"Lean Production" and Workplace Health*

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Abstract: This note studies the aggregated consequences of lean production on occupational hazards in the American private sector over the past fifteen years. We argue that lean production can damage workplace health: it increases the intensity of work both in manufacturing and tertiary industries, and some practices can be incompatible with the learning and the design of safety rules. Using surveys on organizational changes, management literature along with BLS-OSHA data, we show for 26 sectors that reorganization results in a dramatic increase in occupational injuries and illnesses.

Keywords: occupational injuries, lean production, intensity of work, safety

JEL classification: J28 L23

"We believe lean production will become the standard global production system of the twenty-first century. That world will be very different, and a much better, place." (Womack-Jones-Roos, 1991, p. 278)

"[...] lean production would mean further deterioration of conditions of work especially the part of it that fosters and triggers off worker resistance." (Skorstad, 1994, p. 450)

For the past fifteen years, many American firms have been experiencing a deep reorganization of their corporate structures and production. The essential elements[1] of *lean* production or post-fordism are self-directed work-team, flat structure, flexibility, Total Quality Management and Just-In-Time. These innovations seem to enhance productivity[2]. They would have to be implemented by all industries. According to Osterman (1994) or Gittleman et al. (1998), in 1992, two-thirds of American firms already used new workplace practices.

At the same time, workplace health has suffered. Except in the area of construction, the rate of occupational injuries and illnesses has strongly increased over the 1982-1994 period (graph 1). The total cost in 1995 of the 6 million occupational hazards was greater than 100 billion dollars (Levine, 1997).

The aim of this paper is to show that these last facts can be explained by the adoption of new workplace organizations.

The issue has previously been investigated through a variety of case studies which have produced conflicting results. This paper try to examine this issue more comprehensively

[1]See Womack et al. (1991), Milgrom and Roberts (1995), Osterman (1994).

[2]See Berg et al. (1996), Ichniowski et al. (1996) and Ichniowski et al. (1997).

through the use of a large-scale quantitative data base. The paper is organized as follows. In the first part, we present the connections between new practices and health dangers. In part two, we match Osterman's (1994) survey as well as ABI, a bibliographic base of management literature in order to determine whether and when 26 private sectors reorganized; using the OSHA-BLS data set, it will be shown that reorganization increases by about 30% occupational injuries and illnesses both in manufacturing and tertiary activities. Part three is devoted to a discussion.

1 Lean production, pace of work and safety

The logic of lean production is to reduce waste, to maximize the use of production factors, notably labor, so as to reduce idle times and enhance the pace of work By definition, Just-In-Time or Total Quality Management step up time-pressure on workers.

Team organization should also intensify work. Indeed, consider a fordist assembly line composed of n consecutive tasks and n specialized workers: when a worker makes an error or becomes overloaded, other workers on the line must wait. The system creates slack periods, thus in some GM plants at the beginning of the eighties, the average real work time was only 43 seconds per minute (Adler, Goldoftas and Levine, 1996). In a team, workers are multi-skilled: they help their overloaded team mates and therefore they perform without idle time. The case of NUMMI (New United Motors Manufacturing Inc.) illustrates this view. NUMMI is a GM-Toyota joint venture which took over the GM Fremont plant (closed in 1982) in 1984 and employed a large number of its former workers. Toyota applied its production system by grouping workers into small teams (4

to 6 employees); its average effective work time is now 57 seconds per minute (Adler et al., 1997).

Very few data are available about the real work time; all result from case studies. Nevertheless, it is commonly admitted in occupational medicine[3] that the rate of occupational injuries and illnesses is a good proxy of the hardness of work both in manufacturing and tertiary activities. Moreover, new workplace practices can damage workplace health in other ways. Safety orders are particular to each shop. Their designs require a learning phase for both the staff and workers. Thus, the frequency of injuries increases by 10% in automobile plants just after a product change (Adler et al., 1997). Therefore, frequent product change and job rotation are antithetical to an efficient knowledge of safety procedures. They also create muscular problems. The stress on product control and total quality can also trouble workers who pay less attention to their own safety or who suffer from mental stress. But on the other hand, job rotation can also increase workers' interest in the job thereby reducing the number of incidents deriving from boredom. Moreover, safety and health goals can be consistent with quality improvement.

