Technological Innovation, Industrial Relations, and Subcontracting[1]

Leda Gitahy, Flávio Rabelo and Maria Conceição da Costa

This paper discusses the relationship between small and large metal-working companies in the process of diffusion of new automation technologies, mainly Numerical Control Machine Tools (NCMT) and the changing of industrial relations policies in the Brazilian industry. The study is restricted to some metal-working companies in the state of São Paulo. The practice of subcontracting tends to enhance the diffusion of new technologies. The quality of the large company products is influenced by the quality of the services delivered by the small subcontracting partners. Thus, the large company may find it advantageous to transfer new production techniques that they have mastered to its subcontractors. The demands of the contracting company for higher quality standards from its subcontractors will put pressure on the latter to enhance the qualification of its human resources.

Introduction

The purpose of this paper is to discuss the role of the relationship between small and large companies in the diffusion process of new automation technologies and in the change of human resource management practices presently underway in the Brazilian industry.

The problems treated in this section are related to two issues dealt with by economics and industrial sociology: the role of subcontracting and the possible tendency toward decentralizing industrial production. Some aspects related to this issue will be discussed, based on the discussion of the diffusion process of new industrial automation technology (specifically Numeric Control) and their effects on the management policies of the enterprises.

Subcontracting usually implies a certain level of dependency on the service rendering enterprises in relation to their most important clients. On the other hand, the quality of the products produced by the contractors will to a certain extent be determined by the quality of the products delivered. This leads to a degree of monitoring over the productive process of their suppliers. Therefore, it is possible to work under the hypothesis that the efforts of clients to assure the quality of their suppliers' products tend to intensify the diffusion of automation technologies on the production level and also to present new issues to small suppliers relating to the management of human resources.

This paper is based on research carried out in 1987 and 1988 in a group of engineering companies in the interior of the State of São Paulo. The companies in the study can be divided into three categories: large service contracting companies (4), small- to medium-sized service-rendering companies (6), and one company supplying numeric control machine tools.

Diffusion of NCMT in Brazil

The NCMTs began to be introduced in Brazil toward the end of the 1970s. Tauile (1984), however, prefers to consider 1972 as the year that marks the beginning of the diffusion of these machines in the country. The use of NCMT increased significantly in 1974 and gained an impulse from the ambitious industrial restructuring plan launched by the government. In 1980 it is estimated that there were around 478 NCMTs operating in the country, 172 of which, according to Stemmer (1987)[1] were produced nationally. It is also estimated that the total stock of machine-tools in 1980,

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[1] See Table 1. Tauille (1984) estimates that in the same year there were 696 NTMCs, 130 produced nationally, and the majority of which were turners or milling Centres. The difference between the estimates made by the two authors illustrates the difficulty involved in obtaining reliable data.

was 555,000 units (Tauile, 1984). The majority of imported NCMTs came from the USA (48,7%), followed by The Federal Republic of Germany (20,5%)[2]. The ratio between national and imported NCMTs goes from 36% and 74% in 1980, to 76,2% and 3,8% in 1987. Table 2 shows the production of NCMTs by manufacturer.

Tauile's research also sought to characterize the users of this machinery in the country. As far as the source of capital (adopting the criterion of classifying national companies as those with over 50% of Brazilian share control) in 1980, 62% of the users were foreign owned firms. Table 3 shows that, although the diffusion process began in the engineering industry, in 1983 the process continued among other sectors.

When distinguishing by size (based on number of employees), it is possible to observe that the process of diffusion began in the large companies, but that in 1983 this picture seemed to change (see Table 4). While in 1980 only 29% of the users had less than 500 employees, in 1983 these represented 54%. This seems to be in accordance with the international pattern, where the larger firms tend to lead the process of diffusing NCMT. This is probably due to acquisition, installation, operation, and maintenance costs, which are especially high in the initial stages of diffusion in any country. However, it is interesting to note that already in 1980, 7% of the users were companies with less than 100 employees.

According to a survey held by SENAI (National Service of Industrial Apprenticeship) in 1984, two thirds of the users had at the most two NCMTs (Leite, 1985). This situation seems to have been maintained since the data furnished by the machine supplier in our sample show that, between 1973 and 1987, 664 units were delivered to 288 companies, as shown in Table 5.

Table 1 : Brazil: Local Production and Imports of NCMT

YEAR	number	growth rate %	Number	growth rate %	number	growth rate %
until 1979	110	-	274	-	384	-
1980	62	55	32	6	94	-
1981	69	11	55	72	124	32
1982	120	74	30	45	150	21
1983	150	25	30	0	180	20
1984	253	69	53	77	306	70
1985	413	63	60	13	473	54
1986	710	72	180	200	890	88
1987*	1200	69	250	39	1450	63
Total	3087	-	964	-	4051	-

* forecast.
Source: (Stemmer, 1987:32), quoted by Fleury (1987:62)

[2] Curiously, Japanese importation was minimal, although this country is a leader in NCMT production.

Table 2: Production of NCMTs by Manufactures (in units)

	1983	1984	1985	1986	1987
CLT	-	23	40	9	-
Digicon	-	24	42	36	-
Romi*	21	50	122	161	252
Maxitec	17	70	132	248	385
MCS	-	14	20	121	-
Zema	-	1	25	-	-
IBH	-	8	12	-	-
Bonelli	-	2	1	-	-
Total nationals	**38**	**192**	**394**	**575**	**637**
Index	-	48	66	-	-
Traub	-	36	54	-	-
Wotan	-	18	40	-	-
Thissen-Hüller	-	3	17	-	-
Heller	-	12	16	-	-
Engrenasa	-	8	10	-	-
Montra	-	4	-	-	-
Pitler	-	8	15	-	-
Grob	-	6	15	-	-
Brevet & Burkhardt	-	3	8	-	-
Total multi-nationals		**146**	**241**		
Nationals + multi-nationals	**38**	**338**	**635**	**575**	**637**

* The available data goes till September 1987
Source: SEI (1987) for CTL, DIGICON and MCS. Numbers given by the manufacturers for Romi and Maxitec. Stemmer (1987), quoted by Ferreira (1987) for the other manufacturers

Table 3: Users of NCMTs According to Industry Branch (*)

	1980 (% of users) Brazil	1983 (% of users) São Paulo
Mechanical	66,0	48,0
Transport Material	16,6	21,0
Metallurgy	7,0	10,0
Electric and Communication Equipment	5,0	13,0
Others (**)	5,6	8,0

(*) As classified by IBGE.
(**) Includes Research Centres.
Source: Tauile (1984) for 1980 and Leite *et al.* (1983) for 1983

Table 4: Distribution of NCMTs Users According to Size (*)

nº of employees	1980 (% of users) Brazil	1983 (% of users) São Paulo
until 99	7	13
100-499	22	41
500-1000	24	-
>1000	42	-
> 500	66	46

(*) The numbers for 1980 refer to Brazil and those for 1983 to the State of São Paulo, where 74,5% of users were concentrated.
Sorce: Tauile (1984) for 1980 and Leite *et al.* (1983) for 1983.

