CHAPTER V

A Micro-Simulation Analysis of Manufacturing Firms' Demand for Telecommunications Services

by

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1 Introduction

It is now commonly accepted in economics that information and communication technologies have become key factors behind firms' competitiveness and economic growth. This phenomenon has stimulated research on the supply of, and demand for these technologies.

This paper analyzes the factors that affect firm's demand for telecommunications services on the basis of a micro-simulation model of the Swedish economy. The main advantage of microsimulation models lies in the fact that they capture the effects of distributional characteristics. Therefore, the focus of this paper is on the effects of changes in the size distribution of firms that have different propensities to communicate on the total demand for telecommunications services. In other words, the purpose of the paper is not to develop a model for forecasting the demand for telecommunications services, but to develop an analytical tool to understand its micro-determinants better.

The best conceivable method for this purpose is to incorporate the demand structure explicitly into firms' production functions, and to introduce supplier firms in the model. That is, the telecommunications industry should be modeled as one of the sectors that are based on firm-level, micro-data. This method requires additional detailed information on firms' production characteristics. Since such data are not available, it is currently not meaningful to develop the model in this direction.

Instead of explicitly modeling the telecommunications industry, the demand function of each firm can be incorporated into the model. The firms' "demand function" is estimated on firm specific characteristics in the database. The simulation experiments generate those firm-specific characteristics, and the firms' demand for telecommunications is determined indirectly by using the "demand function". This is the empirical method of the paper. The simulation experiments summarized in this paper are presented to demonstrate how the micro-simulation method can be used in this type of analysis. All results obtained are thus tentative, and have to be further collaborated.

The paper is organized as follows. Sections 2 and 3 explain the data sources and the methodology, respectively. The regression estimates of firms' "demand function" are presented in Section 4, and the micro-simulation experiments in Section 5. A summary of results concludes the paper.

2 Data sources

The planning surveys have been conducted each year since 1975. These surveys contain data on firm characteristics such as sales value, expected sales, capacity, etc. (for details, see Albrecht 1987.) The 1989 Survey also included questions on the "fixed" and "variable" costs of telecommunications in 1988, and their components (the share of telephone costs, telex costs, etc.). The database of the micro-simulation model, MOSES, is based on the 1983 Planning Survey. Since it is quite time-consuming to prepare a new database for the MOSES model (A *M*odel of the *S*wedish *E*conomic *S*ystem), 1982 is used as the initial base year.

425 firms responded to the 1989 Survey. 175 of those firms answered one of the questions about the fixed and variable telecommunication costs. There are 78 firms that answered both questions, and some of the other questions that are used in the regression analysis. Therefore, our sample consists of those 78 firms. Basic data about those firms (see Table V.1) show that average expenditures on telecommunications almost equal .5% of total sales in 1988. The distribution of firms by their relative demand (the ratio of telecommunications expenses in total sales) is shown in Figure V.1. Note that the area under the line is equal to total demand for telecommunications.

t-tests are used to check if there are systematic biases in the sample. Table V.2 shows test results for the variables employed in the regression analysis. These tests indicate that there is no systematic sampling bias. The only statistically significant test result at the 10% level is obtained for the SALE variable when the separate variance estimate is used. As shown in the SALE and EMP variables, firms that answered the questions about the telecommunication costs are smaller on average than the industry average, although the differ-

Table V.1 Data about the telecommunication expenditures in a sample of 78 firms, 1988

	Value (million SEK)			Share in output (in %)		
	Fixed	Variable	Total	Fixed	Variable	Total
Max	5.2	52.0	55.0	1.01	1.03	2.02
Min	.02	.1	.1	.01	.01	.02
Mean	.9	3.4	4.2	.11	.32	.44
Standard deviation	1.0	6.7	7.2	.15	.26	.36

Source: The Planning Survey 1989.