Surprisingly, virtually no studies have tried to connect the new practices and the occupational injuries and illnesses. The significant amount of literature on occupational medicine (*American Journal of Industrial Medicine, Journal of Occupational Medicine,...*) does not seem to have included epidemiological studies on the consequences of the high-involvement practices excepting the studies on workplace stress (Hurrel and Murphy,

[3]See e.g. Rom (1992). Stress in the workplace is sometimes used as indicator of performance (e.g. Berg et al., 1996). Bowles et al. (1983, p. 128-130) used the aggregated US injury rate as a proxy for trends in the degree of work intensity.

1996). Until recently, the question of the rise in injuries seems to have been taboo; firms have feared new legal constraints imposed by the OSHA. The decrease of repeated trauma cases in 1995 was a great relief to the American firms (Holyoke, 1997).

The exception is Fairris and Brenner (1998); simultaneously and independently of us, they look for a connection between workplace transformation and the rise in Cumulative Trauma Disorders (CTDs); we will discuss this paper later. Other papers deal only with particular sectors or the consequences of mental pressure.

2 Empirical evidence

This section serves to test a link between the deterioration of workplace health and the new organizations, using detailed data on occupational injuries and illnesses in the United States. We will not study the consequences of a particular practices ; the goal is to determine the net impact of all new workplace practices on occupational injuries and illnesses We use the managerial literature and panel data to determine whether and when the 2-digit SIC sectors adopt new practices. We have created an original database. We consider 26 industries in construction, services and manufacturing. We distinguish 5 periods of 3 years each: 79-82, 82-85, 85-88, 88-91 and 91-94. For the moment, we do not consider the period 1994-1997 because; first new laws have increased the penalties and private insurance has stepped up pressure on firms, resulting in greater attention to ergonomics and safety and therefore in a strong decrease in injuries (See Conway et al., 1998).; second, we do not have enough indicators for reorganisation during this period. In 1979 (resp. 1994), these sectors represented 46% of employment in private sectors (41%),

including 80% of manufacturing employment (84%) and 26% of tertiary employment (21%). For some heterogeneous 2-digit SIC sectors, we use 3-digit classification. Thus, we distinguish motor vehicle production (SIC 371) from aircraft production (SIC 372) and we consider the large sector 806 (hospital) instead of the entire domain of health services.

The next subsection presents the databases used. The second subsection is devoted to the econometric study.

2.1 Description of data

Occupational injuries and Illnesses[4]

The OSHA (*Occupational Safety and Health Administration*), along with the *Bureau of Labor Statistics* publishes the rate of injuries and illnesses by 4-digit SIC industries in the *Monthly Labor Review*. There is also data for the rate of injuries exclusively, the number of fatal cases ... The rate is the number of cases per 100 full-time workers; this choice avoids the effects of the changes in part-time jobs or worked hours[5]. We use only the annual rate of total injuries and illnesses. To simplify, I will refer to this rate as the "injury rate".

The manufacturing industries present a higher rate than do sectors performing tertiary activities (Graph 1). The evolution over 15 years was sometimes dramatic and varied among industries. The natural trend (in the seventies) is a decrease of 1 or 2%.

[4]For a more detailed description and discussion of the weaknesses of these data, see appendix. The data are available on BLS web site http://stats.bls.gov.

[5]The weekly worked hours increased in the eighties by about 7%.

ABI/Inform[6]

ABI/Inform is a bibliographic base which lists about 1.5 million articles from 1100 managerial, finance and human resources reviews over the last three decades. These reviews range from the very general, such as the *Wall Street Journal*, to the very specialized, such as *Bobbin*. We made an exhaustive search for articles about the adoption of high-involvement work practices within a variety of sectors. This research is simplified by the UMI codes (for industries, human resource management...) and key-words (such as "teamwork", "reengineery"...).

Four cases hold:

1. A limited number of articles deal with a particular industry X. We suppose that we will have no data on this sector (NS in table 1).

2. The sector X is the subject of hundreds of articles but very few articles deal with the new workplace organization. We consider in this case that there is no reorganization (NO in table 1)

3. The industry X is the subject of hundreds of articles and dozens deal with the new organization. Moreover, the publication of the latter is concentrated in a particular year Y. We consider that the reorganization began with the year Y.

4. The sector X is the subject of hundreds of articles and dozens deal with the new organization. Moreover, the publication of the latter occurred between Y and Z. We consider that the reorganization is more progressive (Y/Z in table 1).

[6]This base is protected by copyrights. A complete description is available on the commercial web site http://www.umi.com.

