European Manufacturing Survey

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Techno-organisational innovation in the European manufacturing industry

Do European countries differ regarding the diffusion of technical and non-technical innovations in manufacturing companies?

Heidi Armbruster, Steffen Kinkel, Gunter Lay, Spomenka Maloca

In cooperation with P. Llerena, A. Nasini, N. Osmanagic-Bedenik, K. Pandza, C. Roveda, M. Szwejczewski, G. Ulusoy, I.Veza, B. R. Waser and M. Weber

Summary Competitive advantages of European companies are not only generated by R&D based product innovations but also by technical and non-technical process innovations aiming to modernise manufacturing processes. The European Manufacturing Survey (EMS) provides diffusion rates of technical and non-technical innovations across nine European countries. Results reveal that the use of new technologies such as robots, enterprise resource planning and teleservice are most widely spread in Switzerland, Germany and Austria. Contrary to technical innovations, non-technical innovations such as team work, continuous improvement processes and regular appraisal interviews do not show a clear overall pattern across European countries. The use of these non-technical innovations in the surveyed countries varies across the organisational concepts. Reasons for differences in the diffusion rates of technical and non-technical innovations across European countries lay in the field of domestic and labour market conditions and cultural differences between the surveyed European countries.

1. Introduction

Not only product innovation but also process innovation is important for companies' competitiveness

The competitiveness of European companies does not solely depend on R&D and product innovation. The ability to modernise manufacturing processes by implementing technical and non-technical process innovations may very well be equally important. This was conclusively demonstrated by several studies analysing the determinants of a superior business performance. Manufacturing with high performance machines, reshaping organisational structures or working with up to date management concepts are crucial elements of a comprehensive innovation strategy.

Against this background it is surprising that monitoring innovation in Europe is still predominantly focussed on R&D based product innovation. The Community Innovation Survey (CIS) has taken some first steps to include process innovation indicators for measuring organisational change. However, its results remain at a rather general level and do not provide insights to particular concepts of process innovations.

The European Manufacturing Survey (EMS) mainly covers technical and non-technical process innovation

To provide more reliable data, in 2003/2004 a pilot survey was initiated in several European countries. The *European Manufacturing Survey* (EMS) covered Austria, Croatia, France, Germany, Great Britain, Italy, Slovenia, Switzerland, and Turkey. The survey collected data on the types and the extent of innovation activities in the field of technical and non-technical process innovations and on state of the art of manufacturing. 2,249 companies from the participating countries returned a filled in questionnaire specifically developed to cover non R&D based innovation (see box on page 16).

Using this database, this first EMS-bulletin presents a cross-national comparison of the diffusion of selected technical process innovations (industrial robots, enterprise resource planning, teleservice) and non-technical process innovations (team work concepts, continuous improvement processes, appraisal interviews). This comparative analysis highlights the following issues:

Central questions to be answered

- To which extent are technical and organisational process innovations diffused in Europe? Do differences across European countries occur?
- Do differences in size and sector structures of European economies have an impact on country specific diffusion rates?
- Which country specific differences in the diffusion of process innovations are indicators for "being in a top position" or "lagging behind"?
- How can these differences be explained?

To answer these questions a specific methodological approach was developed, which will be presented in the following section.

2. Methodology and presentation of the figures

National diffusion rates of technical and non-technical innovations are controlled for company size and sector structure

In order to analyse the diffusion of technological and organisational process innovations across Europe, country specific data is presented in the following way: Diffusion rates for each country are calculated to show the extent to which the process innovations are used. However, to examine the differences across countries by comparing these diffusion rates might be misleading. This is due to the fact that cross national differences in diffusion rates might be affected by the underlying company sizes and the structure of the manufacturing sector in each country. To control for these differences in size and sector structure weightings are calculated which are based on the size and sector structure of the EU25[1]. The diffusion rates based on weighted data then allow for a cross-national analysis as they are based on the same size and sector structure for every country.

Therefore, there are two kinds of diffusion rates for process innovations to be found in the following figures: First, the national sample value (light grey) for the extent of use in every single country, and secondly the adjusted value for cross-national comparison (dark grey). The latter is based on EU25 weightings and controls for the size and sector specificities of every country.