Table V.2 t-tests for sampling bias

Variable	Group	Number of observations	Mean	Standard error	Pooled variance estimates t-valued (prob.)	Separate variance estimated t-valued (prob.)
SALE	Sample	78	1070.3	148.6	–1.42	–1.75
	Others	133	1678.3	314.7	(.16)	(.08)
EMP	Sample	78	1176.8	191.1	–.96	–1.10
	Others	133	1521.1	249.1	(.34)	(.27)
WIPSH	Sample	78	19.04	1.71	–1.45	–1.55
	Others	133	22.78	1.71	(.15)	(.12)
XSH	Sample	78	.50	.03	–.72	–.73
	Others	128	.53	.03	(.47)	(.47)
INVSH	Sample	78	.045	.004	–.83	–1.09
	Others	132	.260	.198	(.40)	(.28)
SKILL	Sample	78	.198	.004	.49	.49
	Others	133	.196	.003	(.62)	(.62)

Notes: Variable definitions are as follows. SALE, the value of total sales in million SEK; EMP, number of employees; WIPSH, the ratio of work-in-process inventories to total sales; XSH, the share of exports in total sales; INVSH, the ratio of annual investment expenditures to total sales; SKILL, the average wage level.

Source: The Planning Survey 1989.

ences are statistically significant only at the 8-34% levels. Similarly, those firms in the MOSES model have higher output and employment levels than firms in the telecommunications sample.

3 Method

The MOSES simulation model is a micro-to-macro model of the Swedish economy (see Eliasson 1977 and 1985; Albrecht et al. 1989). The modeling project was initiated in 1974 by IBM Sweden and work began in 1975. Two databases for the model have been prepared by using 1976 and 1982 real micro and macro data. 225 firms or divisions defined explicitly in the manufacturing sector in the 1982 database. 154 of those firms are real, i.e. data about those firms come from the Planning Survey of 1983 and from firms' financial reports collected by IUI. The questions about firms' telecommunication expenses were first included in the Planning Survey in 1989. This study is the first attempt to incorporate such data into the model.

The explicit modeling of demand for, and supply of telecommunications services needs more detailed data for both user and supplier firms. Therefore, another method that is widely used in the microsimulation analyses is tried in this study.

Firms' demand for telecommunications is assumed to be dependent on the size of the firm, the types of markets to be served, and its production characteristics.[1] A simple regression model can be written as follows.

$$TEL_i = \alpha_0 \, SIZE_i^{\alpha 1} \, MARKET_i^{\alpha 2} \, PROD_i^{\alpha 3} \, e^{\varepsilon i} \quad (1)$$

This equation can be rewritten by dividing both sides by the value of sales, SALE. In this case, we obtain an equation for the share of telecommunications expenses.

$$TELSH_i = \alpha_0 \, SALE^{-1} \, SIZE_i^{\alpha 1} \, MARKET_i^{\alpha 2} \, PROD_i^{\alpha 3} \, e^{\varepsilon i} \quad (2)$$

A positive relation between the size variable and telecommunications expenditures can be expected. For the size variable, employment (EMP) and the value of output (SALE) are used. Since these two variables are highly correlated, only one of them will be used at a time in the regression estimates.

The share of exports (XSH) can be used as a proxy for market type. A positive coefficient for the share of exports may be expected because international communications are usually more expensive.

The characteristics of production such as the complexity of products and their design may be expected to have a positive effect on the demand for telecommunications. The production of complex and custom-made products, for example, may require intense information flows between producers and users. There are a number of variables available to represent the characteristics of production. In this paper, the ratio of work-in-process inventories to total sales (WIPSH), the investment share (INVSH), and the skill level (SKILL) are used for this purpose.