The number of articles about reorganization in a sector is less than 5 or more than 50.

NB: *A priori* it is possible to use ABI at any level of desegregation. Nevertheless, we use it only for 2-digit SIC industries because UMI codes for industries are at this level and we will have too small a number of articles for each 3 or 4 digit SIC industry (except for the larger ones).

"Organization of work in American Business"[7]

This survey on more than 800 establishments 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 description of the survey). Osterman (1994) shows that the three main characteristics of the new practices are TQM, team and Job rotation. Here, we use 6 questions from this survey:

Are CORE EMPLOYEES involved in:

E21a Self-directed work teams:

E21a1 Year started,

E21a2 Percent involved

E21b Job rotation:

E21b1 Year started,

E21b2 Percent involved

E26c Total Quality Management (TQM):

E26c1 Year started,

[7]This data set is available from Paul Osterman.

E26c2 Percent involved

We have data on these questions for about 600 establishments. Moreover, we have the 4-digit SIC code of each. For 2-digit SIC sectors (with no less than 10 establishments in the survey), we determined a year or a period in which new practices were adopted, and a degree of adoption defined as the average of (E21a2+E21b2+E21c2)/3. These values are reported in table 1.

Baily-Bartelsman-Haltiwanger (1994)

Baily, Bartelsman and Haltiwanger (1994) used data collected on thousands of establishments for the Census of Manufactures of 1977 and 1987. They determined which 3-digit SIC sectors have downsized establishments and which have upsized ones. Downsizing of establishments can be considered as a characteristic of lean production. We report the results in table 1 (U for upsizing and D for downsizing).

The different data sources generally give consistent results. Using these sources and particular studies or events, we construct a variable RP by sector and period:

- $RP = 0$ if there is no reorganization

- $RP = 1/2$ if the reorganization is partial during the period[8]

- $RP = 1$ if there are strong indications that new practices have been adopted during the period.

[8]We also take an alternative specification: $RP = 1$ if there is reorganization (partial or not). Our further results are not altered.

The value of RP are reported in table 1 (0 for $RP = 0$, normal for $RP = 1/2$ and bold for $RP = 1$).

2.2 Results

Let $IT(sector, period)$ denote the increase in percent of total occupational injury and illness rate during the period. Table 1b reports the descriptive statistics of IT and the initial rate of injury. The latter exhibits a large variance, which illustrates a dramatic difference in safety levels both in manufacturing and tertiary activities. IT is also very scattered. Moreover, while 1979-1985 saw improvements in safety, the average workplace health deteriorated over the period 1985-1994 (see graph 1). Here again, the 2-digit SIC sectors experienced widely varying trends over the last decade.

We test IT on RP. The estimation method is OLS with heteroskedastic consistent errors[9]. We test the model on panel data and cross-sections (see table 2).

We first pile in a simple series all the observations for each industry and each period. Regression 1 gives a significant correlation between the growth of injuries and reorganization. More precisely, without reorganization, the rate naturally decreases by 1.5% per year i.e. a rate similar to that measured in the seventies[10]. But, during reorganization, the rate increases dramatically: by more than 30% over three years. The injury rate being very growth inelastic, this coefficient is particularly large. Moreover, the simple

[9] We also perform OLS and weighted tests (by employment, value added...); our conclusions are not altered

[10] Between 1970 and 1980, the aggregated rate of injuries dropped; the rate had slightly increased during the sixties by 1 or 2% per year (Fairris, 1998).

"reorganization" variable can explain more than one-third of the variance. Cross-section analyses by period (regressions 3,4,5) give similar conclusions.

It is also the case if we split the sample into tertiary sectors (services, insurance, bank, transportation) and manufacturing industries (SIC code 20 to 39). The consequence of reorganization on the injury rate is quite similar in services and manufacturing: an increase of about 10% per year. In both cases a large part of the variance is explained. The natural trend is also a continuous decrease (which is non-significant in the service sectors; in fact, the improvement in safety concerned mainly the industrial machinery).

The evolution of the rate of injuries may be influenced by the economic cycle[11], the regulatory policy (see appendix) and the level of the rate (high-rate industries are more likely to reduce the number of injuries). Thus, in table 2b, we add control variables to previous tests: the rate of injuries at the beginning of the period, the growth of occupational hazards during the 6 previous years and dummies for each period. The impact of reorganization remains significant, but the coefficients are lower (for manufacturing the coefficient is half; a large part of this decrease is explained by the strong correlation between the dummy for period 3 and the reorganization). Finally, to avoid idiosyncratic changes, we add (regressions 1bis) fixed effects for each sector in panel estimations; our conclusions are not altered.

