The Computerisation of the "Old" Economy: New Machines, New Structures and New Workers*

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In 1997, all manufacturing firms with more than 50 employees were using computers, even if it was only to handle management tasks. Differences in computer use lay in its intensity, in the configuration of computer systems around a mainframe or else around networked personal computers and in the information technology department's role within the firm. The intensity of computer use and the introduction of new organisational structures are closely related, as are medium-term changes in both areas. In the first half of the nineteen-nineties, computers played a key role in the move towards greater formalisation of operations that was an integral part of new management tools, such as quality standards. In more recent times, firms using just-in-time management, sub-contracting and outsourcing have relied on the interconnections between computer systems made possible new technology.

Computer use has facilitated organisational changes that have transformed the jobs of employees working with computers. Such workers are more independent, but their work is more closely monitored. They are under more pressure and subject to the occasionally conflicting demands of complex organisations. Their personal commitment to their jobs is greater. Access to computers and, to a greater degree, access to the Internet, are still determined by educational attainment, skills levels, responsibilities and seniority. All in all, a firm's use of computers is shaped primarily by the pre-existing structures within the firm, even though employees in firms that have undergone radical reorganisation have easier access to computers than similar employees do in other firms.

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The names and dates in parentheses refer to the bibliography at the end of the article.

There has not been much research into the general aspects of computerisation in firms. Case studies have shed light on the process of introducing computers, but they rarely consider the firm in its entirety (Gollac, Mangematin, Moatty and Saint-Laurent, 1999). Meanwhile, statistical research on the impact of computerisation relies mainly on quantitative measurements that do not shed any light on the different ways firms use computers. Yet, ever since computers first found their way into firms in the middle of the last century, successive generations of machines have provided increasingly advanced technology for the same cost. But technologically advanced machines are not necessarily put to particularly efficient or innovative uses (Greenan, L'Horty, Mairesse (ed.), 2001). In other words, the technological progress in the use of computers is much slower than Moore's Law[1] would lead us to believe. This progress is very closely linked to the firm's organisational choices (Foray and Mairesse (ed.), 1999, first section).

The effects of computerisation do not stem solely from the presence of computers in a firm. The effects stem from a multitude of workplace decisions and learning experiences. It is just as important to understand what firms do and create with their machines, as it is to measure the cost and processing power of the machines. It is critical to analyse how employees use their computers, along with many other resources, to contribute to the firm's technological progress. Furthermore, an analysis of the processes used to select the employees who use computers could help highlight risks of exclusion in the coming "information society."

This paper attempts to look into these three different issues using three statistics sources: the 1997/1998 *Organisational Change and Computerisation Survey* (COI), the 1998 *Working Conditions Survey and the 1997 Work and Lifestyles survey.*

How Firms Use Computers

In order to describe the role computers play in business organisations we need to consider the different ways firms use computers, as well as the quantities of computing hardware they use. The *Organisational Change and Computerisation Surveys* (COI) (see Box 1) address this issue by considering the qualitative aspects of computerisation in firms, along with the quantitative aspects (Caby, Greenan, Gueissaz and Rallet, 1999). The surveys distinguish between computerisation of tasks and computerisation of exchanges of information and knowledge. The surveys also account for the features of various generations of computer hardware. They measure the "scope" of computerisation and describe the organisation of the information technology (IT) function.

The main limitation of this data source is the survey field, which covers manufacturing firms with more than 50 employees, including firms in the agri-food industry. This means that the survey data describe computerisation in the "old" economy. By looking at employees' use of computers, our paper occasionally addresses a wider field, because the Working Conditions Survey covers all members of the labour force in payroll employment.

In 1997, all manufacturing firms with more than 50 employees had computers

A very broad set of survey questions are used to describe computerisation in firms in 1997. The questions are used to construct composite variables using multiple correspondence analysis (MCA) (see Box 2). The questions describe the types of computer hardware used by management and production functions in the firm, data traffic volume over computer interfaces within the firm and between the firm and the exterior, Internet usage, the proportion of blue-collar and white-collar workers using computers, the division of responsibilities between IT departments, users, project groups and external service providers in designing system architectures and in choosing application software, in maintaining and administering systems, and in supporting and training users. Table 1 shows the results of this multiple correspondence analysis and the three composite variables derived from it.

The column headed "row totals" provides an overview of the diffusion of information technology in firms in 1997. All manufacturing firms with more than 50 employees were using computers by then, but computer use was more widespread in management departments than in production departments, with the smallest differential in the diffusion of non-networked personal computers.

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1 Moore's law states that chips double in processing power every eighteen months.

Most firms have the capacity to exchange data internally, either through a computer network or a mainframe system. In 1997, 70% of manufacturing firms with more than 50 employees used a computer interface for internal data transfers, 28% did so for data transfers with suppliers, subcontractors and service providers, 34% for data transfers with customers and 23% for data transfers with social security organisations and government agencies. At the same time, 41% of the firms surveyed reported Internet usage. For 16%, the Internet was used for e-mail, finding information and diffusing information. The scope of computerised exchanges is growing constantly with the development of computer networks, EDI links and the Internet. This development is transforming the relationships between departments within firms and firms'

Box 1

SURVEYS ON ORGANISATIONAL CHANGE AND COMPUTERISATION

In 1997, the Employment Research Centre coordinated a set of matched employer/employee Organisational Change And Computerisation Surveys (COI, 1997). The employee survey was conducted by the Department for the Coordination of Research and Statistics (Dares) and the employer surveys in the various sectors were conducted by the Energy and Manufacturing Statistics Department of the French Ministry of Industry (Sessi), the Central Department for Statistical Surveys and Research at the French Ministry of Agriculture (Scees) and the French National Institute of Statistics and Economic Studies (Insee) respectively. Previously, surveys on these issues had been carried out separately, with Sessi conducting the 1993 Organisational Change Survey of employers and the Work Techniques and Organisation Survey of employees being carried out by Insee in 1987 and by Dares in 1993. Greenan and Hamon-Cholet (2000b) provide details about these surveys.

Matched Employer/Employee Surveys

The surveys were designed after three years of interdisciplinary work by economists, managers and sociologists in a working group focusing on the impact of computerisation on performances (Foray and Mairesse, 1999, First Section). This work was supported by the National Centre for Scientific Research (CNRS), the National Centre for Telecoms Research (CNET), the General Planning Commission and the Higher Institute for Social Sciences (EHESS). Two major themes emerged from the group's work. Firstly, analysis of the impact of the diffusion of information and communications technology must be linked to analysis of the organisational changes that play a mediating role in the creation of innovative uses for this technology. Secondly, to construct a robust system for measuring organisational changes and computerisation, it is better to survey both employers and employees. The group's work led to a project for a set of matched employer/employee surveys (Caby et al., 1999) on organisational change and computerisation.

Three Questionnaires for the Employer Surveys

The field for these surveys was the manufacturing sector, agri-food industries, one service sector (accounting firms) and one retail sector (DIY stores). The firms were selected from the file of firms used for the Annual Enterprise Survey (EAE). The list of firms was then matched to the data from the employers' annual employment information returns (DADS) for 1996, from which a random sample of employees was selected in each firm.

The employer surveys are different depending on the sector. The manufacturing and agri-food industries questionnaire includes detailed questions about organisation and the computerisation process within the firm, whereas the retail trade and services questionnaires focus on how computer networks are organised between firms or establishments. These surveys were conducted by Sessi (Ministry of Industry) and Scees (Ministry of Agriculture and Fisheries), while Insee conducted the surveys of the retail trade and service sectors. The preliminary findings were published in 1998 and 1999 in the publications of the departments that produced the statistics: Favre, François and Greenan (1998) for the manufacturing industry, Roux and Miquel (1998) for the agri-food industries, Cases and Rouquette (1999) for accounting firms (see their article in this issue) and Chardon (1999) for DIY stores.

A Single Questionnaire for the Employee Surveys

All of the surveys use the same questionnaire for employees. It focuses on the employees' jobs, in terms of initiative, communication, pace of work, work evaluation and use of technology. Insee surveyed 9,000 employees in all on behalf of Dares. At the time of the survey, 10% of the respondents no longer worked for the same firm as when they were selected. Of the remaining 90%, 11% could not be reached, 8% were reached but refused to take part and 71% agreed to answer to the survey questionnaire. The preliminary findings presented in Greenan and Hamon-Cholet (2000a) rely on the matching of employers' and employees' answers to the questions relating to work organisation.

This study focuses solely on the manufacturing sector, including the agri-food industries. The response rate stood at 85% of the firms. The findings presented related to firms with more than 50 employees that had been in existence for at least one year at the time of the survey. The survey sample covered 3,205 firms and 4,430 employees.

Table 1
Computerisation of Firms in 1997

As an unweighted percentage of firms (weighted by the inverse of the sampling rate) N = 3,205		Intensity of computer use				Type of hardware		It structure		Row totals
		Low	Medium	High	Very high	Main-fram	Networked PCs	Weak	IT Dept.	
Firm uses...										
... a mainframe for management		38*	64	79	90	89	46	66	70	68 (60)
... a mainframe for production		20	48	67	87	74	38	34	57	56 (48)
... non-networked PCs for management		52	45	47	42	80	11	55	37	46 (46)
... non-networked PCs for production		35	38	39	42	67	9	45	29	38 (36)
... networked PCs for management		45	63	80	95	51	92	58	77	71 (66)
... networked PCs for production		23	43	64	89	36	75	42	59	55 (50)
Intensity of data transfers between departments of the firm via a computer interface										
Intensity is equal to 4 if the firm transfers data: - between management departments - between management and production departments - between design and production departments - between production departments	None	61	25	7	1	22	24	31	15	23 (30)
	1	24	25	13	3	19	13	9	22	16 (18)
	2	10	23	25	11	19	16	12	22	17 (17)
	3	4	19	30	30	21	21	13	28	21 (19)
	4	2	8	25	55	19	26	35	13	23 (16)
Intensity of data transfers with suppliers, subcontractors and service providers										
Intensity is equal to 3 if the firm transfers data: - between management departments and suppliers - between production departments and suppliers - between design departments and suppliers	None	93	81	66	26	67	65	64	68	66 (72)
	1	6	16	23	27	20	17	12	23	18 (16)
	2	1	2	7	21	7	9	7	9	8 (6)
	3	0	1	4	26	6	9	17	0	8 (5)
Intensity of data transfers with customers										
Intensity is equal to 2 if the firm transfers data: - between management departments and customer firms - between production departments and customer firms	None	87	72	54	26	58	60	61	58	59 (66)
	1	12	24	35	39	30	25	16	37	28 (24)
	2	1	4	11	36	12	15	23	5	13 (10)
Data transfers between the firm and social security organisations and government agencies										
Yes		11	20	30	42	28	24	27	25	26 (23)
Firm uses the Internet...										
No		86	62	43	15	54	47	53	49	51 (59)
... for e-mail only		2	5	5	3	3	5	2	5	4 (3)
... for diffusing information only		2	2	3	1	3	1	0	3	2 (2)
... for finding information only		2	8	9	12	9	7	5	11	8 (7)
... for e-mail and diffusing information		0	1	1	2	1	2	1	2	1 (1)
... for e-mail and finding information		3	10	19	29	14	16	12	18	15 (13)
... for diffusing and finding information		1	2	3	6	3	3	3	3	3 (2)
... for e-mail, diffusing and finding information		4	10	17	32	13	19	24	9	16 (13)
Percentage of white-collar employees using computers (managers, intermediate professions and workers)										
0% to 20%		23	5	2	1	8	7	12	3	7 (10)
21% to 40%		25	11	7	2	10	12	12	10	11 (12)
41% to 60%		24	28	22	15	26	18	15	28	22 (21)
61% to 80%		20	38	41	38	36	33	30	39	35 (33)
81% or more		8	18	28	44	20	30	31	20	25 (24)

Table 1 (continued)

As an unweighted percentage of firms (weighted by the inverse of the sampling rate) N = 3,205	Intensity of computer use				Type of hardware		It structure		Row totals
	Low	Medium	High	Very high	Main-fram	Networked PCs	Weak	IT Dept.	
Percentage of blue-collar employees using computers									
0% to 20%	89	82	70	50	76	69	65	78	72 (76)
21% to 40%	7	10	17	27	15	16	17	14	15 (13)
41% to 60%	2	4	6	12	5	7	8	4	6 (5)
61% to 80%	1	2	4	5	2	4	5	2	3 (3)
81% or more	1	2	3	6	2	5	5	2	3 (3)
Division of responsibilities for the five basic tasks of the IT function									
No IT department	60	18	4	2	16	25	35	7	20 (28)
IT department responsible for 1 to 4 tasks	27	42	44	39	37	39	22	52	38 (36)
IT department responsible for 5 tasks	13	40	52	59	47	36	43	41	42 (36)
Users not involved	55	56	54	46	49	56	43	61	53 (54)
Users involved in 1 task	13	24	27	32	28	21	20	28	24 (22)
Users involved in 2 to 5 tasks	32	20	19	22	23	23	37	11	23 (24)
No project groups	75	57	48	33	55	51	59	47	53 (60)
A project group is involved in 1 task	5	16	22	34	21	18	11	27	20 (15)
A project group is involved in 2 to 5 tasks	20	27	30	33	24	31	30	26	28 (25)
No outside providers	19	27	28	28	25	26	29	22	25 (24)
Outside providers involved in 1 to 2 tasks	20	38	47	51	44	35	23	53	39 (36)
Outside providers involved in 3 to 5 tasks	61	35	25	21	31	39	48	25	35 (40)
Column totals	24 (34)	24 (27)	26 (23)	26 (16)	51 (49)	49 (51)	54 (52)	46 (48)	

Key: 38% of the firms with low intensity of computer use have a mainframe for management.
Field: Manufacturing firms with more than 50 employees, including agri-food firms.
Source: Employers survey of the 1997 Organisational Change and Computerisation *Surveys, MEFI - Sessi, MAP - Scees.*

Box 2

MEASURING COMPUTERISATION, ORGANISATION AND CHANGES

There are several different ways of measuring how firms use information and communications technology (Greenan, 1999). The measurements most commonly used for economic research are purely quantitative. The most common measurement is "IT capital," which is derived from national accounts data in macro-economic and sectoral research, or derived from firm's IT budgets in research using individual data (see articles by Cette, Mairesse and Kocoglu and by Crépon and Heckel in this issue). Greenan and Mairesse (2000) and Greenan, Mairesse and Topiol-Bensaid (1999 and 2001) propose two other types of quantitative measurements: the proportion of employees working on computers and the number of employees working to maintain the firm's computers and other electronic equipment.

