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How Europe's economies learn: a comparison of work organization and innovation mode for the EU-15

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This article explores the link between the organization of work and innovation by developing national aggregate indicators for the EU member states of organizational forms and innovation modes (how firms innovate). The organizational indicators are constructed from the Third European Survey of Working Conditions results for 8081 salaried employees in 2000. The innovation mode indicators are calculated using the results of the third Community Innovation Survey (CIS-3) for innovation activities between 1998 and 2000. The analysis shows that in nations where work is organized to support high levels of discretion in solving complex problems firms tend to be more active in terms of innovations developed through their in-house creative efforts. In countries where learning and problem solving on the job are more constrained, and little discretion is left to the employee, firms tend to engage in a supplier-dominated innovation strategy. Their technological renewal depends more on the absorption of innovations developed elsewhere. These patterns remain when we divide the economies into manufacturing and services.

The results suggest that in order to understand national systems of innovation, it is necessary to bring the mode of organization of work into the analysis. Early conceptions of national innovation systems were built upon an analysis of interactive learning between producers and users. Now the analysis needs to be founded also on an understanding of how people interact and learn at the workplace in different national economies. The results also suggest that European policy efforts to improve innovation performance as part of the revised Lisbon strategy would benefit from a stronger focus on the diffusion of innovative forms of work organization. A step in this direction would be to develop indicators of work organization that could be directly linked to innovation performance.

1. Introduction

The innovation literature has long recognized the role of research and development (R&D) and skilled scientists and engineers in successful innovation in science-based sectors. More recent work within the national innovation systems perspective highlighted the importance of other factors to successful innovation, particularly in low and medium technology sectors, where formal R&D frequently plays a secondary role. These other factors include interactions with suppliers and customers, other forms of "open innovation," and feedback mechanisms from the market. These interactions frequently form within localized networks, creating unique innovation systems at the regional or national level (Lundvall, 1988; Nelson, 1993).

Both innovation strategies based on science and interactive networks require learning in order to develop competences and to be able to rapidly exploit external and internal change. In such a "learning economy," the speed of the innovation process is a critical factor in economic performance. Using Danish data, Jensen *et al.* (2007) show that innovation performance is significantly enhanced when firms combine science-based learning with experience-based learning. One possibility is that how firms organize production and the distribution of responsibilities among their workforce could have a significant effect on learning and hence on innovative capabilities.

Some of the early contributions to the innovation literature evaluated the effect of organizational structures on the success of innovation. The Sappho study pointed to the importance of interactions between different divisions of the same firm (Rothwell, 1972). Indirectly, Kline and Rosenberg's (1986) chain-link model of innovation points to the importance of feedback loops and interactions between agents within the same organization, but operating at different stages of the innovation process. Freeman's (1987) analysis of the Japanese innovation system partly explained the success of Japanese innovation performance by the specific organizational characteristics of Japanese firms, while Gjerding (1992) looked at the role of organizational change in national innovation systems. More recently, there have been several systematic attempts to evaluate the effect of specific modes of work organization on national innovation performance (Lundvall, 2002; Lam, 2005; Lam and Lundvall, 2006; Lorenz and Valeyre, 2006).

Work organization could influence innovation performance through two main mechanisms.[1] First, forms of work organization that stimulate interaction among agents with a diverse set of experiences and competences could be more creative, leading to the development of original ideas for new products and processes. Second, work organizational forms that delegate responsibility for problem solving to a wide

[1]We ignore here the effect of organizational forms that provide financial or other incentives to employees to innovate.

range of employees could be more successful both in upgrading the competences of workers and in transforming ideas into new products and processes.

Despite a growing acceptance of the importance of work organization to innovation, only a few studies have used quantitative survey methods to explore the link between organizational environments and learning and innovation (Laursen and Foss, 2003; Jensen *et al.*, 2007; Nielsen and Lundvall, 2006). There is a need to further explore the linkages between workplace organization and the dynamics of innovation at the level of the firm, as well as at the level of sectoral, regional, and national innovation systems. This partly requires indicators that capture how material and human resources, such as R&D and skilled scientists and engineers, are used within the firm and whether or not the organization of work promotes innovation. This could occur through forms of work organization that encourage responsibility and the further development of the knowledge and skills of employees.

This article uses quantitative survey data at the national level to assess the effect of different analytical concepts of work organization on innovative capabilities. The article develops a set of aggregate indicators to explore, at the level of national innovation systems, the relation between innovation and the organization of work. The indicators are constructed from the results of two European surveys. Indicators on the organization of work are obtained from the third European survey of Working Conditions in 2000 carried out at the level of occupied persons. Indicators on national innovative capabilities are obtained from the third Community Innovation Survey (CIS-3), conducted in 2001 but covering innovation activities of enterprises between 1998 and 2000. The survey data on working conditions are used to develop what we believe to be the first EU-wide mapping of the adoption of different types of work organization. The innovation survey data are used to develop a typology of innovation at the firm level and to calculate the distribution of these innovation types within each of 14 EU countries for which data are available.

The article is structured as follows. Section 2 describes the variables to characterize work organization in the 15 countries of the European Union and presents the results of a factor analysis and a hierarchical clustering used to construct a typology of forms of work organization. Section 3 examines differences in the relative importance of these forms across the EU, controlling for the effects of sector, firm size, and occupational category. Section 4 presents the data used to construct a typology of firm-level innovative capabilities or innovation modes, based on the work of Arundel and Hollanders (2005) in cooperation with Eurostat.[2] Section 5 combines the two sets of results to examine, at the national level, the relationship between the forms of work organization adopted in a nation and the distribution of firm level innovation capabilities. The concluding section considers some of the main implications of the research for European policy.

[2]Results for the UK were provided by the Department of Trade and Industry and results for Denmark by the Danish Centre for Studies in Research and Research Policy.

2. Measuring forms of work organization in the European Union[3]

In order to map the forms of work organization adopted by firms across the European Union, we draw on the results of the third European Survey of Working Conditions undertaken by the European Foundation for the Improvement of Living and Working Conditions.[4] The survey questionnaire was directed to approximately 1500 active persons in each country with the exception of Luxembourg with only 500 respondents. The total survey population is 21,703 persons, of which 17,910 are salaried employees. The survey methodology is based on a "random walk" multi-stage random sampling method involving face-to-face interviews undertaken at the respondent's principal residence. In order to provide comparable data to the CIS, which is limited to industrial and service firms in the private sector, the analysis is based on the responses of 8081 salaried employees working in industry or service sector firms with at least 10 employees. This excludes employees in agriculture and fishing, public administration and social security, education, health and social work, and private domestic employees.

It is important to emphasize that the use of employee-level data allows us to capture the prevalence of different forms of work organization within private sector establishments in the EU. However, we are unable to determine the prevalence of particular types of firms or organizational structures. This means that our results allow for the obvious possibility that multiple forms of work organization are in use within the same establishment. We return to the implications of this point in Section 5 on the relationship between different forms of work organization and modes of innovation.

The choice of variables for the analysis is based on a reading of two complementary literatures which address the relation between the forms of work organization used by firms and the way they learn and innovate: the "high performance work system" literature dealing with the diffusion of Japanese-style organizational practices in the US and Europe (Ichiniowski *et al.*, 1997; Osterman, 1994; Gittleman *et al.*, 1998; Wood, 1999; Ramsay *et al.*, 2000; Truss, 2001) and the literature dealing with the relation between organizational design and innovation (Burns and Stalker, 1961; Mintzberg, 1979, 1983; Lam, 2005; Lam and Lundvall, 2006). The "high performance" literature focuses on the diffusion of specific organizational practices and arrangements that are seen as enhancing the firm's capacity for making incremental improvements to the efficiency of its work processes and the quality of its products and services. These include practices designed to

[3]This section draws extensively on Lorenz and Valeyre (2005).

[4]The initial findings of the survey are presented in a European Foundation report by Merllié and Paoli (2001).

increase employee involvement in problem solving and operational decision-making such as teams, problem-solving groups, and employee responsibility for quality control. Many of the practices identified in this literature were innovations developed by large Japanese automobile and electronics firms in the 1970s and 1980s. Some authors refer specifically to the diffusion of the "lean production" model associated with Toyota. (Womack *et al.*, 1990; MacDuffie and Pil, 1997). The diffusion of these Japanese-style organizational practices is thought to have contributed to the progressive transformation of more hierarchically structured firms that relied on Taylor's principles of task specialization and a clear distinction between the work of conception and execution.

The distinction between hierarchical and flexible or "transformed" work organization developed in the "high performance" literature can also be seen in Burns and Stalkers' (1961) classic distinction between "bureaucratic" and "organic" organization. Mintzberg (1983), within the context of a broad distinction between bureaucratic and organic organizations, develops a more complex typology of organizational forms. He identifies two types of organic organization with a high capacity for adaptation: the operating adhocracy and the simple organization. The forms of work organization and types of work practices that characterize these two organic forms are quite different. The simple form relies on direct supervision by one individual (typically a manager) and a classic example of this type of organization is the small entrepreneurial firm. Adhocracies rely on mutual adjustment in which employees coordinate their own work by communicating informally with each other. Various liaison devices such as project teams and task forces are used to facilitate the process of mutual adjustment. Work autonomy is low in the simple organization and high in the adhocracy.

In contrast to these "organic" forms, Mintzberg identifies two basic bureaucratic forms with a limited capacity for adaptation and innovation: the machine bureaucracy and the professional bureaucracy.[5] The key characteristic of work organization in the former is the standardization of jobs and tasks through the use of formal job descriptions and rules imposed by management. Thus there is a high degree of centralization and limited employee discretion over how work is carried out or over the pace of work. In the professional bureaucracy, on the other hand, centralization is low and behavior is regulated and standardized through the acquisition of standardized skills and the internalization of professional norms and standards of conduct. As a result, operating procedures are stable and routinized despite considerable autonomy in work.

[5]Mintzberg also refers to a third bureaucratic form, the "divisionalized" form. Unlike the other four configurations, he describes it as a partial structure superimposed on others (i.e. divisions) each of which is driven towards the machine bureaucracy.

