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THE IMPACT OF UNIONS ON THE DIFFUSION OF TECHNOLOGY: THE CASE OF NC MACHINE TOOLS

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The Case of NC Machine Tools

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Abstract: This paper reports the results from an econometric analysis of the impact of unionism on the diffusion of technology. It is found that the extent of unionism does not have any significant influence on the diffusion rate of NC machine tools in the U.S. engineering industries in the period of 1979-1983.

The Impact of Unions on the Diffusion of Technology: The Case of NC Machine Tools

Introduction

Social scientists have long been interested in the economic effects of unionism. There are many studies focused on the analysis and explanation of the differences between the wage rates of union and nonunion workers, unions' effects on quits and layoffs, the relationships between unionism and firms' productivity and profitability, etc. The influence of labour unions on the rate and direction of technological change is an important research question that has not been adequately documented empirically.

There are various channels by which union presence may influence the diffusion of new technologies. The net union effect, however, is theoretically undetermined. Empirical evidence on the diffusion of specific technologies in various countries is required to shed light on this issue (see, for example, Freeman and Medoff, 1984; Metcalf, 1990).

We present in this paper the results of an econometric analysis of the diffusion of numerically controlled (NC) machine tools in the U.S. engineering industries.[1] This is a part of our ongoing research on the diffusion of flexible automation technologies and the impact of new technologies on

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1. Machine tools are defined as power-driven, nonportable by hand, equipment that is used to cut, form, or shape metals. Engineering industries comprise fabricated metal products, non-electrical machinery, electrical machinery, transportation equipment, and precision equipment industries.

international competitiveness. Other papers written for this study are available from the author upon request (see Carlsson and Taymaz, 1989; Taymaz, 1991).

The NC technology is chosen as a 'test case' in our analysis because of the following reasons. First, machine tools are historically among the most important type of production equipment since the Industrial Revolution. As stated in an UNIDO study (1984: 57), "[a]s production of any machine used in the economy depends heavily on machine tools, it is evident that the machine tool is the basis of our whole mechanized society." Second, the widespread diffusion of NC machine tools after 1975 when the first microprocessor-based NC machine tool was developed has radically changed manufacturing technologies in the engineering industries in all industrialised countries. According to many commentators, this technology has a strong labour-saving bias, and helps the management to increase its control over the production process. Although the debate on the effects of NC technology continues, managers justify their decisions for investing in NC technology by these arguments in many cases (for examples, see Noble, 1984; and Shaiken *et al.* 1986). Accordingly, this technology is likely to trouble labour unions. Finally, it is easier to isolate industry-specific effects on the rate of diffusion since machine tools are extensively used in all types of engineering industries.

The Model

There have been several econometric studies of the diffusion of NC machine tools. The works of Romeo (1975 and 1977), Globerman (1975), Liberatore and Titus (1986), Lintner *et al.* (1987) and others have generated much evidence about the determinants of the diffusion of NC machines. All of these researchers estimated regression models by using data at the firm level. In most of the cases, the dependent variable used in those models is a binary variable, taking on the value one if a given establishment is a user of NC machine tools, and zero otherwise. Therefore, as Lintner *et al.* (1987) correctly stated, those studies measure the probability of a firm's initial decision in adopting NC machines. Romeo (1975 and 1977) used models at the industry level in which the dependent variable is the estimated value of the imitation rate of NC machine tools.

Among the above mentioned researchers, only Lintner *et al.* studied the effects of unionism by including an explanatory variable on the rate of unionisation into their model. They found that unions do not exert any significant influence on the adoption of NC machine tools in the U.K. mechanical engineering industry.

In this study, the rate of diffusion of NC machine tools in the U.S. engineering industries is examined. More specifically, the dependent variable to be explained is the number of NC machine tools as a proportion of total machine tools purchased in the U.S. engineering industries in the period of 1979-1983.

The database of this analysis is obtained from the 13th American Machinist Inventory of Metalworking Equipment for 3-digit industries in Standard Industrial Classification (SIC) 34-38 categories (American Machinist, 1983a). Data were collected by questionnaire from 12,306 plants in the 48 contiguous United States during the first half of 1983. The number of machine tools and related equipment in each industry at the 3-digit SIC level is estimated on the basis of this survey. (For a summary of survey's results and its methodology, see American Machinist 1983b.)

The extent of unionism is one of the explanatory variables in the model. If unionism has a negative influence on the diffusion of NC machine tools, the regression estimate of the coefficient of this variable is expected to be negative.