After reorganization, the rate of injuries remains high: the impact is not transitional.

[11]This point is important since most of the reorganizations in manufacturing occurred just after the depression of the early eighties. However, it is difficult to directly control the tests by the increase of the demand per worker since productivity gains should be a consequence of reorganization (See Ichniowshi et al., 1997). Moreover, productivity is difficult to compute for tertiary activities

This assertion is illustrated by the 3; the latter shows that the rate of occupational hazards for reorganized and non-reorganized sectors. The assertion is also statistically verified. We add in previous tests a dummy "Post reorganization", which takes the value 1 if the industry is not reorganizing and was reorganized. The coefficient of this dummy is not slightly negative as we had first supposed but actually positive (tests 7, table 2 and 2b). The likely interpretation is that the reorganization deepens after the initial phase of massive implementation of new workplace practices.

2.3 The introduction of the 1994-1997 period

Workplace injuries and illnesses drop by about 20% between 1994 and 1997. As we already note, this improvement can be explain by new legal rules and pressure of insurance. But, it is also possible to argue that new workplace practices have a positive or neutral impact on the long run.

In order to test this last view, we assume that all reorganized industries are not reorganizing between 1994 and 1997 i.e. the dummy post-reorganization takes the value 1 during 1994-1997 period for industries which have reorganized before 1994. We thus add 26 observations to the regressions 7. The regressions 1 to 4 in table 3 confirm that the post-reorganization dummy is not significatively negative. Even if we consider the 1994-1997 period alone, the injuries and illnesses do not decrease in reorganized industries. Therefore, the reorganization do no seem result in a re-improvement of safety and health in the long run.

3 Discussion

The previous study confirms that the reorganized industries experienced a dramatic and long-standing increase in occupational injuries and illnesses. This increase is large, about 10% per year during the reorganization. These assessments are contrary to those presented by the promoters of the new workplace organization. Womack and Roos argue that lean production is partially motivated by a wish to improve the interest of work, the responsibility of workers and the quality of work life. According to Ozaki (1996), this last analysis is satisfactory only for the beginning of the reorganization; in fact, the real motivation is better productivity and quality. In a very interesting discussion, Skorstad (1994) states that the "new paradigm" leads to an intensification of work and a loss of autonomy. Recall that the first reference book about the new workplace practices emphasized the "management by stress" (Parker and Slaughter, 1988), already at work in Japan. More generally, according to Ichniowski and al. (1996), "theories of new work practices imply that these new arrangements can cause workers to work harder and share more ideas". The studies on particular cases present a conflicting position. On the one hand, the high-involvement practices would be exciting and attract workers from better-paid jobs (Stamps (1997) for an automotive establishment in Alabama); employees have more autonomy and responsibility (Womack, Jones and Roos, 1991). According to others, we are witnessing an increasing level of strenuousness (Berg and al. (1996) in the apparel sector), a systematization of work (Alséne (1994) on hospitals in Canada), a loss of autonomy and a high and dangerous pace of work (Babson (1993) in a Mazda plant in United States), both for managerial and non-managerial employees (Keefe and

Batt, 1997). Moreover, the new practices would be hard to bear; cases of sabotages would increase (Graham (1993) in a Japanese transplant).

The increase in occupational injuries may be interpreted as a matter of American workers adapting to Japanese methods. Indeed, Japan seems to be a paradise for workers: with “comparable" data, Wokutch and McLaughlin (1992) find that the rate of occupational injuries is seven times lower in Japan. The Japanese transplants in America offer work conditions similar to those in Japan (Kenney and Florida, 1993). But, particular studies on automotive transplants give more dramatic results than the average American establishments (Wokutch, 1992). More precisely, according to Adler, Goldoftas and Levine's (1996) study of the creation of NUMMI, the ergonomic conditions immediately deteriorated: the rate of injuries has quintupled in relation to the rate of the former establishment (a part of this increase may be the consequence of better reporting). At CAMI, a Canadian GM-Suzuki plant that adopted lean production, repetitive strain injuries are also a constant source of conflict (Rinehart et al., 1997). According to Wokutch and McLaughlin (1992), the difference in rates of occupational injuries between the United States and Japan may be the result of a large number of undeclared cases in Japan. Thus, it is not surprising to find that the incidence of fatal injuries (which can be not concealed) is quite similar in the United States and Japan. Moreover, Toyota, the birthplace of lean production, has serious problems with recruitment, in spite of its high wages (Cusumano, 1994): the Ohno's method is now “Oh No!". Nevertheless, Ichniowski (1992) finds for a paper mill plant that the new organization implemented in 1984 has improved the health of workers; Shaiken (1995) finds that team safety is of particular

concern at Chrysler-Jefferson North.