Lam (2005) syntheses and extends these two literatures by contrasting two ideal organizational forms that support different styles of learning and innovation: the "operating adhocracy" and the "J-form."[6] She observes that the operating adhocracy relies on the expertise of individual professionals and uses temporary project structures to creatively combine the knowledge of these experts. High levels of discretion in work provide scope for exploring new knowledge, creating a superior capacity for radical innovation. Compared to the operating adhocracy, the J-form is a relatively bureaucratic form that relies on formal team structures and rules of job rotation to embed knowledge within the collective organization. Stable job careers within internal labor markets provide incentives for members to commit themselves to the goals of continuous product and process improvement. Consequently, the J-form tends to excel at incremental innovation.

In summary, both the high performance and organizational design literatures identify different organizational archetypes and posit a relationship between how a firm organizes work and its innovative style and capacity. In order to identify the prevalence of specific types of work organization, we use the Working Conditions survey data to construct 15 binary variables that cover work responsibilities and tasks and then use cluster analysis to identify four main types of work organization. The 15 binary variables are presented in Table 1.[7]

The first four variables measure the use of the core work practices identified in the high performance literature: team work, job rotation, employee responsibility for quality control, and precise quality norms. Two of these variables capture whether employees engage in learning and problem solving, characteristics of both adhocracies and the J-form. One question captures whether work tasks are complex or not and is relevant to the operating adhocracy.

Work discretion, a characteristic of adhocracies, is measured by two variables that capture whether employees are able to choose or change their work methods and their pace of work. Four variables measure different constraints on employee discretion in setting their pace of work: "automatic" constraints on work pace which is linked to the rate at which equipment is operated or a product is displaced in the production flow; "hierarchical" constraints linked to the direct control which is exercised by ones immediate superiors; norm-based constraints on work pace linked to the setting of quantitative production norms; and "horizontal" constraints linked to how one person's work rate is dependent on the work of his or her colleagues. Hierarchical and automatic constraints are classic characteristics of Taylorist work settings, while norm-based constraints characterize both Taylorism and the Japanese

[6]The term J-form is used because its archetypical practices and forms of work organization are best illustrated by the "Japanese-type" organization discussed in the work of Aoki (1988) and Nonaka and Takeuchi (1995).

[7]For the questions and coding used to construct the measures upon which the statistical analysis is based, see Appendix 1.

Table 1 Variables for work organization and tasks

	Percent of employees affected
Team work	64.2
Job rotation	48.9
Responsibility for quality control	72.6
Quality norms	74.4
Problem-solving activities	79.3
Learning new things in work	71.4
Complexity of tasks	56.7
Discretion in fixing work methods	61.7
Discretion in setting work pace	63.6
Horizontal constraints on work pace	53.1
Hierarchical constraints on work pace	38.9
Norm-based constraints on work pace	38.7
Automatic constraints on work pace	26.7
Monotony of tasks	42.4
Repetitiveness of tasks	24.9
n	8081

Source: Third Working Conditions survey, European Foundation for the Improvement of Living and Working Conditions.

forms of work organization. The horizontal constraints variable provides a measure of whether work is carried out collectively rather than individually. Finally, the two variables measuring task repetitiveness and task monotony capture typical features of Taylorist work settings.

2.1 Variety in European organizational practice

In order to assign employees to distinct categories or groups, we use factor analysis[8] to identify the underlying associations that exist among the 15 variables described in Table 1. We then use the factor scores or the coordinates of the observations on all 15

[8]The factor analysis method used here is multiple correspondence analysis (MCA), which is especially suitable for the analysis of categorical variables. Unlike principal components analysis where the total variance is decomposed along the principal factors or components, in multiple correspondence analysis the total variation of the data matrix is measured by the usual chi-squared statistic for row-column independence, and it is the chi-squared statistic which is decomposed along the principal factors. It is common to refer to the percentage of the "inertia" accounted for by a factor. Inertia is defined as the value of the chi-squared statistic of the original data matrix divided by the grand total of the number of observations. See Benzecri (1973) and Greenacre (1993, pp. 24–31).

Table 2 Work organization clusters

Variable	Percent of employees by work organization cluster reporting each variable				
	Discretionary learning	Lean production	Taylorism	Traditional organization	Average
Team work	64.3	84.2	70.1	33.4	64.2
Job rotation	44.0	70.5	53.2	27.5	48.9
Quality norms	78.1	94.0	81.1	36.1	74.4
Responsibility for quality control	86.4	88.7	46.7	38.9	72.6
Problem-solving activities	95.4	98.0	5.7	68.7	79.3
Learning new things in work	93.9	81.7	42.0	29.7	71.4
Complexity of tasks	79.8	64.7	23.8	19.2	56.7
Discretion in fixing work methods	89.1	51.8	17.7	46.5	61.7
Discretion in setting work rate	87.5	52.2	27.3	52.7	63.6
Horizontal constraints on work rate	43.6	80.3	66.1	27.8	53.1
Hierarchical constraints on work rate	19.6	64.4	66.5	26.7	38.9
Norm-based constraints on work rate	21.2	75.5	56.3	14.7	38.7
Automatic constraints on work rate	5.4	59.8	56.9	7.2	26.7
Monotony of tasks	19.5	65.8	65.6	43.9	42.4
Repetitiveness of tasks	12.8	41.9	37.1	19.2	24.9
Total share of employees	39	28	14	19	

Source: Third Working Conditions survey, European Foundation for the Improvement of Living and Working Conditions.

factors as a basis for clustering individuals into distinct groups of work systems, using Ward's hierarchical clustering method. This method identifies four basic systems of work organization as presented in Table 2.[9] The four clusters capture

[9]For a graphical presentation of the positions of the centers of gravity of the clusters on the first two factors of the MCA, see Appendix 2.

forms of work organization that are characteristic of several of the main organizational forms discussed in the literature: "Discretionary learning," which corresponds to work organization in the notion of an adhocracy, "Lean production" or the J-form organization, the hierarchically structured Taylorist form, and the "Traditional" organization based on a simple management structure.

The first cluster, which accounts for 39% of the employees, [10] is distinctive for the way high levels of autonomy in work are combined with high levels of learning, problem solving, and task complexity. There is a below-average prevalence of the variables measuring constraints on work pace, monotony and repetitiveness. The use of team work is near the average, while less than half of the employees in this cluster participate in job rotation, which points to the importance of horizontal job specialization. The forms of work organization in this cluster correspond rather closely to those found in adhocracies and due to the combined importance of work discretion and learning, we refer to this cluster as the "discretionary learning" form.

The second cluster accounts for 28% of the employees. Compared to the first cluster, work organization is characterized by low levels of employee discretion in setting work pace and methods. The use of job rotation and teamwork, on the other hand, are much higher than in the first cluster, and work effort is more constrained by quantitative production norms and by the collective nature of work organization. The use of quality norms is the highest of the four clusters and the use of employee responsibility for quality control is considerably above the average level for the population as a whole. These features point to a more structured or bureaucratic style of organizational learning that corresponds rather closely to the characteristics of the Japanese or "lean production" model associated with the work of MacDuffie and Krafcik (1992) and Womack *et al.* (1990). This cluster also has the highest prevalence of repetitive tasks, possibly due to codified production methods.

The third class, which groups 14% of the employees, corresponds in most respects to a classic characterization of Taylorism. The work situation is in most respects the opposite of that found in the first cluster, with low discretion and low level of learning and problem solving. Interestingly, three of the core work practices associated with the lean production model—teams, job rotation, and quality norms—are somewhat over-represented in this cluster, implying that these practices are highly imperfect measures of a transition to new forms of work organization characterized by high levels of learning and problem solving. The characteristics of this cluster draw attention to the importance of what some authors have referred to as "flexible Taylorism" (Cézard *et al.*, 1992; Boyer and Durand, 1993; Linhart, 1994).

The fourth cluster groups 19% of the employees. All the variables are underrepresented with the exception of monotony in work, which is close to the average. The frequency of the two variables measuring learning and task complexity

[10]The percentages are weighted.

is the lowest among the four types of work organization, while at the same time there are few constraints on the work rate. As shown below, the sectoral breakdown suggests that this class consists of traditional forms of work organization based on informal and noncodified systems.

3. How Europe's economies work and learn

The cluster analysis identifies three forms of work organization whose features correspond rather closely to the forms of work organization found, respectively, in adhocracies, J-form organizations, and machine bureaucracies or Taylorist firms. As the figures in Table 3 show, the discretionary learning form of work organization is especially prevalent in several service sectors, notably business services and banks and insurance, and in the gas, electricity and water utilities. As one would anticipate, the lean model of production is more developed in the manufacturing sector, notably in the production of transport equipment, electronics and electrical production, wood and paper products, and printing and publishing. The Taylorist form is notably present in textiles, clothing and leather products, food processing, wood and paper products, and transport equipment, while underrepresented in the service sectors. The traditional organizational form is found principally in the services, notably land transport, personal services, hotels and restaurants, post and telecommunications, and wholesale and retail trade.

Table 4 links the four types of work organization by occupational category. As one would expect, the discretionary learning form of work organization is especially characteristic of the work of managers, professionals and technicians, while the lean form of work organization primarily characterizes the work of employees in craft and related trades and machine operators and assemblers. The Taylorist form is most frequent amongst machine operators and the unskilled trades. Finally, the traditional form is most prevalent among service workers and shop and market sales persons.

Establishment size is only weakly correlated with the different organizational models. The learning form of work organization is slightly underrepresented in the medium-size category of establishments (100 to 249 employees). The lean and Taylorist forms increase with establishment size (>250 employees) while the reverse tendency can be observed for the traditional forms of work organization.

In combination, Tables 2, 3 and 4 gives us a better idea of what the different clusters represent. Discretionary learning refers to jobs where a lot of responsibility is allocated to the employee who is expected to solve problems on her own. The business services sector is a typical example, where many jobs continuously deal with new and complex problems. Although some of the tasks take place in a team, teamwork is not seen as imposing narrow constraints on the work. In this category, teamwork may involve brainstorming by professional experts as much as collectively solving narrowly defined problems.