Table 5: Distribution of NCMTs Delivered by Company MAC between 1973 and 1987

n° of NCMTs owned by firm	n° of firms	%	n° of firms	%
1	170	59,3	225	78,04
2	55	19,01		
3	26	9,03	47	16,31
4	16	5,55		
5	5	1,73		
6	2	0,70	9	3,15
7	4	1,40		
9	2	0,70		
10	1	0,35		
12	1	0,35	4	1,40
14	1	0,35		
15	1	0,35		
16	1	0,35		
23	1	0,35	3	1,05
24	1	0,35		
34	1	0,35		
Total	288	100,00	288	100,00

Sorce: Information given by the company (1987-1988).

Toward industrial decentralization?

The decentralization of production has been pointed out by various authors, notably Piore and Sabel (1984), as a possible solution to the persistent crisis that has affected the world economy since the late 1960s. The engineering and automobile industry in Japan and the small producers of Northern Italy are the most often quoted examples of this process.

Piore and Sabel (1984), based on an historical analysis of the constitution of the mass production system and on the forms of usage and control of the work force in the USA and Europe, come to the conclusion that the crisis in the late 1960s indicated the limitations of this system and that the decentralization of productive activities, based on technologies that assure greater flexibility, became an option for the companies to recover from the crisis. The main thesis proposed by these authors is that today the craft system challenges the mass production system as a paradigm for organizing production.

When facing the crisis, the large industrial companies initially resorted to two strategies: mergers[4] and diversification[5], strategies adopted to protect firms from growing market uncertainty[6]. However, this movement resulted much more in speculative gains for certain groups in privileged positions - such as having access to information - than in a better performance for these corporations. The mergers carried out did not work as a guarantee against risks because the instability was not restricted to certain specific markets but was present in the entire world economy.

The strategy of increasing multi-national production[7], best exemplified by the idea of a world car, also failed because of its inability to respond quickly to the variations in the types and levels of demand[8].

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[4] The wave of mergers in the USA, particularly in the early 1980s, was a constant topic of leading economics magazines.

[5] Regarding diversification, see the classic work by Penrose (1959), *The Theory of the Growth of the Firm,* Basil, Blackwell Publisher, London.

[6] Through simultaneous activity in various markets.

[7] Perceived by the authors as an attempt to resolve the problem of lack of international co-ordination.

[8] Several factors obstructed this strategy. Among them it was noted that stock and quality control for the world car were much more expensive than, *e.g.*, the Japanese "Just-in-time/kanban" system. The growing instability of the international

The question, which is posed to companies, is "how can firms pursue a cost reduction strategy and, at the same time, show the necessary flexibility to prosper[9] in a climate of economic insecurity?" (Piore and Sabel, 1984:205).

The solution adopted by several companies and emphasized by the authors, was to reorganize along the lines of the so-called craft production.

The existence of large mass producers and small craft manufacturers operating within the same market is certainly not a new situation. What is interesting to study are the forms which these relationships take in response to crisis situations.

During the boom period of mass production, the more customized articles were restricted to smaller markets with a more fluctuating demand. Given this situation it was not economically feasible or advisable for craft producers to adopt technologically sophisticated equipment. The distinguishing feature in the new picture described by Piore and Sabel (1984) was the association between craft production and the new flexible automation technologies (Piore and Sabel 1984: 206-207). This strategy allowed these firms to both reduce costs and to work with a high level of flexibility, posing a threat to the paradigm of mass production.

The long held idea that flexible equipment could not surpass the gains of mass production has been challenged by the present crisis. It has demonstrated that greater flexibility can mean technological sophistication and more efficient production. Practices that initially appeared as a defensive reaction to survive the crisis turned into expansion strategies[10], which are questioning the paradigm of mass production.

The authors also show that this tendency is not restricted to specific sectors. It can be observed in industries where the mass production system is apparently very mature, such as in steel, chemical, and textile plants as well as in others as different as the machine tool industry which begins to function based on a craft system.

In the case of the machine tool industry the authors base their opinion on two distinct, contrasting but successful experiences in the 1970s: that of the German industry of special purpose machines and of the Japanese manufacturers of general purpose NC machines for small shops. While the Italian success was due to the application of mass production technologies in new areas and regions [11] - such as rationalizing existing lines in industrial metropolis[12] - the Japanese experience reflects the search for new alternatives to mass production. The Japanese success in the engineering sector is parallel and similar to what occurred in parts of the steel, chemical and textile industries (Piore and Sabel,1984:216-220).

The Japanese experience

Piore and Sabel point out that one of the elements that distinguish the Japanese experience is the fact that they inverted the Fordist model of mass production in the machinery industry, *i.e.*, instead of using general-purpose equipment to produce special-purpose machinery, they use special-purpose machinery to produce general-purpose equipment to meet the needs of the remainder of the engineering industry. This characteristic, however, conceals three other elements which are central

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market also hindered this strategy because in a system where important parameters, such as the rate of exchange, are subject to marked variation, it becomes difficult to predict the impact of foreign competition or of world demand.

[9] Many times at the level of costs for mass production.

[10] The resurgence of the "craft production" with a new basis would have appeared as an unexpected result of measures taken more or less by chance, by enterprises, or local governments to face the crisis. It was a process of constant innovation that resulted in new forms of industrial organization, especially in certain specific regions or industries. Due to their success they initiated a process of diffusing new ideas to the remainder of the industries. The authors emphasize the fact that starting at a certain moment the participants begin to understand the underlying principles enough to reproduce their success.

[11] Such as for example the process of industrialization in Eastern Europe, South Corea, and Thailand.

[12] A consequence of the increased competition in the market of sophisticated mass-produced goods.

in understanding the Japanese machine tool industry. First of all, the Japanese industries are verticalized and subcontracting is a very common practice. Secondly, the majority of the machine producers specialize in a few types of products, and, in turn, gather around a more important traditional machine tool producer. Finally, the firms are characterized by the great flexibility and speed with which they can change from one line of products to another (Piore and Sabel, 1984:219-220).

One of the authors who has best studied the role of subcontracting in the industrial structure of several countries and who has highlighted the role of this phenomenon in the process of diffusion of new technologies and employment, is Susumu Watanabe. Of particular interest to our study is an article by this author relating to the diffusion of numeric-control machine tools among small companies in Japan (Watanabe, 1983). This paper is based on the assumption that the incorporation of new technologies by enterprises cannot be explained without taking into account the form and level of competition and the structure of the industry. In order to gain clarity in his analysis, the author uses the term "industrial organization" in a wider way, which, beside the competitive patterns among the various company groups, includes the relationship between departments (R&D, Production, Marketing, etc) within each company. This is an important aspect since the level of diffusion of an innovation cannot only be explained by the nature of the innovation, but also depends on the enterprise's ability to absorb it. The way in which the different departments in a factory are articulated is, in turn, an indicator of its capacity to manage the innovation process.

Watanabe rejects the common practice of analyzing the structure of the market and the level of competition based on data from industrial census. The perspective adopted is that the interrelationship between competition and technological development cannot be treated on such an aggregated level. What is needed is a microanalysis based on field research. This becomes evident when considering, that not all enterprises included in the same industrial branch compete among themselves, be it due to the specific characteristics of the products, or to other variables such as location. Therefore, the type of competition that is relevant to an analysis of the process of diffusion can only happen on a much more disaggregated level.