Considering Qualitative Effects and Organisational Changes

The variables used here provide more information because they attempt to capture the diversity of firms' uses of IT hardware and instead of just providing a quantitative measurement. In addition to looking at the proportion of employees using computers, the variables compare several qualitative criteria. Measuring organisation and organisational changes is just as complex, if not more so. There are no quantitative measurements in this area. Organisation can only be measured using a set of qualitative variables (Greenan, 1996 and 2001).

The set of criteria covered by the survey are not randomly distributed in the population of firms. Some of them are mutually reinforcing and others oppose each other. Overall, the population of firms clusters around different computerisation and organisational "configurations". There is much lively debate amongst economists about the forces shaping these "configurations," but these issues are not addressed here. Multiple Correspondence Analysis (MCA) can be used to identify them by summarising the data into a few indicators that show how the variables converge within the population of firms.

The composite indicators comply with the parsimony principle in the presentation of the findings. They enable us to speak of orderings of the variables instead of the variables in isolation. This leads to a more precise and more parsimonious description of the statistical universe. In addition, regressions on these variables are "better" than those on the primary variables because the Fisher statistic is systematically greater.

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external relationships. This transformation was just starting in 1994, which makes it reasonable to expect that the figures are much higher today than they were in 1997.

Whereas, management employees, intermediate professions and white-collar workers are very likely to use computers, computer use is much more restricted for blue-collar workers. This is

Box 2 (continued)

Measuring and Comparing the Effects of Computerisation and Organisational Changes

Four multiple correspondence analyses were carried out on the employer data from the Organisational Change and Computerisation Surveys (COI). The first two summarised the characteristics of computer use in 1997 and the changes that took place between 1994 and 1997. Two more multiple correspondence analyses were taken from Greenan and Mairesse (1999), on the use of new organisational structures in 1997 and on organisational changes that took place between 1994 and 1997.

Tables 1 and 2 show the multiple correspondence analysis findings on the status and change in computer use. The first multiple correspondence analysis is based on a set of 17 multinomial qualitative variables (48 categories) derived from a set of 57 questions describing the firm's use of computers in 1997. The questions are those in groups 16, 17, 18, 19 and 20 in the employer survey in manufacturing (see Favre, François and Greenan (1998) for the questionnaire and the table sort of the answers to the questions). The second multiple correspondence analysis is based on questions dealing with computer hardware and data transfers (questions 16 and 19) where firms were asked to describe their situations in 1994 and in 1997. Questions dealing with the Internet were included in the multiple correspondence analysis, despite the fact that only the situation in 1997 is described. The Internet was so young in 1997 that we can presume that nearly all of the firms with Internet access in 1997 had started using it sometime between 1994 and 1997. There are 17 variables (43 categories) that play an active role in the second multiple correspondence analysis.

The composite variables describing the firm's computer use in 1997 measure the intensity of computer use, the structure of the system based on a mainframe or networked personal computers and the organisation of the IT function around an IT department or a structure that relies heavily on users and external service providers. The composite variables are derived from the firms' positions on the first three axes of the multiple correspondence analysis (eigenvalues: 0.46, 0.38, 0.31; percentages of explained inertia: 9%, 6%, 4%). The positions on the 3rd axis have been adjusted for the Guttman effect[1]. The unadjusted positions have been replaced by the residuals from the regression on the first axis and their squares, using the method that J.-C. Deville suggested to us.

Two variables capture changes in computer use between 1994 and 1997. The first reflects the intensity of change (derived from the first axis, eigenvalue 0.46; percentage of explained inertia 14%) and the second reflects the focus of change on new hardware or on data transfers (derived from the second axis: eigenvalue: 0.36, percentage of explained inertia 8%).

Tables 3 and 4 show the multiple correspondence analysis findings on the use of "new" organisational structures in 1997. The findings are based on 61 questions from groups 3, 4, 5, 6, 7, 10 and 14 in the "manufacturing" questionnaire (20 variables, 50 categories) and on organisational changes introduced between 1994 and 1997. The latter changes are captured by questions 3, 4, 6, 7 and 14 with a description of the situation in 1994 and in 1997 (14 variables, 35 categories).

Three composite variables are derived. The first describes the intensity of use of new organisational structures in 1997 (1st axis, eigenvalue: 0.46; percentage of explained inertia: 14%). The second describes the focus of these new structures on quality standards and quality management or on just-in-time management (2nd and 3rd axes, eigenvalues: 0.29 and 0.28; percentages of explained inertia: 6% and 5%). The third composite variable describes the intensity of market or pseudo-market rationales (4th axis, eigenvalue: 0.25; percentage of explained inertia: 4%). Three further variables describe organisational changes between 1994 and 1997. The first describes the intensity of change (1st axis, eigenvalue: 0.52; percentage of explained inertia: 19%). The second describes the intensity of the increase in operators' and specialists' responsibilities (2nd and 3rd axes, eigenvalues: 0.35 and 0.30, percentages of explained inertia: 8% and 6%). The third describes the direction of organisational change (4th and 5th axes, eigenvalues: 0.29 and 0.28; percentages of explained inertia: 6% and 5%).

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1 It often happens that some of the factors in a correspondence analysis approximate polynomial functions of the factors on lower axes. The degrees of these polynomials increase for factors on higher axes, (Benzecri, 1973). This is the "Guttman effect." This is particularly the case when a non-observable normal continuous variable underlies the active discrete variables being observed and analysed (Saporta, 1975). A given factor b, *which is parabolic quadratic function of a given factor* a, *can be, as Guttman suggested, interpreted as a degree of intensity of factor* a. *Factor* b *opposes the extreme values of* a *to the mean values. If the functional relationship is perfect,* b *does not provide any new information about* a. *But, as a rule, the relationship is approximate. This enables us to distinguish observations that are very typical of a mean level of intensity of* a, *but which fall outside of the parabola, from observations that combine characteristics associated with low values of* a *with characteristics associated with high levels of* a *and still fall within the parabola. In the present case,* a *is the level of computerisation. As J.-C. Deville suggested, it may be better to replace* b *with the extra information that this factor provide with regard to* a, *which means the residuals from the linear fitting of* b *to* a *and* a^2.

a constant in the computer diffusion process, which is also shown in another way by the unequal use of computers in production and management functions (see below).

In 1997, about one third of manufacturing firms had no IT department and half did not use external service providers and a quarter used the project group model to organise IT functions.

The most highly computerised firms have the most diverse range of hardware...

We used the positions of firms on the first thee axes of the multiple correspondence analysis based on 17 variables to construct three composite variables (see columns in Table 1). The distribution of these 17 variables is examined in the rows of Table 1.

The first composite variable can be interpreted as describing the *intensity of computer use*. It shows a form of hardware cumulativeness. The first major distinction is between firms with a great deal of hardware and those with very little. Intensive computer use is characteristic of firms that operate a wide range of hardware in both management and production functions, firms where more employees than average work with computers, firms that use more data transfers inside and outside the firm and firms that make more frequent use of the Internet. On the contrary, non-networked computers used only for management functions, low numbers of employees working with computers and low numbers of data transfers, which are only made within the firm, are characteristic of a lower level of computerisation. The survey population can be divided into four groups of firms depending on the intensity of their computer use: moderate (34%), medium (27%), high (23%) and very high (16%).

In addition to the intensity of use, two other variables characterise computerisation in firms: *hardware choices and organisation of the IT function*. Manufacturing firms either opt for hardware configurations based on a mainframe or a network of personal computers. The "mainframe" option may very well coexist with non-networked personal computers, whereas the "network" option usually incorporates all of the personal computers in the firm. The option chosen does not seem to have an impact on the pattern of data transfers. Mainframe vendors have been able to adapt to the needs of manufacturing firms by bundling software for intra-firm data transfers with their machines. The choice between a mainframe and a network can be made by firms at any level of computer use; it is not directly linked to the proportion of employees working with computers.

About half of the firms have a dedicated IT department. These IT departments sometimes set up project groups to discuss choices concerning system architectures, hardware and software. They may occasionally call on external service providers, particularly for user training.

In the other half of the firms, the main feature of the IT function is that it relies on major contributions from users and external service providers. This configuration can be found in firms that do not have an IT department (35%), but it is also found in firms that have IT departments. The same is true of firms using project groups. In firms with no IT department, where project groups are used, the level of computer use is low. On the other hand, in firms that rely on project groups and have their own IT departments, the level of computer use is high and involves exchanges of data with entities outside the firm.

... and upgrade their hardware more often

The *Organisational Change and Computerisation Surveys* (COI) combine the description of the situation in 1997 with a description of the changes that took place between 1994 and 1997. Respondents were asked to describe changes in the hardware used and data transfer practices between these two dates. Table 2 has been compiled using the same principles as Table 1, but it focuses on these changes.

Firms invested in IT at the end of the nineteen-nineties to prepare for a series of foreseeable shocks, such as the Y2K bug, the changeover to the euro and the obsolescence of software and hardware.

The most common change made in hardware was to introduce networked personal computers (28% in production functions and 36% in management functions). However, about 10% of the firms adopted a mainframe system in their production or management functions, whereas the proportion of firms introducing non-networked personal computers was nearly the same as the

proportion of firms replacing them (approximately 12%). In terms of data transfers, firms primarily set up new internal links between management departments (25%), between management and production departments (19%), between production departments (15%) and between design and production departments (15%). They also established links between management departments and customers (18%), suppliers (13%) and social security organisations and government agencies (12%).

As in the case of the level of computer use, the first composite variable describes the intensity of change in computers: 35% of manufacturing firms with more than 50 employees did not upgrade their computers at all. Half of these are firms with a low level of computer use that did not make any effort to upgrade their hardware and another 10% were firms that already had very intense computer use. At the other extreme, 17% of the firms made significant changes in their computer use between 1994

Table 2
Computerisation Changes between 1994 and 1997

As an unweighted percentage of firms (weighted by the inverse of the sampling rate) N = 3,205	Intensity of computerisation changes				Changes involve...		Row totals
	Low	Medium	High	Very high	... hard-ware	... trans-fers	
Type of computer hardware change: introduction of a mainframe...							
... for production departments	1	11	13	23	17	6	11 (11)
... for management departments	1	9	12	19	17	4	9 (10)
Type of computer hardware change: introduction of non-networked PCs...							
... for production departments	6	16	18	14	22	6	13 (13)
... for management departments	6	14	14	12	17	7	12 (12)
Type of computer hardware change: replacement of non-networked PCs...							
... for production departments	0	4	21	37	29	1	13 (11)
... for management departments	0	8	28	40	35	2	16 (14)
Type of computer hardware change: introduction of networked PCs...							
... for production departments	1	24	51	68	59	11	32 (28)
... for management departments	7	35	60	73	73	14	39 (36)
Development of data transfers via a computer interface...							
... between management departments	4	19	33	57	23	27	25 (25)
... between management and production departments	0	8	28	58	22	18	20 (19)
... between management departments and suppliers	0	10	16	44	10	19	15 (13)
... between management departments and customer firms	2	15	28	49	15	25	21 (18)
... between management departments and social security organisations and government agencies	2	11	17	26	8	16	13 (12)
... between design and production departments	0	7	19	50	13	18	16 (15)
... between design departments and suppliers	0	5	11	37	5	15	11 (9)
... between production departments	0	6	19	53	16	17	16 (15)
... between production departments and suppliers	0	2	7	32	4	12	8 (7)
... between production departments and customer firms	0	5	10	29	4	14	10 (9)
Firm uses the Internet...							
No	73	51	40	27	49	52	51 (59)
... for e-mail only	2	4	6	5	4	4	4 (3)
... for diffusing information only	1	2	2	2	2	2	2 (2)
... for finding information only	4	11	10	8	9	7	8 (7)
... for e-mail and diffusing information	1	1	1	3	1	1	1 (1)
... for e-mail and finding information	8	14	19	25	17	14	15 (13)
... for diffusing and finding information	2	3	4	5	3	3	3 (2)
... for e-mail, diffusing and finding information	9	14	19	25	15	17	16 (13)
Column totals	30 (35)	30 (30)	20 (18)	20 (17)	43 (41)	57 (59)	

Key: 1% of the firms with low intensity of change in computerisation between 1994 and 1997 introduced a mainframe in their production departments.
Field: Manufacturing firms with more than 50 employees, including agri-food firms.
Source: Employers survey of the 1997 Organisational Change and Computerisation *Surveys, MEFI - Sessi, MAP - Scees.*

and 1997 and, in 1997, 60% of these firms had very intense computer use.

