

The consequences of new workplace practices in the United States *

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Abstract: This paper gives new evidences on the consequences of innovative workplace practices in American manufacturing. Using the correlation between organizational change and increasing occupational injuries and illnesses, we instrument or directly proxy, for detailed industries, reorganization by an indicator "I-reorganization" that is computed with occupational health and safety statistics. In this specification we find that reorganization seems to improve productivity dramatically. In fact, computerization is efficient only in reorganized industries. However, the reorganization is not biased toward non-production workers.

Keywords: workplace practices, occupational injuries, computerization, productivity, inequalities.

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In examining the continuous and high performance of the American economy for nearly the past 10 years, many analysts consider that the United States is the laboratory of the “new economy”. The goal of this paper is to study the period prior to this phase i.e. the eighties and the beginning of the nineties, which can be the basis of the present prosperity. The industrialized economies were concerned during this period by the emergence of the technologies of information and communication (the ICT). The ICT should be by nature biased in toward the most skilled workers and would therefore explain the strong rise of wage inequalities in the United States during the eighties (Berman et al. (1994), Autor et al. (1998) or Aghion et al. (1999)). Nevertheless, this analysis collides with another major stylized fact during this period. This is the Solow’s paradox: how to explain the fact that one sees computers everywhere, that they have a major impact on the job market, while in the statistics they seem to provide no productivity gain?

It is therefore within the black box of the firm that we sought to explain these conflicting observations. Beginning in the mid-eighties at the same time that ICT innovations were increasing, the majority of American firms began to apply massively new workplace practices. These are now well documented (Milgrom et al. (1995), Osterman (1994)); one can mention the autonomous work team, multitask jobs, job rotation, total quality management (TQM) and Just-In-Time. Beyond the idyllic vision presented by the supporters of lean production, beyond the considerable potential gains of productivity claimed by the management consultants and the spectacular successes presented in the magazines, what is the real consequences of these organizational change?

A significant volume of literature has been devoted to this question. Ichniowski et al. (1996) or OECD (1999) review numerous studies that either exhaustively examine one industry, such as metallurgy or investigate several establishments or firms. These works conclude that the new workplace practices have a significant impact on productivity or on the market value of firms. More recently, Bresna-

han et al. (1999) have found complementarities between qualification, ICT and the innovating workplace practices for 400 Fortune firms. They find very strong complementarities. Thus, it is the combined use of the new information technologies and the new workplace practices is correlated with high productivity. In the same way, the ICT with organizational change would have switched the demand toward the most qualified workers.

Unfortunately, these works that have precise organizational or skill indexes are often the most cross-section studies for one period or cannot propose a real longitudinal analysis. To capture the role of innovative practices on productivity and labor demand, it should be necessary to have longitudinal data sets on establishments or firms. Caroli and Van Reenen (1999) have performed such study on France and UK for the eighties. However, they should only capture the first steps of the reorganizing process and sub-estimate the impact of organizational innovations. Indeed, the implementation of new workplace practices in France is recent compared to the U.S. According to Osterman (1994) and Coutrot (1996, 2000), new practices are dramatically less spread in France than in the US in 1992 (see table 1). Thus an analyses of the American case should give a more complete and matured view of the consequences of reorganization. Some American establishment studies use longitudinal data. Huselid and Becker (1996) find no clear relationships between performance and workplace practices when they control for unmeasured firm-level heterogeneity via firm fixed effects. Black and Lynch (1997) try also to control for heterogeneity by using repeated observations over period 1988-1993 (from the LRD); but, because they have no information on workplace practices for years other than in 1993 (from the NES), their study assumes that the innovative practices are fixed over 1988-1993 period. Recently, Cappelli and Neumark (1999) use the same data and the 1996 NES. They have thus a panel of 200 firms from 1993-1996. They conclude that “their results do not appear to be consistent with the view that [high performance] practices are good for employers”; but this work is likely to focus on the adopters in the most recent period. Moreover, Huselid and Becker (1996) consider that a

huge part of the variance of the information in such panel data can be explained by measurement errors; the interpretation of these results is thus difficult.

Long longitudinal statistics also exist at a detailed industrial level. They enable us to study the evolution of precise performance indexes such as the Total factor Productivity (TFP) over a long period beginning before the dramatic development of new workplace practices. But it becomes difficult to have reliable organizational change indicators for hundreds of industries; The surveys on establishments do not provide a large enough sample to be able to have a significant number of establishments for every detailed industry. Thus, an indicator constructed from these information should again suffer from dramatic measurement errors. This paper proposes a simple two-steps methodology for studying, at a detailed industrial level, the consequences of the organizational changes on productivity in the United States and their relationships to computerization and bias toward non-production workers:

(i) A first standard but raw indicator - the R-reorganization- of the adoption of innovative workplace practices is constructed for about one hundred manufacturing industries, using interviews conducted by Osterman (1994).

(ii) We attempt to get around the lack of statistics on organizational change and measurement errors: we instrument or directly proxy workplace innovations with an “I-reorganization” dummy derived from occupational health and safety statistics at industry level, using the positive correlation between the adoption of innovative practices and the rate of occupational injuries and illnesses.

The analysis concentrates on American manufacturing since 1980. This restriction has a number of advantages. First, we have very complete longitudinal data at the 4-digit industry level, including the financial, productive and labor aspects (the NBER productivity Database). Secondly, manufacturing can be considered a laboratory of both new information technology and innovative organizations. In that sense, it provides useful descriptions of the consequences of innovations.

The main findings are:

(i) Instrumentation of the standard index can dramatically modify the estimation

of the impact of reorganization.

(ii) Reorganization per se -even after correction of selection biases- seems to dramatically improve productivity while computerization is neutral, corroborating the Solow paradox.

(iii) In fact, new workplace practices are necessary for an efficient use of computers. The IT paradox is thus solved: ICTs improve the productivity but only in industries, which have an innovative organization “information intensive”; they reduce total factor productivity in the others.

(iv) Organizational and technical innovations have different effects on labor demand: unlike computerization, reorganization is not biased against production workers, and there is also some indication that it may have been biased against non-production labor since the end of the eighties.

This paper is organized as follows: The data and the definition of the reorganization indexes are presented in part one. Part two studies the consequences of innovations on productivity in the American manufacturing sector. Part three is devoted to the evolution of the labor-force composition.

1 Data

In this section, we compute two indexes of workplace innovations for 4-digit SIC manufacturing industries: the R-reorganization index derived from Osterman’s (1994) survey and the I-reorganization dummy derived from occupational injuries and illnesses data. The last subsection details the industrial data.

1.1 The R-index of reorganization

The survey “Organization of work in American Business” was conducted during the spring of 1992 by the Center for Survey Research (MIT) under the direction of Paul Osterman (see Osterman (1994) for a complete description of the survey). Osterman

(1994) shows that the three main innovative practices are TQM, autonomous team and Job rotation. Here, we use 3 questions from this survey:

Are CORE EMPLOYEES involved in:

E21a Self-directed work teams: E21a2 Percent involved

E21b Job rotation: E21b2 Percent involved

E26c Total Quality Management (TQM): E26c2 Percent involved

The data on these questions are available for about 600 establishments. Moreover, we have the 4-digit SIC code of each. Thus, we can take the following definition for about one hundred 4-digit SIC industries.

Definition 1 *At 4-digit SIC level, the degree of adoption of the previous workplace innovative practices is defined as the mean of $E21a2+E21b2+E21c2$. This degree will be called the “R-reorganization” index.*

By definition, this index takes values between 0 and 300 percent.

1.2 The I-reorganization

While the natural trend is a decrease of 1 or 2 % per year, during the eighties, the rate of occupational injuries and illnesses has dramatically increased by 20% in American manufacturing. The adoption of “lean production” explains a part of this rise.

The implementation of new workplace practices is a learning phase for workers and also for regulators of health and safety at the level of the shop. Moreover, workers are particularly vulnerable to occupational health hazards during model changes¹ which occur more frequently in flexible plants. Fundamentally, lean production, by definition, enhances the pace and hardness of work. The new establishments attempt to run as close to 60 seconds of work per minute as possible. Thus, reorganization should be associated with a higher injury and illness rate; various case studies suggest that ergonomic conditions have deteriorated (Adler et al. (1997) at NUMMI, Rinehardt et al. (1997) or Babson (1993) at a Mazda plant). Ergonomists confirm

that just-in-time and increasing worker responsibility for quality control contribute to worsen repetitive stress disorders (Putz-Anderson, 1988). Fairris and Brenner (1998) report that the rate of Cumulative Trauma Disorders (CTDs) has dramatically risen by 400% during the eighties². Note however that job rotation can also increase workers' interest in the job thereby reducing the number of incidents deriving from boredom; safety and health goals can also be consistent with quality improvement.