3. Results

3.1 Diffusion of commercial ERP software modules for production planning and control

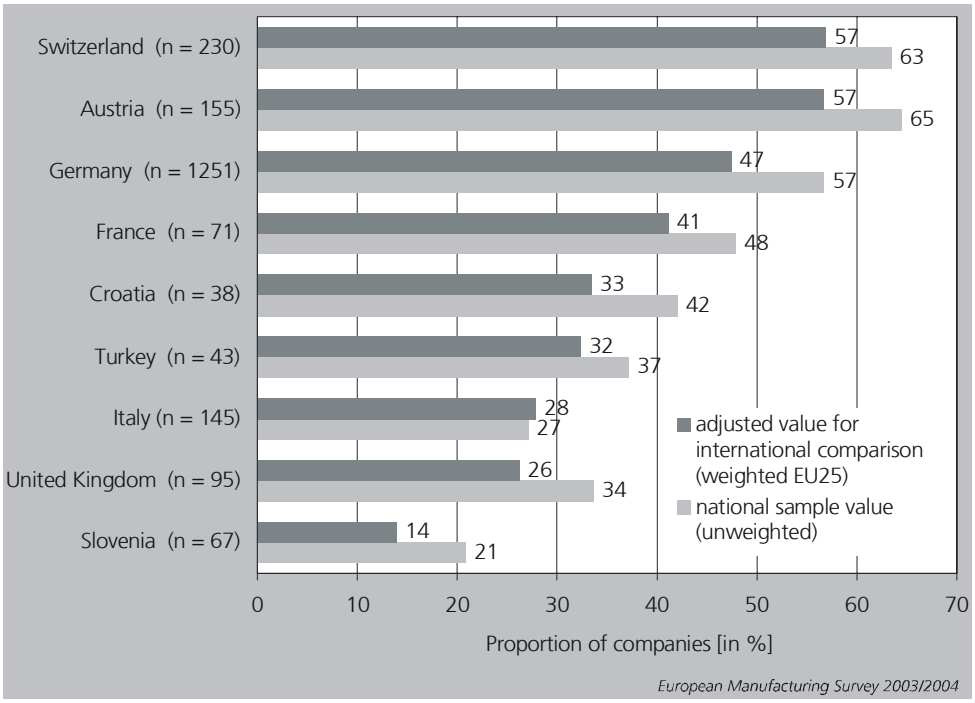
ERP software aims at minimizing stocks, assuring high ability to deliver

Production planning and control includes all operational tasks of time, capacity and, if necessary, space planning for the shop-floor control of manufacturing companies. It aims on minimising stocks and thereby reducing the fixed capital of manufacturing sites while simultaneously assuring a high ability to deliver. Usually production planning and control is backed by IT-based systems. The first software systems for production planning and control were developed in the mid 1960s and became known as material requirements planning solutions

[1] Eurostat, Reference year 2000-2001 (http://epp.eurostat.cec.eu.int)
Firm size and sector were used to calculate weightings for adoption of the EU25 structure to every country.

(MRP). Nowadays, production planning and control systems are complex software tools that cover many more functions than just the traditional batch, time and capacity planning at shop-floor level. They integrate demand management as well as order release and monitoring and consequently reach deep into purchasing and sales of manufacturing companies. These third generation MRP-systems are commonly known as enterprise resource planning (ERP) systems (Ptak and Schragenheim, 2004).

Figure 1: Diffusion of commercial ERP software modules across European countries



Switzerland, Austria and Germany are leading in diffusion of ERP systems

ERP-modules of commercial software providers were first used by manufacturing companies in the early 1980s. In the 1990s diffusion accelerated noticeably. The share of companies using ERP software modules e.g. in Germany rose from about 10 percent in 1990 to about 45 percent in 2000. According to our data of the EMS survey 2003/2004, up to now commercial ERP software modules have been adopted in about 50 percent of the surveyed companies averaged over all examined countries. As expected the country specific diffusion rates of commercial ERP software modules vary distinctly, ranging from 21 percent in Slovenian firms to 65 percent in Austrian firms (figure 1). Especially in the central European states with a strong tradition in the metal and/or electronics industries, Austria, Switzerland and Germany commercial ERP software modules seem to have become an industrial standard, as they are employed by significantly more than half of the companies.

Besides the unweighted national values also the values adjusted to the accumulated size and sector structure of the EU 25 member states show that Swiss,

Austrian and German companies indeed have adopted commercial ERP software modules more frequently than other firms. The UK dropped one position in the adjusted ranking, representing the lower end of a broad midfield. Slovenian companies remain last with an adjusted adoption rate of just 14 percent.

Federal promotion programs in Germany, Austria and Switzerland might have strengthened the use of ERP systems in these countries

Three arguments may help to explain these cross-national varieties in the adoption of ERP-systems. A first one is the existence of federal promotion programmes. In Austria, Switzerland and Germany the development and/or implementation of suitable ERP-systems (called PPS-systems in these countries) has been funded directly or indirectly by special PPS-implementation measures or CIM-development programmes. These measures might at least have given an incentive to the participating firms to convert from hand-made Excel-Sheets to commercial ERP-products. Supply chain management practises of the leading firms, with their inherent linking of ERP-systems, might additionally have triggered implementation processes of commercial ERP software modules at their B2B-suppliers, leading to a broader diffusion.

A second factor would be that one of the world leading providers of commercial ERP-software is located in Germany, using the low spatial, linguistic and cultural distance to Austria and Switzerland to promote its business solutions earlier and more aggressively in these countries and its domestic market Germany. This supply-side factor may also add to the explanation of diffusion differences of commercial ERP software modules in Europe.