Table 3 Forms of work organization by sector of activity

	Percent of employees by sector in each organizational class				
	Discretionary learning	Lean production	Taylorism	Traditional organization	Total
Mining and quarrying	42.4	41.5	3.4	12.7	100.0
Food processing	18.4	34.9	24.6	22.1	100.0
Textiles, garments, leather products	27.2	25.9	30.2	16.8	100.0
Wood and paper products	27.6	40.7	23.9	7.8	100.0
Publishing and printing	31.1	43.8	14.1	11.0	100.0
Chemicals and plastics	34.7	34.1	21.9	9.2	100.0
Metal products and mechanical engineering	31.8	35.7	19.8	12.7	100.0
Electrical engineering and electronics	41.5	38.5	8.6	11.4	100.0
Transport equipment	28.1	38.7	23.2	10.0	100.0
Other industrial production	50.9	22.1	18.4	8.5	100.0
Electricity, gas, and water	58.5	19.4	6.2	15.8	100.0
Construction	40.9	31.4	10.6	17.1	100.0
Wholesale and retail trade	41.5	20.4	11.7	26.4	100.0
Hotels and restaurants	29.7	25.8	16.6	27.9	100.0
Land transport	26.3	24.0	10.2	39.5	100.0
Other transport	39.2	36.1	5.0	19.7	100.0
Post and telecommunications	38.1	27.1	7.7	27.1	100.0
Financial services	58.1	21.5	3.4	16.9	100.0
Business services	57.6	18.7	6.9	16.7	100.0
Personal services	39.7	18.9	7.6	33.8	100.0
Average	39.1	28.2	13.6	19.1	100.0

Source: Third Working Condition survey. European Foundation for the Improvement of Living and Working Conditions.

Lean production also involves problem solving and learning but here the problems are more narrowly defined and the scale of possible solutions less broad. The work is highly constrained and it is often repetitive and monotonous. The extensive use of management techniques such as job rotation (between similar tasks within the same division) and team work may be seen as attempts to overcome the limits of Taylorist production and to create some degree of active participation of production workers and sales staff in order to limit labor turnover and absenteeism.

Table 4 Forms of work organization according to occupational category

	Percent of employees by occupational category in each organizational class				
	Discretionary learning	Lean production	Taylorism	Traditional organization	Total
Managers	69.1	24.7	0.2	6.0	100.0
Engineers and professionals	75.9	14.0	5.2	4.9	100.0
Technicians	61.0	24.6	2.4	12.0	100.0
Clerks	43.2	21.9	9.4	25.5	100.0
Service, shop and market sales persons	30.3	21.4	12.4	35.9	100.0
Craft and related trades	34.2	38.5	16.5	10.8	100.0
Machine operators and assemblers	15.7	37.7	24.3	22.3	100.0
Unskilled trades	14.8	23.9	26.7	34.5	100.0
Average	39.1	28.2	13.6	19.1	100.0

Source: Third Working Condition survey. European Foundation for the Improvement of Living and Working Conditions.

Taylorism is distinctive for low levels of learning and for the virtual absence of problem-solving activity. The work is highly constrained and monotonous. It may be seen as the old-style factory work where the tasks to solve are narrowly defined and repetitive. It is a kind of work where the required qualifications are limited and the worker can easily be substituted by another worker or by a machine. In the era of globalization, this category of work is interesting because it can be easily outsourced to low wage countries.

Traditional organization involves even less complex problems. It is more individualistic than all the other categories and less monotonous than lean production and Taylorism. It includes traditional service jobs. Many of those involve a direct and indirect interaction with local customers and they may therefore be less footloose than the Taylorist jobs.

3.1 National effects on the diffusion of organizational practice

Table 5 shows that there are wide differences in the importance of the four forms of work organization across European nations. The discretionary learning form of work organization is most prevalent in the Netherlands, the Nordic countries and to

Table 5 National differences in forms of work organization

	Percent of employees by country in each organizational class				
	Discretionary learning	Lean production	Taylorist organization	Traditional organization	Total
Belgium	38.9	25.1	13.9	22.1	100.0
Denmark	60.0	21.9	6.8	11.3	100.0
Germany	44.3	19.6	14.3	21.9	100.0
Greece	18.7	25.6	28.0	27.7	100.0
Italy	30.0	23.6	20.9	25.4	100.0
Spain	20.1	38.8	18.5	22.5	100.0
France	38.0	33.3	11.1	17.7	100.0
Ireland	24.0	37.8	20.7	17.6	100.0
Luxembourg	42.8	25.4	11.9	20.0	100.0
Netherlands	64.0	17.2	5.3	13.5	100.0
Portugal	26.1	28.1	23.0	22.8	100.0
UK	34.8	40.6	10.9	13.7	100.0
Finland	47.8	27.6	12.5	12.1	100.0
Sweden	52.6	18.5	7.1	21.7	100.0
Austria	47.5	21.5	13.1	18.0	100.0
EU-15	39.1	28.2	13.6	19.1	100.0

Source: Third Working Condition survey. European Foundation for the Improvement of Living and Working Conditions.

a lesser extent Germany and Austria, while it is the least prevalent in Ireland and the southern European nations. The lean model is most in evidence in the UK, Ireland, and Spain and to a lesser extent in France, while it is little developed in the Nordic countries or in Germany, Austria, and the Netherlands. The Taylorist form of work organization shows almost the reverse trend compared to the discretionary learning forms, being most frequent in the southern European nations and in Ireland, and Italy. Finally, the traditional form of work organization is most prevalent in Greece and Italy and to a lesser extent in Germany, Sweden, Belgium, Spain, and Portugal.

As shown in Tables 3 and 4, each form of work organization tends to be associated with particular sectors and occupational categories. This raises the question of what part of the variation in the importance of these forms across EU nations can be accounted for by the nation's specific industrial and occupational structure, or by other unexplained national factors, such as sociocultural attitudes on the part of management and workers, historical developments, and the rate at which new organizational forms are adopted by firms. In order to determine the importance of

Table 6 Logit estimates of national effects on organizational practice

	Logit estimates without structural controls				Logit estimates with structural controls			
	1 Discretionary learning organization	2 Lean organization	3 Taylorism	4 Traditional organization	5 Discretionary learning organization	6 Lean organization	7 Taylorism	8 Traditional organization
Belgium	−0.22	0.32	−0.03	0.01	−0.23	0.42*	−0.11	−0.09
Denmark	0.63**	0.14	−0.82**	−0.79**	0.79**	0.29	−0.86**	−1.06**
Greece	−1.24**	0.35	0.85**	0.31	−1.33**	0.42	0.84**	0.12
Italy	−0.61**	0.24*	0.46**	0.20*	−0.51**	0.20	0.33**	0.16
Spain	−1.15**	0.96**	0.31*	0.04	−1.15**	1.08**	0.06	−0.17
France	−0.26**	0.72**	−0.29*	−0.27**	−0.32**	0.84**	−0.33**	−0.38**
Ireland	−0.92**	0.91**	0.45	−0.27	−1.11**	1.14**	0.47	−0.50
Luxembourg	−0.06	0.33	−0.21	−0.11	−0.17	0.42	0.00	−0.20
Netherlands	0.81**	−0.16	−1.10**	−0.59**	0.79**	0.02	−0.94**	−0.74**
Portugal	−0.81**	0.47**	0.58**	0.05	−0.78**	0.51**	0.44*	−0.01
UK	−0.40**	1.03**	−0.31**	−0.56**	−0.68**	1.32**	−0.24*	−0.72**
Finland	0.14	0.45*	−0.15	−0.71*	−0.01	0.63**	−0.07	−0.78*
Sweden	0.33*	−0.07	−0.77**	−0.01	0.22	0.06	−0.68*	0.00
Austria	0.13	0.12	−0.10	−0.24	0.33	0.14	−0.26	−0.43*

*Significant at 5%.

**Significant at 1%.

Reference country: Germany.
Source: Third European Survey of Working Conditions. European Foundation for the Improvement of Living and Working Conditions.

"national factors," we use logit regression analysis to provide estimates of the impact of national effects on the relative likelihood of adopting the different types of work organization (Table 6). Germany, the most populous nation within the EU, is the reference case for the estimates of national effects. In each case, the dependent variable is a binary variable measuring whether or not the individual is subject to the particular form of work organization. In the left side of Table 6 (columns 1 through 4), there is only one independent variable for the country where the employee works, with Germany as the reference category. Thus column 1 gives the likelihood that employees are subject to the "discretionary learning" form of work organization in each country relative to the German case.

In the right side of Table 6 (columns 5 through 8), the independent variables include nationality plus three control variables for each employee's sector of work, the establishment size, and occupational category. The respective reference categories

for the estimates are the vehicle sector, firms with 10 to 49 employees, and the occupational category of machine operator and assembler.[11]

As the column 1 results show, the country where the employee works has a significant impact on the relative likelihood of discretionary learning forms of employment. Compared to the German case, for which the use of the discretionary learning form of work organization is near the 15-country weighted average (Table 5), there are three countries where the discretionary learning model is more frequent: Sweden, the Netherlands, and Denmark. There are no significant differences in the use of discretionary learning in four countries: Belgium, Luxembourg, Finland, and Austria. This work form is less frequent in the remaining seven countries. Column 5 indicates that these results are robust after controlling for the effect of firm size, industry structure, and occupation, with the exception of Sweden, for which the coefficient estimate though still positive is no longer significant.

Column 2 of Table 6 presents the estimates of national effects on the likelihood of using the lean form without controls. Compared to Germany, where the use of the lean model is relatively low in relation to the 15-country weighted average (Table 5), Spain, France, Ireland, Finland, the UK, and Portugal display a relatively high propensity to use lean production methods. The coefficients are especially high for the UK, Ireland and Spain and they increase slightly and remain significant when structural controls are included.

Overall, the results show that the large national differences in the prevalence of different forms of work organization are not due to national differences in the distribution of firm size, industry and occupation. Instead, unexplained national factors that could be due to historically inherited management–worker relations or attitudes to organizational innovation strongly influence national differences in the use of different sets of organizational practices.

In so far as the organizational practices adopted by firms can influence their ability to develop and profit from innovation, the results in Table 6 suggest that the large differences within the European Union in national innovative performance[12] might reflect national differences in the distribution of different types of work organization, particularly the use of discretionary learning forms that enhance the opportunities for learning. This possibility is explored in Sections 4 and 5.