Data related to the diffusion of numeric-control machine tools (NCMT) in the Japanese industry point to some interesting facts (see Table 6). Initially it was the large enterprises that introduced NC technology, which gradually spread to the other small and medium ones. However, the most revealing fact only appears when relating the diffusion phenomenon among enterprises to the export performance. Here it is shown that the rapid growth of exports occurs precisely in the same period in which the demand for NCMT by small enterprises becomes more relevant than that of the large ones. In order to explain this, Watanabe puts forth a theory of the product cycle of the new capital goods.

As soon as a new equipment appears, the level of capital investment and even of the technical-management capacity required to handle the innovation restricts usage to large enterprises. These large clients interact with suppliers by making complaints and suggestions, so that the latter can reduce equipment prices and improve quality. In a second phase, some smaller pioneering firms begin to acquire the equipment having in mind the smaller risk now involved. With this, suppliers gain more information about the performance of the equipment as well as suggestions from these new clients about possible improvements that will allow adaptation for enterprises that are technologically and financially even smaller and weaker. The increase in the production scale results in smaller costs, and in the end the equipment becomes attractive to all firms regardless of their size. Once this stage of technological maturity has been reached the new equipment will have good conditions to penetrate foreign markets.

Next, the author points to some factors which explain the success achieved in Japan in producing low cost NCMT. First of all, the fact is that the greatest client of the machine-tool industry is the automotive industry (autoparts producers included). So, the innovations introduced are projected

according to the needs of this industry. Also, smaller and lower cost NCMTs have proven to be the most suited for this clientèle.

Table 6: The Structure of Demand for NC Machine Tools (1967-1981)

		(% of total shipments)			
				Home Market	
Year	Total shipments (million yen) (1)	Exports (2)	Large enterprises (3)	Medium and small enterprises (4)	Others (5)
1967	na	-,-	83,0	13,0	4,0
1968	na	-,-	79,0	21,0	-,-
1969	na	-,-	65,0	32,0	3,0
1970	27,022	2,2	68,5	27,4	1,9
1971	27,978	3,5	61,8	30,9	3,8
1972	27,463	5,9	50,8	38,6	4,7
1973	51,166	3,4	45,1	49,1	2,4
1974	59,276	9,0	42,7	43,1	5,2
1975	42,176	19,1	30,4	42,1	8,4
1976	58,058	31,2	29,4	38,2	1,2
1977	86,306	42,2	27,6	28,8	1,4
1978	122,437	51,3	16,3	31,4	1,0
1979	229,037	43,5	21,4	34,5	0,6
1980	370,147	46,7	18,6	34,3	0,4
1981	467,354	46,8	19,7	32,8	0,7

- Notes:
  "na" stands for "not available".
  "-,-" means "negligible".
  "Large enterprises" are enterprises with 300 or more workers, and "medium and small enterprises" are those with fewer than 300.
  Sources: Column (1): Estimated by dividing the MITT'shipment figures published in the JMTBA statistical Summary by 0,9 as explained in the text. Column (2): Calculated using the data in column (1) above and those in the 2nd column of table 5. Column (3) to (5): adapted from the data on the three groups' shares in the total shipments to the home market by the JMTBA member companies, which are published in Nihon Kôsaku Kikai Kôgyôkai (JMTBA): Sûchi Seigyo Kôsaku Kikai Seisan Jisseki-tô Chôsa (Survey of NC-machine tool production and related matters) Tokyo, various years.
- Source: Watanabe (1983)

In the case of the USA things are quite different, as it is the aeronautic sector that gives impulse to the new technologies in machine-tool production, and this sector requires large and more sophisticated machines.

The second trait specific to Japan is that the market for capital goods, represented by small- and medium-sized enterprises, surpasses the larger ones once this equipment reaches a certain technological maturity.

In a more recent article (Watanabe, 1983), the author mentions the following figures: between 1978 and 1982 the Japanese industry acquired 68,000 numeric-control machine tools. Of these, around 60% were installed in enterprises with fewer than 300 workers, and between 1981 and 1982, a little over one fourth of the value of NCMT shipments were made to enterprises with less than 30 workers. This is not surprising when one considers - still relating to Watanabe's data - that 98% of the 872,000 Japanese industrial establishments employ less than 100 workers.

The Japanese experience once again contrasts with the American. In the USA, according to the American Machinist (December 1978) quoted by Watanabe, of the 50,100 existing NCMTs in the USA, two thirds were in establishments with less than 100 workers. Data from both countries from

the 1972 industrial census allow the following comparison: during that year establishments with less than 10 workers corresponded to 97,8% of the industrial establishments in Japan against 89% in the USA. The percentage of establishments with less than 10 workers was 74,4% in Japan against 50,8% in the USA. In absolute numbers the figures would be as follows: 686,894 and 522,864 establishments with less than 100 and less than 10 workers, respectively, for Japan against 27,240 and 15,985, respectively, for the USA.

Therefore, the industrial structure of Japan is largely responsible for this country's leadership in the exportation of low-cost NCMT production. Going on, however, to explain the diffusion process of this equipment itself among small- and medium-sized enterprises, Watanabe places at the forefront the fact that over 50% of them do subcontracted work for larger firms. "The choice of technology and the investment decision of these enterprises are governed largely by the decisions of the parent firms about the type of product and the selling price desired" (Watanabe, 1983:23). However, it is important to remember that the subcontracting system in Japan functions basically through a monopsony, which makes this relationship much more vital for the small subcontracted enterprise.

Piore and Sabel's study (1984) seems to confer a greater level of autonomy to these smaller suppliers. They argue that the Japanese success with NC would be strong evidence of a sort of reaction on the part of subcontracted firms in the engineering industry during the crisis in the 1970s. These enterprises started to feel the effects of the growing instability of their clients' markets and as a response adopted techniques, which reduced time and money expenditures in the changing from one product to another; this also increased sophistication and quality of production (Piore and Sabel, 1984:218).

The same study points out the active role played by parent firms, but stressing the autonomy of the subcontracted firms. They show that an important characteristic of the Japanese model is the desire of the large firms in the export sector to create a federation of efficient suppliers ("Zaibatsu" model). These suppliers are linked to a final assembler (export firm), although being independent enough to take initiative in response to changes in the market. For this purpose, the assembler establishes a program of permanent collaboration with its suppliers. They would identify those suppliers which were more willing to innovate, would suggest lay-outs, and would reward the suppliers that learned more rapidly. One consequence of this integration was, that subcontracted enterprises created a tradition of permanent innovation and of organizational plasticity (Piore and Sabel 1984:225).

Watanabe's description of the process tends to see the parent firm exerting more direct pressure on the supplier, specially in the initial phase of NCMT diffusion. To face the crisis that began in the 1970s these enterprises made a large effort to reduce costs and improve quality. Due to the industrial structure already described, this effort would necessarily have to pass on to the suppliers. During the initial period of NC introduction, when this equipment was still costly, one of the ways used by large enterprises to induce their suppliers to acquire this equipment was to offer better prices for metal cut on NCMTs. Only when the price of these machines came down significantly and they became more reliable did the suppliers begin to purchase them out of their own accord. It so happened that they simultaneously had begun to realize that without owning this equipment it would be hard to continue receiving orders from their parent firms or to attract new clients[13].