In a companion paper, Askenazy (1999b), we give a complete discussion and statistical evidence, which support a clear relation between innovative practices and increasing occupational injuries and illnesses: the rate of all occupational injury and illness³ rises steadily in *2-digit* SIC sectors that are in the process of reorganizing. More precisely, the periods of reorganization (i.e. of heavy implementation of new practices) for 26 sectors are determined using Osterman (1994) survey and a statistical treatment of 1.5 millions articles of one thousand human resources and managerial reviews (ABI/Inform bibliographic base). The reorganization resulted in a statistically significant 30 percent increase of the frequency of all occupational injuries and illnesses increases in manufacturing and also in tertiary activities (see Graph 1)⁴; about, one third of the variance of injury rate since 1979 is explained by organizational change.

Therefore, reversing the previous correlation, we can compute with occupational injury and illness data, a "I-reorganization" dummy which instruments or directly proxies the adoption of new workplace practices. The advantage of this method is that the rate of injury and illness is given by by the OSHA (*Occupational Safety and Health Administration*), along with the *Bureau of Labor Statistics* in the *Monthly Labor Review*⁵ for 450 detailed 4-digit SIC manufacturing industries since 1976. There is also data for the rate of injuries exclusively, the number of fatal cases ... Precisely the rate is the number of cases per 100 full-time workers; this choice avoids the effects of changes in part-time jobs or worked hours⁶. These data have a good degree of reliability (see appendix B). In this paper, we use only the annual rate

of total injuries and illnesses. We are now able to give the exact definition of “I-reorganization”.

Definition 2 *Consider an industry. A year t is a year of I-reorganization if and only if the log of the 3-year moving average of workplace injury and illness rate at $t + 1$ minus its value at date $t - 1$ is equal to 0.1 (a 10% shock). An industry is “I-reorganized” if it experienced at least one I-reorganization year during the eighties. The “I-reorganized” dummy takes the value one if the industry is “I-reorganized”; otherwise it is zero.*

Due to lack of data, this dummy is available for only 229 4-digit SIC industries⁷; they represent about 50% of manufacturing employment since 1975. The choice of the 10% cutoff is not arbitrary: it tries to stick to the stylized facts on real organizational change in American manufacturing. Thus, this definition is consistent with the observed spread of new workplace practices: The I-reorganizing years occurred during the eighties, and two-thirds of them between 1986 and 1989 (see Graph 1b). In general, I-reorganized industries experienced several years of I-reorganization. Such reorganization occurred in all the macro sectors but more dramatically in some - Electronic, transportation equipments, apparel- than in others - lumber and wood, furniture, printing and publishing-. At 2-digit SIC level, I-reorganized criterion is consistent with both Osterman’s survey and managerial literature. Consistent with the firm-level studies on new workplace practices, about two-thirds of the industries (and of the manufacturing employment) are I-reorganized. At the 4-digit SIC level, R-reorganization and I-reorganization with the 10% cutoff have a very significant ($p < 0.01$) positive correlation. Thus the I-reorganization dummy can be a good instrument for R-reorganization.

To conclude, the I-reorganized dummy is of course a basic proxy of new practices, but it has two advantages: firstly it avoids large measurement errors in surveys conducted by interview and secondly, it captures changes which have real and significant impacts on workplace organization.

Remark 1 *Even if the reader rejects the previous connections between intensification, injuries and illness, and the adoption of new practices, again the latter is associated with a learning phase for workers and safety regulators, during which the number of workplace hazards should increase; therefore I-reorganization can be interpreted as an index to a transitional damage of workplace health and safety due to organizational change.*

1.3 Industrial data

In addition to the data on injuries and illnesses, we use the NBER productivity database computed by Bartelsman, Becker and Gray, Feenstra's data set on international trade, and data on investments in computers excerpted from the *Census of Manufactures*. Bartelsman, Becker and Gray (1996) give a complete presentation of their *Census Manufacturing Industry Productivity Database* and the methodology used for computing the Total Factor Productivity Index. The version (November 1998) used in this paper covers 450 manufacturing industries from 1958 to 1994 in the United States. Most data are drawn from the *Annual Survey of Manufactures*. For each year and each industry, we have the 4-digit code SIC (1972 definition), the total employment⁸, the total payroll (apart from benefits), the number of production workers, the annual hours worked by production workers, the wages of production workers, the value added, the cost of inputs, the end-of-the year inventories, investment, the real values of equipment and construction stocks, the energy costs, the value of shipments, the Total Factor Productivity, and the price deflators for energy, investments, inputs and final goods. In addition, Feenstra's set gives for each industry the value of exports and imports from 1958 to 1994 (Feenstra, 1996). Finally every 5 years, the Census Bureau publishes in its supplemental data for the *Census of Manufactures* the value of investments in computer and data processing systems by 4-digit SIC industries. Due to disclosure, the firms may not have been reported and so the data are not available for all industries.

Summary statistics are reported in table 2.

2 Reorganization and productivity

This section analyses the consequences of both organizational change and computerization on productivity.

2.1 Labor productivity

We have computed (see appendix A for methodology) for the I-reorganized sector (the aggregate of I-reorganized industries) and the non-I-reorganized sector (the aggregate of non-I-reorganized industries) the labor productivity from 1976 to 1994. Graph 2 presents the results. From 1976 to 1983, the two sectors had exactly the same productivity growth: 1% per year on average (productivity slowdown). From 1983 to 1994, while the non-I-reorganized sector continued to grow slowly, 1.4% per year, the labor productivity improved in the I-reorganized sector with a 4% per year growth rate, resulting in a 50% increase over 11 years⁹. The I-reorganization defined with the data on injuries and illnesses yields large improvements; they correspond to the “miracle” described in the management literature (e.g. Womack et al., 1996).

2.2 Total factor productivity

In fact, the best way to determine the consequences of innovations on productivity is to study the trends of Total Factor Productivity (TFP).

Graph 3 presents the total factor productivity level for both I-reorganized and non-I-reorganized sectors (see appendix A for methodology). The TFP is pro-cyclical because it is not fully corrected by the factor capacity utilization rates. The two sectors experienced a small TFP growth between 1976 and 1982. Then, up to 1987, the TFP have increased in the two sectors. The evolution is then chaotic due to the recession of the early nineties; nevertheless, the gap of TFP growth has widened

between the two sectors. Thus, from 1982 to 1994, the I-reorganized sectors have gained only 2 points of TFP while the I-reorganized industries have gained 16%. Moreover, this performance is unique since 1958 (see Graph 3b).

We will statistically verify these findings for the period from 1982 to 1992. We consider this period because:

- 1) innovative workplace practices and computerization dramatically expand during this period,
- 2) Osterman's data were collected in 1992,
- 3) we have computer investments in 1992 from the *Census*,
- 4) 1982 and 1992 occurred at about the same point of the business cycle.

Note that the same exercise expanded to the 1982-1994 period gives similar conclusions. In order to capture aggregate impacts, as Berman et al. (1994), Autor et al. (1998) or Feenstra et al. (1999) do, the estimations are weighted -here by the average industry employment at the beginning and at the end of the period. Moreover, as Berman, Bound and Griliches (1994) argue, weighting reduces data noise caused by the shift of firms between industries and the periodic redrawing of the ASM firm sample.

Column 1 of table 4 presents the regression of the growth of the TFP on the degree of R-reorganization (computed directly from Osterman's database). Reorganization results in an average annual increase of 0.3 TFP points. Nevertheless, this coefficient is not statistically significant. But, as we have already noted, the R-reorganized index certainly includes large measurement errors because of the small size of the sample and the erroneous declarations of employers. Therefore, we instrument this indicator with the dummy I-Reorganized built from workplace injury stats (which again have a good degree of confidence). The regression (2) shows that the impact of the reorganizations on the TFP becomes statistically significant and larger: about 0.4 point per annum on average. Thus, completely reorganized industries (i.e. $R - index = 300$) can reach an annual TFP improvement of 1.2 points during the 1982-1992 period. However, the explained part of the variance

is very small. Besides, if one uses the I-reorganized dummy directly, the impact of reorganization on productivity becomes very statistically significant. The impact of the reorganization proxied by the I-reorganization dummy is 0.8 points per year. Note also that the share of the variance explained by I-reorganization is higher -5 %- but remains small.

2.3 The selection bias

Recent papers have shown the importance of selection bias in estimation of the consequences of ICT (see e.g. Entorf et al., 1997). A positive correlation between performances and an innovation, can just reflect the fact that industries with particular characteristics both experience good performances and are more able to implement innovations, and thus can not reflect a causality.

This issue can be particularly relevant for organizational innovations. Indeed, the latter could be endogenous to the technological level, the international pressure or the development of corporate governance

Most theoretical and empirical analyses¹⁰ of the diffusion of new workplace practices stress the catalyst role of Information Technologies. ICT should enhance horizontal communication in firms (Hammer and Champy, 1993). The new practices should allow for multitask work (Lindbeck and Snower, 1996). Using the French datasets, Coutrot (1996) and Greenan (1996), find in their respective studies a significant correlation between organizational change and the use of technically advanced equipment. More fundamentally, using a sample of Fortune firms, Brynjolfsson and Hitt (1998) and Bresnahan et al. (1999), show that ICT and organizational change are strongly correlated. Thus, I-reorganization may be correlated to IT investments. Unfortunately, our data for detailed industries only pertain to computer and data processing equipment investments during the census years. Therefore, it is possible to study the latter correlation for only one aspect of Information Technology: computerization¹¹.