[11]A third model which included controls of age, gender, and a measure of the importance of further education received by the employee gave substantially the same results. The only differences were that working in Austria becomes a significant predictor of the likelihood of working under the discretionary learning forms, working in Portugal is no longer a significant predictor of the likelihood of working under the lean forms, and working in Finland or Austria is no longer a significant negative predictor of the likelihood of working under the traditional forms.

[12]As an example, the 2005 European Innovation Scoreboard finds a 2.5-fold difference between the best and worst EU-15 member states on the Summary Innovation Index.

4. Measuring differences in innovation mode

Economists and business scholars frequently measure innovation by R&D expenditures or by the number of patents applied for or granted. The weaknesses of these measures are well known. R&D does not necessarily result in the development of new products or processes and many innovative firms do not perform R&D. A large fraction of innovations are not patented and the importance of patenting varies according to sector. Furthermore, R&D and patents entirely fail to capture innovation that occurs through diffusion processes, such as when a firm purchases innovative production equipment or product components from other firms. The Community Innovation Surveys (CIS) were in part designed to respond to these limitations by providing survey-based estimates of the percentage of manufacturing firms and selected service sector firms[13] that have developed or introduced a new product or process over a three-year time period. However, the CIS estimates of the percentage of innovative firms are based on a very broad definition of innovation ranging from intensive in-house R&D that results in new-to-market products or processes to minimal effort to introduce manufacturing equipment purchased from a supplier. Consequently, a broad all-encompassing definition where a distinction is made between "innovative firms" and "noninnovative firms" is both misleading in international comparisons and fails to provide a clear picture of the structure of innovation capabilities within individual countries.

In order to overcome these limitations, we draw on a taxonomy developed by Arundel and Hollanders (2005), in collaboration with Paul Crowley of Eurostat, in order to classify all innovative CIS respondent firms into three mutually exclusive innovation modes that capture different methods of innovating, plus a fourth group for noninnovators.[14] The classification method uses two main criteria: the level of

[13]CIS-3 did not include firms in several sectors covered in the Third Working Conditions Survey: construction (NACE 45) and several service sectors: retail trade (NACE 52), automobile trade and repair (NACE 50), hotels and restaurants (NACE 55), some business services (NACE 74.1 and NACE 74.4 to 74.8), and personal services (NACE 90 to 93). However, CIS-3 did include wholesale trade (NACE 51). The main effect is that the CIS innovation modes data will underestimate the percentage of firms with traditional forms of work organization.

[14]Data are available for all EU member nations in 2000 with the exception of Ireland. The original Arundel, Hollanders, and Crowley classification makes a further distinction between lead innovators that make continuous use of R&D and are active on national or international markets and lead innovators that make only occasional use of R&D and/or are only active on local or regional markets. Since our interest is the relation between forms of work organization and the capacity for creative in-house development of novel products or processes regardless of R&D expenditures or the scope of markets, we have merged these two categories into a single "lead innovator" group. For full details on the methodology for innovation modes, see Annex B of the Trend Chart document "EXIS: An Exploratory Approach to Innovation Scoreboards (http://trendchart.cordis.lu/scoreboards/scoreboard2004/pdf/EXIS.pdf).

novelty of the firm's innovations, and the creative effort that the firm expends on in-house innovative activities. The three innovation modes are as follows:

4.1 Lead innovators

For these firms, creative in-house innovative activities form an important part of the firm's strategy. All firms have introduced at least one product or process innovation developed at least partly in-house, perform R&D at least on an occasional basis, and have introduced a new-to-market innovation. These firms are also likely sources of innovations that are later adopted or imitated by other firms.

4.2 Technology modifiers

These firms primarily innovate through modifying technology developed by other firms or institutions. None of them perform R&D on either an occasional or continuous basis. Many firms that are essentially process innovators that innovate through in-house production engineering will fall within this group.

4.3 Technology adopters

These firms do not develop innovations in-house, with all innovations acquired from external sources. An example is the purchase of new production machinery.

Table 7 presents the distribution of firms according to innovation mode for 14 EU nations for which the necessary data are available and also includes the percentage of firms that did not innovate. The results are weighted to reflect the distribution of all firms within the industry and service sectors covered by CIS-3. The results show that Finland, Germany, Sweden, and Luxembourg have the highest percentage of firms in the lead category of innovators, while Germany, Luxembourg and Austria have the highest percentages of firms that are technology modifiers. In Spain, Greece, and the UK over 80% of firms are either adopters or noninnovators.

5. The relation between organizational practice and innovation mode

As our introductory discussion pointed out, much of the discussion in the organizational behavior literature on the relation between organization and innovation focuses on whether or not particular organizational designs are better suited for undertaking radical or incremental innovations. Radical innovations can be defined as innovations that transform existing markets or industries and upon which many incremental innovations are developed. For example, Lam (2005) and Lam and Lundvall (2006) argue that Mintzberg's (1979, 1983) "operating adhocracy" form of organization, which relies on networks of professional experts and the creation of ad hoc project teams, is especially adapted to developing novel or radical

Table 7 Distribution of innovation modes in 14 EU member nations, 1998–2000

	Leaders	Modifiers	Adopters	Noninnovators	Total
Belgium	20	16	14	50	100
Denmark	19	11	14	56	100
Germany	25	25	11	39	100
Greece	13	5	10	72	100
Italy	18	15	4	64	100
Spain	8	5	19	67	100
France	20	10	11	59	100
Luxembourg	24	20	4	52	100
Netherlands	22	16	8	55	100
Portugal	18	16	13	54	100
UK	11	5	16	68	100
Finland	29	10	3	55	100
Sweden	25	14	8	53	100
Austria	20	20	9	51	100

Source: Third Community Innovation Survey (CIS).

innovations characteristic of new emerging technologies. The firms of Silicon Valley provide good examples of this organizational form (Saxenian, 1994; Bahrami and Evans, 2000). In contrast, it is widely asserted in the literature on the Japanese firm that its organizational design is especially suited for progressive or incremental improvements in product quality and design. (Aoki, 1990; Womack *et al.*, 1990; Coriat, 1991). The Japanese organization relies on firm-specific knowledge that is embedded in the firm's organizational routines and relatively stable team structures for continuous product and process improvement.

Since the business practices and forms of work organization captured in our discretionary learning and lean clusters correspond rather closely to those that characterize the "operating adhocracy" and the "Japanese-firm," this literature led us to anticipate differences in the relative frequency of radical and incremental innovations in a nation depending on the relative prevalence of the discretionary learning and lean forms of work organization. Developing empirical indicators to identify radical and incremental modes of innovation is problematic, however. Survey manuals, such as the Oslo Manual that provide the basis of the CIS questions, do not propose guidelines for how to measure radical innovations. This makes it difficult to bring survey-based evidence to bear on the various propositions developed in the organizational literature.

Our typology of innovation modes captures a different but related distinction in the nature of innovation by distinguishing between firms that have developed,

in-house, "new-to-market" product or process innovations (lead innovators) versus firms that have only introduced "new to firm" innovations that were partly or entirely developed outside the firm (technology modifiers and technology adopters). This distinction is not identical to the difference between radical and incremental innovations, since not all "new-to-market" innovations will have major transformative impacts on markets or industries. However, there are large differences along the continuum between lead innovators and technology adopters in each firm's capacity to explore new knowledge, which is conceptually similar (although on a different scale) to the difference between radical and incremental innovations.

In order to provide evidence that bears on the proposed link between organizational practice and innovation modes, in this section we start by presenting a series of scatter plot diagrams showing, for all sectors, the correlations between the frequency of the four innovation modes and the frequency of the discretionary learning, lean and Taylorist forms of work organization for the 14 EU nations for which data are available. We then present separate sets of correlations for manufacturing and for services.[15]

Figure 1 presents the results of this exercise for the discretionary learning (DL) form of work organization. The main result is that there is a positive correlation between discretionary learning and the frequency of the two innovation modes for which the levels of novelty and creative in-house effort are the highest, the lead innovators and modifiers, while there is a negative correlation between discretionary learning and the frequency of noninnovators. Furthermore, the strongest positive correlation is between lead innovators and discretionary learning, with an R^2 of 0.39.[16]

Figure 2 presents the same analysis using the frequency of the lean form of work organization. The results tend to go in the opposite direction of those for discretionary learning. Thus they show a negative correlation between the frequency of the lean form and the frequency of the two innovation modes which depend on in-house creative effort for innovation, and a positive correlation with the frequency of adopters and noninnovators.[17]

Figure 3 shows that the frequency of the Taylorist forms of work organization are negatively correlated with the frequency of lead innovators and positively correlated

[15]In order to calculate the correlations on the basis of survey samples which are harmonized to the fullest extent possible, firms from construction (NACE 45), hotels and restaurants (NACE 55) and personal services (NACE 90 to 93) have been excluded from the Working Conditions Survey sample.

[16]The correlations between the frequency of discretionary learning and the frequencies of lead innovators and non-innovators are significant at the 0.05 level.

[17]All these correlations are significant at the 0.05 level or better with the exception of the positive correlation between lean and the frequency of adopters, which is significant at the 0.10 level.