Thirdly, the three leading countries Austria, Switzerland and Germany are very well positioned in traditional medium-technology industries such as mechanical engineering, automotive industry and their suppliers. Due to the industries' high export rates and the resulting tough international competition, exporting companies in these sectors usually have a stronger need for technical process and management innovations to keep their complex production systems competitive. One element is the use of advanced planning and control systems, leading to higher implementation quotas of commercial ERP software modules compared to countries with other industrial specialisation patterns and lower exporting activities like Croatia, Turkey or Slovenia.

3.2 Diffusion of teleservice

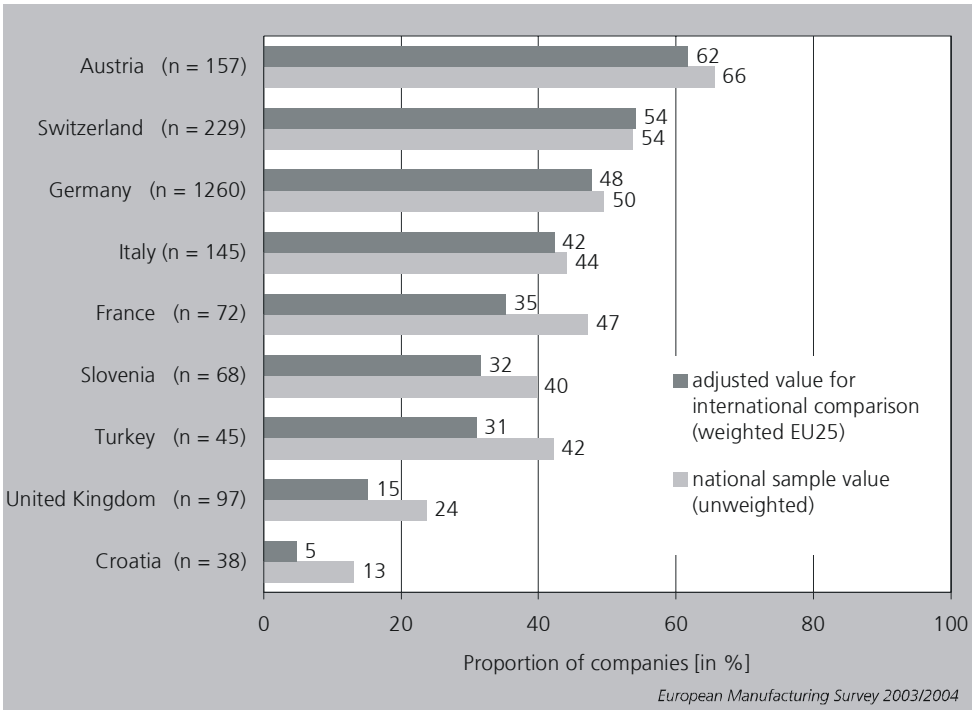
Teleservice facilitates remote diagnosis and repair

Teleservice is a specific performance feature, which is included in manufacturing technology. It enables the suppliers of the technology to communicate process data from the facilities of their customers to their own offices. Teleservice function facilitates remote diagnosis and assists repair in case of malfunc-

tion. By combining sensors, machine control units and ICT, teleservice can help cut down cost as well as the mean-time-to-repair. In this context teleservice offers much more than just a hotline. First applications of teleservice are reported from the early 1980s. Since then an increasing number of plant and machinery constructors have offered this innovative technology. However, its diffusion started off slowly. In the 1990s only a minority of customers in Japan, the US and in Germany made use of teleservice (Hudetz/Harnischfeger 1997).

Against this background the figures collected by the EMS survey 2003/2004 show that nowadays teleservice is a technology which is widely-used throughout European firms. On average, 30 to 50 percent of the surveyed companies have implemented this innovation in their shop floors. However, there are remarkable differences between countries: Figure 2 illustrates that teleservice diffusion rates vary from 66 percent in Austria down to 13 percent in Croatia.

Figure 2: Diffusion of teleservice within European countries



More than half of the Austrian, Swiss and German companies use teleservice

The comparison of surveyed diffusion rates and adjusted rates, eliminating the effects of country specific size and sector structures, proves that firms indeed seem to have implemented this technical process innovation differently. In Austria, Switzerland, Germany and Italy (adjusted to an EU 25 structure) averagely half of the surveyed companies make use of teleservice. In France, Slovenia and Turkey about one third of the companies has implemented this technology and in the UK and Croatia only 15 percent respectively 5 percent are users of this innovative concept.

Teleservice diffusion are above average in countries with a strong machine tool supplier base

At least three aspects may contribute to an interpretation of this divergence: First of all, the adjusted country specific diffusion rates of teleservice are only above average in those countries where the supply side of this technology is located. Italy, Germany and Switzerland are the leading countries for machine tool production. The manufacturers of these investment goods may have used their close relationships to customers in their respective domestic markets (including Austria) to introduce teleservice as an innovative "add-on" to their products. Tight relationships to lead users play an important role in developing an innovative product feature to maturity. For one thing the increased efforts of teleservice vendors in their domestic markets might explain the clear edge of Italian, German, Swiss and Austrian companies in adopting this innovation.