The firms making changes in their computer systems either focused on upgrading their hardware or on developing data links with their customers and suppliers. In the first case, the development of data transfers focused on internal communications, whereas, in the second case, the firm's strategy aimed at opening up to the outside by developing all possible links with customers and suppliers. However, these two approaches cannot be distinguished on the basis of the intensity of Internet usage or the types of uses involved.

Computerisation is Part and Parcel of Organisational Change

As Breton (1990) reminds us, the French word for computer is "ordinateur" and not "calculateur." The term "ordinateur" was chosen to stress that the machine is used chiefly to set information in order and organise it. In fact, computerisation is part of a much broader movement to reorganise (Veltz and Sarifian, 1993) and rationalise production and knowledge in business firms (Foray, 2000).

The movement is based on information technology and on the many changes that have affected the organisation of production and the organisation of product and process design. Simply put, we can say that a firm is composed of a production system that manages the flows and transformation of raw materials and products and an information system that manages flows of information and the production of collective knowledge (Greenan, 2001). IT is primarily a tool for organising the information system. For example, when a firm computerises its catalogue of products and services, it formalises and stores information about its business that can then be distributed more easily. But IT also plays a role in the interface between the information system and the production system. This means that when a firm establishes a computer link with a subcontractor, it transforms the operation of one segment of its production process.

Computerisation goes hand in hand with new organisational structures

The *Organisational Change and Computerisation Surveys* were designed to capture both computerisation and organisational practices in firms. The surveys therefore describe the use of a set of management tools or organisational structures.

The management tools covered in the *Organisational Change and Computerisation Surveys* take the form of set procedures, working methods and operating principles. They were chosen because they were described as "new" or "modern" at the time the survey was conducted, yet were sufficiently well known for the related vocabulary to be familiar to the managers surveyed. Greenan and Mairesse (1999) discuss how to measure these tools and the organisational changes involved in their introduction. Their impact on employees' tasks is discussed in Greenan and Mairesse (1999) and in Greenan and Hamon-Cholet (2000a). This paper provides only an outline of the organisational practices in the firms surveyed.

The new management tools are intended to manage *quality issues* (ISO certification, total quality management, value analysis, function analysis and failure mode, effects and criticality analysis-FMECA), *time constraints* (just-in-time production and delivery systems, preventive maintenance systems), *internal transactions* (profit centres, internal customer/supplier contracts), the *boundaries of the firm* (sub-contracting, outsourcing), *employee motivation structures* (self-managed work groups, problem-solving groups and project teams) (see Box 3). Firms were asked to specify the number of management layers and how responsibilities on the shop floor were divided between management, operators and specialists[2]. These questions captured some of the effects related to the management tools covered, since the tools were often described as introducing decentralised operational decision-making with the effect of flattening management structures, empowering operators and making their jobs more rewarding.

Table 3 describes the use of new organisational structures in manufacturing firms with more than 50 employees in 1997. The column headed

2 We examined the division of responsibility for 10 "indirect" shop-floor tasks: adjusting machines, 1st level maintenance, assigning tasks to operators, controlling the quality of supplies and production, participating in productivity improvements and project teams, stopping production, preliminary analysis and resuming production in the event of a failure. The categories of personnel considered are: operators, management, and specialists. The survey specified that management included all of the employees with formalised authority over other employees, that operators were workers directly involved in production either individually or as members of working groups; and that specialists were employees with specific technical skills such as quality or maintenance, whose activity is specialised in their field.

Box 3

NEW ORGANISATIONAL STRUCTURES: TOOLS FOR MAKING PRODUCTION PROCESSES MORE FLEXIBLE

A - New Structures to Manage Quality

ISO 9001, ISO 9002 and EAQF Certification

ISO 9001, ISO 9002 and the French automotive manufacturers' EAQF standards describe a set of procedures to be followed in order to attain a quality objective. The standards may address production, but they also cover other areas of the firm's activity, such as training and research. These structures are referred to in the body of the text under the term "*ISO certification*".

Other Certification Systems or Total Quality Management Approaches

The firm may also have obtained certification under other standards, such as ISO 9003 or other certification systems, or it may be engaged in a total quality management programme that has not yet been certified. This is what the body of the text refers to as "*total quality management*". The ISO certification described in the preceding paragraph appears to be more demanding and more formalised that the "*total quality management*" described here.

Quality Guarantees Obtained from Suppliers

Firms may require their suppliers to provide quality guarantees and to comply with ISO standards or other formalised quality management systems.

Value Analysis, Function Analysis and FMECA

FMECA stands for Failure Mode, Effects and Criticality Analysis. The purpose of these three methods is to analyse the impact of design choices on processes and products in terms of product value for the customer, machine failures, security, etc. This is referred to as "*product and process analysis*" in the body of the text. These organisational structures are more recent than the ones previously discussed, but they are part of same vast drive to achieve greater control of quality issues.

B - New Structures to Manage Time Constraints

Just-in-Time Customer Deliveries

Firms offer deliveries at the customers' discretion and at very short notice. This enables the customers to operate with very small inventories.

Just-in-Time Deliveries from Suppliers

In the same way that firms may require suppliers to provide quality guarantees, they may also require their suppliers to introduce just-in-time delivery systems.

Just-in-Time Production Systems

Firms may start production only when they receive customer orders and still provide rapid delivery. This is a more demanding system than just-in-time deliveries since it puts pressure on all of the firms' processes and not just on packing and shipping. Just-in-time production is also linked to customised orders. Firms cannot produce and stockpile goods if customers demand specific options. Other expressions, such as "lean" manufacturing or "agile" manufacturing are used to describe similar production systems.

5S Method and Total Productive Maintenance (TPM)

The 5S method comes from Japan. The 5 S-terms translate as sort, set in order, shine, standardise and sustain. TPM and 5S are aimed at motivating operators to improve equipment by systematising the collection and analysis of information about leaks, frequently-occurring minor failures, access problems, degraded operating modes, etc. This is referred to as "preventive maintenance." The methods involved are more recent than those used for just-in-time systems. We could categorise these methods with the new structures introduced to manage quality issues. However, they are aimed at preventive management of local production problems and rapid remedies when problems arise. This means that they are helpful tools for management of the tight deadlines and delivery times that make any failure a very costly event.

C - New Structures to Manage Firms' Boundaries

Profit Centres

A profit centre is a unit within a firm that has some fiscal latitude and relative freedom to make its own choices. It is often backed up by an internal accounting system that is used to measure the unit's profit. Thus a firm may have regional profit centres or, if it is engaged in several different sectors (e.g. glass and cardboard), each line of business could be constituted as a profit centre.

Formalised Intra-Firm Customer/Supplier Contracts

Firms that use formalised intra-firm customer/supplier contracts manage internal exchanges of goods and services as if they were occurring on a market. In a profit-centre structure, intra-firm customer/supplier contracts create market mechanisms inside the firm. These are referred to as "*pseudo-market structures*".

Subcontracting

The questionnaire asked firms if they used subcontracting to match their production capacity to demand. Therefore, the subcontracting measured is capacity-related subcontracting, meaning a situation where a firm delegates part of its production to another firm.

➔

"row totals" shows their distribution in the total population and the other columns show the three composite variables derived using the same method as for the composite computer use variables discussed above.

New Directions in Industrial Rationale and Intensity of the Market Rationale

The cumulativeness of organisational structures is comparable to that of computer hardware. Firms can first be divided into those that do not make much use of them and those that use practically all of them. The intensity of use of new organisational structures goes hand in hand with a greater number of management layers. This shows that there is a size effect and closer involvement of operators and specialists in the "indirect" tasks that make up the daily work on the shop floor.

The other two composite variables focus on the specific directions taken through the combinations of structures introduced. The second variable shows the opposition between an industrial rationale based on quality and a rationale that is more concerned with cutting all costs with just-in-time management. Firms that favour just-in-time management have less complex structures than firms that focus on quality control. On average, the former have fewer management layers, their specialists are less involved in shop-floor issues and they outsource less work. Observations in the field show that this type of organisational structure is common for subcontractors since it meets their customers' requirements (Gorgeu and Mathieu, 1995). Quality control methods and just-in-time management may or may not be used with a system for motivating blue-collar workers through working team or group structures such as self-managing work teams, problem-solving groups and project teams. Where such systems exist, they are more likely to involve a smaller role for management on the shop floor and broader responsibilities for operators.

The third variable, which we have called market rationale intensity, shows how internal transactions have become contractualised as a result of organisational structures based on profit centres and the introduction of intra-firm customer/supplier contracts, as well as production that relies on market mechanisms by using subcontractors, production that involves suppliers in the design of the end product and outsourcing. The more intensive the market rationale, the fewer areas are subject to management and specialist intervention on the shop floor. On the other hand, the breadth of operators' responsibilities is not sensitive to this variable and there is no clear correlation to the number of management layers.

Changes Based on Just-in-Time Management or Product and Process Analysis

As was the case for computer use, some of the survey data can be used to capture organisational changes between 1994 and 1997

Box 3 (continued)

Outsourcing

Firms may decide to outsource certain functions. This means they hire other firms to carry them out. The most frequently outsourced functions relate to legal services, telephony and networks. When firms outsource and subcontract, they are turning to the market to organise their own production. Both these situations are referred to as "market rationale" in the body of the text.

D - New Structures to Manage Employee Commitment

Self-Managed Working Groups

These are groups of blue-collar or white-collar workers who are collectively responsible for a set of activities. The groups are given relative freedom to organise their internal structures. The groups work together on an ongoing basis.

Problem-Solving Groups

These are groups of blue-collar or white-collar workers who meet regularly to address problems that have come up and to find solutions for them.

Project Groups

These are cross-disciplinary groups of employees who meet as needed to set up a new project (e.g. product innovations). The groups include specialists from different departments in the firm and, occasionally, operators (blue-collar employees, supervisors and technicians). Self-managed work groups, problem-solving groups and project groups are intended to promote greater commitment from employees through group structures. These are referred to collectively as "*employee motivation structures*" in the body of the text.