Organizational change and reengineering can be also an endogenous response of firms to the increasing and future pressure of foreign competitors on American markets (Wood, 1994). For example, Japanese firms have induced GM and Ford to adopt innovative work practices in the late eighties (Womack et al., 1991).

Finally, the development of corporate governance during the eighties has induced firms to cut costs and downsize in order to improve profits. The industries with low return to capital should have been particularly concerned. Unfortunately, the ASMs do not provide data on benefits at 4-digit SIC level and therefore it is not possible to compute the return to capital. However, other things being equal, we can consider that industries with both high production and non-production wages¹² offer bad performances to shareholders.

Because, IT investments, adaptation to foreign competition or corporate governance should result in productivity improvement, it is necessary to determine the causal effect of reorganization. Crepon and Iung (1999) propose a simple two-steps method to estimate the causal effect of an alternative: the weighting method (see appendix A for details). The first step is to perform a probit or logit test on I-reorganized dummy. The second one uses the estimates of the probability of I-reorganize as weights on the observed or "naive" impact of I-reorganization.

Because most adoptions of new workplace practices occurred after 1983 in manufacturing and because I-reorganization years are concentrated in the second part of the eighties (Graph 1b), we will determine the characteristics of the industries in 1982. Table 3 presents a set of pooled cross-industry regressions covering the alternative I-reorganized / non-I-reorganized with regard to the values in 1982 of the explanatory variables (i.e. just before the reorganizations). Columns 1 and 3 include import penetration measure, average wage of production workers, average wage of non-production workers, non-production workers' share in the employment, capital intensity and value added per worker. We also include the 3-year moving average of the rate of total occupational injury and illnesses; it is reasonable that the implementation of harder practices is more acceptable in industries with a low

frequency of workplace hazards. In columns 2 and 3, we include the share of computer (and peripheral data processing equipment) in total investment in 1982 and 1987 for 4-digit SIC industries¹³; the period from 1982 to 1987 corresponds to the spike of I- or R-reorganization and to an acceleration of computerization in all industries. Computerizations in 1982 and 1987 are never significantly correlated with I-reorganization. Value-added per employee, capital intensity are not significant. In fact, these variables are killed by the average wage of production workers, which is significantly correlated with I-dummy; the associated coefficient is particularly high. Import penetration is also significant having a rather large coefficient. These findings support that reorganization could be an endogenous response to international and shareholder pressures. Finally, as expected, the initial weakness of occupational injuries and illnesses is very significant.

Remark 2 : *These results are not necessarily inconsistent with previous studies which found a clear correlation between IT and organizational change. Indeed, the latter are based on firm data sets and their tests are controlled by industry. Therefore, at firm level, high - compared to the average of the industry- computerization can be useful for implementing innovative workplace practices; but heavy investments in computers are not necessary for low technological industries.*

We are now able to perform the second step of Crépon et al. (1999) method. Table 4b show the causal effect of I-reorganization estimated with the 3 models of table 3.

The re-estimations support the idea that “naive” tests can overestimate the consequences of I-reorganization on productivity. However, after correction of the selection bias, the impact of I-reorganization on TFP remains large -at least 0.6% per year- and is still statistically significant. Therefore, we can consider that selection bias is of second order compared to the observed effect of I-reorganization on TFP.

2.4 Computerization and TFP

The previous tests confirm that organizational changes ensure important improvements in productivity in the manufacturing sector. Nevertheless, the weakness of the R^2 in “naive” regressions suggests that other mechanisms have played more crucial roles in the performances of American firms. These mechanisms could be connected with the development of information technologies.

The debate on the impact of computerization on productivity is still unresolved (see Brynjolfsson and Yang (1996) or Morrison (1997)). Computers should ensure large productivity gains and a new industrial revolution. New technology has seen failure in many firms; the efficiency gain may be low and the costs of computerization may be higher than the improvements in productivity (Schrage, 1997).

We can use our data to evaluate the impact of computerization between 1982 and 1992. Since computer performance and nominal computer investments improved in the eighties, we would like to have the stock of computer for 1992. These data are not available at 4-digit SIC level. Following again Berman et al. (1994) or Autor et al. (1998), we consider that the level of computer investment in 1992 -here divided by the employment- should proxy for computerization in the early nineties. We redo the previous test on TFP, including this index¹⁴ (columns 3 to 6). The effects of reorganization identified in the previous subsection are not altered. Computerization has no significant positive impact on productivity. In fact it appears to be negative. Note again that our analysis is limited to computers and data processing systems; we do not conclude that the new technology as a whole has a negative impact. In fact, we just find as many studies the productivity paradox

Brynjolfsson and Hitt (1998) show for a sample of 1000 Fortune firms from 1987 to 1994 a complementarity for productivity between decentralization and investments in Information Technology (this result is particularly significant for the nineties). Bresnahan et al. (1998) and (1999) confirm these findings with the same survey: Fortune firms with low IT and low new workplace practices have higher

productivity than those with one but not the other. They thus stress the role of “IT-enabled organization”.

We are able to test here their view for all the American manufacturing, without a statistical bias toward large firms and with complete longitudinal data for TFP. We regress the TFP on computerization and on the cross-product of computerization and the I-or R-index. Columns 7 to 9 give coherent results. The computerization is very significantly¹⁵ positive for growth if and only if the industry is reorganized according to the R or I-index. The outcome of computerization is large in reorganized industries: e.g., on average about 1% of annual TFP growth, in I-reorganized industries. Moreover, this mechanism explains about one-fifth of the variance of the growth of TFP over the 1982-1992 period. Therefore, this paper shows that computerization is not a necessary condition for I-reorganization¹⁶ but rather that I-reorganization may be necessary for an efficient use of computers. Finally, the term -reorganization \times computerization- kills the impact of reorganization alone

These results strongly support the complementarity for productivity between IT and new workplace practices. Moreover, the Solow paradox is solved. Indeed, the small aggregated effect of computers should be in fact split into two parts:

1) in non-reorganized establishments, computers bring about a decrease in TFP, not because they reduce the output but rather because computer expenditures increase the capital stock without raising the output.

2) in reorganized establishments, which therefore use intensively information, computers, as expected, dramatically improve productivity.

Remark 3 *The previous evidences solve the Solow paradox but also show a new paradox. Why some industries (and thus firms) were blind accumulating computers without productivity improvement? Vogue, mimesis, network necessity, very long-run view?*

Finally, if the “new economy” is identified with a reshaped productivity expansion due to IT, it began in the reorganized American manufacturing industries in the

eighties. Note also that because of SIC changes in 1987 and lacks of occupational injury data, computer industry (357 SIC87) is excluded from the sample used in this paper. Thus, the productivity improvements exhibited here are independent of the huge gains in computer production (See e.g. Gordon (1999)).

Because of the dramatic consequences of workplace change on productivity, we can also think that they can have a large impact on skill requirements. The next section is devoted to this issue.

3 Production and non-production workers

The American manufacturing data have been already extensively used to determine the skill-bias of technological innovations, trade or outsourcing (Berman et al. (1994), Autor et al. (1998), Feenstra et al. (1999)). In this section, we use our indexes of reorganization to estimate the impact of organizational innovation.

3.1 The dramatic change in wage bill composition

The *Annual Survey of Manufactures* does not indicate the skill composition of the workforce. Therefore, information on the level of education of the workforce is not available at a four-digit industry level¹⁷. Nevertheless, it provides production and non-production employment. Studies based on the CPS data set display a strong correlation between employment status and skills or experience; therefore, we first follow Berman et al. (1994) or Autor et al. (1998) in using the non-production workers' share in the wage bill to capture the importance of skilled employees at industry level.

Graph 4 documents the evolution of the non-production workers' share in the total or operating wage bills since the seventies. It appears that the skill upgrading was very sharp from 1976 to 1986. This point is largely documented; for example,

in Berman et al. (1994) or Autor et al. (1998), computerization and IT were determined to be the culprits¹⁸. These authors and most industry-level studies limit their analyses to the eighties, yet we see that the early nineties underwent a clear period of stabilization. The stability of the ratio of production to non-production workers can challenge previous studies on the impact of innovations on skill upgrading: Does computerization remain skill-biased? Does the diffusion of non-traditional structures reverse the trend?

A growing volume of literature offers some hints for answering the second question. On the one hand, more autonomy and responsibility, the ability to perform of a wider range of tasks should require a higher skill-level (for a clear defense of this statement, see Caroli (1998)). Using large establishment surveys, the 1984 and 1990 WIRS for Britain and REPOSE 1992 for France, Caroli and Van Reenen (1999) provide evidence indicating that plants which introduce organizational change (such as the delayering of hierarchies) tend to reduce their dependence on low-skilled employees. Bresnhan et al. (1999) give some evidence of the complementarities between skills and innovative practices for Fortune firms. However, case studies do not completely support this assertion; for example, when NUMMI, the laboratory of Toyota's lean production in the United States, was created, most workers who were hired were also former employees of the particularly low-efficient Fremont-GM plant which had closed two years before (Adler et al., 1997). In France, the new lean car part and accessories plants, created in the nineties, hire mainly low-educated workers who have "memory" skills and can acquire specific competencies during on-and-off the job training; therefore, workers are *ex ante* unskilled and *ex post* specific-skilled (Gorgeu, Mathieu, 1995). Caroli and Van-Reenen (1999) show that reorganized plants in Britain train up the remaining workers in general skills; using his survey of U.S. establishments, Osterman (1995) finds also that high performance work organizations provide more training than do other establishments.