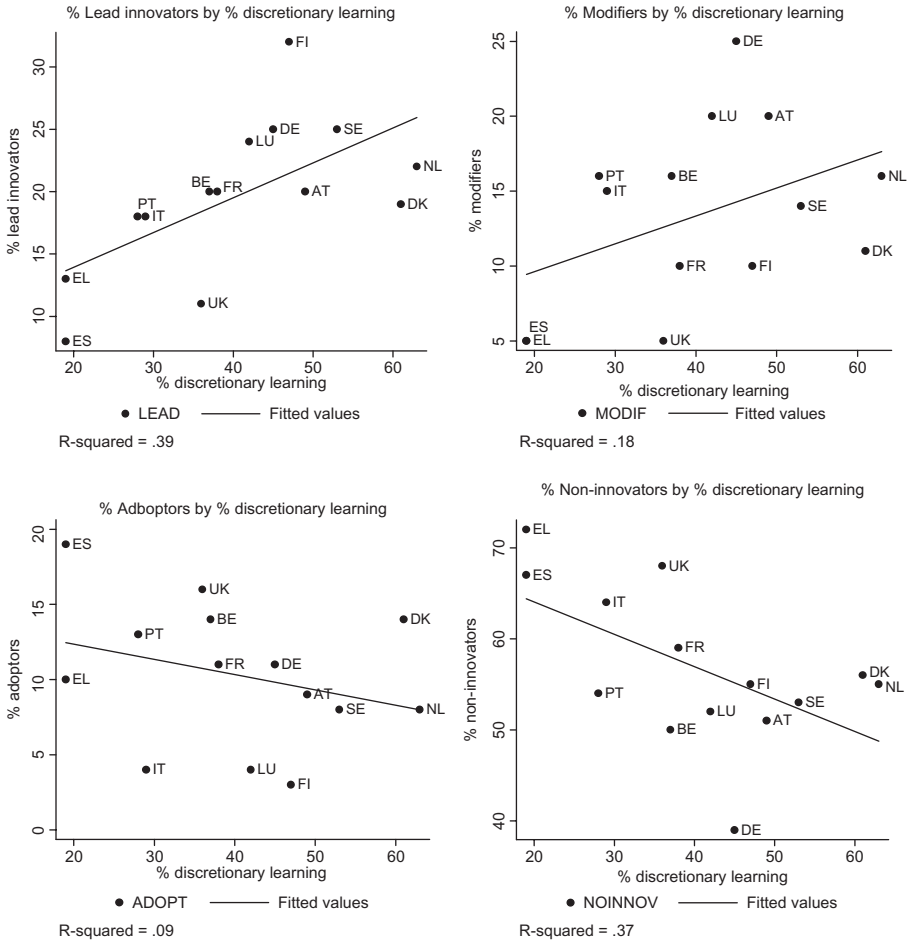

Figure 1 Correlations between innovation modes and discretionary learning, all sectors.

with the frequency of noninnovators. The correlations are relatively weak, though, and are not significant at the 0.10 level.

These results provide support for the view that there are systemic links between the way work is organized in a nation and the distribution of different innovation modes.[18] More specifically, the positive correlation between discretionary learning and the frequency of lead innovators provides support for the hypothesis developed in the qualitative literature that the forms of work organization characteristic of operating adhocracies support the exploration of new knowledge that is needed for

[18]The innovation modes are only weakly correlated with the frequency of the traditional forms of work organization (*R*-squared less than 0.10 in all cases).

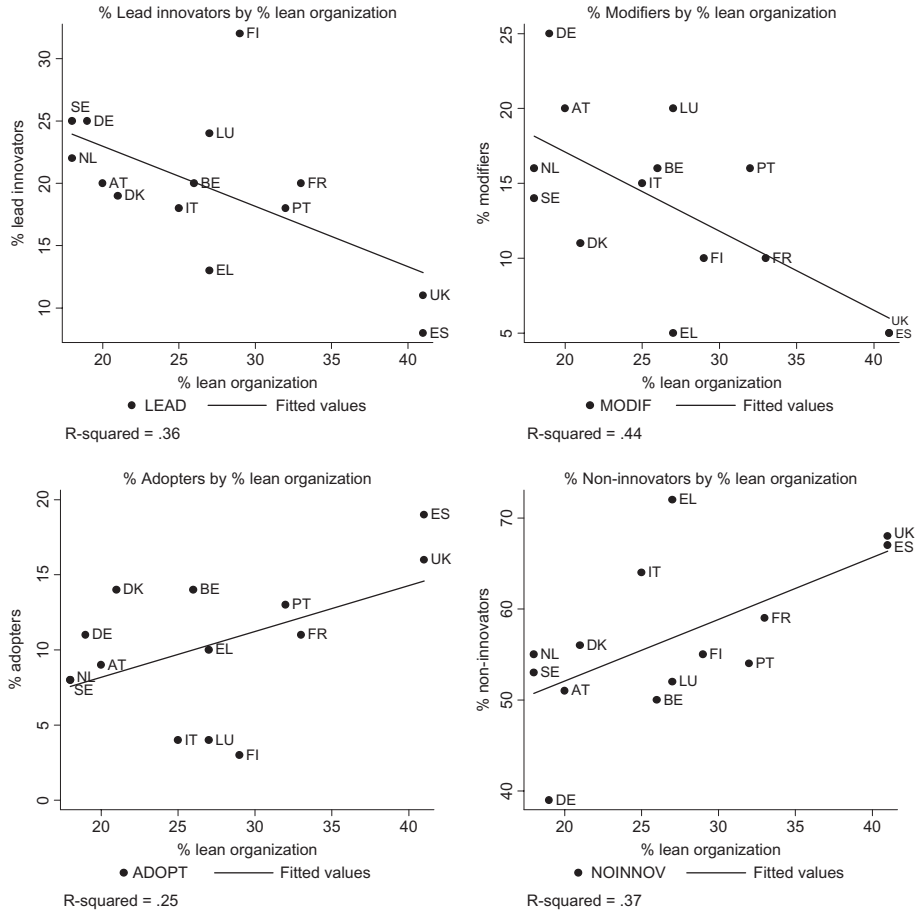

Figure 2 Correlations between innovation modes and lean organization, all sectors.

creative, in-house innovative activities that can lead to the development of new-to-market innovations and possibly radical innovations.

The results, however, are unexpected in two respects. First, while the negative correlation between the frequency of Taylorism and lead innovators and the positive correlation between Taylorsim and noninnovators are consistent with ideas developed in the organizational design literature, the correlations are relatively weak compared to those observed for the discretionary learning and lean forms of work organization. One possible explanation for this is that our employee level data is picking up that some innovating firms use Taylorist work organization for production operations while discretionary learning is practised in more knowledge-intensive activities. If this were the case, there would be little reason to expect variations in its use to be strongly correlated with innovation mode. This possibility is further explored below in the section comparing manufacturing and services.

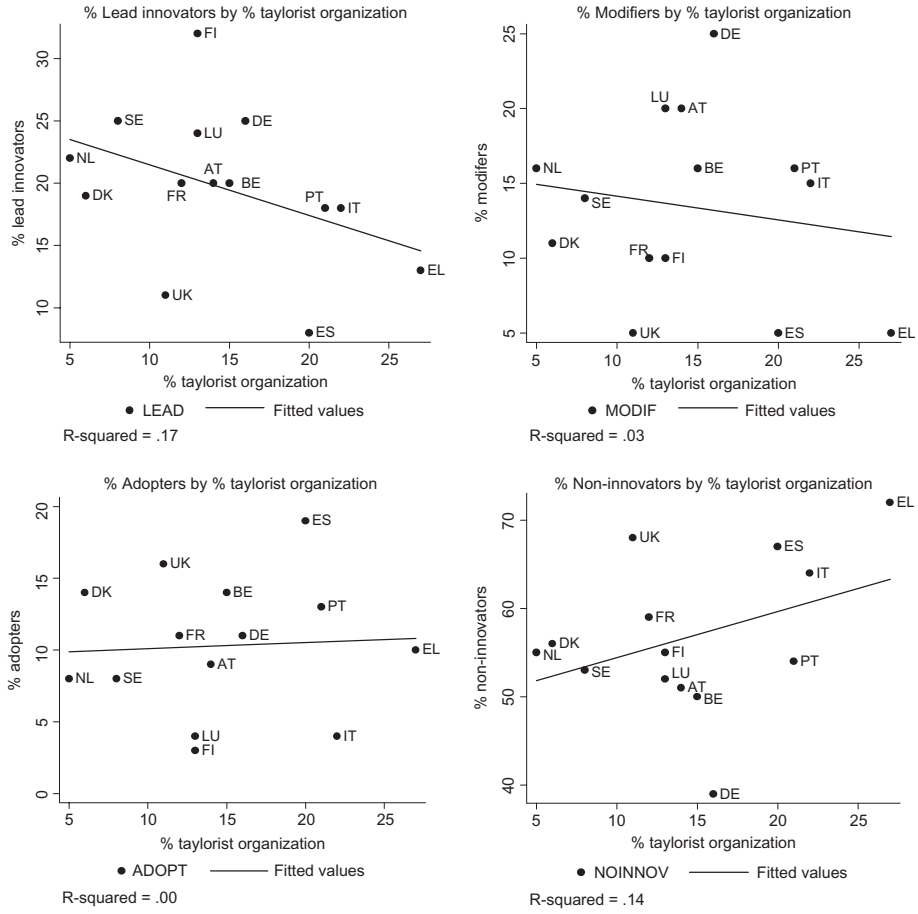

Figure 3 Correlations between innovation modes and Taylorist organization, all sectors.

Second, while the negative correlations shown in Figure 2 between the lean forms of work organization and the frequency of the lead innovators are consistent with our reading of the organizational design literature, the negative correlation with the frequency of modifiers is not. Based on the Japanese experience, we expected the frequency of the lean forms to be positively correlated with the prevalence of technology modifiers, which are dominated by innovation based on minor incremental improvements. Furthermore, the results in Table 2 show that employees subject to the lean forms of work organization report above average rates of problem solving and learning. Nevertheless, the negative correlation with the frequency of technology modifiers is the highest observed (R^2 value of 0.44) while the lean forms are positively correlated with the prevalence of firms that either do not innovate or which only innovate through adopting new technology. Firms grouped in this latter

category do not need to invest very much in exploring new knowledge in order to innovate.[19]

The lack of a positive correlation between the lean form of work organization and the prevalence of modifiers could be due to limitations with the data, but an alternative possibility is that the lean model could have been adopted by European firms as a more efficient alternative to Taylorism, without adopting the Japanese emphasis on the delegation of decision-making responsibility to shop-floor employees. Under these conditions, the problem solving and learning tasks reported by employees subject to lean organization could be severely limited by the high prevalence of reported constraints (Table 2), limiting opportunities to suggest or implement incremental improvements.[20] This interpretation finds support in the fact that monotonous and repetitive work is as frequent or even more frequent in the lean production category than it is in Taylorist work form. If true, such restrictions on lean organizational forms could explain part of an innovation performance gap between Europe and Japan.