There are a number of alternatives for the unionisation variable. In this paper, the extent of collective bargaining coverage for all workers (UNIONC) and for production workers (UNIONCP) are used to represent the extent of unionism. Those data at the 3-digit SIC level are estimated by Freeman and Medoff (1979) from the Expenditures for Employee Compensation survey for 1968-1972. They also supply data on the extent of union membership for both categories estimated on the basis of the 1973-1975 May Current Population Survey (CPS) at the 3-digit Census Industry Code (CIC) level.

Kokkelenberg and Sockell (1985) estimated the three-year moving averages of the extent of union membership for 3-digit CIC industries for the period of 1974-1980. Curme *et al.* (1990) also present estimates of union membership and contract coverage density for 3-digit CIC industries, based on calculations from the 1983-1988 CPS tapes.(2)

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2. The 3-digit CIC data cover only a subset of the 3-digit SIC industries. An analysis of those variables used in our regression model reveals that there are significant systematic biases in this subset. (Industries that are included in both classifications tend to have significantly higher values for the SIZE, NCSTOCK, FLUCGR, and WIP variables.) Accordingly only the SIC data (the UNIONC and UNIONCP variables) are used in the regression estimates.

Table 1. The extent of unionism in the U.S. engineering industries, 1968-1988 (in percent)

	Contract coverage density				Union membership density			
	prod work	all workers			all workers			
	1968-72	1968-72	1984	1988	1973-75	1978	1984	1988
Cases	42	42	32	32	30	30	32	32
Mean	61.6	45.8	31.0	25.6	39.8	38.2	29.3	24.1
Std Dev	26.2	20.5	16.0	14.2	15.8	17.2	16.0	13.9
Corr with UNIONC	.95	1.00	.76	.74	.79	.82	.75	.74

Sources: Freeman and Medoff, 1979; Kokkelenberg and Sockell, 1985; Curme *et al.*, 1990.

A summary of the union membership and contract coverage density data is shown in Table 1. As may be expected, the average values of both variables have gradually declined in 1970-1988. However, the distribution of these variables across the engineering industries does not show any significant change. For example, the correlation between the union membership variables in 1974 and 1988 is higher than .90.

There are, of course, other variables that influence the diffusion rate. These variable should be incorporated into the model to obtain an unbiased estimation for the coefficient of the unionism variable. Thus, the following variables are also included into the regression model.

SIZE is equal to the average firm size as measured by the number of employees in 1979. It is argued that the NC technology becomes more well-suited to the needs of small firms as it develops, and the market share of small firms "has grown with the increasing maturity of the technology of NC machine tools" (Jacobsson, 1986: 46). Thus, a positive coefficient of this variable is expected.

CAPL, the capital-labour ratio, is defined as the value of depreciable assets per employee in 1979. NC machine tools are generally more expensive than conventional machine tools, and they tend to increase the capital-labour ratio because of labour-saving effects. Firms/industries that have higher investment capacities may easily increase their NC machine stock. Hence, we expect the CAPL variable to have a positive coefficient.

SPEC is the specialisation ratio (the share of products classified in that industry to industry's total output) in 1977. SPEC is expected to have a negative coefficient since a higher value of this variable may show the suitability of this industry for specialised (presumably, mass) production.

WIP, the measure of work-in-process inventories as a proportion of total inventories in 1979, is a proxy for product complexity. Since "[t]he use of NC is positively correlated, *ceteris paribus*, with greater part complexity..." (Adler and Borys, 1989: 391), the coefficient of this variable is expected to be positive.

FLUCGR is equal to the standard deviation of annual industry growth rates in the period of 1977-1985, and represents the level of market fluctuations. Since the increase in the instability of markets is stated among the factors that favor the use of flexible automation systems, the coefficient of this variable is expected to be positive. TECH is equal to the share of technicians in total employment in 1980. It is suggested that NC technologies can be more advantageous for those firms with higher-skilled labor. Thus, a positive coefficient for the TECH variable is expected. Finally, the number of

NC machine tools as a proportion of the total number of tools purchased before 1979, NCSTOCK, is also included into the model to capture the effects of unspecified factors.

In brief, the model can be written as follows.

$$NCNEW_i = \alpha_0 + \alpha_1 \, UNION_i + \alpha_2 \, NCSTOCK_i + \alpha_3 \, SIZE_i + \alpha_4 \, CAPL_i + \alpha_5 \, SPEC_i + \alpha_6 \, WIP_i + \alpha_7 \, FLUCGR_i + \alpha_8 \, TECH_i + \epsilon_i$$

where ϵ_i is the random error term.