At the same time, delayering, by definition, results in a reduction of supervisors. Therefore, the main victims of reorganization will be in middle-management

and not production employment (Dopson and Stewart (1993) or Wheatley (1992)). Thus, the effect of a non-traditional structure on employment composition is *a priori* ambiguous. As for productivity, no quantitative study has been conducted at a cross-industry level. The next subsection presents the method for estimating skill (or more exactly non-production) upgrading.

3.2 Estimating methodology

For our samples of American industries, we use a very standard approach derived from that of Berman, Bound and Griliches (1994) to estimate the evolution of the proportion of non-production workers in the total workforce. We consider that the cost function is translog with two variable factors -production and non-production workers- and $n = 3$ quasi-fixed factors -capital stocks K_i : IT (computerization), construction and conventional equipment-. Assuming that this function is price-homogeneous to a degree one, the Shephard's lemma yields the non-production workers' share in the wage bill:

$$SB_N = \alpha_N + \beta_N \ln(w_N/w_P) + \beta_{PY} \ln Y + \sum_i^n \beta_{Ni} \ln(K_i/Y), \quad (1)$$

where w_P is the production workers wage and w_N is that of non-production employees. We estimate the following first difference equation :

$$dSB_N = \alpha_S + \beta d \ln(w_N/w_P) + \beta_Y d \ln Y + \sum_i \beta_i d \ln(K_i/Y). \quad (2)$$

Of course, we will add to this equation the R- and I- indexes for reorganization. This equation has the advantage of separating the impacts of computerization and standard capital accumulations. If $\beta_i > 0$, then capital of type (i) is a substitute for production employment and/or a complement to non-production workers i.e. it is skill-biased. Note that contrary to Berman et al. (1994), we do not necessarily assume that $d \ln(w_P/w_N)$ is similar across all industries.

The estimations are weighted by the average of the industry employment at the beginning and at the end of the period, once again in order to capture the aggregate

effects on the composition of the labor force and to correct for heteroskedastic bias.

3.3 Innovations and occupations

As in the previous section about productivity, we determine here the respective impacts of organizational innovations and computerization on employment composition¹⁹.

Table 5 presents a set of pooled industry regressions covering the 1982-1992 period²⁰ in an attempt to explain changes in the employment non-production workers' share within the four-digit industries. Columns (1) to (4) include the R-reorganized index and I-reorganized dummy. Tests (3) and (4) also include the evolution of the relative costs of non-production workers. All these regressions indicate that from 1982 to 1992, the impact of reorganizations on "non-production upgrading" is statistically insignificant and small. Particularly, in this case R- and I-indicators give similar results. Along with the growth of non-production costs, the overall growth of the log equipment value-added-ratio is positively and very significantly related to non-production upgrading. These findings confirm that capital and skilled workers are complements of one another and substitutes for production employment.

The effect of I- or R-reorganization on production stabilization is not altered when specifications are expanded to include computer investment in 1992²¹ (regressions 5 to 8). Here again, computerization and reorganization per se have very different consequences. Consistent with previous studies on American manufacturing, computer investment results in a rise of about 0.2 percentage points per annum for the non-production workers' share²² from 1982 to 1992. This rise accounts for approximately twice the total increase during this period.

Finally, unlike productivity, the cross-product of computerization and reorganization has no robust impact on the composition of employment (tests 9 and 10); there is an unclear complementary effect of organizational and technological innovations toward non-production workers in American manufacturing.

Under the hypotheses that new workplace practices are correctly proxied by the workplace injury and illness trends or by the aggregate of Osterman's survey, we can conclude:

Proposition 1 *The reorganization in the operating manufacturing industry is not biased against production workers.*

Note that the effect of reorganization exhibited here is not necessarily inconsistent with the findings of Caroli and Van Reenen (1999). Indeed, the lean production was first implemented at the level of manufacturing shops that were making heavy layoffs of production workers; then it was extended to the whole corporation, firm administration and white-collar jobs (the reengineering of Hammer and Champy, 1993). Therefore, Caroli and Van Reenen's study, which only applied to the eighties and early nineties for France and Britain, where the adoption of new workplace practices was more recent than in United-States, should capture only the first wave. This view is corroborated by Coutrot (2000). Using again REPOSE 1992 but also REPOSE 1998 surveys, Coutrot shows that the diffusion of ICT is the chief explanation for the shift toward skilled occupations between 1992 and 1998 in France, while the massive organizational changes are associated with only a small employment reallocation effect. Finally, our analysis is restricted to production versus non-production employment. Thus, we have no information on a possible bias toward hiring more educated workers or training current ones. The production versus non-production dichotomy is certainly too raw an instrument for capturing the real skill-change in reorganized industries. We simply show that reorganization does not eliminate production employment. It reverses the trend of the eighties and works against the consequences of computerization on production labor; the manufacturing workforce will not be composed only of white-collar workers. Thus, this paper complements rather than refutes the findings of concordant firm-level studies on skill upgrading.

4 Conclusion

New workplace practices, which have already known much success in the United-States, are based on an intensification of work. Actually, their adoption has been accompanied by a dramatic increase in occupational injuries and illnesses. We use this correlation to define by detailed 4-digit SIC industries a concept of I-reorganization: an industry is I-reorganized if it experienced a strong increase in occupational injuries and illnesses. I-reorganization should instrument direct evidence on workplace changes or should directly proxy the implementation of new workplace organizations.

The reorganized industries faced higher import penetration. Fundamentally, these industries have higher labor costs and have fewer supervisory staffs.

The reorganization ensures large productivity gains. Basically, the reorganizations are necessary for an efficient use of computer technology. The Solow paradox is in fact the result of a strong decrease of TFP in computerized but non-reorganized industries, and an increase in computerized **and** reorganized industries. The computers dramatically enhance productivity but only in industries for which the structure of the establishments uses intensively information. Thus there is no IT paradox.

Otherwise, contrary to computers, the reorganization does not seem biased against production workers in American manufacturing. Nevertheless, we have no evidence on changing skill requirements into production or non-production categories.

This empirical work emphasizes the key role played by the workplace reorganization on the present “new economy”.

Appendix A: methodology

Computation of labor productivity

For computing the labor productivity, we use the BLS method: Tornqvist's formula²³. Let $v_{i,t}$ be the value of shipment at year t in sector i . Let Q_t denote the output (for example) for all the I-reorganized industries, $q_{i,t}$ be the output of sector i in year t and $p_{i,t}$ the price index of products from this industry. The following relation holds

$$\frac{q_{i,t}}{q_{i,t-1}} = \frac{p_{i,t-1}}{p_{i,t}} \frac{v_{i,t}}{v_{i,t-1}}.$$

The average weight of sector i at date t , we call $w_{i,t}$ defined as: $w_{i,t} = (s_{i,t} + s_{i,t-1})/2$, where

$$s_{i,t} = \frac{v_{i,t}}{\sum_j v_{j,t}}.$$

The Tornqvist formula gives an approximation of the output growth:

$$\frac{Q_t}{Q_{t-1}} = \exp\left[\sum_i^n w_{i,t} \left(\ln \frac{q_{i,t}}{q_{i,t-1}}\right)\right].$$

If 0 is the reference year, the productivity index at date t is: $\frac{Q_t L_0}{Q_0 L_t}$, where L_t is the total employment.

NB: this definition does not include variations in annual worked hours. Since we do not have the number of hours worked by non-production workers, it is impossible to compute a perfect index. A partial solution can be to extrapolate the evolution of non-production hours by using production hours. This method gives very similar relative results. The numbers of hours worked per production worker in reorganized and non-reorganized industries differ by a small percentage (1 or 2 % during the period studied in this paper); these numbers were constant until 1980, then they increased slightly to become 7% higher in 1994 (in both sectors). Moreover, the evolution of non-operating employment is small and can modify the value of productivity change by less than 1 or 2%.

Total Factor Productivity

The 5 factors TFP index for each 4-digit SIC industry is given by Bartelsman-Becker-Gray (see Bartelsman, Becker and Gray (1996) for a description).

In order to compute the TFP of a reorganized sector, for example, it is necessary to create aggregated price indexes for labor or inputs. This long methodology multiplies risks of error. This is why we choose a very simple method for aggregated sectors. Let TFP_t denote the growth of Total Factor Productivity for year $t - 1$ from t and let $TFP_{i,t}$ be the growth of Total Factor Productivity to year for the sector i from $t - 1$ to t . We consider that $TFP_t = \sum \nu_{i,t} TFP_{i,t}$, where $\nu_{i,t}$ is the weight of industry i in year t . We take various specifications for the weight: employment, shipments or value added. These three specifications give quite similar results. We take in this paper the intermediate specification: employment.