Some large firms, *e.g.*, began to send in their specifications on NC tapes and no longer in blue prints. Another pressuring factor was the tendency of these parent firms to rationalize their subcontracting jobs, including several items in one part, which ended up in specifications that could only be met by NCMTs. A third important pressure factor was that with the diffusion of NCMTs prices, paid for subcontracted services came down. Consequently, even when a job could be done on conventional machines, only the use of the new equipment assured attractive margins of profit for the subcontracted enterprises. Besides, to increase their flexibility in view of the changes in the

[13] Information gathered by Watanabe in interviews carried out in several of these enterprises.

pattern of demand, the large Japanese firms adopted the Kanban model in their dealings with suppliers. The introduction of NCMTs was a better way for these small firms to face the new demands of the parent firms.

The role of NCMT producers in the diffusion of this technology among small and medium sized enterprises must also be mentioned. Watanabe says that around 1972 a producer began to offer four week training courses to its clients. A team from this enterprise would also follow the installation and initial use of NCMTs and offer on-the-job-training. Because of the appeal of this strategy among users, the example was followed by most other producers. This is by Watanabe considered to be one of the secrets of the rapid diffusion of the Japanese NCMTs.

The Italian experience

In some regions of Northern Italy something very similar to the Japanese case happened, although with very different motivation. There the effort of large enterprises to articulate a network of qualified suppliers was not observed. Everything seems to indicate that they adopted a decentralized production scheme as a temporary response to the workers upheaval that had been observed in former years (Piore and Sabel, 1984:226).

What assured the survival and prosperity of these subcontracted enterprises were the federations they formed. This joint action made independent access to the markets easier, just as it was also important to foster the innovation of products and processes. Thus, a set of small- and medium-sized enterprises that were increasingly using NC was formed, and it was flexible enough to face the variations of the demand. This, for small enterprises, reflects in the internal production of NCMTs, that experiences significant growth. As the authors point out, Italy is already a leading European NCMT producer, second only to West Germany. Another fact that confirms this was the appearance of several consulting firms in the region of Bologne that were specialized in adapting the technology of large enterprises to the needs of small shops.

Four factors are mentioned as being basic to the development of this process: (a) the Italian extended family, (b) the fact that craft work is considered a distinct economic activity (small firms are exempt from paying several social benefits and this assures flexibility of labour utilization), (c) the existence of a commercial tradition linking Italian provinces to world markets, and (d) the co-operation of regional governments.

Still with regard to the Italian case there is an interesting study by S. Brusco about the region of Emilia-Romagna (Brusco, 1982). Two things stand out in this region: (1) the good economic performance recently observed in this region in comparison to the rest of the country and (2) the existence of a productive structure with low level of verticalization, and where subcontracted work done by small enterprises is abundant. There are actually industrial districts made up of small enterprises according to their product. Different from what would be expected, this system is not limited to consumer goods but also includes the engineering sector. The region is characterized by great flexibility in labour utilization and by what is called the black labour market.

Data on the prevailing inter-industrial relationships are also presented. In the case of the clothing industry the following composition was observed in relation to the legal category of craft workers: half are workers who work at home and are enrolled as craftsmen simply to avoid paying taxes and social contributions, one quarter is self employed, and one quarter is subcontracted. Subcontracting not only happens between large and small firms, but craftsmen also commonly pass part of their work on to others in a chain of subcontracting. The author demonstrates, for instance, how craftsmen from the region of Modena and Reggio, who produce directly for the market, subcontract the work of craftsmen from neighbouring provinces setting up what could practically be considered a metropolis-colony relationship between Modena and Reggio and these provinces. Another important aspect raised by Brusco is that the relationship of subcontractors and their clients cannot be interpreted as monopolistic domination. Subcontracted firms have the flexibility of changing

clients due to prices and no collusion is observed among contractors in the sense of forcing an artificial fall in prices (Brusco, 1982:171).

Regarding the trigger of this process, Brusco's analysis agrees largely with that of Piore and Sabel. However, he observes that it is precisely in the sectors where it was possible to break up the productive process, without resorting to inferior technology, that the decentralizing process was most intense (Brusco 1982:172). This means, that the smaller the savings coming from the vertical integration within a sector, the greater the chances of observing a decentralization in production there. The organizing role of the craftsmen and small business people is also highlighted by the author.

Another issue relates to the validity of this model in facing foreign competition, especially coming from the Third World. The author argues in favour of this validity based on three points: (1) the flexible use of labour in the region, (2) enterprises using modern technology (NCMT are commonplace among subcontractors in the engineering sector, for instance), and (3) the characteristics of the model tend to favour the flourishing of new enterprises. More qualified workers, *e.g.*, start to identify areas where the firm could use subcontracted work and thus have the chance of setting up their own business. The subcontracted firms, as their relationships with clients develop, learn techniques for dealing directly with the market and can at a certain point start their own production.

Concerning competition with Third World producers it must be noted that it usually happens in the inferior sectors of the market. Thus, the firms in the region make a constant effort to upgrade their products, also requiring more advanced technology. There is therefore a tendency toward specialization and advancement to higher levels of the market, which is more difficult for the Third World to access. The use of modern technology, assuring flexibility to the productive process, was crucial to the birth and consolidation of the Emilia-Romagna model and continues to be basic to its survival and prosperity.

Finally, it is worth commenting on the way the work market, a key element in the system, functions. There are clearly two segments in this industrial structure, according to the size of the industry. There is the primary sector, made up of workers in large enterprises, where unions have a strong hold. In this sector work legislation is nearly always respected, union representatives are recognized by the company, and they negotiate salary agreements that are above the national average. Brusco also points out a tradition of reasonable negotiations between companies and unions in the region. Correspondingly, the union enjoys great power within the factories and factory owners count on a safe atmosphere to carry out their production and investment plans.

In the secondary sector things are quite different. First of all it has a very heterogeneous composition ranging from highly qualified workers, who register as craftsmen with higher salaries than those stipulated by union agreements, to workers coming from the South with little or no qualification. There prevails a very disperse salary situation, which is determined largely by: (1) the level of demand, (2) the intensity of work, and (3) the level of qualification. These two markets are connected and there is mobility among them except for some marginal groups of workers (*i.e.*, immigrant women and middle-aged peasants). The others, however, specially during periods of high demand, have the facility of choosing which sector they wish to work in. Obviously the more qualified have greater liberty as they have the possibility of starting their own business.

Nevertheless, it is expected that this flexibility will decrease in the case of a recession but this cannot yet be affirmed with total certainty as there recently has not been any prolonged crisis in the region. Brusco, however, does make a very interesting simulation in this respect. The basic idea is that the lower the level of vertical integration in a sector, the smaller the effects of a crisis in terms of unemployment. The author adopts the hypothesis that the subcontracted firms enjoy enough flexibility to alter their production according to the fluctuations of the demand. It presupposes all contractors as belonging to the primary sector and the subcontracted firms to the secondary one. Given this, in the case of crisis in a specific sector where production was highly verticalized, one

would verify a high number of lay offs in the primary sector. This will tend to generate tensions in the work market, not only due to the number of workers laid off but also because of the strong influence of the union in the sector. However, if the level of integration is low, part of the negative impact will be passed on to the subcontracted enterprises. These, instead of laying off workers in the same proportion, can change their clientèle and thus protect themselves from the fall in demand by their traditional clients. Not only does the number of fired employees decrease greatly but these dismissals do not set off such serious labour conflicts as unions are not as active in this sector. In this field research, *e.g.*, it is found, that the majority of subcontracted enterprises passed unscathed during the years of 1982 and 1983.