A more precise study of American data may strengthen our understanding of the intensification of work. Indeed, the rate of illness has exploded since 1983 increasing by 400%. This increase is completely explained by the dramatic growth of the repeated trauma cases[12]: they increased twelvefold between 1983 and 1994 i.e. during the key years of reorganization (graph 2). The most striking phenomenon is the increase in the tertiary sectors[13]: telephone companies, groceries or hospitals are now sectors with high levels of repeated trauma. Fairris and Brenner (1998) use Osterman's survey. They assume that each plant experiences the CTD frequency of its 3-digit SIC industry. They regress the CTD rate in 1991 (or the growth from 1986 to 1991) on the new workplace indexes at establishment level. The size of their sample (about 300) enables them to control by the percentages of female, union and blue-collar workers, as well as 2-digit SIC sectors and plant size. Workplace change accounts for a small part of the rise in CTD[14]. Yet, as the authors claim, the use of CTD data may be not valid since OSHA stepped up pressure on reporting CTDs in the eighties. In any case, Fairris and Brenner advocate further investigations. Note that CTDs represent a small part of all injuries and illnesses and that their exclusion from our data does not alter our results. We argue here that all occupational hazards are better indicators for understanding the consequences of new practices.

[12]Carpal-tunnel syndrome is the most widespread case; it generally necessitates a surgical operation.

[13]See OSHA report, *Repetitive tasks loosen some workers' grip on safety and wealth*, (1994).

[14]Nevertheless, they find that Quality Circle has a positive relationship with CTDs.

It is worthwhile to look at the European case. According to the European Foundation for the improvement of living and occupational conditions (1996), new workplace practices also increases in European countries intensity of work. The latter is not fully compensated by higher autonomy of workers. Temporal pressure also deepens.

In France, sociologists (see Gollac and Wolkoff,1996) give strong indications that the adoption of lean production in France is associated with higher pressure on workers and a deterioration of work conditions[15]. Case studies confirm this observation. For example, Gorgeu and Mathieu (1995) study the new plants for motor vehicle parts and accessories; innovative organization induces ergonomic problems which require the intervention of the ANACT (the French equivalent of OSHA). Recently, in 1998, Renault-Douai plant was extensively reorganized and is now considered to be a showcase of new organizations for Renault management: the work has become more intensive. The number of deaths at Douai was 27 in 1998 compared to 15 on average during the previous seven years.

The longitudinal survey of occupational conditions (*Conditions de travail* INSEE-DARES, see Aquain et al. (1996)) reports that after decreasing for years, the number of French workers who claim to stand in a painful posture for long periods was 26% in 1991 up from 16% in 1984. The percentage of workers who claim to have to carry heavy loads was 21% in 1984 and 30% in 1991. The percentage of workers who worry about occupational accidents was 27% in 1984 and 35% in 1991. Finally, the time pressure increases: workers performing short delays were 40% in 1984 and 55% in 1991.

[15]Unfortunately, the French data on injury rates (computed by the *Caisse Nationale d'Assurance Maladie* are very detailed but unreliable.

4 Conclusion

New workplace practices have been extensively diffused in American private sectors over the last two decades. At the same time, occupational injuries and illnesses have dramatically increased. This paper tests the assumption that this increase is in part a consequence of the new organizations. The latter improve the pace of work and are not compatible with safety rules. A number of case studies both in America and Europe confirm this wisdom.

Using the Osterman (1994) survey, a statistical study of management literature, and BLS-OSHA data, we show for 26 sectors that reorganization results in a dramatic increase of about 30% in all occupational injuries and illnesses both in manufacturing and tertiary activities.

We do not argue that any new workplace practices damages workplace health, but we argue that their net consequences are dramatic.

Therefore, there are costs as well as benefits to the adoption of new workplace practices: the higher productivity associated with innovative organization is supported by workers who experience worsened workplace health.