Table 3
Use of New Organisational Structures in 1997

As an unweighted percentage of firms (weighted by the inverse of the sampling rate) N = 3,205	Intensity of use of new organisational structures				Focus on…				Intensity of the market rationale				Row totals
					... quality		... just-in-time						
	Low	Medium	High	Very high	Without teams	With teams	Without teams	With teams	Low	Medium	High	Very high	
Organisational structures for managing quality													
ISO certification	17*	56	70	89	70	71	48	40	59	54	58	58	57 (49)
Other total quality management approach	14	33	50	68	43	50	34	38	39	41	40	44	41 (35)
Value analysis, function analysis, FMECA	2	15	40	79	39	37	29	27	34	33	31	35	33 (26)
Quality certification required of suppliers	28	76	90	98	85	83	68	53	71	71	73	74	72 (66)
Involvement of suppliers in product design	22	42	51	67	51	42	48	38	22	41	49	70	45 (42)
Organisational structures for managing time constraints													
Just-in-time deliveries	7	31	55	84	32	10	81	46	51	44	38	40	44 (39)
Just-in-time production	9	26	52	81	28	8	78	47	45	43	40	37	41 (38)
Preventive maintenance (5S or TPM)	0	5	22	63	22	24	20	23	26	24	20	19	22 (16)
Just-in-time deliveries required of suppliers	24	46	64	87	50	22	85	55	51	55	57	55	55 (52)
Involvement of more than 10% of production employees in...													
... self-managed work teams	10	24	37	61	7	42	24	61	31	32	31	35	32 (30)
... problem-solving groups	6	19	39	73	9	54	17	61	43	35	30	26	34 (29)
... project teams	4	14	27	45	2	39	3	51	27	22	21	19	22 (19)
Pseudo-market structures													
Profit-centres	13	31	47	66	44	41	34	35	23	36	39	56	39 (31)
Formalised internal customer/ supplier contracts	9	24	41	61	32	32	37	32	17	30	35	51	33 (29)
Reliance on market													
No outsourcing	33	25	22	24	18	23	28	37	18	24	32	31	26 (27)
One or two outsourced functions	29	30	30	26	35	29	25	26	33	29	27	26	29 (28)
Three to five outsourced functions	25	26	29	25	27	25	30	22	33	28	23	20	26 (27)
Six to fifteen outsourced functions	13	19	19	25	20	23	17	15	16	19	19	23	19 (18)
Use of subcontractors to adjust production capacity	49	51	56	67	67	50	57	47	29	51	68	75	56 (55)
Management responsibilities measured on the basis of a list of 10 indirect tasks on the shop floor													
Zero to three tasks	23	21	17	16	7	21	17	33	1	5	16	56	19 (20)
Four or five tasks	18	25	25	31	29	26	25	18	21	28	31	19	25 (23)
Six or seven tasks	34	32	36	35	47	34	30	23	32	40	41	22	34 (33)
Eight to ten tasks	26	22	22	18	17	19	28	26	46	27	12	3	22 (24)
Operators' responsibilities measured on the basis of the same list of 10 indirect tasks on the shop floor													
Zero to two tasks	48	26	12	4	19	18	25	30	9	19	27	39	23 (27)
Three or four tasks	24	29	26	15	33	18	26	15	31	27	22	14	24 (25)
Five or six tasks	19	27	31	30	32	28	26	19	35	27	24	19	26 (26)
Seven to ten tasks	9	18	31	51	16	36	22	36	25	27	27	28	27 (22)
Specialists' responsibilities measured on the basis of the same list of 10 indirect tasks on the shop floor													
Zero to one tasks	49	25	17	12	10	22	27	45	17	25	25	37	26 (31)
Two or three tasks	27	24	20	15	25	19	25	16	17	22	26	21	21 (23)
Four to six tasks	17	34	37	38	38	35	30	21	23	32	36	34	31 (28)
Seven to ten tasks	69	17	26	39	27	24	18	18	43	21	14	8	22 (18)
Number of management layers between operators and head of firm													
Zero to two layers	38	20	15	8	8	10	29	35	13	23	22	25	21 (28)
Three layers	31	27	29	20	21	25	31	30	42	30	21	14	27 (30)
Four layers	20	33	26	34	34	27	28	23	14	20	35	44	28 (25)
Five or more layers	11	20	30	38	37	38	12	12	31	27	22	17	24 (17)
Column totals	26 (33)	27 (28)	23 (22)	25 (17)	28 (25)	21 (19)	26 (29)	25 (27)	26 (25)	26 (26)	24 (25)	25 (24)	

Key: 17% of the firms with low intensity of use of new organisational structure are ISO certified.
Field: Manufacturing firms with more than 50 employees, including agri-food firms.
Source: Employers survey of the 1997 Organisational Change and Computerisation *Surveys, MEFI - Sessi, MAP - Scees.*

(see Table 4). Once again, the first composite variable shows the intensity of organisational change. Approximately four out of ten firms did not introduce any of the changes covered by the survey. Three out of ten made marginal changes, whereas one out of six made most of the changes. Each new organisational tool is more likely to be introduced if the others already have been. The only exception is the use of subcontractors, since increases and decreases in subcontracting are positively related to the intensity of change. Organisational change is associated with a smaller role for management, an expansion of operators' and specialists' responsibilities and a flatter management structure. Even though there are a wide variety of production models (Boyer and Freyssenet, 2000) and organisational changes (Veltz and Zarifian, 1993), the findings compare observations in the field (Ichniowski, Shaw and Prennushi, 1997) and the findings of an earlier national survey carried out by SESSI in 1993 (Greenan, 1996)[3].

The other two composite variables describe changes in areas of responsibility on the shop floor and the direction shown by choices of new organisational structures. The respective areas of responsibility for management, operators and specialists remained unchanged in two thirds of the firms and changed in the others. According to the firms, the number of management layers decreased or increased in line with changes in areas of responsibility.

Organisational changes were either made as part of the development of just-in-time management, or to accompany the introduction of product and process analysis (value analysis, function analysis and FMECA) or preventive maintenance methods (5S and total productive maintenance – TPM). Each firm's pattern of change can show either a predominance of internal changes or external changes. When the underlying push for organisational change comes from the introduction of just-in-time management and there is predominance of internal changes, the firm is more likely to adopt organisational structures related to quality. In this case, the operators' breadth of responsibilities expands, but only moderately so, the specialists' role on the shop floor expands substantially and, in one third of these firms, the number of management layers increases. On the other hand, when the organisational changes focus on external relationships, firms introducing just-in-time management develop the market rationale, with an increase in sub-contracting and outsourcing of more than three new functions.

Organisational change is much less intense in firms that focus on product and process analysis or preventive maintenance methods, while keeping the emphasis on their internal operations. Firms in this category are less likely to introduce all of the new organisational structures, other than product and process analysis and preventive maintenance methods. When the introduction of such structures comes with a change in the firm's external relationships, the latter change cannot be interpreted as development of a market rationale. Even though one or two more functions may be outsourced, there is a substantial decrease in the use of subcontractors. Such firms also develop ISO standards and quality management, without actually changing the division of responsibilities on the shop floor and one half of such firms shed a management layer.

There is no such thing as technological determinism

What links can we expect to find between computerisation and organisation, and between technological change and organisational change? The theoretical literature on the subject provides only one clear answer, which is that information technology opens up new organisational possibilities. All the other issues are still open questions and a wide variety of answers have been found (Greenan, 2001).

For example, there is a debate about the impact of information technology on communication costs. We would expect the impact of growing computer use on organisational choices to vary according to the costs. Intuitively, we expect such costs to fall when computers are used. However, some observers maintain that the cost of transferring information is the only cost that decreases. Communication also implies that the information transmitted is understood as well. Yet, when computers are used, we are tempted to be less selective about the information we send, which makes it more complicated for the recipient to process and analyse the information received. In this way, the use of computers would tend to push up the overall cost of communication.

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3 The development of specialists' prerogatives, which showed up in statistics starting in 1993, is the only phenomenon that has not been widely discussed or explained in the literature.

We also read frequently that the use of computers encourages firms to decentralise. Some theoretical work has produced findings that could be interpreted as upholding this view. Decentralisation can even extend beyond a firm's own boundaries, since computers enable firms to work with their subcontractors and service providers as if they were an integral part of the firm. In this case, computers are used to share knowledge about production and supervise partners' work (Guilloux, 1992; Caby and Jaeger, 1998).

Table 4
Organisational Changes between 1994 and 1997

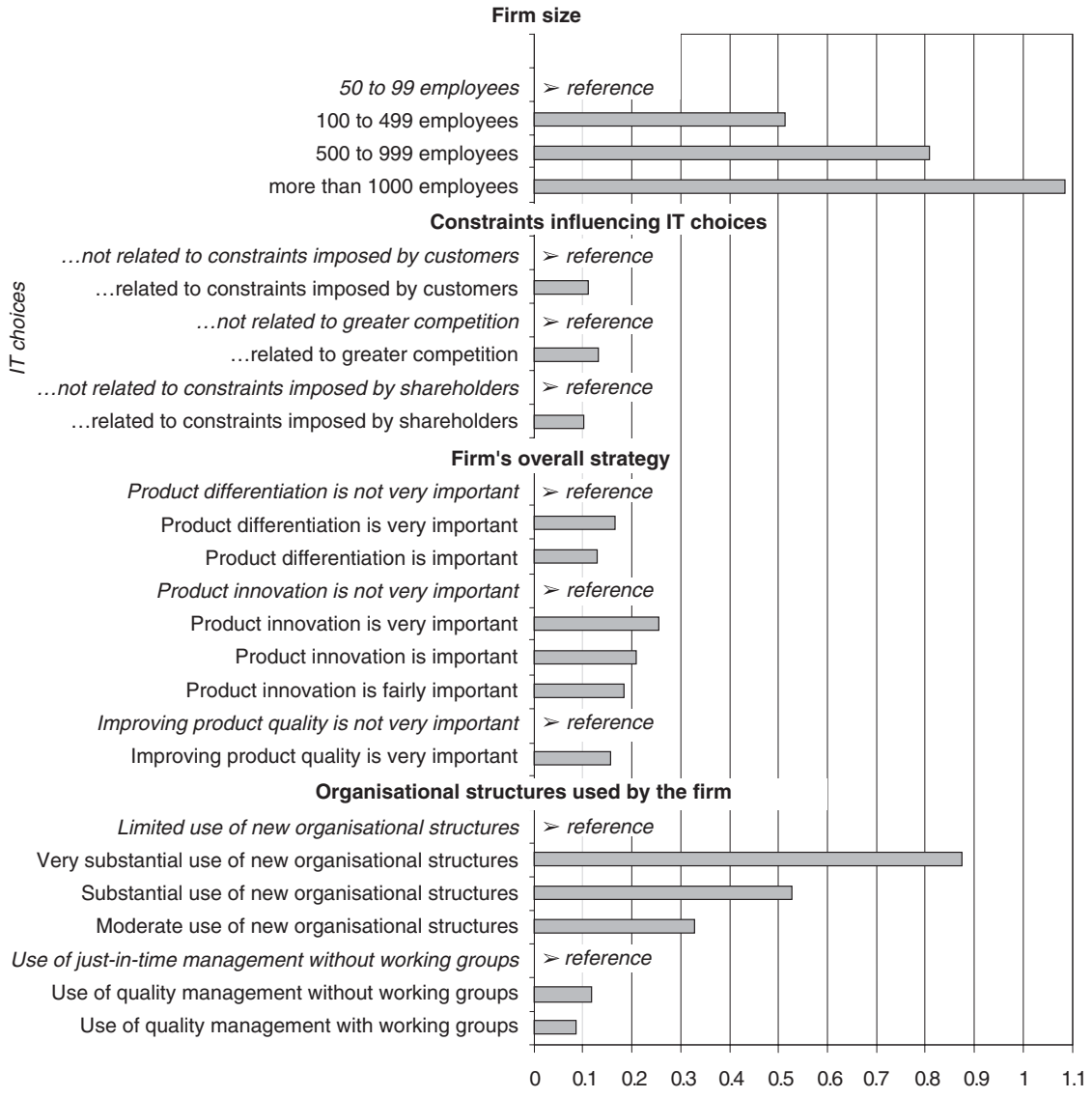
As an unweighted percentage of firms (weighted by the inverse of the sampling rate) N = 3,205	Intensity of organisational changes between 1994 and 1997				Intensity of increase in operators' and specialists' responsibilities			Changes focus on...				Row totals
								…TPM et FMECA		... Just-in-time		
	Low	Medium	High	Very high	Stable	Medium	High	Internal	External	Internal	External	
Development of organisational structures for managing quality												
ISO certification	0	39*	54	76	39	34	33	26	48	42	36	37 (31)
Other total quality management approach	0	19	36	57	23	28	21	11	43	29	15	24 (20)
Value analysis, function analysis, FMECA	0	4	20	61	17	19	16	14	31	14	9	17 (13)
Development of organisational structures for managing time constraints												
Just-in-time deliveries	0	4	32	72	24	15	22	7	17	38	38	22 (19)
Just-in-time production	0	3	32	69	24	13	21	7	16	37	36	21 (18)
Preventive maintenance (5S or TPM)	0	4	17	52	14	18	15	13	26	13	6	15 (10)
Development of pseudo-market structures												
Profit-centres	0	6	18	45	16	11	10	10	17	15	17	14 (10)
Formalised internal customer/ supplier contracts	0	4	21	53	18	11	15	10	16	22	20	16 (13)
Development of reliance on market												
No increase in outsourcing	83	55	46	35	61	45	65	83	47	47	42	58 (61)
One or two new outsourced functions	12	29	28	29	22	31	19	10	47	23	15	23 (22)
Three to fifteen new outsourced functions	5	16	26	36	17	24	16	7	6	30	43	19 (17)
Decrease in use of subcontractors	8	22	24	31	19	24	17	8	5	19	57	20 (19)
Increase in use of subcontractors	2	6	8	11	4	7	12	2	14	8	0	6 (5)
Decrease in managers' responsibilities measured by the number of tasks they are involved in												
Zero tasks	100	91	79	67	99	64	65	91	90	79	82	87 (88)
One or two tasks	0	7	15	22	1	36	6	7	6	13	14	9 (8)
Three or more tasks	0	2	6	11	0	0	29	2	4	8	4	4 (4)
Increase in operators' responsibilities measured by the number of tasks they are												
Zero tasks	97	68	45	25	83	21	38	78	61	37	69	64 (70)
One to three tasks	3	25	34	34	13	52	13	2	25	56	17	22 (19)
Four or more tasks	0	7	21	41	4	27	49	19	14	7	14	14 (11)
Increase in specialists' responsibilities measured by the number of tasks they are involved in												
Zero tasks	99	86	76	67	98	53	65	86	93	78	74	84 (85)
One or two tasks	1	11	17	24	2	45	7	14	5	4	24	12 (11)
Three or more tasks	0	3	7	9	0	2	28	0	2	18	2	4 (4)
Change in the number of management layers between operators and head of firm												
No change	89	73	59	45	86	45	29	83	57	48	83	70 (73)
Increase by one layer	6	9	9	6	4	14	14	0	0	33	5	7 (9)
Decrease by one layer	5	15	27	35	8	35	42	8	43	19	5	18 (15)
Decrease by two or more layers	0	3	5	14	2	6	15	9	0	0	7	5 (3)
Column totals	31 (38)	29 (29)	20 (18)	20 (15)	65 (67)	22 (20)	14 (13)	33 (36)	27 (24)	19 (18)	21 (23)	

Key: 39% of the firms with medium intensity of organisational changes are ISO certified.
Field: Manufacturing firms with more than 50 employees, including agri-food firms.
Source: Employers survey of the 1997 Organisational Change and Computerisation *Surveys, MEFI - Sessi, MAP - Scees.*

However, it could also be argued that computers enable firms with many management layers to maintain their vertical organisational structure despite an increasingly unstable environment. In this case, computers are used for quicker access to strategic information and for closer, and even real-time, monitoring of employees' work (Alonzo, 1998; Bergouignan, 1988; Prunier-Poulmaire, 1992; Rule and Brantley, 1992).

