand, incentive mechanisms must be developed to persuade the technology leaders to collaborate more in the standardisation processes.

Further, the advantages for the export strategies of enterprises of commitment to standardisation on a national level must be clearly emphasised. For standardisation alone makes it possible that parts of national standards can be successfully adopted in European and international standards.

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