The natural question resulting from this discussion is to what extent features of the decentralization phenomenon can be seen at the core of the new technology-diffusion process in course of the Brazilian metal mechanic industry. A strict answer, however, would require much more encompassing research than what we were able to do. However, we feel that our case study can add a few elements to the discussions.

Subcontracting and technological innovation at Campinas

This study deals with subcontracting of specific services, part- and tool machining, carried out within a segment of the engineering industry in São Paulo. The idea was to select a sample containing large enterprises contracting machining services, a supplier of industrial microelectronically-based automation equipment (machine tools with numeric control), and subcontracted enterprises. The criterion used to choose subcontracted enterprises was the possession of NCMTs, since our interest was to investigate the influence of terminal industries and of suppliers in the diffusion of this equipment. Subcontracted enterprises were located based on information given by the service-contracting enterprises and by the NCMT supplier as the purpose was to investigate the nature of the relationship among these enterprises. All together eleven enterprises were chosen from the interior of the State of São Paulo, divided as follows: Aeronautic (1), automotive parts (3), computers (1), operative machines (1), and enterprises rendering milling services (6).

Table 7: Relationships between Sample Firms

Firms	Supply NCMT	Cients	Competitors
EMPA	MAC	AUTOP2	EMPC EMPE
EMPB	MAC	AUTOP1 AUTOP2 AERO	EMPC EMPE
EMPC	MAC	AUTOP1 AERO	EMPB EMPE EMPF
EMPD	MAC	MAC AUTOP1 AUTOP2 AUTOP3 AERO	EMPB
EMPE	MAC	COMP AUTOP2 AUTOP3	EMPB EMPC EMPF
EMPF	MAC	AUTOP1 AUTOP2 COMP	

Source: Questionnaire survey 1987-1988.

Table 8: Year of Initial Introduction of NCMT

	Large firms	Small firms
1970	MAC	
1972	AERO	
1979	AUTOP3	
1983	AUTOP1; AUTOP2	EMPD
1985		EMPB; EMPC; EMPE; EMPF
1987		EMPA

Source: Questionnaire survey 1987-1988.

The Subcontracting Companies

The first portion of our sample consists of six firms located in the interior of the State of São Paulo, most of them in the city of Campinas. This region is noted for its industrial growth and the existence of a large amount of small craft producers. Tables 9 and 10 draw a picture of employment and performance of these firms. The significant increase in both these factors is even more impressive considering that the early 1980s was a period of severe recession in the engineering sector. In some of our sample firms employment levels remained almost unaltered during the worst years. This might confirm the hypothesis raised by S. Brusco (1982) about the positive influence of a network of subcontracting regarding employment during a recession. Although today only enterprise A can be considered a small venture in 1980, all were considerably small in size.

Table 9: Employment in the Subcontracted Firms (1980=100)

	1980	1981	1982	1983	1984	1985	1986	1987	1988
EMPA					18	19	24		28
EMPB	31	49	48	46	69	75	140		140
Index EMPB	100	120	180	240	300	320	380	380	400
EMPC	25	30	45	60	75	80	95	95	100
Index EMPC	100	120	180	240	300	320	380	380	400
EMPD		2	9	9	25	62	85	90	82
Index* EMPD		100	450	450	1250	3110	4250	4500	4100
EMPE	35	60	60	40	60	100	150		260
Index EMPE	100	171	171	133	171	286	428		5200
EMPF	240	240	160	90	150	200	250	330	280
Index EMPF	100	100	66	37	63	83	104	138	117

*EMPD 1981= 100.
Source: Information given by the firms 1987-1988

Table 10: Revenues of the Subcontracted Firms (1980-1987) in US$ 1000

	1980	1981	1982	1983	1984	1985	1986	1987
EMPA							109.73	440.32
EMPB	37.95	473.04	724.68	506.77	596.04	1801.63		4171.69
Index EMPB	100	1246	1909	1335	1570	2850		10992
EMPC	572.05	582.33	342.24	333.90	415.12	729.61	2520.76	2100.50
Index EMPC	100	102	60	58	72	127	441	367
EMPD			161.66	91.98	325.11	741.35	1424.22	1087.52
Index* EMPD			100	57	201	458	881	673
EMPF	4626.25	3960.20	3334.83	2578.05	3312.7	6475.73		7152.00
Index EMPF	100	86	72	56	72	113		154

Note: EMPB bought another firm in 1987.
* 1882=100
Source: Information given by the firms (1987-1988).

It is worth tracing some of the history of these enterprises and describing the market where they operate. Table 11 has some data about the origin of the enterprises in the sample. Except for enterprise A, all others were founded by former workers with a reasonably good experience in mechanics, almost always graduates from SENAI courses. In many cases these enterprises became the suppliers of the companies from where their owners originally came. The most common process is that, in which a more specialized worker has an idea of the type of services the enterprise requires and sets up his own business to fill this gap in the market. The parent enterprise often encourages this process, because of its desire to decrease its verticalization levels.

Table 11: History of the Subcontracted Firms

Firm	Year of foundation	Background of owners
EMPA	1973	Family enterprise. The father and two sons came from the rural area. They had sold a small property and did not know how to invest the money. They had no previous knowledge of mechanics. One of the sons studied with a friend who was na engineer and thus learned the basics about milling.
EMPB	1980	All four owners are former workers from a large multinational auto-part enterprise in the region. Initially they founded a tool making business in 1974, which was incorporated to enterprise B in January 1986. All were graduates from SENAI courses.
EMPC	1973	Three of the four owners had worked previously in milling in large multinational auto-part factories in the region. The other left the firm where he was employed due to salary problems and had the idea of setting up his own business. In 1977 they acquired another milling business.
EMPD	1981	Both owners worked in a large machine tools industry, beside also having worked in the auto-parts and automotive industries (nearly 20 years of experience). Both studied at SENAI (turnery and adjusting), they had technical high school level courses and one of them graduated in Mechanical Engineering in Mogi das Cruzes. During the crisis of 1980 they were fired and decided to found enterprise D
EMPE	1972	The main partner worked formerly in car sales. Another, today a technical director, studied adjusting at SENAI, did technical high school level courses, and worked in auto-part and operating machine enterprises. The third founding partner studied machines and motors at the Getulio Vargas Technical School and worked with auto-parts and computers. The fourth is an accounting technician.
EMPF	1966	One of the owners was a turnery manager in another service rendering enterprise in the city; he later helped in the foundation of a new enterprise, but had disagreements with the partners and went on to found enterprise F. The second has mechanical experience and a university degree. The third has done a technical course as turnery mechanic.

Source: Interviews with owners/managers (1987-1988).

The history of enterprise B illustrates this statement. The business left by the owners was a large milling-service contractor in the region, although also owning a large milling installation itself. Soon after enterprise B was created it became its main client and today continues to be among the major ones. During the interview the engineers at this enterprise said, that supporting the development and qualification of some preferred suppliers is an internal policy. Closer ties with one or some larger enterprises represent an important growth factor for subcontracted businesses. However, it must be observed that the type of ties found in our research are much weaker than those in the Japanese case. The small enterprises in our research avoided becoming too dependent upon a sole client.