The variables derived from the *Organisational Change and Computerisation Surveys* (COI) can be used for empirical exploration of these issues on the sample of manufacturing firms. There are indeed relationships between the organisational structures of firms in 1997 and their level of computer use (see Chart I). Other explanatory variables for the level of computer use were also taken into consideration, such as

Chart 1
Factors of the Intensity of Computer Use



Key: The intensity of computer use is a composite variable derived from the firms' positions on the first axis of an MCA using the variables describing the computer use situation in 1997. The coordinates have been standardised. The minimum is - 2.59 and the maximum is 2.29. The information shown in the chart corresponds to coefficients that are significant at the 5% level (excluding sectoral indicators) from an analysis of variance (N = 3,205 firms, R^2 = 0.49). The reference situation for the firms includes the following criteria (mean coordinate for this situation: - 1.74): apparel manufacturing firms with fewer than 100 employees, with few constraints on their IT choices, with a fairly undefined strategy, making limited use of new organisational structures, with a focus on just-in-time management without setting up working groups, with little use of structures related to the market rationale. The mean intensity of computer use is greater than 0.51 in other firms that meet all of these criteria, except that they are in the category of firms with 100 to 499 employees.
Field: Manufacturing firms with more than 50 employees, including agri-food firms.
Source: Employers survey of the 1997 Organisational Change and Computerisation Surveys, MEFI - Sessi, MAP - Scees.

the firm's reported overall strategy[4], the constraints[5] reported as influencing the firm's IT choices, the size of the firm, which is an indirect indicator of the complexity of its information and production systems and its access to financial resources, and its business sector. The survey questionnaire also listed eight obstacles to computerisation in a firm: lack of control over the financial costs, hardware and/or software compatibility problems, serious system failures at start-up or occasional failures, problems keeping abreast of changes in IT tools, problems finding IT tools that suit the firm's needs, problems finding employees with specific skills, training and placement problems and employee motivation problems. These problems are frequently cited in research into the diffusion of IT, but none of them shows a significant correlation to the intensity of computer use. Therefore, we have not used these variables in our regressions.

A firm's organisational structure has as much influence on the intensity of computer use as its size

Size is an important factor in the intensity of a firm's computer use. The largest manufacturing firms are the ones with the highest level of computer use. The industry sector is another influential factor. The most highly computerised sectors are publishing, printing, reproduction graphics, electrical and electronic equipment, electrical and electronic components, pharmaceuticals, beauty and cleaning products and the automotive sector. At the other extreme, the least computerised sectors are apparel and leather goods, mineral products, textiles, wood and paper.

A firm's organisational structure has nearly as much influence as its size. The most highly computerised firms are the ones that have adopted new organisational structures. New organisational structures go together with new technological tools.

If we now consider the combinations of organisational structures in use, we can see that the intensity of computer use is not sensitive to the intensity of the market rationale and that an industrial rationale that focuses on quality produces a higher level of computer use than an industrial rationale that focuses on just-in-time management.

The distinctive feature of organisational structures related to quality concerns is that they tend to increase the use of more formalised procedures within the firm. Computers are the natural choice for information systems that are codified, with a standard presentation and formalised coordination procedures (Caby, Greenan, Gueissaz and Rallet, 1999). Therein lies one of the sources of convergence between computer use and quality standards.

Firms with product-centred strategies are more highly computerised. The firms that make the most extensive and varied uses of information technology are those where product differentiation, the creation of new products and quality improvements are very important to the firm's strategy. This finding is in line with the previous finding about organisational structures. Computers are tools that help firms get a firmer grasp of the complexities of product quality and innovation.

The constraints that have a decisive influence on the level of computer use are greater competition, customer requirements and constraints imposed by shareholders or the parent group, with the exception of requirements arising from financial restructuring.

The Advent of the Networked Firm

The correlations between the levels observed in 1997 show parallels between changes in firms' organisational structures and their computer use. The same correlations are still strong when we look at changes that took place in the three years from 1994 to 1997. These parallel changes are therefore the product of short-term adjustments. The estimated model compares computerisation changes to organisational changes. The other variables are the same as in the static model, to wit: firm size and sector, overall strategy and the constraints that influence IT choices (see Chart II).

The size of the firm and the intensity of organisational change are the most influential factors for the intensity of changes in computer use. The most dynamic technological environments are found in large firms where organisational

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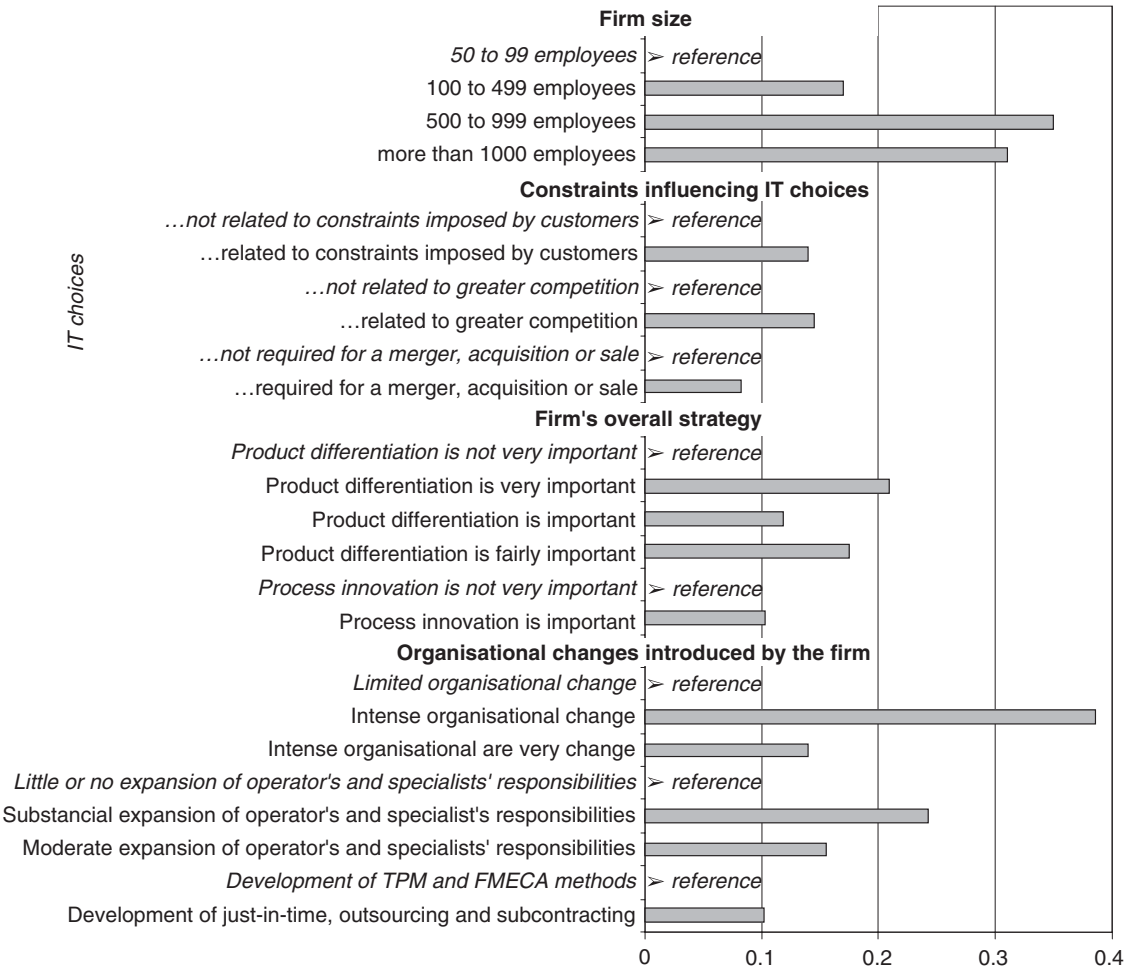
4 Firms were asked to rate the importance of creating new products, differentiating existing products, improving product quality, reducing costs and developing new production processes in their overall strategy, using a scale from one to four.

5 Firms were given a list of seven different constraints that could influence their choices: greater competition, market uncertainty, constraints imposed by customers, constraints imposed by suppliers, subcontractors and service providers, regulatory constraints, constraints arising from a merger, acquisition or sale and other constraints imposed by shareholders or the parent group.

structures have undergone sweeping changes. All else being equal, the sectors where firms have seen the most change in their computerisation are electrical and electronic components, publishing, printing, reproduction graphics, chemicals, rubber and plastic, electrical and electronic equipment and mechanical equipment.

The patterns of organisational change also have an influence. The more operators' and specialists' areas of responsibility expand, the more firms upgrade their computer hardware and increase data transfers. But firms that develop just-in-time management by emphasising the market rationale are also major users of new computer hardware. The most recent forms of information technology facilitate data exchanges with entities outside the firm. This suits the needs of firms where the pressures arising from just-in-time flows to customers are passed on to suppliers, subcontractors and service providers. Networking seems to play an important role in the most recent computerisation and organisational adjustments. The relationships revealed in statistical work are in line with field observations that point to the advent of the "networked firm" in industry (Veltz, 2000).

Chart 2
Factors of the Intensity of Computerisation Changes



Key: The intensity of computerisation changes is a composite variable derived from the firms' positions on the first axis of an MCA using the variables describing the computerisation changes between 1994 and 1997. The coordinates have been standardised. The minimum is - 1.07 and the maximum is 4.63. The information shown in the chart corresponds to coefficients that are significant at the 5% level (excluding sectoral indicators) from an analysis of variance (N = 3,205 firms, $R^2 = 0.14$). The reference situation for the firms includes the following criteria (mean coordinate for this situation: - 0.82): apparel manufacturing firms with fewer than 100 employees, with few constraints on their IT choices, with a fairly undefined strategy, making limited organisational changes between 1994 and 1997, with a focus on TPM and FMECA and changes in the division of responsibilities limited to the shop floor. The mean intensity of computerisation change is greater than 0.17 in other firms that meet all of these criteria, except that they are in the category of firms with 100 to 499 employees.
Field: Manufacturing firms with more than 50 employees, including agri-food firms.
Source: Employers survey of the 1997 Organisational Change and Computerisation Surveys, MEFI - Sessi, MAP - Scees.

In terms of business strategies, recent computerisation changes are linked to product differentiation and the development of new processes. Competitive pressure and customer requirements play as much of a role in changes in computerisation as restructuring resulting from mergers acquisitions and sales does. The role of restructuring in computerisation changes in industry is another sign of the advent of the "networked firm" that is emerging as large groups seek greater flexibility in their internal coordination procedures.

All in all, the differences in the findings based on level data and those based on trend data show how flexible information technology is. Firms can use IT in many ways, especially as ongoing advances in technology facilitate new types of information processing. In the first half of the nineteen-nineties, personal computers participated in the shift towards the more formalised procedures inherent in such management tools as quality standards. In the second half of the decade, firms developing just-in-time management, subcontracting and outsourcing made full use of newly available possibilities that made networking computers easier.

Computers, Organisation and Employees

Computer use is closely linked to organisational changes, which means that the work of computer users is substantially different from the work of other employees, including those with the same occupations (Cézard, Dussert and Gollac, 1992). This assertion has been confirmed by the 1998 Working Conditions Survey[6]. Computer use brings with it some specific discomforts, drawbacks and advantages, but the difference stems primarily from organisational changes related to computer use, once the differentials due to different skill levels and occupational categories have been stripped out[7].

More Independent Employees

Employees who use computers have a more extensive communications network. These communications are not restricted to exchanges of information; they are a basis for true cooperation. Computer users are more likely than other employees to report that they are able to cooperate to do their work properly (see Table 5). They are more likely to get help from their local workmates and supervisors, as well as from colleagues in other places and even from people outside of the firm. Computer users are also more independent than their colleagues. They are less likely to be told how to work to reach the goals set for them and they are slightly less likely to follow the instructions they are given to the letter. They are given greater initiative. They are less likely to call on another person (a supervisor, for example) when events take an unexpected turn and they are more likely to resolve the situation on their own.