High wage countries have a stronger diffusion of teleservice

Wage levels might offer a second explanation. In countries with higher hourly wage rates an increased necessity exists to invest in automated, productive manufacturing equipment. If such equipment has too many down-times and the mean-time-to-repair exceeds a certain amount of hours, significant costs arise. To avoid these costs it is economically justified to invest in an innovative technology like teleservice. In countries with lower wages and less capital intensive manufacturing such a technology may diffuse more slowly. Here, the economic necessity to implement teleservice is not as pressing. Therefore it is not surprising that in high wage countries like Germany, Switzerland or Austria the diffusion of teleservice is more advanced compared to countries with lower wages like Croatia or Turkey.

Last but not least the telecommunication infrastructure may account for cross-national differences in regards to the application of teleservice (Chung 2002). In regions with reliable and advanced telecommunication networks the preconditions for an implementation of teleservice are superior. This too could be an explanation for the differences in teleservice diffusion in Europe.

3.3 Diffusion of industrial robots and automated handling devices

Industrial robots are automatically controlled multipurpose manipulators

Automated handling devices can be used to handle the material flow of workpieces or tools from one spot to another, carrying the right volume of parts with the accurate orientation at the proper time to the exact position. Non-automated, manual handling devices are called manipulators and are not an integral part of our definition. Industrial robots (IR) are a specific class of automated handling devices. An industrial robot is officially defined by ISO (Standard 8373:1994) as an automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes. Typical applications of industrial robots include welding, painting, ironing, assembly, pick and place, pallet-

izing, product inspection, and testing (World Robotics, 2002). In the following we will use the term industrial robots or IR, always implicitly including automated handling devices in our understanding.

The origin of industrial robots can be found in reactor technology, where automated instead of manual handling devices have been used at an early stage within radioactive rooms. First industrial applications of IR in Europe have taken place in the early 1970s. From the mid 1980s to 2000 the adoption rate of industrial robots rose from about 3 percent to about 22 percent, still representing only a minority of industrial companies in Europe.

Industrial robots are less used in Eastern European countries

Nowadays Industrial Robots are used in about 27 percent of European manufacturing companies, according to our data of the EMS survey 2003/2004. The array of country specific IR diffusion rates is not very broad, ranging from 20 percent in Turkey to 34 percent in Austria and France (figure 3, light grey bars). Taking a look at the adjusted values, based on the accumulated size and sector structure of the EU 25 member states and therefore appropriate for cross-national comparisons (dark grey bars), the following patterns emerge: The ranking of IR diffusion rates can be divided into three sections. Switzerland is the leading country with almost a third of its industrial companies using IRs. It is followed by a broad midfield, ranging from Austria with 27 percent IR users to Germany with 23 percent covering all big manufacturing countries like France, Italy and the UK. At present, the small Southeastern countries Croatia, Slovenia and Turkey seem to lag behind regarding IR adoption.

High wages might account for stronger use of IRs

In the following, two approaches seek to explain these cross-national differences. First of all, cross-national differences in wage levels might once again help to understand the varying share of industrial companies using IRs. In countries with low wages the high investments in IRs – in order to substitute labour intensive manufacturing for automated, capital intensive manufacturing - do not pay off. The resulting pay-back periods are too long, due to the minor amount of saved wage expenses. Consequently Turkey, Croatia and Slovenia, with their comparatively low wage levels, also have lower IR diffusion rates, while Switzerland, having the highest wages in our European sample (Schroeder, 2005), ranks first in industrial IR adoption.