Higher values of WIP inventories may indicate batch-type production. Since this type of production is generally associated with custom-made, non-standard products, a positive effect of this variable on the demand for telecommunications is expected. In a similar

[1] For a similar model used to examine the factors which influence the growth in demand for telecommunications services in the Italian manufacturing industries, see Antonelli (1989/90).

way, a positive coefficient for the SKILL variable is expected. Since data for the share of skilled personnel are not available in the Planning Survey of 1989, the average wage rate is used as a proxy for the average skill level. Higher values of the investment share may indicate a higher capital-intensity of production. Capital-intensive firms are usually connected with flow-type production that should require a less telecommunications intensive production. They have relatively more stable connections with their suppliers and customers, and their units of transactions are presumably larger.

The profit margin (PM = value added – wages/value added) is also included in one of the regression estimates to capture the relation between this variable and telecommunications intensity. This is the variable used in firms' profit targeting in the MOSES model. The effect of the PM variable is not a priori unambiguous. Although this variable has a negative correlation with the TELSH variable (-.38 which is statistically significant at the 10% level, two-tailed test), its coefficient in the regression estimation is not significantly different from zero.

In brief, the following regression model is used to determine firms' demand for telecommunications.

$$TEL_i = \alpha_0 \, EMP_i^{\alpha_1} \, XSH_i^{\alpha_2} \, INVSH_i^{\alpha_3} \, WIPSH_i^{\alpha_4} \, SKILL_i^{\alpha_5} \, e^{\varepsilon_i} \qquad (3)$$

TEL : the level of telecommunications expenses, in million SEK
EMP : the number of employees
XSH : the share of foreign markets in total sales
WIPSH : the ratio of WIP inventories to sales level
INVSH : the ratio of investment expenditures to sales level
SKILL : average wage level
ε : the random error

In the regression estimates, the log-form of this equation is used. Since this equation is estimated in the log-form, the estimated coefficients are elasticities. In other words, the coefficients show the percentage increase in the dependent variable (TEL) from a 1% increase in the explanatory variables.

This equation is estimated in the following section by using the 1988 data from the Planning Survey of 1989. The model is simulated from 1983 to 1993 to generate the explanatory variables for MOSES firms for the same years. Each firm's demand for telecommunications is found by using the estimated coefficients of Equation 3. The distributional characteristics of demand for telecommunications are obtained in the same way. Although Section 5 presents the results of a standard simulation experiment, various experiments can be performed by changing different policy variables and model parameters to determine their effects on the demand for telecommunications.

Before the regression estimates and simulation experiments are presented, two major caveats of this method should be emphasized. First, strictly speaking, the equation presented in this section is not a real demand equation since it excludes the price of telecommunications services. Telecommunications data are not yet available for other years. Thus, it is not possible to estimate price elasticities. Although there are some studies indicating that even household demand is highly inelastic,[2] this problem should be explored in detail when the Planning Surveys for later years become available. Second, we assume that the regression model is structurally stable. Relative price changes, new innovations in telecommunications technologies, etc., will also affect the structure of the model. The simulation period is relatively short, only 10 years. Hence, we assume that the effects of those changes are not significant.

4 Regression estimates

Regression estimates of Equation 3 are shown in Table V.3. The equation is estimated for total (TEL), fixed (FIX), and variable (VAR) telecommunication costs. The estimated coefficients have expected signs and the explanatory power of equations are relatively good for the TEL and VAR variables.

[2] For example, see Park et al. (1983); Bewley and Fiebig (1988). For the estimates of demand elasticity of telephone call time in Sweden, see Lang and Lundgren (1989); Sjöholm (1990).