However, there are strict rules governing this more independent way of working. The work is done within more formalised structures. One of the most characteristic features of computer users' work is the fact that they receive written instructions (Moatty, 1993). This is indicative of the greater formality that comes with greater independence. Computer users are more likely to be held to precise quality standards and they are slightly more likely to be held to quantitative standards or strict deadlines. In fact, flexibility and constraints are closely intertwined. The pace of work is explicitly set by standards, but it is most frequently determined by customer demands that have to be met immediately. Typically, computer users often have to drop what they are doing to handle an unexpected task. They are also more likely than other employees to have to change jobs to suit the firm's needs.

Employees who use computers are under more pressure, but their independence and the fluctuations in demand mean that the pressure can be managed with greater flexibility. They work to tighter deadlines, but they can negotiate them in most cases. They are more likely to be able to take breaks when they like. Yet most of these employees state that they do not have enough time to do their work properly and thus they are more likely to put in extra hours. They are also more likely to consult with their colleagues to establish their work schedules, which is a sign both of more pressure and more flexibility for managing it.

All in all, employees using computers do more intense work. They are subject to more complex

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6 For more information about this survey, see Box 1 in the article by Sylvie Hamon-Cholet and Catherine Rougerie in this issue.
7 The findings cited hereinafter have been obtained after stripping out the effects due to the distribution by occupation under the 455-item PCS classification of occupations and social and occupational categories. More specifically, we have eliminated the specificities of computer professionals. However, the frequency data can be presented to provide a fair overview of computer users' working conditions and work organisation (see Table 5).

organisational effects, which are related to market-oriented work and formalised procedures. They often report that they receive conflicting orders and work instructions. They do not always have enough information to do their job properly. This means that they are subject to greater mental stress. They are more likely than their colleagues to feel rushed "all the time" or "often". Even moderate noise can disturb them when they are working. They are slightly more likely to experience tension in their relations with the public, with their colleagues and with their supervisors. Yet, computer users enjoy better collective support to help them cope with job pressures. They are much more likely to discuss organisational and operational problems with the other members of their work unit. They are more likely to have opportunities for cooperation in their day-to-day work. This greater support is still not sufficient, however, since

Table 5
Working Conditions and Work Organisation for Computer Users in 1998

Percentage of employees reporting that they... N = 18,774	All employees		White-collar		Blue-collar	
	Users	*Non-users*	Users	*Non-users*	Users	*Non-users*
Pace of Work						
... have to meet standards and schedules	23	*24*	19	*16*	48	32
... have to meet external demand immediately	64	*44*	65	*52*	50	36
... have to keep pace with colleagues	28	*26*	26	*18*	43	34
... have to coordinate their timetable with colleagues	23	*14*	24	*17*	16	12
Cooperation						
... can cooperate to do their work properly	92	*80*	93	*77*	89	*82*
Help						
... get help from managers	65	*54*	65	*49*	66	*59*
... get help from colleagues	79	*65*	73	*60*	80	*71*
… get help from other people in the firm	49	*33*	49	*32*	47	*34*
... get help from outside the firm	27	*13*	29	*15*	17	*11*
... deal with organisational and operational issues together with their colleagues	80	*57*	80	*60*	80	*53*
Independence and Initiative						
... are told how to do their work	10	*19*	9	*13*	15	*25*
... have to follow instructions to the letter	33	*41*	32	*36*	38	*47*
... have to call in others in the event of an incident	21	*36*	20	*30*	31	*42*
... can change their deadlines	45	*27*	44	*22*	45	*31*
... receive written information concerning their work	79	*50*	79	*50*	79	*50*
... have to meet quantitative quality objectives	23	*17*	20	*9*	50	*26*
Mental Stress						
... often have to drop what their doing to handle an unforeseen task	65	*46*	66	*47*	61	*44*
... don't have enough time to do their job properly	29	*20*	29	*19*	24	*21*
... don't have enough information to do their job properly	26	*16*	26	*16*	25	*16*
... receive conflicting instructions	39	*31*	38	*27*	48	*35*
... have to cope with difficult situations on their own	28	*20*	29	*23*	25	*18*
... are always or frequently rushed	56	*48*	56	*45*	53	*49*
Tense Situations						
... experience tense situations with customers	35	*25*	*37*	36	17	*12*
... experience tense situations with managers	33	*27*	*33*	25	36	*29*
... experience tense situations with colleagues	24	*18*	*24*	19	24	*17*
Errors						
... an error on their part would harm the firm's finances	56	*44*	53	*31*	76	*59*
... an error on their part would harm product or service quality	69	*61*	67	*56*	83	*66*

Key: See footnote 6.
Field: All members of the work force in payroll employment.
Source: 1998 Working Conditions *Survey, MES - Dares.*

computer users are also more likely to say that they are left on their own to deal with difficult situations.

Despite massive diffusion, computerisation only affected one out of two employees in 1998

Computer users' work is different from non-users' work and they work within different organisational structures. They are selected for their social qualities, since the ability to use a computer is not the only job requirement. They must also be able to adapt to the various organisational changes stemming from computerisation (Gollac, Mangematin, Moatty and de Saint-Laurent, 1998). Furthermore, the ability to use computers does not depend solely on generic cognitive abilities (Gollac and Kramarz, 1997). Even the most user-friendly software is made for people who are used to dealing with abstract representations. This gives people with high educational attainment an advantage. In more general terms, the use that people make of computers is determined by their "cultural capital," meaning their propensity to try to understand and to take an interest in school-like work and to experiment with computers. Social skills are also critical, such as the ability to fit into extensive social interaction and mutual support networks (Gollac, 1996). The room that the organisational structure leaves for initiative is another decisive factor for making computer use more effective.

Therefore, despite massive diffusion, computer use is still not really the norm (Cézard, Gollac and Rougerie, 2000). In 1987, when the first measurements were made in France, the proportion of computer users at work was 26% of all employees (Gollac, 1989), this rose to 39% in March 1993 and to 51% in March 1998 (Cézard and Vinck, 1998). The time that each user spent on a computer also increased, with half of the users working on computers more than three hours per day. The average proportion of working time now spent on a computer is one out of five hours for both users and non-users together. The very rapid diffusion of computers did not lead to more uniform probabilities that employees have access to computers (Moatty, 1995a). In 1998, as in 1987, the likelihood that an employee used a computer varied substantially according to their position in the firm and their cultural capital (see Table 6). For management employees, computers are standard work tools; almost all of them have one, regardless of their exact job description. These employees spent an average of three hours a day on a computer in 1998, as opposed to two hours a day in 1987. In contrast, the role of the computer for white-collar workers is similar to the role of machines (not tools) for blue-collar workers in industry as a whole. Computer use for white-collar workers depends on their occupation (and not on their position in the firm, as is the case for management employees) and, in the occupations where computers are most widely used, most of their work is done on computers. In industry, however, white-collar workers use computers just as much as management employees, even though they have less training. Computer use by blue-collar workers is still marginal and very unequal depending on their occupations. Blue-collar workers are more or less clearly excluded from computer use depending on the division of labour, which varies from one industry sector to another. All else being equal, the diffusion of computers has primarily favoured supervisors and managers, especially those who have decision-making power over pay and promotion for the members of their team, and the computer gap between employees with no supervisory responsibilities and their bosses has widened over time.

Users tend to be highly educated employees who are well established in the firm

Computer use does not depend solely on the employee's position within the firm. Computer use for employees in the same positions increases as a function of their cultural capital. Educational attainment is the indicator for cultural capital and it has a strong influence on the likelihood that an employee will use a computer. In 1998, 19% of employees with no higher education used computers for their jobs, whereas 82% of employees with graduate and post-graduate degrees used computers (see Table 6). The gap relating to educational attainment was wider in 1998 than it was in 1987. The simple fact that computer use is linked to use of written language provides a partial explanation of the lower likelihood of computer use by less educated employees. Not only are computer users expected to be able to read quickly and write, but also computerised work is more frequent in formalised structures that rely heavily on written communications (Moatty, 1998).

Employees with more seniority are likely to have greater access to computers. This is partly

because firms tend to place expensive tools that often play a critical role in the organisation in the hands of their most trusted employees and partly because a firm footing in one's working environment enables employees to build up social capital and a support network that helps them make the best use of computers. On the other hand, temporary workers and employees on short-term contracts are less likely to use computers.

The selection of computer users occurs both internally and in the hiring processes of the most highly computerised firms. In manufacturing firms in 1997, an employee's educational attainment was a much more discriminating factor in determining whether an employee was a computer user than it was for determining the type of firm likely to hire that employee. Employees with a year or more of seniority, i.e. relatively well-established employees, were the respond-

Table 6
Which Employees Use Computers?

Proportion of employees using computers	1987 n = 17,475		1998 n = 18,774	
	Frequency (in %)	*Estimated coefficient (standard d*eviation)	Frequency (in %)	*Estimated coefficient (standard deviation)*
By occupational category				
Managers	51	*0.25 (0.08)*	85	*0.71 (0.09)*
Intermediate professions	39	*- 0.13 (0.06)*	71	*0.17 (0.05)*
White-collar workers	31	*réf.*	51	*réf.*
Skilled blue-collar workers	7	*- 1.85 (0.08)*	24	*- 1.35 (0.06)*
Unskilled blue-collar workers	3	*- 2.5 (0.12)*	11	*- 1.98 (0.09)*
By educational attainmente				
Post-graduate degree	49	*0.23 (0.10)*	82	*0.92 (0.10)*
Undergraduate degree	43	*0.22 (0.09)*	77	*0.83 (0.09)*
Secondary school	50	*0.44 (0.08)*	73	*0.85 (0.08)*
Vocational certificate	36	*réf.*	54	*réf.*
Occupational proficiency certificate	24	*- 0.27 (0.07)*	43	*- 0.22 (0.07)*
Elementary school certificate	13	*- 0.82 (0.09)*	23	*- 0.85 (0.09)*
No educational attainment	8	*- 0.98 (0.09)*	19	*- 1.03 (0.08)*
By seniority				
Up to one year	18	*- 0.55 (0.08)*	41	*- 0.40 (0.06)*
2 to 6 years	25	*- 0.23 (0.05)*	49	*- 0.23 (0.05)*
7 to 16 years	27	*réf.*	53	*réf.*
17 years or more	31	*0.29 (0.06)*	60	*0.41 (0.05)*
By management responsibilities in firm				
Power over promotion and pay of subordinates	48	*0.48 (0.08)*	80	*0.70 (0.09)*
Power over subordinates. but not for promotion and pay	34	*0.29 (0.05)*	66	*0.40 (0.05)*
No subordinates	22	*réf.*	45	*réf.*

Key: Frequency corresponds to the proportion of employees using computers. The estimated coefficients are those from a logistic regression where the explained variable is access to computers and the explanatory variables are the occupational category, educational attainment, seniority, management responsibilities, as well has gender, age, nationality and the status and size of the firm (the latter variables are not shown in the table). The estimated coefficient can be interpreted as the deviation from the reference population (denoted ref. in the table).
Field: All members of the work force in payroll employment.
Source: 1997 Working Techniques and Work Organisation *Survey and 1998* Working Conditions *Survey, MES – Dares.*

ents for the "employee" survey of the *Organisational Change and Computerisation Surveys* (COI). The proportion of graduate and post-graduate degree holders in this population was 35% in the case of computer users and only 4% in the case of non-computer users. The proportion of graduate and post-graduate degree holders amongst stable employees of firms with "very intensive" computer use, which account for 44% of the employees covered by the Organisational Change and Computerisation Surveys (COI), is comparatively closer to the proportion amongst stable employees of firms with less intensive computer use, 27% versus 19%. Internal selection of computer users on the basis of educational attainment substantially amplifies the effect of differentials between employees' educational attainment in various firms, depending on the intensity of computer use.

When it comes to selection by age, the mechanism that excludes the youngest employees is different from the one that excludes the oldest. Whereas only 30% of under-twenty-fives are stable employees of firms with "very intensive" computer use, the proportions are 40% to 50% in the older age groups. Selection on the basis of the type of firm explains some of the low level of computer use by the youngest employees in manufacturing firms. On the other hand, the low level of computer use by employees aged over 45 years does not stem from the fact that they work in firms with less intensive computer use, but from internal selection. For a given gender and level of educational attainment, over-forty-fives are more likely than thirty-year-olds to work in a firm with very intensive computer use.