Determination of the causal effect

We have split the industries into I-reorganized and non-I-reorganized industries. The interpretation of the correlation between I-reorganization and higher productivity as a causal relation poses numerous problems. The more accurate problem is the selection bias. Indeed, some characteristics of the industries should simultaneously affect performance and the ability to implement innovative workplace practices. The identification of the causal effect requires restrictive assumptions. In this paper, we follow Crépon and Iung (1999) in the framework of Rubin's causal model (Rosenbaum and Rubin, 1983).

Consider $i = 1 \dots N$ industries. We want to study the performance of these industries: y_i (here TFP). Let ino_i be the I-dummy. Rubin's model introduces two stochastic variables, y_{0i} and y_{1i} , corresponding to the potential performance regardless of whether the industry is I-reorganized or not. Only one variable is observed. More precisely, we observe $(y_i = (1 - ino_i)y_{0i} + ino_i y_{1i}, ino_i)$. Rubin defines the causal effect as

$$c_i = y_{0i} - y_{1i}. \quad (3)$$

This quantity is not observable and non-identifiable. However, some characteristics can be identified, notably $E(c_i)$.

Assume that potential performances and the organizational change are independent conditionally the observable characteristics of the industries. Under this assumption, the causal effect is (see for a proof the appendix 3 in Crépon and Iung, 1999)

$$E(c_i) = E\left[y_i \left\{ \frac{ino_i}{\pi(x_i)} - \frac{1 - ino_i}{1 - \pi(x_i)} \right\}\right], \quad (4)$$

where $\pi(x_i) = E(\text{ino}_i = 1|x_i)$. Thus, we can estimate the causal effect by using the empirical expectations and by replacing π by a convergent estimator (Logit or Probit); the estimator of the causal effect is named the "weighting estimator". Crépon and Iung (1999) show that this estimator (with logit) is asymptotically normal and has for asymptotic variance the variance of ϕ_i :

$$\phi_i = y_i \left\{ \frac{\text{ino}_i}{\pi(x_i)} - \frac{1 - \text{ino}_i}{1 - \pi(x_i)} \right\} - c_o \quad (5)$$

$$-E \left[\left\{ \frac{\text{ino}_i(1 - \pi(x_i))}{\pi(x_i)} - \frac{\pi(x_i)(1 - \text{ino}_i)}{1 - \pi(x_i)} \right\} y_i x_i \right] E[\pi(x_i)(1 - \pi(x_i))x_i'x_i]^{-1} [(\text{ino}_i - \pi(x_i))x_i'].$$

Finally, note that this estimation results in significant imprecisions for our sample of only two hundred industries.

Appendix B: data on occupational injuries and illnesses

The BLS-OSHA national surveillance program has been conducted since 1971; it is an annual survey of a sample of 250,000 establishments with more than 10 employees. The sites are randomly selected. The response rate is about 95%. The employer declarations are confidential (except between 1981 and 1988; see below for the consequences of this policy). Information from the survey is provided on all occupational injuries and illnesses involving loss of consciousness, restriction of work, transfer to another job or medical treatment beyond first aid (see *BLS Handbook*, April 1997).

We use in this paper the rate of total injuries and illnesses, so not only the cases involving lost workdays. This choice may avoid the consequences of different state-compensation regulation and is less affected by the following weaknesses than lost workday cases.

The BLS data have been criticized; they do not distinguish the nature of injuries and their severity, give vague definitions and have overlapping categories²⁴ (MacNeelly (1991), Rubens et al. (1995)).

Nevertheless, Murphy et al. (1996) claim that the BLS data are not so bad: they are based on a large sample size, the response rate is high and the data collection is standardized; "filtering effects exist at each step in reporting process that reduce the likelihood that an illness or injury at a worksite will appear in a national aggregate".

Moreover the different sources on occupational injuries (OSHA-BLS, *National Council on Compensation Insurance data, National Electronic Injury Surveillance System...*) give quite coherent data.

Of particular concern to users of the BLS data was the decision by the Fed-OSHA in 1981 to use required employer injury logs in making decisions about which manufacturing plants to inspect. This procedure raised concern (National Research Council, 1987) and was discontinued in 1988. Studies of state and county-based occupational health reporting systems indicate weaknesses during the period 1981-1988. For example, in Michigan, the BLS was determined to underestimate by a factor four the number of missed workdays (Oleinick et al., 1993) in 1986. In fact, the disincentives to report adverse health events might be significant. Moreover, the frequency of inspections varied widely with a shift away from inspecting large establishments. Ruser and Smith (1988, 1991) have very carefully studied these questions for lost-workday injury rates. They assemble a data set by matching exhaustive records for manufacturing establishments. Their controlled longitudinal analysis confirms previous studies²⁵: there is little evidence to suggest that OSHA inspections modified the lost workday injury rate. The consequences of record-checking are more mitigated; the effect is virtually zero for inspected establishments (i.e. about half of the employment) but the non-inspected establishments underreported consistently after 1981 (about 10%). According to Ruser and Smith, the global underreporting rate by industry was about 5% in the early eighties. Thus, the end of the recordcheck policy and improvements in the sanction program may explain a small part of the observed increase (in data) of accidents in the late eighties. Therefore they can not explain the relative increase in injuries in only some industries. More precisely, the BLS made two pilot surveys in 1987 and 1997 on the employer declarations in 1986 and 1996. They show that underreporting was quite high -about 10% in 1986 - but that it had not increased because it was about 11% in 1996 (Conway et al., 1998); thus we can really consider that the policy change in 1988 did not modify the reporting behavior of employers.

Notes

¹Thus, Adler et al. (1997) report that the 1993 model change at NUMMI, the GM-Toyota joint-venture, resulted in a 12-percent increase in worker absences due to safety problems.

²However, when they look for a statistical connection between new workplace practices, at the establishment level, and the increase of CTDs at a 3-digit SIC level, they find no clear positive correlation except for Quality Circles.

³The CTDs represent about only 3% of all occupational hazards.

⁴We regress the growth of injuries and illnesses during 6 periods of 3 years from 1979 to 1997 for 26 2-digit SIC sectors, on a dummy: reorganizing=1, non-reorganizing=0. The tests include controls such the initial rate of injuries and fixed effects.

⁵For a more detailed description and discussion of the weaknesses of these data, see appendix B.

⁶The weekly worked hours increased in the eighties and contributed to the growth of inter industry differentials (Leamer and Thonberg, 1998).

⁷The listing of these industries is available from the author upon request.

⁸Payroll and employment are only for operating plants. The ASM does not provide data on the employment of auxiliary units (mainly central offices and also research laboratories and warehousing) at the 4-digit SIC level. Workers in auxiliary units are considered to be non-production workers; their share in the total manufacturing employment has slightly increased over the past 20 years; they represented 7% of total employment in 1994. Data by 2-digit SIC reveal minor trends among major groups. Therefore, the introduction of non-operating workers may modify only marginally the results. Nevertheless, it is important to keep in mind that the analyses of wages and employment are limited to operating workers (see note 19).

⁹If we correct the labor productivity with the increase of hours worked or the increase of non-operating workers, the growth in the eighties is about 7% lower in both the I-reorganized and non-I-reorganized industries (see appendix A).

¹⁰Milgrom et al. (1995). See Aghion et al. (1999) for a review.

¹¹At the end of the eighties, the total stock of IT in American manufacturing is about two times the value restricted to computers.

¹²One can also argue that higher wages can reflect higher skills; nevertheless Krueger and Summers (1988) show that the addition of human capital controls results in a small drop in the standard deviation of the industry wage differentials.

¹³The data for 1977, 1982 and 1987 were kindly provided by Eli Berman. They have been used as criteria for computerization by Berman et al. (1994) and Autor et al. (1998).

¹⁴We also tried to control these regressions with the computerization in 1982. The conclusions are unchanged.

¹⁵We have also performed the same tests using OLS weighted or unweighted and corrected for heteroskedasticity with White's method. They reach the same conclusions.

¹⁶Because I-reorganization is not correlated with the computerization in 1982 (see previous section) or in 1992 (tests non-reported), it is not possible to argue that industries reorganize for further implementations of IT.

¹⁷The CPS gives these statistics for only 82 CIC manufacturing industries.

¹⁸A large body of theoretical literature has recently emerged to explain that present technical change, or more generally, the diffusion of General Purpose Technology is skill-biased (See Aghion et al., 1999).

¹⁹The ASM does not provide the statistics of auxiliaries (mainly labs and head offices) at a 3 or 4-digit SIC level, and outsourcing. Thus, our work is restricted to the production plants. Employees in auxiliaries are classified as non-production workers; their share in the total wage bill has increased but remained small for two decades: from 5.5% to 7.5%. The study of trends at a 2-digit SIC level reveals tiny but significant differences between reorganized and non-reorganized sectors. Therefore, we can consider that their exclusion induces that the analyses of skill-upgrading in U.S. manufacturing presented in this paper slightly underestimate the skill-bias of reorganization.

²⁰Here again, the tests over 1982-1994 gives similar results.