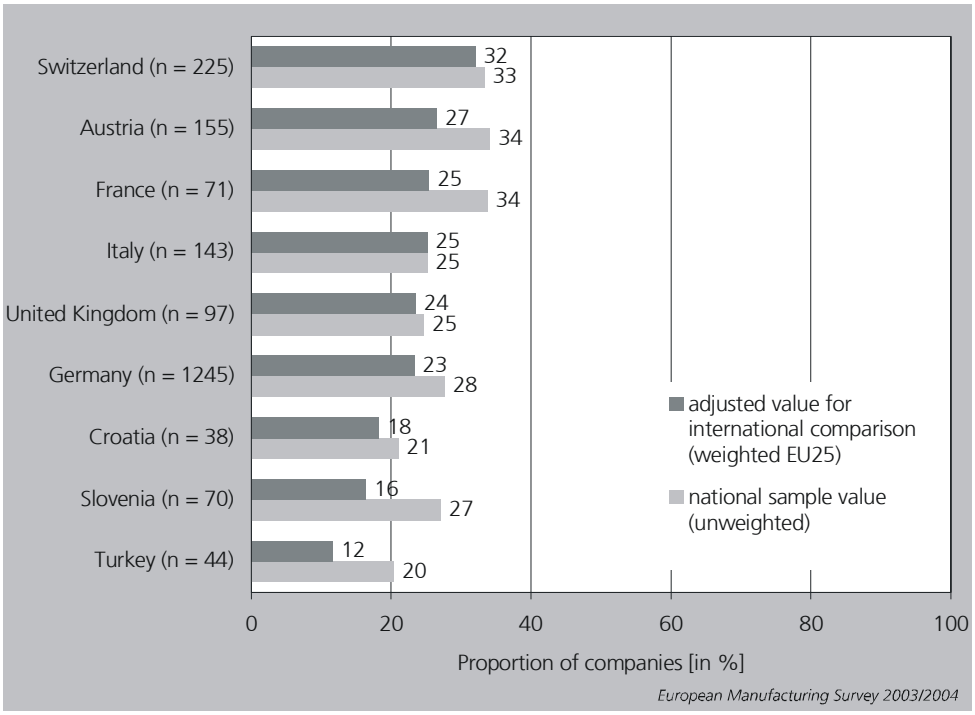


Figure 3: Diffusion of industrial robots and automated handling devices across European countries

Countries with higher export rates more of use IRs

Secondly the size of the domestic market and the export orientation of an industry may present parameters that explain the cross-national differences at hand. In countries with a relatively small domestic market for manufactured goods and with low export rates, many companies experience overall volumes that are not sufficient to realise the necessary batch sizes for a profitable IR-application. This may as well be the case in sectors were serial production is in common use (like the electronics industry, automotive supplying, etc.). These countries in particular include Turkey, Croatia and Slovenia, whereas the other countries either have far bigger domestic markets for manufactured goods (Germany, UK, France, Italy) or are more intensely dedicated to exports (especially Switzerland, Austria and Germany).

3.4 Diffusion of the concept of Continuous Improvement Process (CIP)

CIP aims at incrementally improving product and process quality to gain competitive advantage

Continuous improvement process (CIP) is a management concept which tries to initiate favourable changes in companies by taking incremental, but continuousal steps and avoiding quantum leaps. This concept was popularised in Japan where it is known as "Kaizen" and has been translated to "continuous improvement" in Western countries. The main focus of CIP is the improvement of product and process quality in order to gain long-term competitive advantages. The involvement of employees and their encouragement to participate are key elements of CIP. Employees and particularly teams of employees are asked to actively make suggestions in order to improve business processes and product quality. Initially CIP had only been covering production processes but mean-

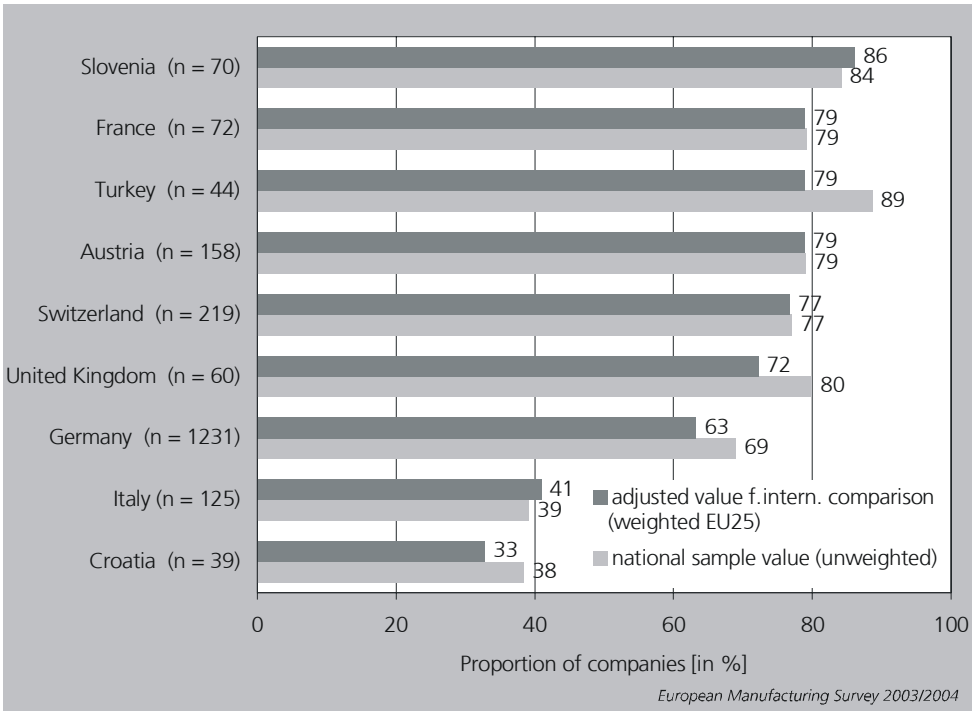
while may comprise all business processes of a company (Bessant, Caffyn and Gallagher, 2001).

High use of CIP in European countries

Analyses of the EMS data of 2003/2004 reveal that the vast majority of European manufacturing companies have implemented and are using CIP. Far more than half of the manufacturing companies in Slovenia, France, Turkey, Austria, Switzerland, the United Kingdom and Germany indicate that they make use of this organisational concept. Only in Italy and Croatia less than 50 percent of the manufacturing companies use CIP. Thus, this very high diffusion rate indicates that the Japanese concept of CIP (Kaizen) has been successfully adopted in European countries.