The course followed by these entrepreneurs is not very different from those in Northern Italy described by Brusco and Piore and Sabel. Situations were created where the specialized worker feels encouraged to work on his own and the competitive atmosphere favours the development of

these ventures. For followers of more sociological approaches, it may be interesting to note that in the case of the only exception (enterprise A) the founders were of Japanese origin.

Regarding the enterprises in the sample, it is important to remember the fact that they are among the most successful in their field. Their performance has allowed them to invest in more advanced technology - numeric control. According to one of the entrepreneurs interviewed, the most common course for this type of business is, that after some years it can no longer amortize its expenses with equipment, refraining from new investments and ending up obsolete. The effort to constantly modernize equipment is generally very expensive. There are, *e.g.*, some companies, which acquired their first NCMT at higher values than their fixed assets.

Table 12, describing the technological capability in terms of NC of each of the six firms, gives an idea of the modernization effort of these enterprises. Purchases are heavily concentrated between 1985-1987, partially because of the euphoria during the "Plano Cruzado". No enterprise, however, demonstrated regret over the purchases nor financial difficulties because of them. This compound of machinery is largely made up of relatively simple NCMTs; only enterprises F and D had somewhat more sophisticated machines (Milling Machines and Machining Centres). This does not mean that the machines are inexpensive. In February 1988, according to information given by these enterprises, the price of a GALAXY (a simple NC lathe) was around US$ 320,000. These enterprises were also investing in systems to program the more modern NCMTs. Enterprise F, *e.g.*, has a totally automatic programming system and enterprise E is soon to be installing an even more sophisticated one. Automatic systems provide a significant increase in speed for programming activities, especially regarding parts that have more complex geometry.

Table 12: Use of NCMTs in the Subcontracted Firms

Firms	Number and types of NCMTs	Programming	Equipment
EMPA	• 1 Centur 30 AIII (lathe) Manual programming (Romi), November 1987	• Edition and transport through PC	• PC Microtec
EMPB	• 4 Galaxy (Romi) lathes, August and November 1985, August and June 1986	• Manual programming. Edition and transport through PC	• PC Unitron APPLE II
EMPC	• 3 Galaxy (Romi) lathes, 1 ECN 40 (Romi) lathe, 1985 • 2 Milling M. Interact 4 (Romi), 1987	• Manual programming. Edition and transport through PC	• PC Unitron APPLE II • printer Emilia/ Elebra
EMPD	• 3 ECN 40 (Romi) lathes, two in 1983 and one in 1986 • 1 Galaxy (Romi) lathe in 1986	• Manual programming. • The firm plans to begin automatic programming through CAD/CAM within 6 months	• not yet decided
EMPE	• 4 Galaxy (Romi), 2 in 1986, 2 in 1987.The first NCMT acquired was a Cosmos (Romi) lathe, in 1985, that was exchanged	• Manual programming and manually inserted into the machine	
EMPF	• 11 Galaxy (Romi) lathes, since 1985 • 3 Milling M Interact (Romi), 1988 • 1 Machining center (Wotan), 1987	• Already software for automatic programming, but, programs manually using PC to transport and store	• Software: Progmax (Maxitec)

Source: Information given by the firms 1987-1988.

Their market is roughly divided according to size (size and quality of the machine compound) and type of enterprise (see Table 12). In the area of milling services there are two types of enterprises: the tool makers, that work with small lots and manufacture more complex parts, and those dedicated to "production", i.e., dealing with large lots of parts with simpler specifications. However, the

division is not hard-set and there are enterprises that operate in both segments. Size is a basic element for competition. In the case of more technically complicated parts the companies with more advanced technology are at an advantage. The same enterprise, however, may lose to smaller less equipped ones when it comes to a relatively simple part, because its indirect costs would be greater. Therefore, our sample has enterprises A and F at two extremes. While the first one has only recently acquired a small NC lathe, the other has the most advanced machines such as milling machines and machining Centres. Thus, they are enterprises that operate in very distinct market segments. This is also reinforced by the fact that they are located in different cities. The division of the market by location is also considerable in the sector, especially regarding smaller enterprises. Larger ones have a wider range of action. Enterprise F only competes more strongly with one larger enterprise in the same city, most of its competitors located in the city of São Paulo.

Table 13: Main Type of Production of Each Firm

Size of batches	EMPA	EMPB	EMPC	EMPD	EMPE	EMPF
Large	X				X	X
Small		X	X	X		

Source: Information given by the firms 1987-1988.

In this sense, acquiring NCMTs can be an important competitive strategy for these enterprises (see Table 14). The installed capacity, with an emphasis on the level of advancement of the equipment, largely determines the type and volume of orders a firm will receive. One of the entrepreneurs interviewed mentioned the large amount of orders that could not be met in the past for lack of an NCMT. Many times the clients themselves take the initiative of calling suppliers' attention to this fact.

Table 14: Motives for Introduction, Problems Related to the Use of NCMTs, and Competitive Strategies

Motives	**% of the firms that mentioned**
1. To produce with more precision/quality	100%
2. To compete with other firms	80%
3. To produce efficiently in small batches different types of products	60%
4. To cope with the shortage of skilled labour	60%
Problems	**% of the firms that mentioned**
1. Financial pressure due to the high costs of the machines	100%
2. Lack of maintenance capability	100%
3. Limited reliability	40%
Strategies	**% of the firms that mentioned**
1. Introduction of automation in production processes	75%
2. Reduce labour costs	75%
3. Diversification	60%
4. Increase labour productivity	50%

Source: Information given by the firms.

Although these are enterprises where the cost of manpower is a significant part of total costs, reducing salary expenses is not among the main reasons for introducing a new technology. However, none of them experienced a reduction in the number of employees because of the introduction of NCMTs. On the other hand, several owners acknowledged that without these machines they would have had to employ a larger contingent of personnel. The shortage of qualified labour has also encouraged the diffusion of numeric-control machine tools. There is a consensus among enterprises that a worker with good qualifications in mechanics does not remain unemployed in the region. There is even tight competition between enterprises for these workers.

The main motivation for the introduction of NCMTs is linked to the improvement of the quality of their products, since this is a major competitive advantage in the search for more clients. During a period when most of their clients suffer from the retraction of the internal market and are trying to expand exports, the quality factor gains special relevance to them, and this is passed on to their suppliers, as was described previously. The process of choosing and qualifying suppliers becomes more strict, specially on the part of multi-national corporations. The ultimate goal is to work exclusively with quality-assured suppliers, in order to do away with inspecting the goods received.

As is also clear from Table 14, the two main problems faced by these enterprises regarding the use of NC technology are the high cost of these machines and the lack of maintenance capacity. The main obstacle to diffusion is undoubtedly the price of the equipment. Besides the fact that Brazilian NCMTs are on the average three to four times higher than similar foreign equipment (according to information given by our interviewees), this internal price has risen more than inflation[2].

Only enterprise F was beginning to set up its own maintenance crew with knowledge in electronics and capable of solving most NCMT problems. The remainder depended almost entirely on the manufacturers to care for the problems of electronic nature in this equipment. It is in the area of maintenance that the great lack of qualification in NCMTs is felt.