²¹We have also tried to include computer investment in 1982 and the evolution of the import and export penetration measures. These variables were never significant and did not alter the coefficient associated to computerization in 1992.

²²This impact is similar to Bernman et al. (1994) findings. Autor et al. (1998) find less sharp results: the growth of computer investment share from the seventies to the eighties accounts for the annual increase of 0.09 points during the 1979-1989 period.

²³See *BLS Handbook of Methods*, chapter 11, April 1997.

²⁴Murphy et al. (1996) estimate that overlap concerns less than 2.5 % of cases.

²⁵Except Scholz and Gray (1990): the 10% increase in inspections with **penalties** reduces the rate of lost-workday injuries by 1%. Note that this effect is small compared to the trend for injury rates in the eighties.

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Table 1: spread of innovative workplace practices in France and the US
% of establishments using

	US 1992	France 1992	France 1998
Autonomous team	54.5	11.9	35.0
TQM*	33.5	12.4	33.8
Job rotation	43.4	23.8	-

Source: Osterman (1994), Coutrot (2000). Establishments with 50 or more employees * Total quality management for the US and ISO norm for France

Table 2: summary statistics

	Max-sample				
	Unweighted		Weighted		
	1982	1992	1982	1992	N
I- dummy		0.67		0.64 (0.48)	229
Va	55.15 (28.29)	70.15 (46.40)	53.71 (22.85)	68.18 (41.11)	229
Capital	71.44 (71.81)	87.72 (88.29)	63.86 (58.22)	80.33 (74.41)	229
Computer	2.73 (3.01)	6.89 (7.93)	3.41 (3.62)	6.81 (5.89)	219- 207
Import penetration	0.08 (0.10)	0.13 (0.14)	0.07 (0.12)	0.12 (0.12)	229
Non-production share	0.27 (0.11)	0.28 (0.11)	0.30 (0.14)	0.30 (0.15)	229
Non-production bill	0.35 (0.11)	0.37 (0.12)	0.37 (0.14)	0.39 (0.15)	229

	Sub-sample				
	Unweighted		Weighted		
	1982	1992	1982	1992	N
R-index		99.03 (62.19)		98.81 (54.95)	117
I- dummy		0.72		0.67 (0.47)	117
Va	56.60 (27.80)	73.09 (49.59)	55.36 (22.54)	71.40 (42.99)	117
Capital	71.66 (76.83)	90.43 (91.92)	67.46 (61.88)	86.49 (79.17)	117
Computer	3.15 (3.40)	6.44 (5.71)	3.75 (3.94)	6.98 (6.08)	117- 110
Import penetration	0.07 (0.08)	0.12 (0.11)	0.07 (0.08)	0.11 (0.10)	117
Non-production share	0.28 (0.12)	0.28 (0.13)	0.32 (0.15)	0.32 (0.16)	117
Non-production bill	0.36 (0.13)	0.38 (0.14)	0.38 (0.15)	0.40 (0.16)	117

Source: Author's tabulations based on the NBER productivity database

Weight= average employment in 1982 and 1992.

R-index: R-reorganization index (see definition in the text)

I-dummy: I-reorganization dummy (see definition in the text)

Va: value added per worker (000 1987 \$)

Capital: capital stock per worker (000 1987 \$)

Computer: share of computers in the total investment in %

Import penetration: imports/ (imports + shipments)

Non-production share: Non-production workers' share in the total employment

Non-production bill: Non-production workers' share in the total wage bill.

Table 3: Causes of reorganization.
Dependent variable: columns 1-3, I-reorganized dummy

Variables in 1982	Mean S-deviation	1	2	3
C		0.52 (0.61)	0.33 (0.37)	0.45 (0.49)
Import penetration #	0.08 (0.10)	3.64** (2.81)	3.85** (2.87)	3.53** (2.59)
Computerization @ in 1982	0.027 (0.030)	-	3.66 (0.88)	-1.12 (-0.02)
Computerization @ in 1987	0.060 (0.056)	-	-	4.36 (1.46)
Wage of production workers (000\$)	16.44 (4.68)	0.12** (2.67)	0.14** (2.87)	0.14** (2.85)
Wage of non-production workers (000\$)	24.05 (3.66)	-0.01 (-0.20)	-0.01 (-0.12)	-0.03 (-0.58)
Non-production share ##	0.27 (0.11)	-1.07 (-1.01)	-1.28 (-1.10)	-1.97 (-1.58)
Value added per employee (00000\$)	0.47 (0.24)	-1.03* (-1.97)	-0.99 (-1.78)	-0.75 (-1.33)
Capital stock / value added	1.25 (0.90)	0.01 (0.08)	0.01 (0.08)	0.09 (0.51)
3-year moving average of occupational injuries	12.70 (5.03)	-0.10** (-4.65)	-0.10** (-4.65)	-0.10** (-4.47)
R ²		20	20	21
R ² Kullback-Leibler		18	18	19
N	Max. sample	229	219	208

Import penetration = imports/(imports+shipments). ## share of non-production workers in the total employment. @ Computerization is the computer share in the total investments. Estimation PROBIT.

*: p<0.05 **: p<0.01 Author's tabulations

Table 4: Productivity and reorganization

Dependent variable: Annual growth of TFP from 1982 to 1992

In*100	Mean (Std dev.) Weighted	1	2 IV	3	4	5	6 IV	7	8	9 IV
C	0.63 (1.72)	0.31 (0.88)	-3.52 (-1.97)	0.13 (0.71)	0.77** (4.32)	0.24 (1.07)	-3.19 (-1.78)	1.85** (3.35)	1.18** (4.58)	1.18** (3.72)
R-reorganization	101.75 (54.37)	3.41E-03 (0.81)	4.19E-02* (2.36)	-	-	-	4.36E-02* (2.29)	-0.93E-02 (-1.91)	-	-
I-reorganization	0.68 (0.47)	-	-	0.79** (3.41)	-	0.86** (3.53)	-	-	-0.61 (1.86)	-
Computerization in 1992#	306.76 (290.08)	-	-	-	-3.61E-04 (-0.86)	-4.13E-04 (-1.00)	-1.13E-03 (-1.31)	-4.63E-3** (-3.60)	-3.59E-3** (-5.66)	-8.21E-2** (-4.54)
Computerization in 1992* R	34722.34 (45309.62)	-	-	-	-	-	-	3.63E-5** (3.59)	-	6.41E-5** (4.66)
Computerization in 1992* I	196.38 (279.36)	-	-	-	-	-	-	-	4.90E-3** (6.21)	-
F	-	0.60	-	5.82**	0.37	4.42**	-	3.83**	13.57**	-
R ²	-	1	1	5	0	6	2	13	21	10
N	Max samp.	117	117	229	207	207	229	110	207	110

New computer expenditures per worker in 1992 (\$ 1992).

Estimations 1,3,4,5,7,8 OLS weighted by the average employment in 1982 and 1992 ;

Estimations 2,6,9 IV weighted by the average employment in 1982 and 1992 ; R-reorganization is instrumented by I-reorganized dummy

Computerization in 1992* R is instrumented by Computerization in 1992* I

T-statistics in parentheses. *: p<0.05 **: p<0.01

Author's tabulations.

Table 4b: Selection bias

Impact of I-reorganization on annual growth of TFP from 1982 to 1992

	“Naïve”	1	2	3
Impact in %	0.79	0.61	0.86	0.74
(Standard deviation)	(0.22)	(0.25)	(0.26)	(0.27)
Number of observation	229	229	219	208

Column “naïve” is just the result in column 3 of table 4. Columns 1 to 3 refer to the estimation of the causal effect after determination of the selection bias using tests of columns 1 to 3 of table 3. See appendix A for computational method.

Table 5: The impact of reorganizations and computers
Dependent variable: Annual change in non-production workers' share in the total wage bill 1982-1992