A comparison of the absolute national sample values with the adjusted values (again controlling for firm size and sector structure) across European countries reveals that supposedly the implementation of CIP occurs independently from sector structure and firm size. In all surveyed European countries except for Turkey and the United Kingdom, there is hardly any difference to be seen between the two values.

Figure 4: Diffusion of Continuous Improvement Process across European countries



Although we find a high level of adoption of CIP across nearly all surveyed European manufacturers, there are still country specific discrepancies of CIP diffusion. The rate of diffusion ranges from 86 percent in Slovenia and 79 percent in France, Turkey and Austria, to 63 percent in Germany and 33 percent in Croatia.

The share of component suppliers in a country, might serve as an explanation for this particular distribution across European countries. Component suppliers are forced to adapt their business processes to those of their clients, in this case the original equipment manufacturers (OEMs), in order to remain competitive. Therefore, CIP is widely-used in the component supplier industry. It serves as an instrument to continuously improve and adapt business processes to environmental circumstances (Stockmar, 2004). The Turkish and Slovenian manufacturing industries comprise a high number of component suppliers. This fact presents a possible explanation for the very high diffusion rates of CIP in Slovenia and Turkey.

The degree of CIP's diffusion might be due to the share of component suppliers in a country

In addition, the very high diffusion of CIP in Slovenia might partially be explained by an initiative of the Slovenian Ministry of Economy promoting CIP among Slovenian manufacturers to become more competitive in the global economy before joining the EU in 2004. A project was initiated with the idea that 60 Slovenian companies implement "20 Keys" – a holistic, continuous improvement system, which involves all functions and all people in an organisation. Eventually, the group of 60 companies might have been an "ambassador" of good practice of CIP in Slovenia that encouraged more and more Slovenian companies to embark on similar projects.

3.5 Diffusion of regular appraisal interviews

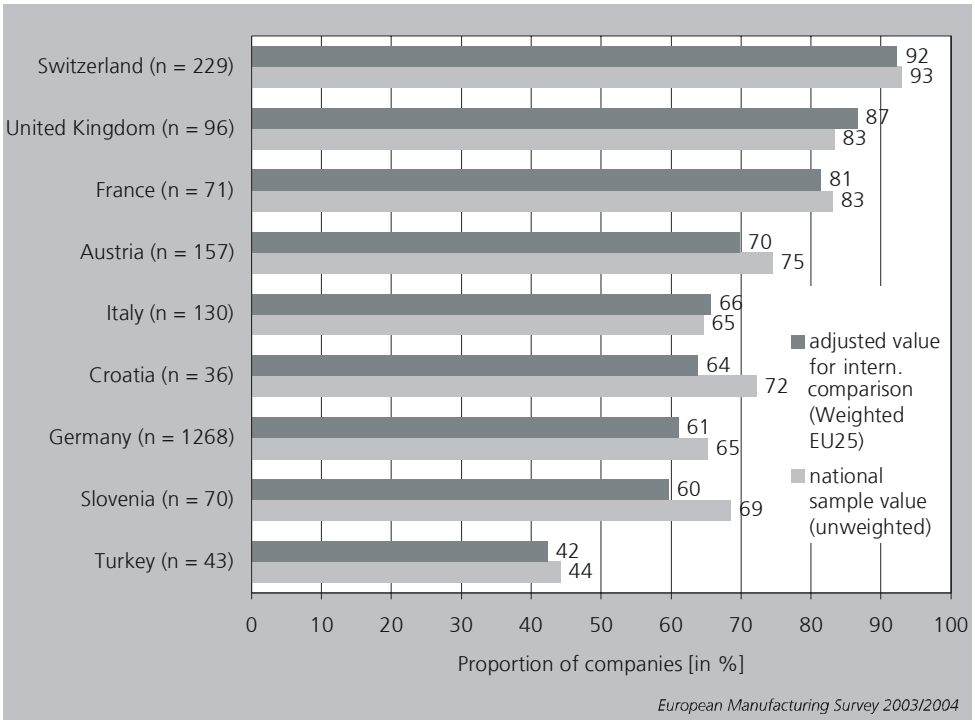
Appraisal interviews are regular face-to-face meetings between employees and their managers and are one part of a human resources development concept. The appraisal presents an opportunity to give feedback on work content and work load as well as to review on what has been achieved during the reporting period and to agree on objectives for the following one. The main intentions of appraisal interviews are to review employees' performance, to assess their potential by identifying strengths and weaknesses, to identify training needs and to deal with career planning. Additionally, the appraisal interview may be used to determine whether employees should receive financial reward for their performance. Appraisal interviews are applied to increase employee performance and motivation, to enhance cooperation between employee and manager and to bring the employee's goals in line with those of the organisation (Wunderer, 2000).