Table V.3 Regression estimates of firms' demand for telecommunications

Explanatory variables	LTEL 1	LTEL 2	LTEL 3	LTELSH 4	LFIX 6	LVAR 7
	Dependent variables					
LSALE		−.13		−1.13**		
		(.70)		(6.10)		
LEMP	1.02**	1.14**	1.02**	1.14**	1.00**	1.07**
	(12.67)	(5.88)	(12.46)	(5.88)	(7.43)	(11.32)
LSKILL	1.50**	1.66**	1.54**	1.66**	2.16**	1.11**
	(3.51)	(3.41)	(3.51)	(3.41)	(3.01)	(2.20)
LWIPSH	.19**	.16*	.16*	.16*	-.01	.22**
	(1.70)	(1.34)	(1.39)	(1.34)	(0.04)	(1.67)
LINVSH	−.27**	−.27**	−.25**	−.27**	−.25*	−.27**
	(2.39)	(2.38)	(2.10)	(2.38)	(1.29)	(2.07)
LXSH	.11	.12*	.15*	.12*	−.01	.12
	(1.23)	(1.36)	(1.54)	(1.36)	(.04)	(1.23)
LPM			−.25			
			(1.00)			
Constant	−4.09**	−3.77**	−4.25**	−3.77**	−3.74**	−5.56**
	(4.09)	(3.41)	(4.16)	(3.41)	(2.22)	(4.73)
Number of observations	78	78	77	78	78	78
R^2	72.8	73.0	72.7	44.8	48.6	67.4
Adjusted R^2	70.9	70.7	70.3	40.1	45.1	65.2

Notes: * means statistically significant at the 10% level, one-tailed test. ** means statistically significant at the 5% level, one-tailed test. Numbers in parentheses are t-values. Variable definitions: LTEL: the level of telecommunications expenses; LTELSH: the share of telecommunications expenses in output; LFIX and LVAR: the level of fixed and variable telecommunications expenses, respectively; LSALE: the value of total sales; LEMP: the number of employees; LSKILL: the average wage level; LWIPSH: the share of WIP inventories; LINVSH: the ratio of annual investment expenditures to total sales; LXSH: the share of exports in total sales; LPM: the profit margin (value added−wages/value added). All variables are in log-form.

5 Simulation experiments

The model is simulated for 11 years by using the modification function, MSTART190, and the database R1982.91.[3] Firms' demand for telecommunications are found by using the first model in Table V.3. A number of adjustments have been made to adapt the model for changes in wages and prices over time. First, an approximation for the INVSH variable is used since this variable exhibits wide annual fluctuations in the model. The INVSH variable is calculated as .15*K1/S, where K1 is the value of physical capital stock, and S total sales value. The average of this variable is very close to the real INVSH variable in 1988. Second, wage rates are deflated by using the domestic consumer prices index (CPI) based on 1988 wages to obtain comparable SKILL variables for each year. The TEL variable obtained in this way is interpreted as the value of telecommunications expenses in 1988 prices. Therefore, those expenses are divided by the price index to obtain their value in current prices. Since there is almost no difference between the CPI and the GNP deflator, the former is used for this purpose. The share of telecommunications expenses (TELSH) is found by dividing the TEL variable with the total value of sales in current prices.

Real growth rates of industrial output and telecommunications expenses are shown in Figure V.2.[4] Telecommunication expenses have increased relatively more after 1988. Thus, as depicted in Figure V.3, there is an increase in the weighted average of the TELSH variable after this year. As a result of this change, the share of telecommunications expenses in total output increased modestly from .48% in 1983 to .57% in 1993.[5]

There may be three factors that cause this phenomenon. First, the telecommunications intensity of bankrupt firms (exits) and new firms (entrants) may be different. For example, if exiting firms have lower

[3] In the MOSES model, each experiment is carried out by making changes in the original model (changes in the behavioral equations, variables, etc.) by using a modification function, MSTARTxx. This allows to keep model in its original form. There are two datasets (for 1976 and 1982) with various versions. For details on the model and databases, see Bergholm (1989).

[4] Note that all figures refer to firms' demand for telecommunications services, not total demand. As stated in a study of ECE (1987: 138-139), "[i]n countries with a high telephone density, such as the United States and Sweden, business telephones generally account for one third or less of the total telephone population." The share of business telephones in the total number of telephones in Sweden is only 31.1%.