Training of operators/setters has not been a problem for the enterprises in the sample. They make use of the training courses administered by the suppliers for both operation and programming. Preference to work with NCMTs is usually given to conventional machine operators between 20 and 25 years old and with better levels of schooling, but there are some variations to this. The qualification of a NC machine operator will depend much on what type of activity this person will be carrying out. If setting or even programming activities are added to the task of, then the level of qualification required rises considerably.

At the enterprises visited, however, no case of associating operation and programming was found. Actually, the operators' tasks in these enterprises were very limited; they place the piece, supervise operation and, at the most, make corrections in the measurements. The most critical tasks associated to setting NCMTs are carried out by the machine setter. This professional has a higher level of qualification as in these enterprises he is also usually responsible for programming. Therefore, this person is a setter/programmer. Enterprises using this system claim that the number of NCMTs, which is still reduced, does not justify hiring programmers to work in an isolated manner in an office. Enterprise F is an exception, where programming is carried out in an office by a 25-year-old professional with an uncompleted university level. This is easy to understand in view of the larger compound of NCMTs this enterprise has. It must be pointed out that this professional began his career in the enterprise, operating conventional machines and later NCMTs.

At enterprise A one of the owners himself programs the NC machine, and many times carries out setting and operation. Normally, however, a worker with a higher level of education and more professional experience is chosen to work as a setter/programmer. Operation, as such, is left to less qualified employees. At one of the companies the owner stated that he placed the least qualified workers, those who were not expected to progress in their career and who earned the lowest wages, to operate NCMTs.

All persons interviewed agreed, that it was not worth hiring a specialized professional, such as a tool maker, to operate a NCMT. In this sense it is possible to say there was no lowering of

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[2] According to information given by one entrepreneur interviewed, the variation of the prices of these equipments in US$1000, was: 1) PFAUTER PA300 185, in 1978 and 700 in 1988; 2) TORNO INDEX GUI000 307 in 1978, 673 in 1980, 410 in 1985 and 1100 in 1988; 3) MAQUINA LAVAR DURR 61 in 1979 and 250 in 1988; 4) BROCH.EXTERNA 25 T 428 in 1982 and 450 in 1988; 5) FURAD.MULT.BREVET FU310 27 in 1979 and 120 in 1988; 6) MAQ.TEMPERA P/INDUÇÃO 146 in 1980 and 260 in 1988; 7) REBARB. SU MOD.SCT350 27 in 1981, 12 in 1985 and 100 in 1988; 8) CENTRO USINAGEM GROB BZ50 642 in 1985 and 1200 in 1988; 9) TORNO PETRA 255 in 1985 and 600 in 1988. This information helps visualize what has been taking place.

qualifications in these enterprises with the introduction of this new technology. What happens is just that a more qualified conventional machine professional is dislocated to work with NCMTs and is given the task of setting and/or programming, and this tends to increase his qualification and earnings.

In terms of wages the picture is not very clear. A NC operator tends on the average to earn more than the conventional machine operator, but his wages are always less than those of specialized conventional-machines operators. The highest wages in these enterprises are in the tool making section, where introducing NC technology would require getting more sophisticated, therefore more expensive machines. wages for NC setters do not differ much from conventional ones, but when differences are observed, they are always in favour of the former. However, enterprises still have little experience in numeric-control technology.

Undoubtedly, the fact that they work for enterprises in which quality is essential weighed heavily on the diffusion of NCMTs among these subcontracted enterprises. Many of the contractors, as will be seen further on, implanted the just-in-time system, or are in the process of doing so, and this requires more flexibility on the part of their suppliers.

As was mentioned before the main enterprises in the region, contracting-machining services are making considerable efforts to increase their penetration into foreign markets. They act in segments where quality in part configuration is essential to assure their acceptance in these markets. In the case of the aeronautic industry this is a critical factor because of the norms in approving their products. Although passing a reasonable portion of machining services on to others may be advantageous as far as costs are concerned, this project meets with an insufficient number of qualified suppliers. The ownership of an NCMT already indicates a higher technological level of a subcontracted enterprise. It works as a guarantee for the client. There are cases in which the very specifications of a part requires NCMT machining. Consequently the more "select" machining services will be given to enterprises that are more technologically capable. This is why owning NCMTs gains increasing importance for clients when they select their machining services suppliers.

Anyway, we are far from the Japanese model. In our case there was no co-ordinated effort on the part of large enterprises to constitute a network of qualified suppliers. The initiative to innovate clearly came from the smaller enterprises. Clients were certainly favourable to the process but this did not imply more active participation on their part. The tendency toward co-operation between subcontracted enterprises and clients is much weaker in our sample than what is related by Watanabe in describing the Japanese model. This, however, does not mean, that there was no support whatsoever.

It is true that the type of encouragement varied greatly. Enterprise C, working for the large aeronautic industry, stated that they received verbal encouragement from the latter in the sense of what type of NCMT to acquire. This can be easily understood since, of the nearly sixty machining service-rendering suppliers of the aeronautic industry, only five or six have NCMTs and this enterprise has met increasing difficulty tin contract services that require greater precision - the very type that is done by enterprise C.

The greater the difficulty in finding a subcontracted enterprise to carry out a certain type of service, the greater the incentive to invest in qualifying existing suppliers. The same enterprise C stated that they received no support from other clients as it is easier for them to find suppliers who fit their needs. Generally, however, subcontracted enterprises do not count on their clients as technical advisers, such as in the Japanese case. The situation here is similar to that in Italy. What all contracting firms do is to carry out rigorous monitoring of their suppliers' production. They do periodical inspections and distribute manuals explaining the quality standards required. Presently, the majority of them have been insisting upon their suppliers introducing Statistical Quality Control. They do not, however, appear to help in implanting the techniques needed to meet these requirements.

The role of the NCMT supplier is crucial. This enterprise, besides being the absolute leader in the NCMT market (it controls 55%), is characterized as producing relatively simple machines at a price level which is accessible to small- and medium-sized enterprises. Until recently there was only one other company from the interior of São Paulo competing in this market of small enterprises. Due to a serious financial crisis it could only penetrate this market firmly starting in 1986.

All enterprises in the sample highlighted the role the leading manufacturer played in the decision to acquire NCMTs. It has a wide network of representatives in the country and therefore can easily identify potential clients. Once identified, its Technical Marketing department develops an effort to explain the characteristics and advantages of NCMTs.

The owners of these target enterprises are then invited to participate in a numeric-control management course and offered the opportunity to have one of the designs of their parts made on one of their NCMTs. These courses are generally frequented by owners of small and medium-sized enterprises who do not have much opportunity to stay updated on their own about the advances of production technology.

During an interview the Technical Marketing director of this large manufacturer mentioned the intention of this company to become a type of consultant to its clients regarding the use of new automation technology. This would even include equipments and systems not produced by the company. He mentioned the case of automatic programming software. Many clients have looked to this company for information on the type of system that would be most convenient for them. The NCMT producer, in spite of not commercializing software, has a wide experience in programming and is therefore capable of advising its clients.