These results can be particularly relevant for the industrial debate in Europe. The success of American economy for the past ten years induces Europeans to implement the American organizational innovations. And, empirical evidence of Dublin Foundation shows a current damage of workplace conditions in UC.

Appendix: reliability of 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).

In this paper, we use 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 regulations and is less affected by the following weaknesses than are lost workday cases.

The BLS data have been criticized; they do not distinguish the nature of injuries and their severity, provide vague definitions and have overlapping categories[16] (MacNeelly (1991), Rubens et al. (1995)). Nevertheless, Murphy et al. (1996) claim that the BLS data are reliable: 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 discontin-

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

ued 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 studies[17]: 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 consider that the policy change in 1988 did not really modify the reporting behavior of employers.

Note also the particular case of the automotive industry. During the eighties, the BLS-OSHA

[17]Except 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.

stepped up pressure on the 371 SIC industry in order to improve its reporting. Therefore, the large increase in injury rates in the motor vehicle industry (SIC 3711) may be mainly due to variations in reporting practices (Adler et al., 1997). However, this trend is also consistent with case studies on the adoption of lean production in the automotive industry (see discussion in the text and Adler et al., 1997).

Remark on SIC changes

In 1987, the SIC had changed[18]. As we quote in the text, we do not consider changed industries in sections 3 and 4. Nevertheless, in part 2, at the 2-digit SIC level, we use sectors which experienced change in their definitions. Excepting 36 and 38 SIC, these changes are minor and do not affect health data (at most by 1%). The case of electronic 36 and instruments 38 is more questionable because a large part of 36 SIC becomes 38 SIC in 1987; nevertheless, if we remove these two industries from our sample, our conclusions are not altered. We also try to aggregate these two sectors into one sector; again, the tests lead to the same results.

[18]The NBER provide a complete transition matrix from 1972 to 1987 SIC at http://www.nber.org.

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Table 1: sources on the reorganization by sectors in the United States

SIC 87	industry	ABI	Others studies or events	Baily-B-H [1994] de 77/87	Osterman [1992] index (year)	Reorganizing period*
1500	General building contractors	no	na		ns	0
1600	Heavy construction, except building	no	na		ns	0
1700	Special trade contractors	no	na		ns	0
2000	Food and kindred products	86/88	na	diverse	>40 (87)	**3**
2200	Textile mill products	85/88?	NIC competition	D	ns	3, 4
2300	Apparel and other textile products	88/91	88 beginning of modular production Dunlop-Weil [1996]	diverse	>20 (88)	4, 5
2600	Paper and allied products	84/89		D	>25 (85)	**3**
2700	Printing and publishing	87/91		U	>20 (88)	**4?**
2800	Chemicals and allied products	84/88		D	30 (85/88)	**3**
3300	Primary metal industries	84?		D	>20 (84)	**3**
3400	Fabricated metal products	84?		D	>40 (84?)	**3**
3500	Industrial machinery and equipment	85/87		D	>30 (82/89?)	**3**
3600	Electronic and other electric equipment	86/89		diverse	40 (85)	3,4
3710	Motor vehicles and equipment	84/94	NUMMI in 1984	D	40 (85)	2, **3, 4**, 5
3720	Aircraft and parts	87/90	85: first team reorganization at Boeing	U	35 (89)	**3, 4**
3800	Instruments and related products	ns	na	diverse	>45 (86/87)	**3**
4500	Transportation by air	87/91	Airline Deregulation Act (1978); Hallowell [1996]		ns	**4**
4800	Communications	84/86	Keefe-Batt [1997]: deregulation between 1984 and 1989		ns	3,4
4900	Electric, gas and sanitary service	ns	State monopoly of electric services; but Natural Gas Policy Act (1978)	NS	ns	0
F	Wholesale trade	no	na		>30 (<70 or >90?)	0
6000	Depository institutions	88/90/91	Depository Institutions Deregulation Act (1980)		<10 (ns)	**4**
6300	Insurance carriers	84/94			>15 (ns)	3,4,5
6400	Insurance agents, brokers, and service	84/94			ns	3,4,5
6500	Real estate	85/94			ns	3,4,5
7000	Hotels and other lodging places	no	na		30 (<70 or >89?)	0
8060	Hospitals	84/91	Hospital reform		ns	3,**4**

* normal for RP=1/2 and bold for RP=1; 2 for the periods 1982-1985 ... 5 for 1991-1994.