[5] Incidentally, the corresponding figure for the Japanese industry is very close to these values. In a study of information technology and economic growth in Japan, the share of telecommunication expenses in total domestic output is found .53% in 1984, and estimated to be .54% in 2000 (Imai 1987).

telecommunications shares (low value of the TELSH variable) than those of new firms, the high-TELSH firms will capture an increasing share in total demand. Second, the growth rates of low- and high-TELSH firms may be different. If high-TELSH firms have higher growth rates, they will increase their share. Finally, the majority of firms may increase their telecommunications intensity thereby increasing the aggregate telecommunications intensity as a result of changes in those variables that determine their demand for telecommunications. This is sufficient to tell that income elasticities of demand should not be estimated on macro data.

Figure V.5 depicts the weighted average TELSH values of new firms (NEW), exiting firms (EXIT), and remaining firms (REM) during the simulation experiment. This figure reveals that there are not significant differences among those firms in terms of their TELSH values. In other words, the gradual increase in the aggregate telecommunications intensity cannot be explained by the differences in exiting and entering firms' telecommunications intensity.

Figure V.4 shows the demand distribution of firms by their sales value. Note that the area under the curves is equal to total value of telecommunications expenses. There are significant changes in the distribution of these expenses after 1988. This figure indicates that firms with low initial telecommunications intensity exhibit higher increases in their demand for telecommunications in this period. On the other hand, these firms have higher growth rates as shown in Figure V.6. There, the growth rates from 1983 to 1993 of 182 firms that remained in the experiment for all years are plotted against their 1993 TELSH values. (A similar figure is obtained when the 1983 TELSH values are used instead of 1993.) As shown in this figure, those firms that have initially lower TELSH values grew faster in the simulation than other firms (the correlation coefficient of these two variables is equal to -.40 which is statistically significant at the 1% level).[6] But the effect of this change cannot compensate for the increase in the TELSH values of those firms. In brief, the major part of the increase in total telecommunications expenses came from the intensified use of telecommunications services by those firms that have relatively low initial TELSH values. The differences in growth rates determined the changes in the distribution of relative demand for telecommunications. The impact of this factor is also revealed when the actual level of total demand is compared with "potential" demand. If all 182 firms grew at the same average growth rate, their

[6] This negative relationship still holds for other measures of telecommunication intensity such as the share of telecommunication costs in total value of inputs or the ratio of telecommunication costs to value added.

total demand for telecommunications would be 10% higher than the actual level. In other words, estimates based on aggregate data that do not take into account the micro, distributional effects would have an error margin of 10%. This result shows the advantage of micro-simulation analysis over the conventional analysis based on aggregate data. The changes in the distribution of micro-entities matter a lot in the determination of macro-variables.

A similar relationship is also observed for the rate of return variable.[7] The rate of return is negatively correlated with telecommunications intensity. The correlation coefficient for these variables in 1992 is equal to -.37 which is statistically significant at the 1% level. This negative relationship still holds for each sub-sector as shown in Figures V.7a-d.

Those results are surprising. A positive relationship between firms' "profitability" and technological competence on the one hand, and demand for telecommunications on the other would rather be expected.[8] Note, however, that the TELSH variable (the share of telecommunications expenditures in total output) found in this study is a log-linear function of a number of firm characteristics. The correlation between the TELSH variable and any performance-related variable such as the rate of return directly reflects the relation between those firm characteristics and the performance-related variable. For example, the SALE variable is negatively correlated with the TELSH variable, and positively correlated with the rate of return variable (both of them are statistically significant at the 1% level in 1993). Thus, the negative correlation between the TELSH and the rate of return variable to some extent reflects the effect of firm size on both variables.[9] (It is also noteworthy that another performance-related variable, the profit margin, has a coefficient which is not statistically different from zero in the regression estimates of the TELSH variable as shown in Table V.3, although the TELSH variable is negatively correlated with the profit margin.) Therefore, it is quite difficult to determine causality relations between telecommunica-