All subcontracted enterprises stated that they maintain straight ties with this manufacturer. In the case of enterprise D, the founders were former employees and presently had this producing enterprise among their main clients. The owner stated that he had received much incentive from this supplier upon initiating the acquirement of NCMTs. One of the owners of enterprise F stated, that due to the more advanced stage of his enterprise in the use of numeric-control machines, it was even serving as a field for this manufacturers experiments in NCMT.

Managing the innovating enterprise

Due to the subcontracting relationship, which is set up, on one hand, between large enterprises and, on the other, between small- and medium-sized ones, analysing the possibility of management policies passing on from large enterprises to their subcontracted firms was tried The tendency observed in the sample was a growing movement toward modernization, specially in large enterprises. This movement of consolidating the so-called "enterprise culture" presupposes the existence of new policies for managing the work force, *e.g.*: labour stabilization policies, the introduction of participative frameworks and changes in the work and wage structures. In a second phase, this "enterprise culture" is passed on, or rather, assimilated by small- and medium-sized enterprises, and is complemented by the subcontracting relationship that is set up between them.

The literature on this theme points to some similar cases. The studies done by Sabel (1982) and Brusco (1982) pioneered in the sense of pointing to a decentralizing movement in the productive sector, especially in northern Italy. This movement would lead to a closer relationship between small and large enterprises and new modes of union-enterprise relationships.

The Sabel and Piore (1984) study discusses the relationship between technological modernization and new work-place relations, more specifically related to the management of the work force. According to the authors, in the USA, until the beginning of the 1980s the American industrial restructuring due to the crisis in the 1960s can be seen as a mixture of practices found in other countries. These range from the introduction of new technologies, the flexibilization of production, to the decentralization where several small enterprises are formed surviving because of the relationship they set up with larger ones. At the core of this process toward new ways of organizing

production, there appears an innovative management movement that perceives the need for changes on the shop-floor regarding the redefinition of industrial relations, especially in large enterprises.

This movement had two different sources. The first group was basically made up of intellectuals, innovative entrepreneurs, who tried to think of ways to increase the quality of work life: "this group drew on American ideas of industrial psychology that aimed to create harmony in the factory by harmonizing the informal groups surrounding each work place (Piore and Sabel, 1984:241). One of the slogans of this movement was "humanization" of work, where there would be a reduction of the monotony and opportunity for workers to exercise their individuality.

The second line of innovators was a group of young entrepreneurs connected with the Harvard Business Review, whose motivation was more competition than humanistic doctrines. As markets were less stable some entrepreneurs tried to increase productive flexibility, therefore considering the current job classification system two narrow, constituting an obstacle to progress. The goal was to establish a new and flexible form of work control that would be beyond the reach of the union movement.

The introduction of this system in some large North-American corporations made the percentage of employees affiliated to unions between 1979 and 1982 decrease from 59 to 50%, and job lay-offs, on the other hand, increased by 25% (Piore and Sabel, 1986: 243). Although these changes were difficult to implant in factories where there was a strong union movement, unions managed to live with them.

In Brazil, the diffusion of microelectronic-based technologies begins in the middle of the 1970s, at the same time as the beginning of the recession and of the crisis in the model of work prevailing during the "economic miracle". Facing the economic crisis, the appearance of workers' movements and the process of political opening, this model begins to be questioned by the various social sectors (workers, businessmen, State) and no consensus is yet perceived within these sectors about new forms to be adopted. It is in this context that different experiences in managing the work force (CCQ, KANBAN, semi-autonomous groups) and in company-union relationships - such as the factory commissions (Ford, VW, etc) - spring up from within productive units and the process of new technologies is intensified (Gitahy, 1983 and 1988).

The objective of these new human resource policies found in the enterprises visited is to be able to count on a more participative, more educated work force, *i.e.*, that will "have the capacity and interest to face the demands of operation and maintenance of new equipment and the interest in improving the quality of the products" (Carvalho, 1987:197). Another objective that is sought by this new "mentality" of HR people is neutralizing unions' power within the factories. Of the five factories visited all of them tried to replace the role of the union, be it in the internal resolution of the problems workers face daily, be it in the implantation of social-security policies. In the first solution - internal solution - the managers' strategy is to individualize workers, placing value not only on the worker as an individual with unique characteristics, but also the idea that he is not confused with the collective, which at its limit is the union. According to one of the entrepreneurs (from a small service rendering factory): the changes are not imposed, they are discussed. This because we are dealing with specialized personnel not found on the market". In this factory specifically there was a reduction in intermediate overseer positions (50%): "What happened was an increase in qualification of the workers and not a reduction in personnel."

Our hypothesis is that, due to the subcontracting relationship, there is a parallel process of de-centralization and passing on of modernization taking place, or of the large enterprises' culture toward the smaller ones.

In order to demonstrate this hypothesis we have listed the innovations found among large and small enterprises:

- Large enterprises, or parent enterprises:

The most significant enterprise in our sample, not only in size but also in having the largest number of subcontracted services (496 in 1987) and the greatest diversity of factory-worker involvement and relationship policies. These involvement policies are called "communication channels, *e.g.*, bilateral communication, field research, opinion polls, department meetings, executive interviews, open door policy, speak openly, round tables, kick-off meetings, leadership program, and participative management. Among these, those which give an idea of participation and involvement are:

a) Open doors: created in the USA, by the founder of this enterprise, consists in schedules set by immediate overseers and managers, when they are available for their workers. The idea is that overseers are not inaccessible, and that dissatisfaction (individual) is seen to.

b) Speak openly: by filling out a form (attached) the workers can give their opinion, point out irregularities, etc. Answers are sent out by mail and suggestions that are viable for the company are implemented. The most interesting suggestions are published in the factory's internal magazine.

c) Suggestion program: it aims to encourage greater interaction between the company and the workers. All ideas are complied to, whether or not they will benefit the company.

Regarding the human resource philosophy we observed the implantation of a management system based on the manager-worker relationship that is set up without the interference of third parties, specially unions. Some of the participative programs pointed out work as sensors to measure this relationship, such as opinion polls, speak openly, open doors, etc. Personnel management, or the industrial relations department, only works as staff, relations regarding personnel management are dealt with by area managers. Therefore, it is up to the immediate management to apply and validate involvement programs. This immediate management faces challenges and obligations as it fires, promotes and chooses its workers.

The relationship of this company to the union is to resolve any capital vs. work conflicts without the intervention of the union, using its own channels of internal dialogue (speak openly, etc). In interviews with the managers they claim to have met all the demands of the local union and to have even gone beyond what is presently demanded. In spite of this they try to keep friendly relations with the union allowing it to communicate with workers outside the factory gates. Anyway the number of unionized workers is minimal, in 1987 it was 2,7% of the total force.

- Small- and medium-sized enterprises:

As a result of the case study carried out in the seven factories in the metal mechanic sector the subcontracting relationship that is set up with large companies (Table 1) is, if not totally, at least partially passed on . The innovations - or what we would call "modernization" that is consolidating itself in the large industries - are a part of the subcontracting that is present among different enterprises.

One of the reasons for this interrelationship between large and small enterprises are the demands, such as those for product quality, placed by the international market. Those demands are part of the innovation strategy of large companies dictated by the international market. Thus, what is often called "quality assurance" is presented as a basic condition to choose a supplier or subcontracted firm.

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