Regular appraisal interviews aim at giving feedback, reviewing employees' performance and assessing potentials

Regular individual appraisals are widely spread in European countries

The EMS data of 2003/2004 bears evidence that regular appraisal interviews are widely spread in manufacturing companies across Europe. In almost all European countries regular appraisal interviews are carried out by at least half of the surveyed companies. In Switzerland, the United Kingdom and France, up to 90 percent of the manufacturing companies apply regular appraisals. However, in Turkey only 40 percent of the manufacturers make use of this measure. Comparing the national sample values to the adjusted values, which control for size and sector discrepancies, shows that there is almost no difference between the two. Most notably this means that the difference in use of regular appraisal interviews across European countries is not due to size and sector differences in these countries.

Figure 5: Diffusion of regular appraisal interviews across European countries



Cultural differences might explain different degrees of diffusion of regular appraisal interviews

However, a possible explanation for the varying diffusion of appraisal interviews across European countries might be found by taking a closer look at the cultural differences between the European countries. It is reasonable to assume that cultural aspects have a distinct influence on human resources management practices. For instance, the discrepancy between the use of appraisal interviews in Turkey, on the one hand, and in Switzerland, on the other hand, might be due to a different perception of hierarchies between managers and employees. Case study research on cultural differences between one country and another found that Swiss people perceive a minor hierarchical distance than Turkish people (Hofstede, 1980). This means that Turkish employees more likely accept inequalities of power and wealth within organisations than Swiss employees do. Appraisal interviews are based on a certain feeling of equality between em-

ployee and manager as well as on the employee's participation. Consequently they might be less accepted in countries with a higher power distance among employees than in countries with a lower one. In addition, the high diffusion of regular individual appraisals in Swiss companies might also be explained by the strong national culture in Switzerland of integrating citizens into political decision-making processes. This tradition of direct democracy in Switzerland might also have influenced companies by involving their employees into regular individual appraisals.

Thus, it might be concluded that national culture influences the human resources management and respectively the use of performance appraisals. This circumstance has yet been confirmed by several other studies analysing the influences of national culture on personnel management practices (Barmeyer, 2003; Hanel et al., 1999).

3.6 Diffusion of team work in production across European countries

Team work aims to increase product and process flexibility and productivity

Since the 1990s team work has been intensely discussed as one important element of a lean factory. It is argued that, contrary to the tayloristic way of production, the implementation of team work into the production process increases product and process flexibility as well as productivity (Womack, Jones, Roos, 1990). Team workers have a high variety of skills allowing for job rotation within the team so that they can fill in for one another. The enlargement of skills and responsibilities as well as the cooperation with other workers is supposed to have a positive impact on the worker's job satisfaction and task commitment which in turn positively supports the team's productivity.

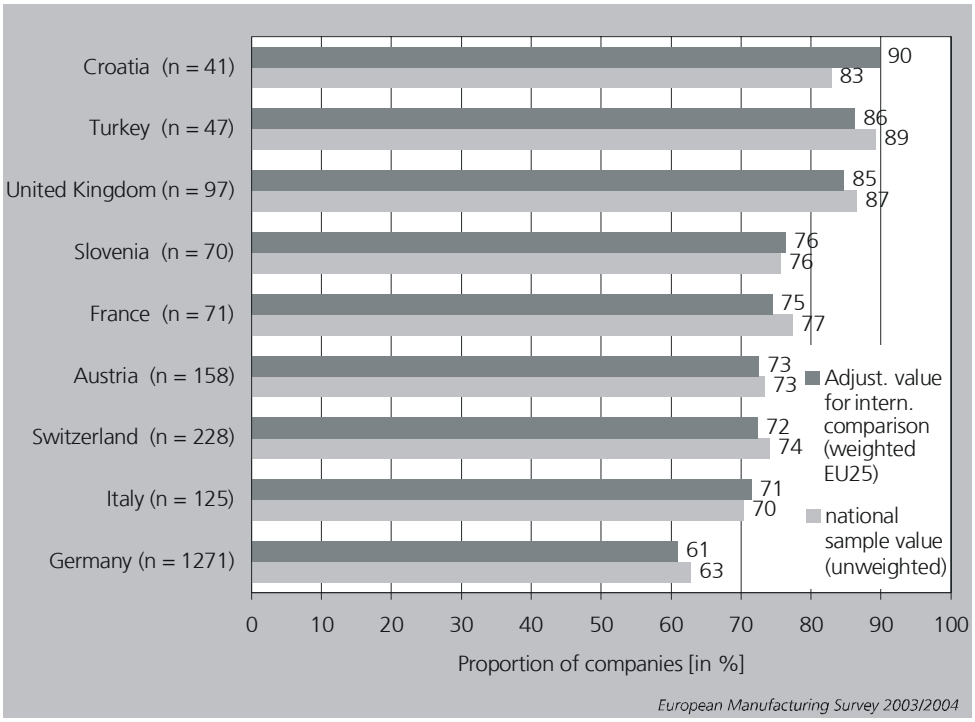
High diffusion of team work across all European countries

The EMS data of 2003/2004 reveal that there is a high diffusion of team work in production across all European countries. On average 75 percent of the surveyed manufacturing companies make use of team work in their production processes. However, to which extent team work is put into practice still differs across European companies. In Croatia, Turkey and the United Kingdom up to 90 percent of the examined companies use team work in production. Approximately three quarters of the Slovenian, French, Austrian, Swiss and Italian manufacturing companies apply team work in their production processes. The lowest diffusion rate is revealed in Germany where only 60 percent of the companies utilise team work concepts in production (figure 6). As already observed with the diffusion of CIP and regular appraisal interviews, again there are barely any differences to be found between the national sample values and the adjusted values. Thus, the differences between the diffusion of team work in pro-

duction across countries cannot be explained by effects of firm size and/or sector structure.