ln*100	Mean (Std dev.) Weighted	1	1b IV	2	3 IV	4	5 IV	6 IV	7	8	9 IV	10
C	0.16 (0.41)	0.21* (2.46)	0.59** (2.72)	0.31** (6.00)	0.35 (1.58)	0.13* (2.61)	0.31 (1.43)	0.11 0.53	0.10 (1.65)	-0.04 (-0.69)	-0.10 (-1.35)	0.02 (0.26)
R-reorganization	101.75 (54.37)	4.16E-4 (0.47)	-4.33E-3* (-2.01)	-	-3.42E-03 (-1.78)	-	-3.73E-03 (-1.88)	-2.98E-03 (-1.68)	-	-	-	-
I-reorganization	0.68 (0.47)	-	-	-0.17** (-3.16)	-	-0.14** (-3.01)	-	-	-0.17** (-3.26)	-0.14** (-3.12)	-	-0.07 (-0.77)
Computerization in 1992#	6.74 (6.03)	-	-	-	-	-	0.029** (4.01)	0.025** (4.04)	0.026** (5.70)	0.023** (5.57)	0.058** (4.67)	0.038** (3.92)
Computerization in 1992* R	724.8 (1008.9)	-	-	-	-	-	-	-	-	-	-2.42E-4* (-2.35)	-
Computerization in 1992* I	4.32 (5.24)	-	-	-	-	-	-	-	-	-	-	-0.014 (-1.35)
<i>d co</i>	-0.011 (0.033)	9.12** (3.47)	12.27** (3.60)	8.50** (4.84)	9.69** (3.15)	7.09** (4.57)	6.51 (1.91)	4.96 (1.65)	3.89* (2.10)	3.11 (1.91)	3.89 (1.43)	3.99* (2.16)
<i>d equip</i>	0.010 (0.036)	-0.91 (-0.46)	-1.09 (-0.48)	-1.30 (-0.99)	0.66 (0.33)	-0.09 (-0.08)	-0.74 (-0.35)	0.68 (0.37)	-0.93 (-0.72)	0.15 (0.13)	0.37 (0.19)	-1.02 (-0.79)
<i>d va</i>	0.017 (0.033)	5.04** (3.24)	8.00** (3.43)	4.45** (4.19)	7.97 (3.96)	5.03** (5.37)	4.76* (2.12)	5.21** (2.71)	2.00 (1.84)	2.89** (2.99)	0.03 (1.76)	1.92 (1.76)
<i>d ineq*100</i>	0.63 (0.91)	-	-	-	0.19** (4.50)	0.19** (8.08)	-	0.18** (4.45)	-	0.18** (7.63)	-	-
F	-	5.40**	-	10.00**	-	23.83**	-	-	12.27**	24.18**	-	11.01**
R ²	-	23	20	15	27	39	23	40	30	46	31	31
N	Max samp.	117	117	229	117	229	110	110	207	207	110	207

New computer expenditures / total investment in %

$d va$ = annual log change of value added (deflated by the CPI)

$d equip$ = annual log change of real equipment stock – $d va$

$d co$ = annual log change of real construction stock – $d va$

$d ineq.$ = annual log change of the ratio non-production wage/ production wage.

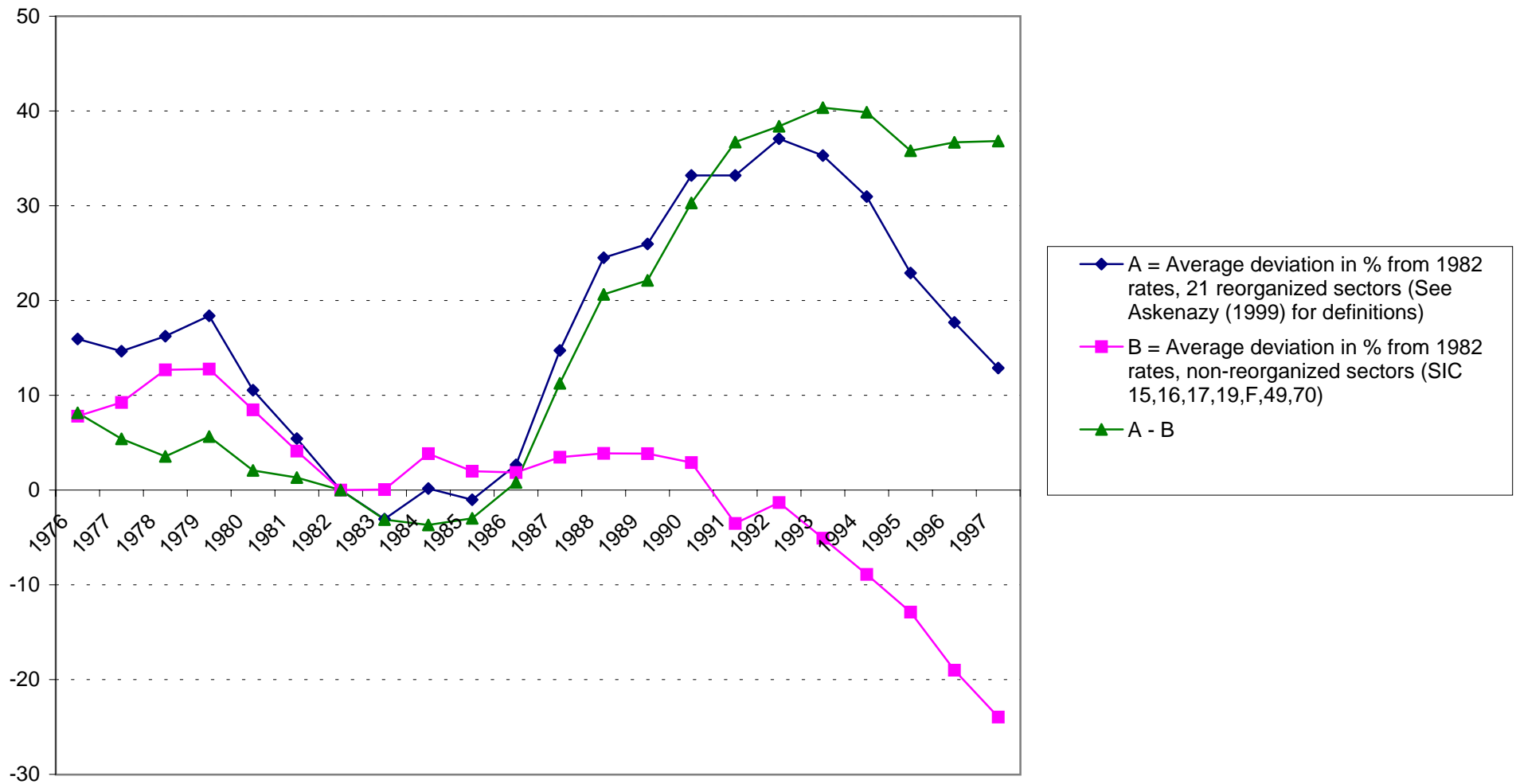
Estimations 1,2,4,7,8,10 OLS weighted by the average employment in 1982 and 1992 ;

Estimations 1b,3,5,6,9 IV weighted by the average employment in 1982 and 1992 ; R-reorganization is instrumented by I-reorganized dummy

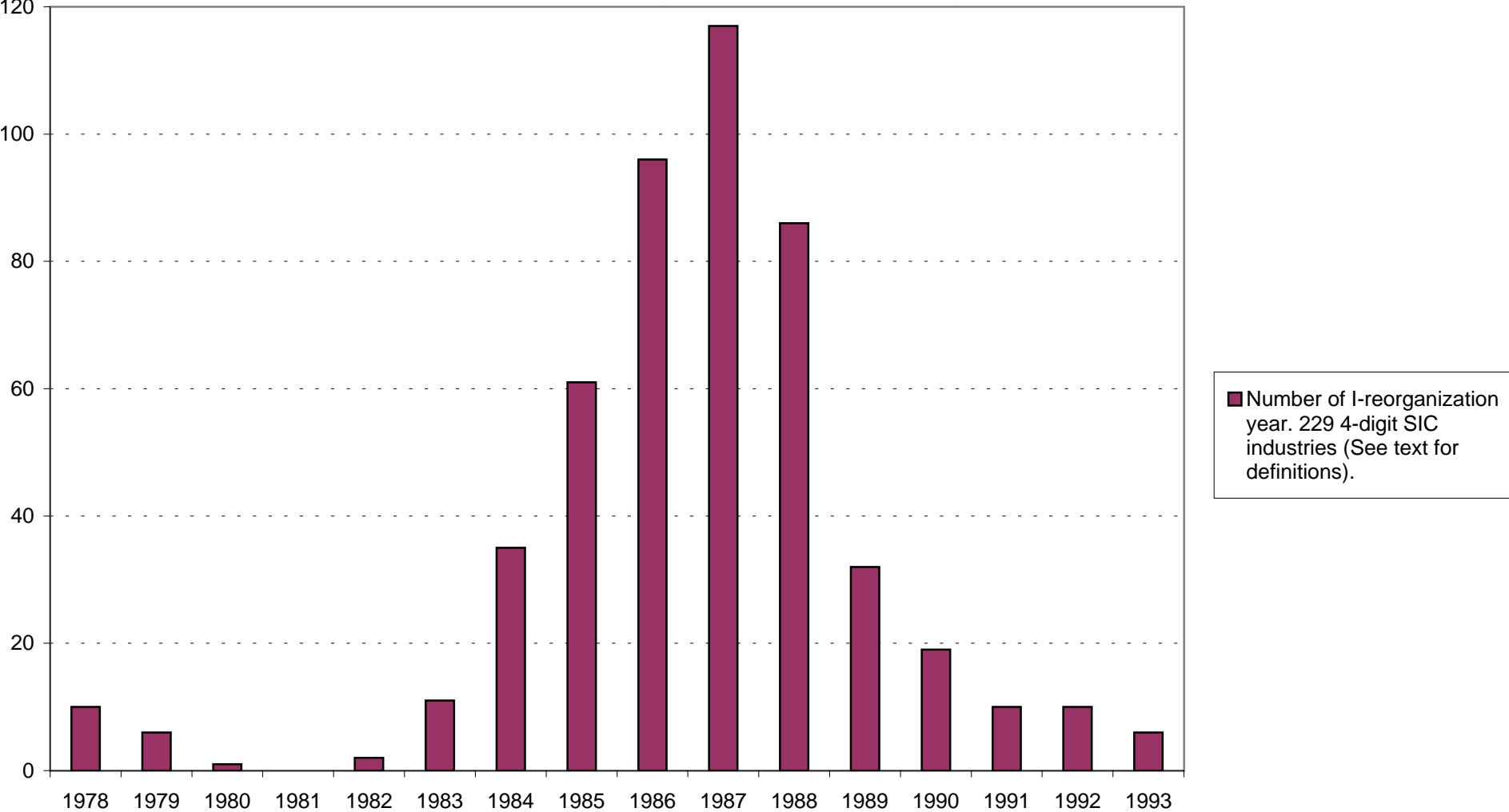
Computerization in 1992* R is instrumented by Computerization in 1992* I

T-statistics in parentheses. *: $p < 0.05$ **: $p < 0.01$ Author's tabulations.