TABLE 1b: descriptive statistics

Mean (Std-deviation)	All industries All periods	All periods manufactu ring	All periods tertiary activities	All sectors 1985-1988	All sectors 1988-1991	All sectors 1991-1994
Increase in % of the rate of occupational injuries and illnesses, during the period	1.75 (20.46)	1.94 (25.69)	4.23 (13.55)	19.82 (31.80)	4.86 (17.11)	-3.00 (8.36)
Rate of occupational injuries and illnesses at the beginning of the period	9.55 (5.16)	10.88 (4.93)	6.16 (3.96)	8.50 (4.70)	10.13 (5.86)	10.05 (5.48)
Number of observations	128	65	48	26	26	26

Table 2
Analysis of the consequences of observed reorganizations on occupational injuries and illnesses from 1979 to 1994

Increase in % of the rate of occupational accidents during the period	1 All industries All periods	1b: fixed effects All industries All periods	2 All periods manufacturing	3 All periods tertiary	4 All sectors from 1985 to 1988	5 All sectors from 1988 to 1991	6 All sectors from 1991 to 1994	7: fixed effects All industries All periods
c	-5.22*** (-4.83)	-	-7.98*** (-4.78)	-0.58 (-0.43)	1.06 (.32)	-3.42 (-1.39)	-4.59** (-2.62)	-
Reorganization	35.03*** (4.54)	32.43*** (5.66)	39.08*** (3.72)	25.68*** (4.07)	39.01** (2.62)	22.66*** (3.86)	13.82*** (3.94)	34.20*** (5.43)
Post reorganization	-	-	-	-	-	-	-	4.75 (1.55)
R^2	36	42	38	33	29	30	18	42
Number of observations	128	128	65	48	26	26	26	128

OLS robust. T-statistics in parenthesis. *** significant at 1%, ** at 5%, * at 10%

Table 2b
Controlled regressions

Increase in % of the rate of occupational accidents during the period	1 All industries All periods	1b: fixed effects All industries All periods	2 All industries All periods	3 All periods manufacturing	4 All periods tertiary	5 All sectors from 1985 to 1988	6 All sectors from 1988 to 1991	7: fixed effects All industries All periods
c	temporal dummies	temporal dummies	temporal dummies	temporal dummies	temporal dummies	1.88 (0.21)	6.07 (0.95)	temporal dummies
Reorganization	27.64*** (3.99)	22.31*** (4.30)	29.08*** (3.80)	20.94** (2.48)	15.18** (2.31)	35.62** (2.24)	18.46*** (3.15)	30.90*** (4.74)
Hazard rate in % at the beginning of the period	-0.64** (-2.79)	-3.79* (-1.85)	-0.30 (-1.18)	-0.28 (-0.69)	-0.38 (-0.77)	-0.29 (-0.36)	-0.91 (-1.63)	-3.92* (-1.90)
Growth in % of the rate during the 6 previous years	-	-	-0.09* (-1.95)	-0.04 (-0.56)	-0.12 (-1.62)	-0.23 (-0.83)	-0.02 (-0.26)	-
Post reorganization	-	-	-	-	-	-	-	14.96** (2.57)
R^2	48	61	42	47	39	29	56	63
Number of observations	128	128	101	52	37	25	25	128

OLS robust. T-statistics in parenthesis. *** significant at 1%, ** at 5%, * at 10%

Table 3
Analysis of the consequences of observed reorganizations on occupational injuries and illnesses from 1979 to 1997

Increase in % of the rate of occupational accidents during the period	1	2: fixed effects	3	4
	All industries All periods	All industries All periods	All industries 1994-1997 period	All industries 1994-1997 period
c	-6.16*** (-4.84)	temporal dummies	-15.77*** (-6.72)	-13.89*** (-3.27)
Reorganization	36.17*** (4.69)	29.97*** (4.69)	-	-
Hazard rate in % at the beginning of the period	-	-3.53* (-1.85)	-	-0.19 (-0.54)
Post reorganization	-2.64 (-0.32)	13.69** (2.37)	2.46 (0.73)	2.40 (0.72)
R^2	38	64	1	2
Number of observations	154	154	26	26

OLS robust. T-statistics in parenthesis. *** significant at 1%, ** at 5%, * at 10%

3: Injury rates for reorganized and non-reorganized sectors ; base 0 = 1982