Two potential reasons for differences in the diffusion of team work across European countries can be identified. The first one is that varying diffusion rates might be due to national differences in work organisation across the investigated European countries. Several studies reveal that lean production, which includes an integration of planning, operating and controlling tasks, is most evident in the United Kingdom and France. On the other hand, the traditional model of work organisation with a higher monotony of work is most evident in Italy and Germany (Lorenz and Valeyre, 2004). Figure 6 shows exactly this distribution. 85 percent of the British companies interviewed, apply team work in production whereas only two thirds of German manufacturing companies make use of this concept.

Figure 6: Diffusion of team work in production across European countries



Business strategy might influence the use or non-use of team work

The second possible explanation for discrepancies between diffusion rates of European countries are different business strategies of the examined companies. Additional analysis reveals that those countries having a high diffusion rate of team work in production also pursue a business strategy of high flexibility in order to cope with customers' interests. For instance, British companies indicate that customised products and delivery on schedule are important competitive factors. These factors require a high amount of product and process flexibility which is achievable by the implementation of team work. Team workers can fill in for each other if a worker becomes unavailable.

4. Conclusion

Industrial robots, ERP and teleservice are most often used in Switzerland, Austria and Germany

One can draw three main conclusions. First, Switzerland, Austria and Germany are the leading European countries for the selected technical innovations. Industrial robots, enterprise resource planning and teleservice are more widely spread in Switzerland, Austria and Germany than in the Southeastern European countries and partially in the UK.

No clear pattern on the use of non-technical innovations across European countries

Secondly, contrary to technical innovation no overall pattern can be observed in the case of non-technical innovations. At the level of individual non-technical innovations, it is nevertheless worth highlighting specific observations in order to reveal differences between European countries as a basis for further exploring the reasons for these differences. For instance, CIP and team work in production are most evident in Southeastern European countries while regular appraisal interviews are widely spread in Western European countries. This scattered picture emphasises that non-technical innovations should not be compared on an aggregated and general level. However, it is important to compare single concepts of non-technical innovations such as team work in production, CIP or regular appraisal interviews across European countries. This allows for revealing differences between European countries and offers more useful and reliable results concerning the diffusion of non-technical innovations in Europe.

Thirdly, a comparison of the reasons behind major differences in diffusion paths indicates that the more extensive use of technical innovations could be due to domestic market or labour market conditions (high export rates, wage level). On the other hand, the tendency to use certain non-technical innovations rather than others might reflect cultural differences between the investigated European countries, as their successful implementation relies on a smooth embedding in the respective cultural context.

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European Manufacturing Survey 2003/2004

The European Manufacturing Survey (EMS) was conducted in 2003/2004 as a pilot survey in nine European countries. The survey covers Austria, Croatia, France, Germany, Great Britain, Italy, Slovenia, Switzerland and Turkey. In total 2.249 firms answered questions concerning manufacturing strategies, the application of innovative organisational and technological concepts in production and questions of personnel deployment and qualification. In addition, data on performance indicators such as productivity, flexibility, quality and returns was collected.

The responding companies present a cross-section of the main manufacturing industries. Producers of rubber and plastics are represented by 11 percent, producers of metal works by 27 percent, mechanical engineering by 31 percent and electrical engineering by 10 percent.

The European Research Partners:

Dr. Matthias Weber, ARC Systems Research, Depart. of Technology Policy, Austria

Prof. N. Osmanagic-Bedenik, Economic Faculty, University of Zagreb and
Prof. Ivica Veza, Technology Faculty, University of Split, Croatia

Prof. Patric Llerena, BETA Université Louis Pasteur Strasbourg, France

Dr. Marek Szwejczewski, School of Management, Cranfield University, Great Britain

Prof. Claudio Roveda, Fondazione Rosselli and
Allesio Nasini, Institute for Industrial Promotion, Rome, Italy

Dr. Krsto Pandza, Faculty of Mechanical Engineering, University of Maribor, Slovenia

Prof. Bruno R. Waser, Institute of Management and Regional Economics, Lucerne School of Business, Switzerland

Prof. Gunduz Ulusoy, Competitiveness Center, Sabanci University Istanbul, Turkey

Readers that are interested in specific analyses please contact:

Dr. Heidi Armbruster, Fraunhofer ISI, Germany
Tel.: + 49 (0)721 6809 319 E-Mail: armbruster@isi.fraunhofer.de

Further information's to the survey and research partners are available on our web site http://www.innovationen–in-der-produktion.de/en/.