5.1 Differences between manufacturing and services

The relationships observed at the level of national aggregates could be the outcome of contradictory patterns in different parts of the economy. Due to access limitations to the CIS data, we were unable to conduct detailed analyses at the sector level,[21] but it is possible to divide the economy into two main sectors—services and manufacturing. Below we present a series of scatter plot diagrams showing, for manufacturing and services separately, the correlations between the frequency of the four innovation modes and the frequency of the discretionary learning, lean and Taylorist forms of work organization. This analysis is interesting since it will also allow us to determine

[19]Some investment in learning will nevertheless be required, both to select the new technology to adopt, and to adapt employee skills and competences to its use.

[20]The vast literature on the transfer of Japanese management practices by Japanese multinationals to their affiliates located in Europe and the US and during the 1980s and 1990s provides evidence relevant to this issue. Most of this literature argues that Japanese management practices are modified in the process of transfer resulting in hybrid organizational forms combining elements of work organization and HRM practices characteristic of the host country. See Kenney and Florida (1993), Liker *et al.* (1992), and Oliver and Wilkinson (1992). For evidence on the limited delegation of decision-making authority to shop-floor personnel in Japanese transplants located in the UK, see Lorenz (2000) and Doeringer *et al.* (2003).

[21]Access to CIS-3 data was restricted, with the results for innovation mode calculated in-house by Eurostat and by national statistical offices at our request. Both lacked the resources to conduct detailed analyses at a highly disaggregated sector level. Since then, the micro CIS-3 data for some countries can by analyzed by researchers on site at Eurostat, but unfortunately the microdata for most of the original EU-15 countries are still unavailable.

in a preliminary manner whether the observed relations between forms of work organization and modes of innovation display sector specificities.

Figure 4 presents the correlations between the frequency of discretionary learning and the innovation modes. In both manufacturing and services, the frequency of discretionary learning varies between a low of about 20% and a high of about 70%. The frequency of lead innovators tends to be somewhat higher in manufacturing than in services and the frequency of noninnovators somewhat lower.

The relations between the frequency of discretionary learning and the frequency of the innovation modes that are observed for all sectors combined are for the most part reproduced for manufacturing and for services separately, though the positive correlation with lead innovators is somewhat higher for manufacturing. The results support the basic conclusion about the positive relation between the use of discretionary learning and firms' capacities for knowledge exploration and innovation.

Figure 5 presents scatter plot diagrams showing the correlations between the frequency of use of lean organization and the innovation modes. Manufacturing and services exhibit some noticeable differences, with services displaying stronger negative correlations between the frequency of lean organization and the frequencies of both lead innovators and modifiers, and a stronger positive correlation between the frequency of lean organization and the frequency of noninnovators. The results suggest that while the lean forms of work organization are poorly suited to the requirements of knowledge exploration and innovation in general, this is especially the case for services. One possible explanation for this pertains to the coverage of CIS-3, which excludes retailing, hotels and restaurants, and personal services and so is relatively weighted to the more knowledge-intensive service sectors such as business and financial services. Some of the defining characteristics of lean work organization, such as strong hierarchical and norm-based constraints on work pace, may be especially unsuited to the dynamics of knowledge exploration and innovation in these service sectors.

Figure 6 shows the correlations between the frequency of Taylorist forms of work organization and the innovation modes. The differences between manufacturing and services are even more striking than for the case of the lean forms of work organization. While there is no obvious relation between the frequency of Taylorism and the frequency of the innovation modes for services, there is a statistically significant negative correlation between the frequency of Taylorism and the frequency of lead innovators, and a comparably strong positive correlation between Taylorism and the frequency of noninnovators. This difference between manufacturing and services might be accounted for along the lines suggested above. Although the frequency of use of Taylorist methods of work organization varies considerably across EU nations, it is relatively low in the service sectors with an average frequency of less than 9%. This low frequency of use of Taylorism could simply reflect the fact that within the service sectors under consideration, Taylorist work methods are primarily used for ancillary operations within firms that are predominately organized

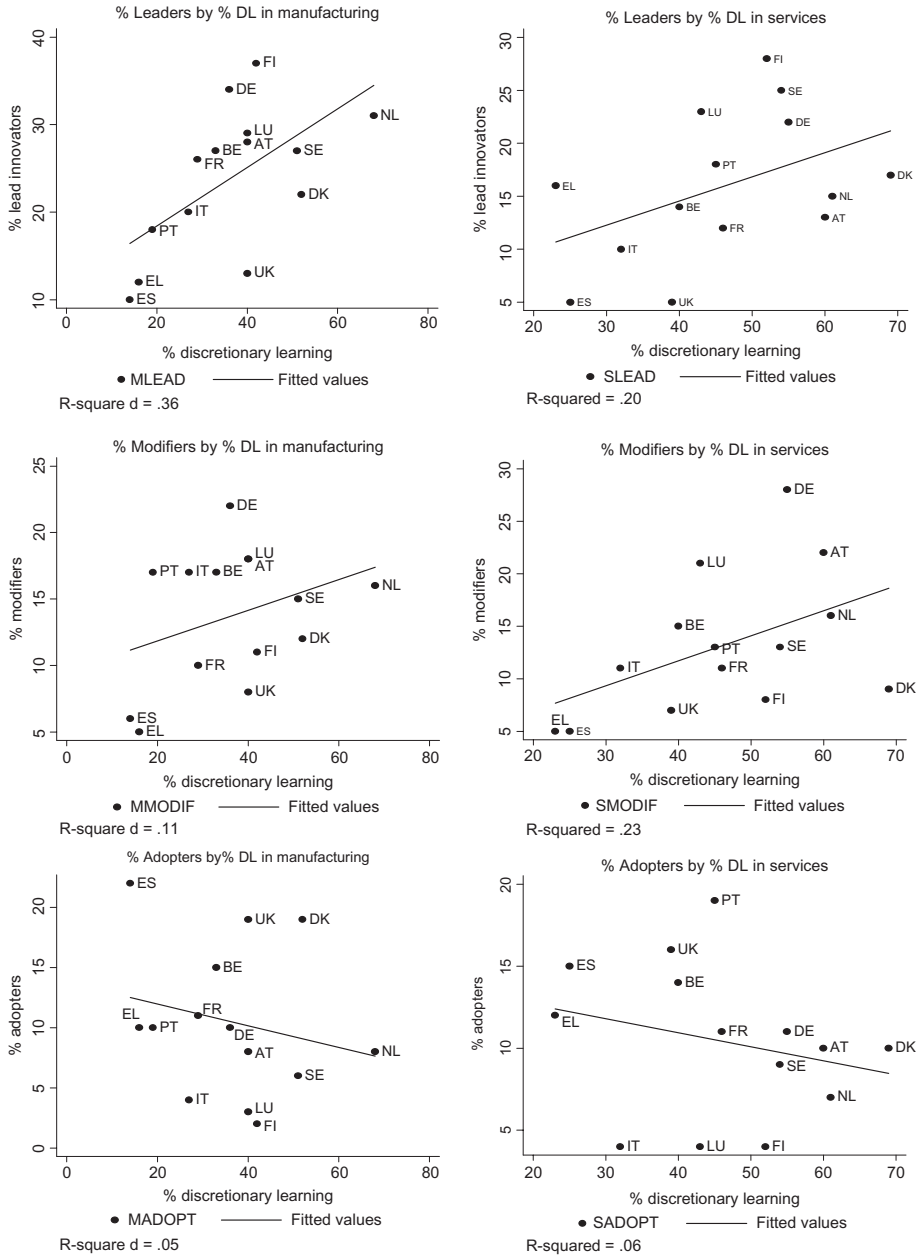

Figure 4 Correlations between discretionary learning and innovation modes for manufacturing and for services.

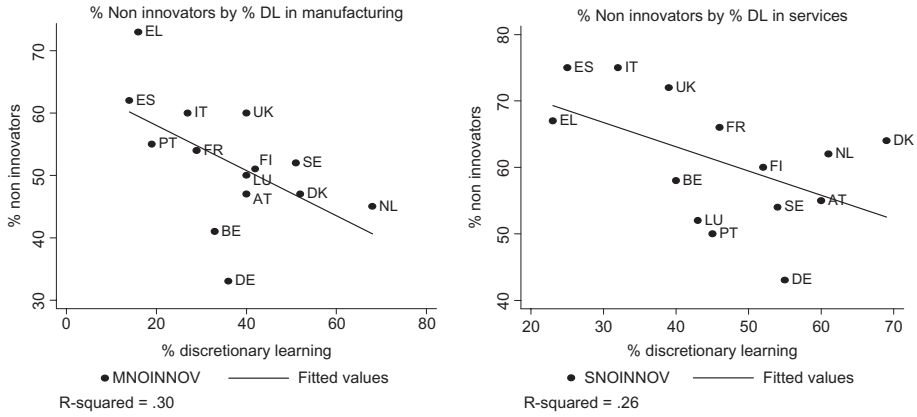

Figure 4 Continued.

according to either the discretionary learning or lean principles of work organization. Under these circumstances, there would be little reason to expect that variations in the use of Taylorism would be sharply correlated with the frequency of each innovation mode. A fuller treatment of this question would require access to disaggregated data.

6. Conclusion

This article develops a set of EU-wide aggregate measures that are used to explore, at the level of the national innovation system, the relation between innovation and the organization of work. Although our data can only show correlations rather than causality and are aggregated at the national level, they support the view that the way work is organized is highly nation-specific and that it co-evolves with an equally highly nation-specific distribution of different modes of innovation.