Regression estimates

Some descriptive statistics about variables and data sources are shown in Table 2. The mean value of the collective bargaining coverage of all workers (UNIONC) is much lower than that of production workers (UNIONCP). The mean value of the NCNEW variable is five-fold higher than that of the NCSTOCK variable. This shows the rapid pace of the diffusion of NC machine tools in the period of 1979-1983.

The regression results are shown in Table 3. White's method is used to estimate the heteroskedasticity-consistent covariance matrix. The ordinary least squares (OLS) estimates have somewhat lower t-values but there is not any change in the interpretation of the regression results.

Table 2. Descriptive statistics of all variables

Variable	Cases	Mean	Std Dev
UNIONC	42	45.81	20.53
UNIONCP	42	61.62	26.16
NCNEW	42	16.36	7.52
SIZE	42	174.69	272.41
CAPL	42	16.22	6.75
SPEC	42	90.05	3.79
WIP	42	.89	.62
FLUCGR	42	10.12	7.81
TECH	42	3.96	2.93
NCSTOCK	42	3.15	1.72

Variables: UNIONC: the extent of collective bargaining coverage for all workers in 1968-1972, UNIONCP: the extent of collective bargaining coverage for production workers in 1968-72, NCNEW, the share of NC machine tools in machine tool investment in 1979-1983, NCSTOCK, the share of NC machine tools in machine tool investment before 1979, FLUCGR: the standard deviation of industry growth rate in the period of 1977-1985, SIZE: the number of employees per establishment in 1979, TECH: the share of technicians in industry employment in 1980, CAPL: the value of depreciable assets per employee in 1979, WIP: the share of work-in-process inventories in total value of inventories in 1979, SPEC: the specialization ratio in 1977,
Sources: UNIONC and UNIONCP: Freeman and Medoff (1979), NCNEW and NCSTOCK: American Machinist (1983a), TECH: NSF, *Scientists, Engineers, and Technicians in Manufacturing and Nonmanufacturing Industries: 1980-1981* (Washington, DC: NSF, 1983), SIZE: Bureau of the Census, *County Business Patterns, 1979*, SPEC: Bureau of the Census, *Census of Manufacturing Industries, 1977*. All other variables: Bureau of the Census, *Annual Survey of Manufactures, 1979.*

Table 3. Determinants of the diffusion of NC machine tools (Dependent variable: NCNEW)

Variables				
UNIONC	-0.02	-0.02		
	(-0.72)	(-0.74)		
UNIONCP			-.02	-.01
			(-0.69)	(-0.58)
SIZE	-0.02**	-0.02**	-0.02**	-0.02**
	(-4.69)	(-4.29)	(-4.48)	(-4.09)
CAPL	0.42**	0.41**	0.41**	0.40**
	(4.57)	(4.56)	(4.61)	(4.61)
SPEC	-0.61**	-0.56**	-0.61**	-0.56**
	(-2.83)	(-2.67)	(-2.86)	(-2.69)
WIP	6.68**	6.88**	6.65**	6.91**
	(3.19)	(2.92)	(3.16)	(2.91)
FLUCGR	0.12		0.13	
	(1.36)		(1.41)	
TECH	0.14		0.16	
	(0.53)		(0.63)	
NCSTOCK	1.99**	2.16**	2.02**	2.19**
	(3.36)	(3.87)	(3.30)	(3.81)
Constant	53.88**	50.57**	54.04**	50.61**
	(2.83)	(2.70)	(2.86)	(2.72)
R^2	71.6	70.0	71.6	69.9
Adj-R^2	64.7	64.8	64.7	64.8
F-statistic	10.39**	13.59**	10.40**	13.56**
	(8, 33)	(6, 35)	(8, 33)	(6, 35)

Note: ** (*) means statistically significant at the 5% (10%) level, two-tailed test. Numbers in parentheses are t-values calculated by using the heteroskedasticitity-consistent covariance matrix.

The coefficient of determination, R^2, is around .70 in all estimates. The coefficients of all variables have the expected sign. Moreover all but two of the coefficients are statistically significant at the 5% level. The diffusion rate of NC machine tools is higher in industries characterised by capital-intensity, product complexity, higher initial NC stock, small size, and lower specialisation.

The coefficients of the unionism variables have negative sign but their t-values are very low. In other words, they are not significantly different from zero. Thus, our results show that the extent of unionism has no impact on the diffusion of NC machine tools in the U.S. engineering industries in the period of 1979-1983.

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