Selection takes place regardless of the intensity of the firm's computer use

Regardless of the intensity of computer use in a firm, the characteristics of stable employees and their jobs still affect the likelihood of computer use. On the whole, the same characteristics have the same sort of effects, yet there are subtle differences. Firms making the most advanced use of computers will give computers to employees that less advanced firms would deem incapable. The ability to make effective use of a computer is not an intrinsic quality of an individual. It depends on the length and type of training provided, the time allowed for learning on the job and the organisational context: how independent employees are, how user cooperation is organized, whether resource persons have been named, how computerised work fits in with other tasks, etc. (Bonvin, Combessie, Faguer, Gollac and Monsigny, 1994; Benghozi, Flichy and d'Iribarne, 2001). The likelihood of employees with the same individual characteristics using computers depends on the intensity of computer use in the firm. Even in firms with very intensive computer use, the relative likelihood of employees working with computers decreases with old age, low educational attainment and low skill levels. But these "unfavourable" characteristics are by no means an absolute obstacle to computer use. In such firms, computers are used by 60% of the employees aged 55 and older (as opposed to 45% in the other firms covered by the *Organisational Change and Computerisation Surveys* (COI), 38% of employees with no higher or secondary educational attainment (as opposed to 26%), 50% of skilled blue-collar workers (as opposed to 29%) and 24% of unskilled blue-collar workers (as opposed to 18%).

Firms with low intensity of computer use tend to confine such use to specialists, who are selected on the basis of their individual characteristics. They are well trained, but they are often classified as white-collar workers since computers have not penetrated deeply into the work organisation and are sometimes used merely to automate routine management tasks. Regardless of the intensity of computer use in a firm, the level of an employee's training is still a determining factor, but not in the same way (see Table 7). In firms with low intensity of computer use, there is a wide gap between employees with secondary educational attainment and those without, whereas undergraduate degree holders tend to be seen as specialists. In firms with very intensive computer use, the gap occurs at a lower level of educational attainment, between employees with elementary school educations and those with no educational qualifications, even though higher education degree holders are still more likely to use a computer. The distribution of computers by position and occupation is also different. In firms with less intensive computer use, there is a degree of specialisation in the computer use of white-collar workers, compared with the computer use of management personnel and, more especially, intermediate professions.

New organisational structures increase the intensity of computer use

Obviously, we cannot investigate the effect of the type of computerisation in a firm on the likelihood of its employees using computers, since

the proportion of employees using computers is one of the variables used to define the type of computerisation. On the other hand, we can see how the type of organisational structure affects the likelihood that a stable employee will use a computer. Computer use is therefore directly linked to organisational changes and 68% of the employees use computers in the firms covered in the 1997 *Organisational Change and Computerisation Surveys* (COI) that are classified in the quartile making the most intensive use of new organisational structures. The percentages in the other quartiles are 62%, 52% and 42%. This gradation is confirmed by an analysis that strips out all other differences, and even when the employees' individual characteristics are taken into account. Computer use seems to be slightly more related to innovations that give rise to greater formalisation of procedures, such as ISO standards, than to the development of market or pseudo-market structures. This finding is in line with the previous analysis of firm data.

Table 7
Which Employees of Manufacturing Firms Use Computers?

Proportion of employees using computers n = 4,430	Very high intensity of computer use in the firm		Low to high intensity of computer use in the firm	
	Frequency (in %)	*Estimated coefficient (standard deviation)*	Frequency (in %)	*Estimated coefficient (standard deviation)*
By occupational category				
Managers	96	*- 0.34* (0.52)*	86	*- 1.31 (0.30)*
Intermediate professions	90	*- 0.75 (0.42)*	78	*- 1.46 (0.25)*
White-collar workers	94	*réf.*	90	*réf.*
Skilled blue-collar workers	50	*- 2.59 (0.40)*	29	*- 2.85 (0.24)*
Unskilled blue-collar workers	24	*- 3.16 (0.41)*	18	*- 3.35 (0.25)*
By educational attainment				
Post-graduate degree	96	*0.64* (0.47)*	88	*1.12 (0.28)*
Undergraduate or technical school degree	92	*0.70 (0.37)*	92	*1.77 (0.23)*
Secondary school	82	*- 0.25* (0.31)*	73	*0.77 (0.18)*
Vocational certificate	73	*réf.*	48	*réf.*
Occupational proficiency certificate	66	*- 0.29* (0.21)*	42	*- 0.11* (0.13)*
Elementary school certificate or no educational attainment	38	*- 1.20 (0.23)*	26	*- 0.63 (0.14)*
By seniority				
Up to one year	67	*- 0.60* (0.40)*	63	*- 0.32* (0.26)*
2 to 6 years	76	*- 0.11* (0.23)*	55	*- 0.26 (0.13)*
7 to 16 years	72	*réf.*	50	*réf.*
17 years or more	66	*0.11* (0.20)*	47	*0.20* (0.12)*
By management responsibilities in firm				
Power over promotion and pay of subordinates	93	*0.29* (0.30)*	80	*0.47 (0.17)*
Power over subordinates. but not for promotion and pay	83	*0.61 (0.22)*	65	*0.46 (0.13)*
No subordinates	62	*réf.*	43	*réf.*

Key: Frequency corresponds to the proportion of employees using computers. The estimated coefficients are those from a logistic regression where the explained variable is access to computers depending on whether or not the subject works for a firm with a high intensity of computer use. The explanatory variables are the occupational category, educational attainment, seniority, management responsibilities, as well has gender, age, nationality and the status and size of the firm (the latter variables are not shown in the table). The estimated coefficient can be interpreted as the deviation from the reference population (denoted ref. in the table). It is significant at the 5% level. An asterisk indicates that the coefficient is not significant.
Field: Employees of manufacturing firms with more than 50 employees, including agri-food firms.
Source: 1998 Working Conditions *Survey, MES – Dares.*

Computerisation case studies carried out at the end of the nineteen-eighties and in the early nineteen-nineties often focused on firms that wanted to follow market developments but still maintain their bureaucratic organisational structure. Computers were helpful for this purpose since they make it possible to process formalised information rapidly (Gollac, Mangematin, Moatty and Saint-Laurent, 1999). The nineteen-nineties saw an increase in the use of written language by employees (Moatty, 1995b) that was simultaneous with the introduction of formalised organisational structures, such as ISO standards, which require employees to "write what you do and do what you write". The computer's role in this was perhaps to facilitate an increase in formalisation without jeopardising responsiveness to the market[8]. More recent organisational and IT adjustments may, as we have seen, reflect a new direction in developments in which networking of employees and firms plays a central role.

Job Selection Based on Computer Skills

The selection of users is reinforced by the selectiveness of jobs involving computer use. Computers are used for a wide range of work, from the most routine tasks to jobs requiring a great deal of expertise. Multiple correspondence analysis can be applied to the *Organisational Change and Computerisation Surveys* (COI) findings to bring order to the diversity of computer jobs. The findings of this survey of a narrower sample using a more detailed questionnaire confirm that the findings for the economy as a whole also hold true for employees in the manufacturing sector (Gollac and Kramarz, 2000). Users are primarily differentiated by the level of their computer skills, which depends on their technical skills and access to computers in their work. There is also the contrast between users' individual "portable" computer skills and their computer skills that are strictly job related. The first type of skills involve using computers for operations that could be useful in another job or even in a non-professional context (e.g. scientific calculations), whereas it would be difficult to find a non-professional use for the second type of skills (e.g. cash management and banking operations).

We selected some practices that are fairly widespread and yet distinctive in order to analyse the diffusion of these different types of computer use. Use of portable computers is characteristic of individual computer skills. When employees spend more than three hours per day working on computers, it is a sign that computers are inextricably linked to their jobs and that their average level of computer skills is fairly high. Workers who produce programs to meet other employees' needs typically have a high level of expertise, while at the opposite extreme, employees who never use computers for tasks undertaken on their own initiative typically have a low level of computer skills.

All else being equal, a computer user who has a portable machine is most likely to be a highly educated male in a management position or an intermediate profession. Social selection is very strong, therefore, within the already select group of computer users, even though portable computer use with in this group diminishes with seniority and management responsibilities. The apparently paradoxical effect of seniority can be explained by the fact that working with a portable computer is typically a sign that an employee's computer use is based on skills and practices that are easily transferable to other jobs and other firms. Long hours spent in front of a computer are typical primarily of women's jobs, white-collar workers and users with no management responsibilities. The likelihood that an employee will work long hours on a computer decreases with age, which is not the case with the use of portable computers. On the other hand, it does not depend on educational attainment, except that less educated employees are slightly less likely to spend more than three hours per day working on a computer. The selection of users who produce programs for their colleagues has characteristics of both the diffusion of individual skills and the diffusion of job-related skills. Men are more likely to do programming work and the likelihood increases sharply with educational attainment, diminishes slightly with seniority and shows little change with age. The likelihood is stronger in higher occupational categories, but there is less variation than for the use of portable computers.

All else being equal, employees who never use computers for tasks undertaken on their own initiative are most likely to be blue-collar workers, less educated or older. Those who use computers for routine tasks have a lower social and

8 Consideration of the firm's organisational structure does not diminish the influence of individual variables. But the latter may reflect the selection of workers deemed to be capable of fitting into a given structure. The variety of forms of work organisation at the individual level is by no means fully determined by the overall organisational structures of firms (Greenan and Hamon-Cholet, 2000a).

cultural level than other users. With regard to employees in the manufacturing sector as a whole, they tend to reflect the mean with regard to educational attainment and occupational category. In most cases, computer use also reflects an inquiring attitude similar to that of employees who seek to understand, and not merely operate, industrial machinery (Bernoux, Magaud, Raveyre, Saglio and Villegas, 1994). Curiosity about computers is linked to cultural capital and schooling, but work organisation can promote or hinder employees' explorations.

Overall, the most highly educated and skilled users use computers in ways that are both more sophisticated and less dependent on their immediate working environment. This hierarchy of computer use is complementary to the selection of users. The strength of this hierarchy and the principles behind it do not seem to be dependent on the type of computerisation characteristic of the firm. However, even though users at the highest social and cultural levels are still likely to spend less time working on computers than users in the mean levels, the gap is smaller in the most highly computerised firms.

Greater Selectivity of Internet Access

The diffusion of the Internet in industry was just starting in 1997. Only 6% of the employees covered by the Organisational Change and Computerisation Surveys (COI) used the Internet at work. Internet use was characteristic of a high level of computer skills that were more likely to be portable skills rather than job-related skills (see Table 8).

Internet use introduces new selection effects that are different from those of computer use in general. In 1997, using the Internet at work was the prerogative of employees in management jobs and intermediate professions. These groups accounted for 94% of Internet users, with management employees alone accounting for 66%. All else being equal, the gap between management employees and blue-collar workers is much greater and the distribution of disparities by occupational categories is much more visible when it comes to Internet use, as compared to computer use in general. However, the selection of Internet users is just a more extreme form of the selection of computer users. Once it has been adjusted for age, skills, education, etc., the likelihood of Internet use does not increase at all with seniority and barely increases with management responsibilities. In 1997, the Internet was as much an expert's tool as much as a manager's tool. Internet use was directly dependent on the users' individual characteristics, whereas computer connections back in 1994, including connections with the entities outside the firm, depended more on how the firm as a whole used computers. It is too early to say whether this situation will be transitory or lasting.

Computers are working tools that change the relationship to work

Computer users have a different relationship to their jobs than their colleagues do since their work organisation and their working conditions are substantially different. They have more independence, but they feel more responsible. In 1998, computer users in the same occupations as other employees were more likely to feel that an error on their part could have a serious impact on costs and quality. The 1997 *Work and Lifestyles Survey* showed that this feeling of responsibility was part of a more general attitude. Computer users were more likely to declare that they were "*very committed*" to their jobs, that their jobs helped them "*keep up to date*," that they "*encountered new tasks at work that require planning and adaptation*" and that they "*improve existing procedures by experimenting with new procedures*." Their commitment was based on their feeling that they were working for themselves as well, to maintain and increase their value on the job market. This feeling is partly justified and partly an illusion (Entorf, Gollac and Kramarz, 1999; di Nardo and Pischke, 1997). Computer users are less worried about losing their jobs and believe that they have better chances of promotion. But they also seem to think that their advantage is fragile when there is no institutional recognition to back it up and maintain their advantage once they leave the firm. All else being equal, computer users are more likely than their colleagues to think that they would have problems finding an equivalent job if they were to lose their current one. They have more of a stake in their job, career and pay, which makes them more committed to their work. As a general rule, regardless of whether they make a greater commitment to their jobs as a matter of choice, their work plays a greater role in their lives (Baudelot and Gollac, 1999).

In some cases, computer use per se is a source of greater commitment. Except for "relationships", the words that came up most frequently in answers to the open question "*Do you have*

the opportunity at work to do things that you enjoy and cannot do elsewhere?" were "computers" and "Internet." One computer user out of ten spontaneously cited computers as a thing they enjoyed at work and could not do elsewhere. The proportion would be much higher if we did not implicitly exclude computer users who use computers at home as well as at work. This group often includes the most avid computer users.

Computers are also auxiliaries in new social relationships

All else being equal, commitment to one's job increases with educational attainment. If we assume that this finding at a given instant holds true over time, we could think that an increase in the supply of educated labour will be a determining factor in the adoption of new ways of working that require a new relationship to work.

Table 8
Which Employees Use the Internet?