Before going further in terms of conclusions we need to introduce some caveats. Both the data set behind the work organization analysis and the data set behind the pattern of innovation modes are from surveys pursued in parallel in the EU-15; in the first case addressed to employees and in the second to management. There are obvious problems with interpreting survey data emanating from different countries. Different responses to the same question may reflect national "cultural" differences rather than real existing differences. For instance the big gap in the share of innovative firms between Germany and the UK calls for closer scrutiny. Another issue is if the substantial differences, both in terms of work organization and innovation modes, between the two Nordic countries of Denmark and Finland are real or reflect different attitudes among employees and managers. Finding new ways to "triangulate" results of national surveys with the aim to make them more

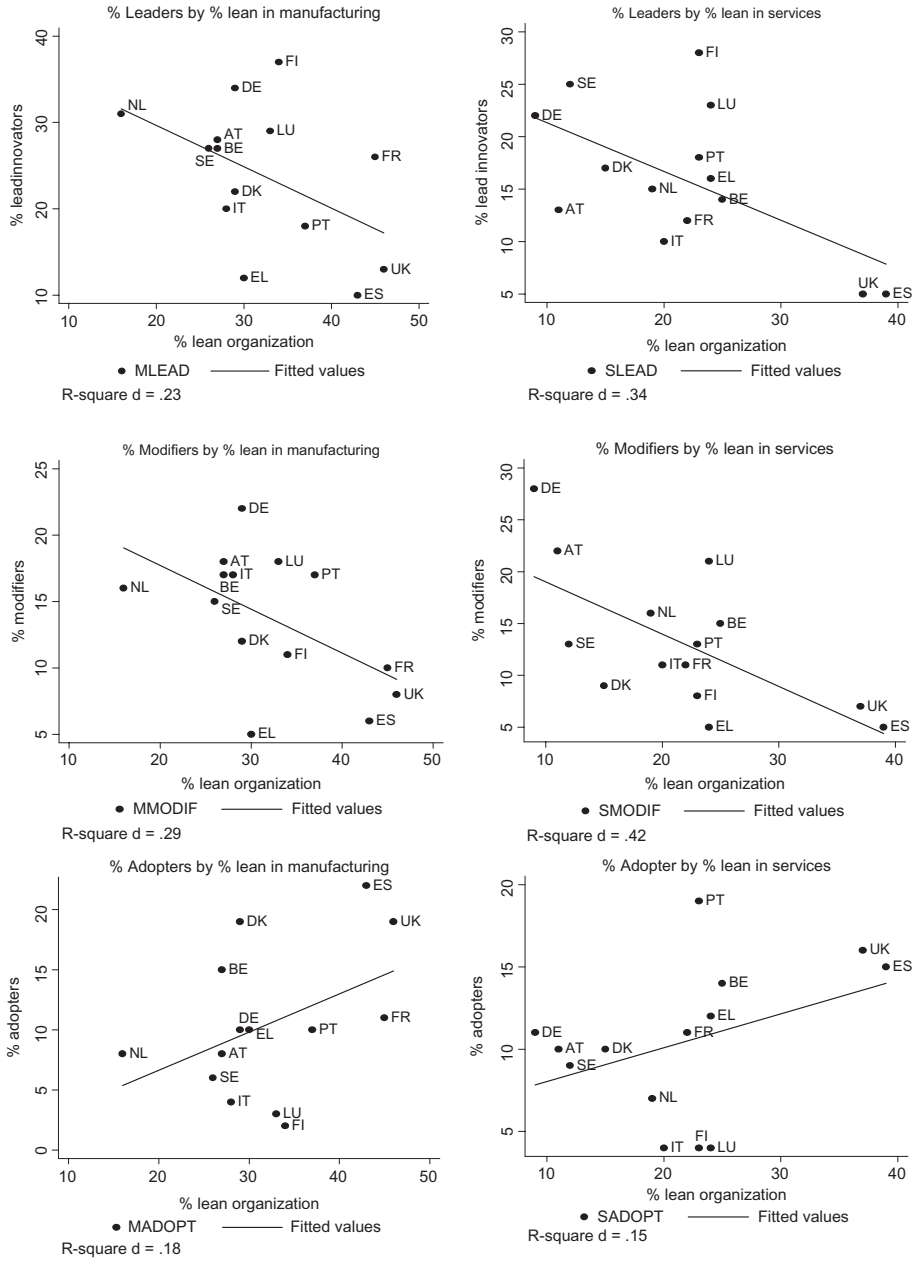

Figure 5 Correlations between lean organization and innovation modes for manufacturing and services.

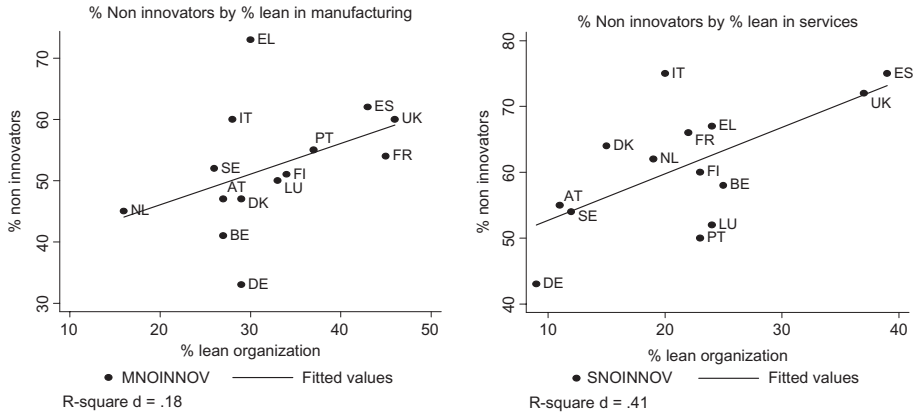

Figure 5 Continued.

reliable—for instance by combining detailed case studies with testing questionnaire responses in different countries—is a major challenge. Until we get more reliable methods, we must work on the assumption that the observed national differences are either real or that cultural biases equally affect the responses from employees and from managers. With this in mind, we will point to what we see as the main findings and their implications for future research, indicator work and public policy.

A first major finding is that in nations where work is organized to support high levels of discretion in solving complex problems, firms tend to be more active in terms of innovations developed through their own in-house creative efforts. In countries where learning and problem solving on the job are constrained, and little discretion is left to the employee, firms tend to engage in a supplier-dominated innovation strategy. Their technological renewal depends more on the absorption of innovations developed elsewhere. The negative correlation between "lean production" and "modifier innovation" raises important questions about how successful European firms have been to make the J-form of organization support innovation. Our analysis gives rise to new hypotheses on how management techniques such as job rotation and teamwork are related to innovation. They point to a need to develop analytical concepts that can link workplace organization and the dynamics of innovation at the level of the firm.

Second, the results indicate that learning and interaction within organizations and at workplaces are at least as important for innovation performance as learning through interactions with external agents. Therefore, in order to understand national systems of innovation it is necessary to bring the organization of work into the analysis. Early conceptions of national innovation systems were built upon an analysis of interactive learning between producers and users. Now the analysis needs to be founded also on an understanding of how people interact and learn at the workplace in different national economies.

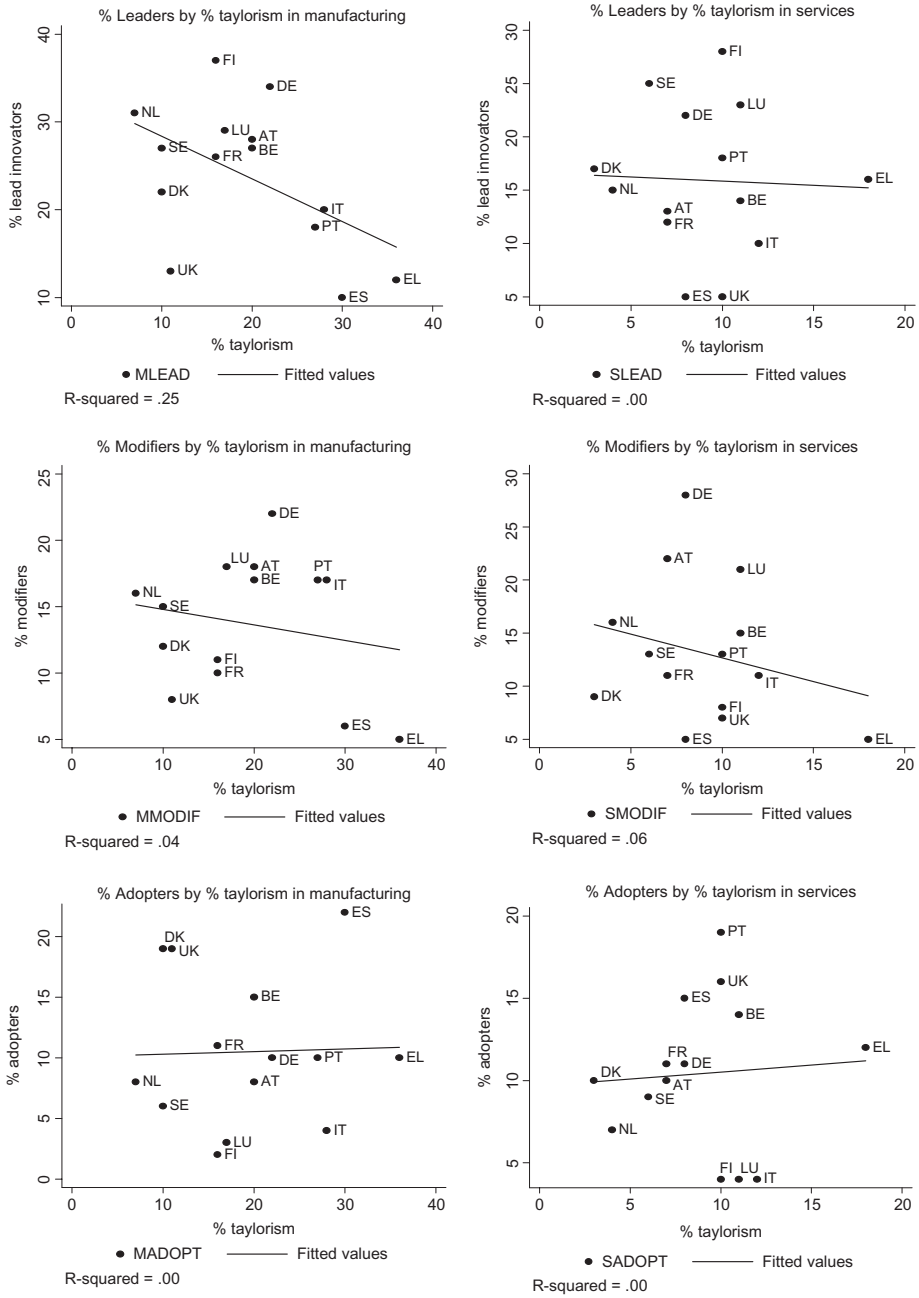

Figure 6 Correlations between Taylorist organization and innovation modes for manufacturing and for services.