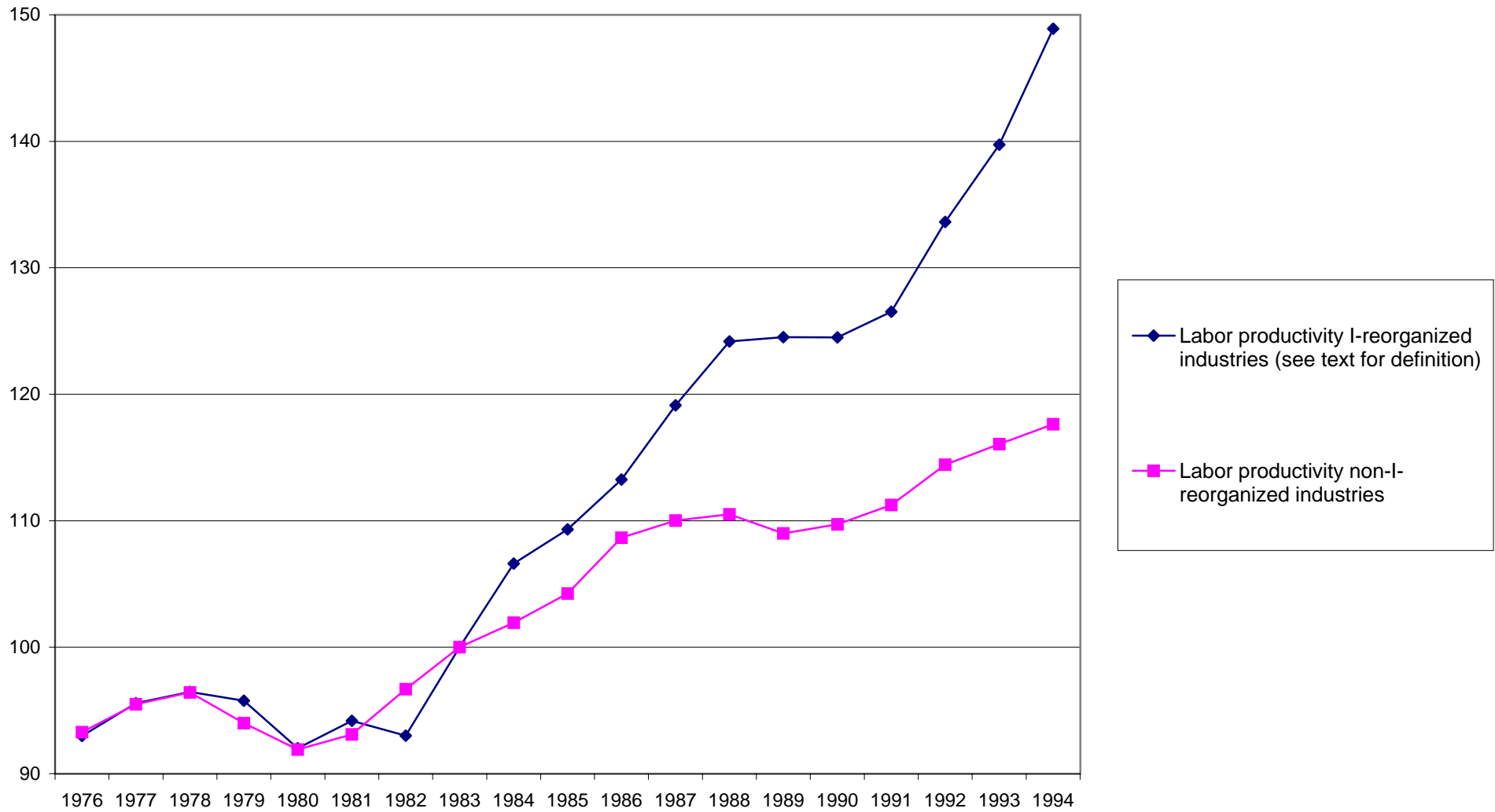
**Graph 1: Injury and illness rates for reorganized and non-reorganized sectors;
base 0 = 1982 (Sources and definitions in Askenazy (1999)).**



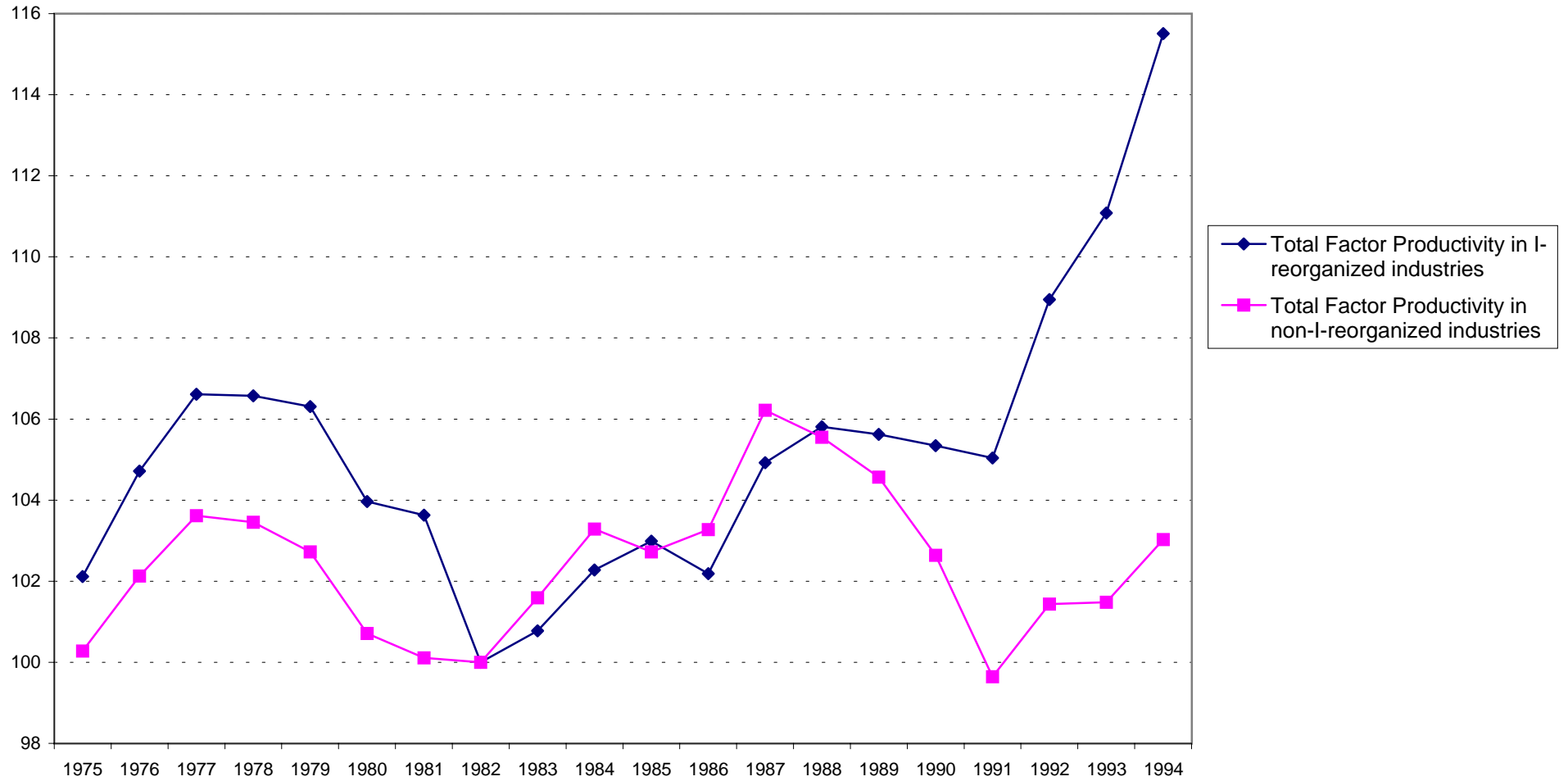
Graph 1b: Number of I-reorganization year. 229 4-digit SIC industries.



**Graph 2: Labor Productivity in I- and non-I industries;
base 100 = 1983 .**



**Graph 3: Total Factor Productivity in I- and non-I industries;
base 100 = 1982 (see text for definitions).**



Graph 4: Non production wage bill in total manufacturing wage bill 1976-1996
(Source: ASM various years)