Proportion of employees using the Internet	Out of all employees n = 18,774		Out of employees using computers N = 9,465	
	Frequency (in %)	*Estimated coefficieny (standard deviation)*	Frequency (in %)	*Estimated coefficieny (standard deviation*
By occupational category				
Managers	29	*1.79 (0.12)*	35	*1.64 (0.12)*
Intermediate professions	8	*0.77 (0.11)*	12	*0.67 (0.11)*
White-collar workers	3	*réf.*	5	*réf.*
Skilled blue-collar workers	1	*- 1.65 (0.25)*	2	*- 0.95 (0.25)*
Unskilled blue-collar workers	ns	*- 2.71 (0.59)*	ns	*- .42 (0.59)*
By educational attainment				
Post-graduate degree	29	*1.55 (0.19)*	35	*1.37 (0.19)*
Undergraduate degree	12	*1.03 (0.19)*	15	*0.84 (0.19)*
Secondary school	8	*0.83 (0.19)*	11	*0.65 (0.19)*
Vocational certificate	3	*réf.*	5	*réf.*
Occupational proficiency certificate	2	*0.06* (0.19)*	5	*0.14* (0.20)*
Elementary school certificate	1	*- 0.36* (0.31)*	4	*0.07* (0.31)*
No educational attainment	1	*- 0.24* (0.25)*	5	*0.3* (0.25)*
By seniority				
Up to one year	7	*- 0.03* (0.11)*	16	*0.06* (0.11)*
2 to 6 years	7	*- 0.02* (0.10)*	15	*0.03* (0.10)*
7 to 16 years	7	*réf.*	14	*réf.*
17 years or more	6	*- 0.06* (0.10)*	10	*- 0.14* (0.11)*
By management responsibilities in firm				
Power over promotion and pay of subordinates	19	*0.11* (0.10)*	24	*0.00* (0.10)*
Power over subordinates. but not for promotion and pay	10	*0.03* (0.09)*	15	*- 0.06* (0.09)*
No subordinates	5	*réf.*	11	*réf.*

Key: Frequency corresponds to the proportion of employees using the Internet. The estimated coefficients are those from a logistic regression where the explained variable is Internet use (for all employees and for employees using computers only). The explanatory variables are the occupational category, educational attainment, seniority, management responsibilities, as well has gender, age, nationality and the status and size of the firm (the latter variables are not shown in the table). The estimated coefficient can be interpreted as the deviation from the reference population (denoted ref. in the table). It is significant at the 5% level. An asterisk indicates that the coefficient is not significant.
Field: All members of the labour force in payroll employment.
Source: 1998 Working Conditions *Survey, MES - Dares.*

On the more specific matter of computers, qualitative research suggests that the gap between employees' aspirations and their actual achievements, as in the case of people whose jobs are less skilled than their training could have led them to expect, makes it easier to believe in the virtues of technology and generates more interest in technology. This belief plays an important role in shaping behaviour at a time of great uncertainty about the future (Bonvin, Combessie, Faguer and Monsigny, 1994). In an extreme case, that is nonetheless typical, this belief is behind the rationale of people who accept the long hours and very difficult working conditions that "start-ups" or "hot-lines" impose on their less skilled employees in exchange for delayed compensation in such risky forms as stock options or the future prospect of steady employment and promotion. The new attitude that puts greater value on "projects" is also promoting greater commitment to innovation (Boltanski and Chiapello, 1999). This new attitude also enables management employees (but not necessarily their less skilled colleagues) to derive benefits from experiments even when the latter are not very successful.

When we consider the overall implementation of information technology, we see that it is more than just a new technology; it provides the impetus for new forms of economic organisation and that it also facilitates certain forms of social organisation. However, the social relationships created around computer use are not radically new; they are very strongly influenced by the traditional divisions based on culture and skills. □

REFERENCES

Alonzo P. (1998), "Les rapports au travail et à l'emploi des caissières de la grande distribution : de petites stratégies pour une grande vertu", *Travail et emploi*, No. 76, pp. 37-51.

Baudelot C. and Gollac M. (1999), "Bonheur, travail et sociologie", paper presented to DSDS seminar, Insee.

Benghozi P.-J., Flichy P. and d'Iribarne A. (2000), "Le développement des NTIC dans les entreprises françaises", *Réseaux*, No. 104, pp. 31-58.

Benzécri J.-P. (1973), *L'analyse des données*, Dunod.

Bergouignan M.-C. (1988), "Cuir-chaussure : établissements Imbert, Miramont-de-Guyenne (47)", *Nouvelles technologies de travail des femmes en Aquitaine*, Publications Maison des Sciences de l'Homme d'Aquitaine No. 120, Presses Universitaires de Bordeaux.

Bernoux P., Magaud J., Raveyre M.-F., Ruffier J., Saglio J. and Villegas G. (1984), "Qui connaît les machines?", report to France's General Planning Commission, CEE, GLYSI.

Boltanski L. and Chiapello E. (1999), *Le nouvel esprit du capitalisme*, Gallimard, Paris.

Bonvin F., Combessie J.-C., Faguer J.-P., Gollac M. and Monsigny O. (1994), "Une machine qui change la vie?", report to Dares, No. 94/24.

Boyer R. and Freyssenet M. (2000), *Les modèles productifs*, Éditions La Découverte, Collection Repères, Paris.

Breton P. (1990), *Une histoire de l'informatique*, Éditions La Découverte, 2nd edition, Éditions du Seuil.

Caby L. and Jaeger C. (1998), "La relation fournisseur-client et les technologies de l'information et de la communication", Réseaux, No. 91.

Caby L., de Coninck F., Dubois P., Gollac M., Greenan N., Mairesse J., Moisdon J.-C., Rallet A. and Vickery G. (1999), "Mesurer les liens entre informatisation, organisation et performances", in Foray, D. and J. Mairesse (ed.), *Innovation et performance*, pp. 131-169, Éditions de l'EHESS, Paris.

Caby L., Greenan N., Gueissaz A. and Rallet A. (1999), "Quelques propositions pour une modélisation", in Foray, D. and J. Mairesse (ed.), *Innovation et performance*, pp. 131-169, Éditions de l'EHESS, Paris.

Cases C. and Rouquette C. (1999), "Les comptables à la pointe de l'informatique", *Insee Première*, No. 677.

Cézard M., Dussert F. and Gollac M. (1992), "Taylor va au marché : organisation du travail et informatique", *Travail et Emploi*, No. 54, pp. 4-19.

Cézard M., Gollac M. and Rougerie C. (2000), "L'ordinateur, outil de travail et bien culturel, diffusion de l'informatique et sélection des ordinateurs", *Actes de la Recherche en Sciences Sociales*, No. 134, September, pp. 22-28.

Cézard M. and Vinck L. (1998), "Plus d'un salarié sur deux utilise l'informatique dans son travail", *Premières synthèses*, No. 53.2, Dares, France's Ministry of Labour.

Chardon O. (1999), "Commerce du bricolage : l'informatique fédère les entreprises dans les réseaux", *Insee Première*, No. 638.

Di Nardo J. E. and Pischke J. S. (1997), "The Returns to Computer Use Revisited: Have Pencils Changed the Wage Structure Too?", *Quarterly Journal of Economics*, vol. CXII, No. 1, February, pp. 291-303.

Entorf H., Gollac M. and Kramarz F. (1999), "New Technologies, Wages and Worker Selection", *Journal of Labor Economics*, No. 3, vol. 17, pp. 464-491.

Favre F., François J.-P. and Greenan N. (1998), *Changements organisationnels et informatisation dans l'industrie*, Collection Chiffres Clés, Paris, French Ministry of the Economy, Finance and Industry.

Foray D. (2000), *L'économie des connaissances*, Éditions La Découverte, Collection Repères, Paris.

Foray D. and Mairesse J. (ed.) (1999), *Innovation et performance*, Éditions de l'EHESS, Paris.

Gollac M. (1989), "L'ordinateur dans l'entreprise reste un outil de luxe", *Économie et Statistique*, No. 224, pp. 17-25, September.

Gollac M. (1996), "Le capital est dans le réseau. La coopération dans l'usage de l'informatique", *Travail et emploi*, No. 68, pp. 39-60.

Gollac M. and Kramarz F. (1997), "L'ordinateur, un outil de sélection? Utilisation de l'informatique salaire et risque de chômage", *Revue économique*, 5, vol. 48, September, pp. 1115-1143.

Gollac M. and Kramarz F. (2000), "L'informatique comme pratique et comme croyance", *Actes de la Recherche en Sciences Sociales*, No. 134, September, pp. 4-21.

Gollac M., Mangematin V., Moatty F. and Saint-Laurent A.-F. (1999), "A quoi sert donc l'informatique? Revue d'études de cas", in Foray, D. and J. Mairesse (ed.), *Innovation et performance*, pp. 76-130, Éditions de l'EHESS, Paris.

Gorgeu A. and Mathieu R. (1995), "Recrutement et production au plus juste, les nouvelles usines d'équipement automobile en France", *Dossiers du Centre d'Études de l'Emploi*, nouvelle série, No. 7.

Greenan N. (1996), "Innovation technologique, changements organisationnels et évolution des compétences", *Économie et Statistique*, No. 298, pp. 15-29.

Greenan N. (1999), "Technologies de l'information et de la communication, productivité et emploi : deux paradoxes", in Brousseau E. and A. Rallet (ed.), *Technologies de l'information, organisation et performances économiques*, Chap. 1, pp. 75-159, French General Planning Commission Report.

Greenan N. (2001), *Changements organisationnels et performances économiques : théories mesures et tests*, Doctoral Thesis at EHESS.

Greenan N. and Hamon-Cholet S. (2000a), "Les salariés industriels face aux changements organisationnels en 1997", *Premières synthèses*, No. 09.3, Dares, French Ministry of Labour.

Greenan N. and Hamon-Cholet (2000b), "C.O.I.: a Matched Employer/Employee Survey on Organizational Change and Computerization", *International Conference on Establishment Surveys II*, Buffalo (www.eia.doe.gov/ices2), New York, 17-21 June.

Greenan N. and Mairesse J. (1999), "Organizational Change in French Manufacturing : What Do We Learn from Firm Representatives and from their Employees?", *NBER Working Paper*, No. 7285.

Greenan N. and Mairesse J. (2000), "Computer and Productivity in France: Some Evidence", *Economics of Innovation and New Technologies*, vol. 9, pp. 275-315.

Greenan N., L'Horty Y. and Mairesse J. (ed.) (2001), *The Puzzling Relations between the Computer and the Economy*, pending publication by MIT Press.

Greenan N., Mairesse J. and Topiol-Bensaid A. (1999), "Investissements immatériels, productivité et qualification", *Revue économique*, vol. 50, No. 3, May, pp. 417-430.

Greenan N., Mairesse J. and Topiol-Bensaid A. (2001), "Information Technology and Research and Development Impacts on Productivity and Skills: Looking for Correlations on French Firm-Level Data", *NBER Working Paper*, No. 8075, January, pending publication in Pohjola, M. (ed.), *Information Technology, Productivity and Economic Growth*, Oxford University Press, chap. 6, pp. 119-148.

Guilloux V. (1992), "Coordination inter-organisationnelle, système d'information et juste-à-temps. Une étude empirique dans le secteur textile prêt-à-porter", *Technologies de l'information et société*, No. 4-3, pp. 309-332.

Ichniowski C., Shaw K. and Prennushi G. (1997), "The Effects of Human Resource Management Practices on Productivity: a Study of Steel Finishing Lines", *American Economic Review*, vol. 87, No. 3, June, pp. 291-313.

Moatty F. (1993), "Qui utilise l'informatique au travail?", *Dossier de recherche*, No. 51, Centre d'études de l'emploi.

Moatty F. (1995a), "Public, privé : la diversité des critères d'accès à l'informatique", *Revue Française des Affaires Sociales*, vol. 49, No. 1, pp. 69-88.

Moatty F. (1995b), "Les communications de travail comment et avec qui?", *Lettre du Centre d'études de l'emploi*, No. 39, October.

Moatty F. (1998), "Travail, communication, et polarisation spatiale", *Revue d'Économie Régionale et Urbaine*, No. 2, pp. 185-209.

Prunier-Poulmaire S. (2000), "Flexibilité assistée par ordinateur. Les caissières d'hypermarché", *Actes de la recherche en sciences sociales*, No. 134, September, pp. 29-36.

Roux P., and Miquel A.-M. (1998), "Objectifs: qualité et flexibilité (enquêtes sur les changements organisationnels et l'informatisation dans les IAA de 1994 à 1997)", *Agreste Primeur*, la statistique agricole, No. 45, October.

Rule J. and Brantley P. (1992), "Computerized Surveillance in the Workplace: Forms and Distributions", *Sociological Forum*, pp. 405-423.

Saporta G. (1975), "Dépendance et codage de deux variables aléatoires", *Revue de statistique appliquée*, No. 23, pp. 43-63.

Veltz P. (2000), *Le nouveau monde industriel*, Gallimard, Paris.

Veltz P. and Zarifian P. (1993), "Vers de nouveaux modèles d'organisation", *Sociologie du travail*, No. 1, pp. 3-25.