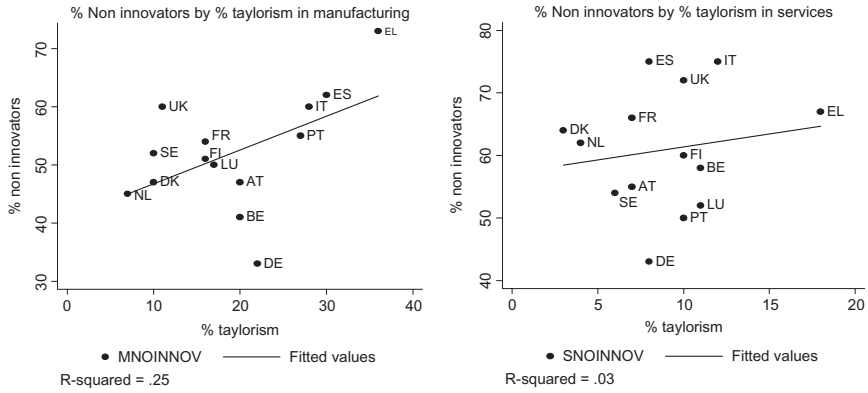

Figure 6 Continued.

A third implication is that indicators for innovation need to do more than capture material inputs such as R&D expenditures and human capital inputs such as the quality of the available pool of skills based on the number of years of education. Indicators also need to capture how these material and human resources are used and whether or not the work environment promotes the further development of the knowledge and skills of employees. One step toward more adequately addressing the relation between organization and innovation is to gather and analyze complementary firm-level data on both innovation modes and organizational forms. One option is to develop better indicators of organizational innovation and practices in future CIS surveys, as proposed by the third revision of the Oslo Manual in 2005. The CIS could respond to some of the limitations inherent in relying on the employee-level data of the European Survey on Working Conditions by supplying establishment-level data on the way knowledge flows and knowledge sharing are organized within firms and how they relate to other aspects of corporate strategy.

Fourth, some tentative policy implications may be drawn from the analysis. Though based on simple correlations that cannot establish a causal relation, our results suggest that European policy efforts to improve innovation performance as part of the revised Lisbon strategy need to take a close look at the effects of organizational practice on innovation. The bottleneck to improving the innovative capabilities of European firms might not be low levels of R&D expenditures, but the widespread presence of working environments that are unable to provide a fertile environment for innovation. If this is the case, European policy should make a major effort to develop policy instruments that could stimulate the adoption of "pro-innovation" organizational practice, particularly in countries with poor innovative performance.

Finally, a striking result is that there are fundamental differences by country both in how work is organized and in how firms innovate. These differences remain after controlling for differences in industrial structure. It is a major challenge for future research to understand the underlying "unexplained" national factors that influence

firms' organizational choices as well as their innovation performance. Preliminary analysis suggests that some specific variables reflecting institutional differences among the countries are quite strongly correlated with the prevalence of discretionary learning (levels of trust, labor market, and welfare state characteristics as well as frequency of vocational training). We have chosen not to introduce these issues here since it would require a thorough analysis of the role of institutions in shaping national systems of innovation. Such an analysis is a major challenge for future research.

We hope our results will widen the debate and stimulate further theoretical work and comparative research exploring the links between organizational forms, innovative performance, and the institutional context within Europe.

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Appendix

Organizational variables

Variable		Mean
Team work	1 if your job involves doing all or part of your work in a team, 0 otherwise	64,2
Job rotation	1 if your job involves rotating tasks between yourself and colleagues, 0 otherwise	48.9
Quality norms	1 if your main paid job involves meeting precise quality standards, 0 otherwise	74.4
Discretion in fixing work methods	1 if you are able to choose or change your methods of work, 0 otherwise	61.7
Discretion in setting work pace	1 if you are able to choose or change your pace of work, 0 otherwise	63.6
Horizontal constraints on work pace	1 if on the whole your pace of work is dependent on the work of your colleagues, 0 otherwise	53.1
Hierarchical constraints on work pace	1 if on the whole your pace of work is dependent on the direct control of your boss, 0 otherwise	38.9
Norm-based constraints on work pace	1 if on the whole your pace of work is dependent on the numerical production targets, 0 otherwise	38.7
Automatic constraints on work pace	1 if on the whole your pace of work is dependent on the automatic speed of a machine or movement of a product, 0 otherwise	26.7
Employee responsibility for quality control	1 if the employee's main paid job involves assessing him or herself the quality of his or her own work, 0 otherwise	72.6
Employee problem solving	1 if your job involves solving unforeseen problems on your own, 0 otherwise	79.3
Learning new things	1 if your job involves learning new things on your own, 0 otherwise	71.4
Task complexity	1 if your job involves complex tasks, 0 otherwise	56.7
Task monotony	1 if your job involves monotonous tasks, 0 otherwise	42.4
Task repetitiveness	1 if your work involves short repetitive tasks of less than one minute, 0 otherwise	24.9

Graphical Representation of Factor Analysis - 15 Organizational Variables

Figure A1 presents graphically the first two axes or factors of the multiple correspondence analysis (MCA). The first factor or axis, accounting for 18% of the inertia or chi-squared statistic, distinguishes between Taylorist and "post-Taylorist"

organizational forms. Thus on one side of the axis we find the variables measuring autonomy, learning, problem solving, and task complexity and to a lesser degree quality management, while on the other side we find the variables measuring monotony and the various factors constraining work pace, notably those linked to the automatic speed of equipment or flow of products, and to the use of quantitative production norms. The second factor or axis, accounting for 15% of the chi-squared statistic, is structured by two groups of variables characteristic of the lean production model: first, the use of teams and job rotation which are associated with the importance of horizontal constraints on work pace; and second those variables measuring the use of quality management techniques which are associated with what we have called "automatic" and "norm-based" constraints. The third factor, which accounts for 8% of the chi-squared statistic, is also structured by these two groups of variables. However, it brings into relief the distinction between, on the one hand, those organizational settings characterized by team work, job rotation, and horizontal interdependence in work and, on the other hand, those organizational settings where the use of quality norms, automatic, and quantitative norm-based constraints on work pace are important. The second and third axes of the analysis demonstrate that the simple dichotomy between Taylorist and lean organizational methods is not sufficient for capturing the organizational variety that exists across European nations.

The projection of the center of gravity of the four organizational clusters coming out of the hierarchical classification analysis (Table 2) onto the graphic representation of the first two factors of the MCA shows that the four clusters correspond to the quite different working conditions. The discretionary learning cluster is located to the east of the graph, the lean cluster to the south, the Taylorist cluster to the west, and the traditional cluster to the north.

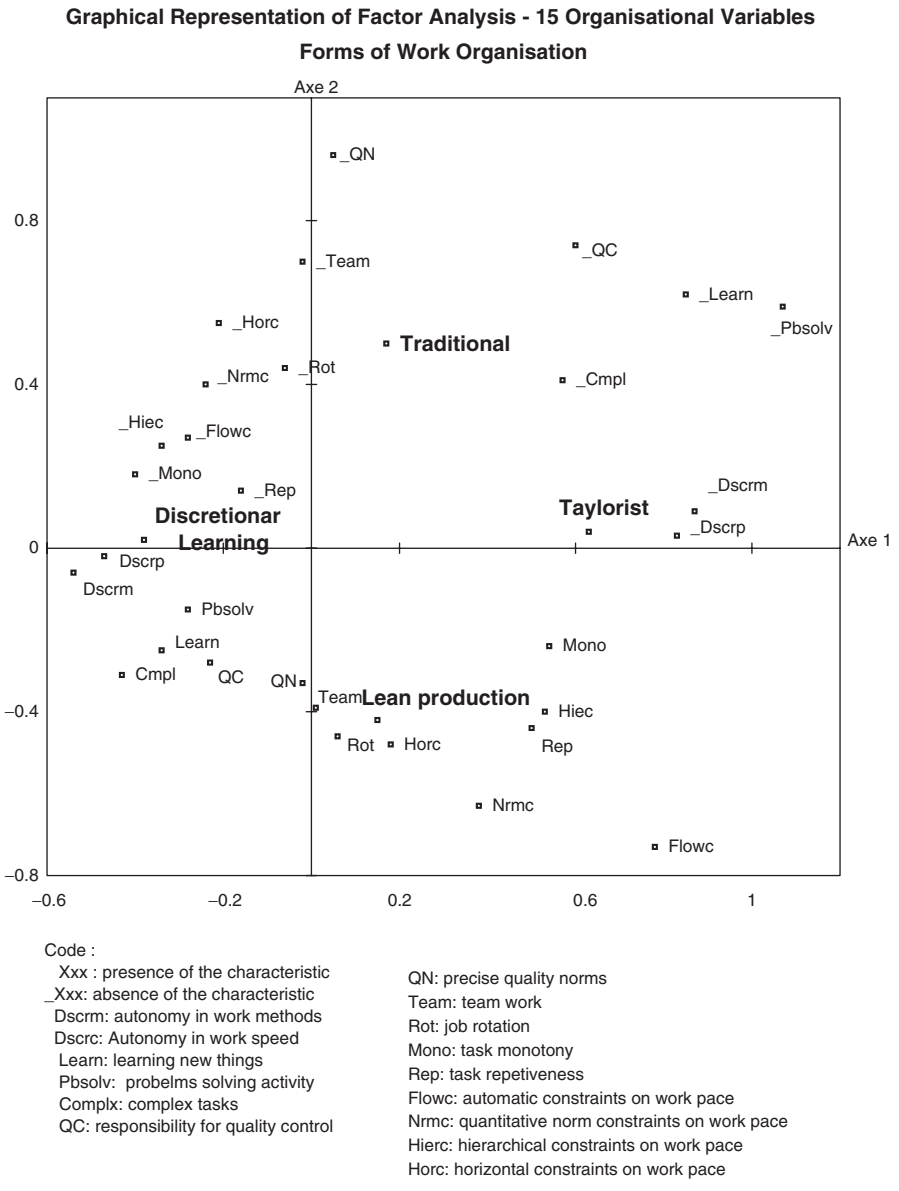

Figure A1 Forms of work organisation.