[7] The rate of return is defined as the profit per unit of assets valued at current reproduction costs. There is an outlier firm that have a very high rate of return. This firm is not shown in Figure V.7 and excluded in the estimation of the correlation coefficient.
[8] Incidentally, an econometric study by Loveman (1988) found that "IT [information technology] capital had little, if any, marginal impact on output or labor productivity" in a sample of establishments in the U.S. and Western European manufacturing industries. In this study, IT capital is defined to include computing machines, databases, purchased software, telecommunications, telex and satellite equipment, and document generation equipment.
[9] Similar correlations are calculated for the real data obtained from the Planning Survey of 1989. In the sample of 77 firms used in the estimation of Equation 3 in Table V.3, the correlation coefficients are as follows: LSALE-LPM: .32, LSALE-LTELSH: -.20, LPM-LTELSH: -.38. All coefficients are statistically significant at the 5% level, one-tailed test.

tions intensity and performance-related variables, especially, given the fact that our results critically depend on the regression estimates of the TEL variable.

6 Conclusions

A micro-simulation method for the analysis of firms' demand for telecommunications has been shown to help explaining the determinants of demand for telecommunications. Microsimulation methods allow the analyst to generate time-series of simulated demand estimates that are determined by a number of firm characteristics and the size distribution of firms.

This exploratory study tells that total demand for telecommunications is a very complex function of various economic variables. Therefore, future research is needed to improve the estimation of firms' "demand function" that should incorporate the effects both of changes in relative prices and of changes in telecommunications technology, as it is used in firms' information systems.

Figure V.1 The distribution of telecommunications demand by firms size, 1988

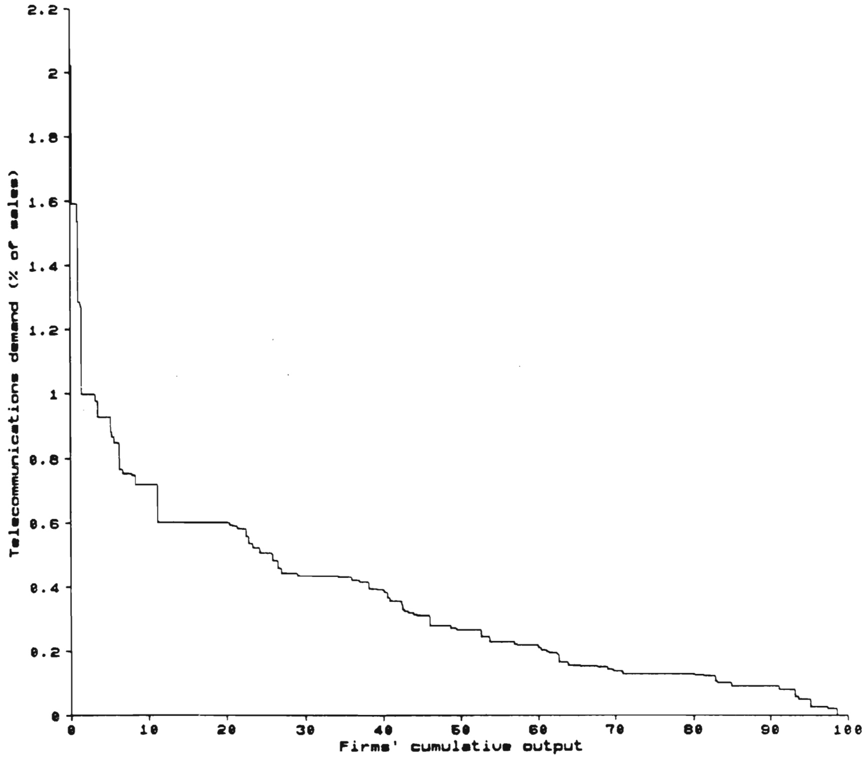


Figure V.2 Real growth rates of industrial output and telecommunications demand, 1984–93

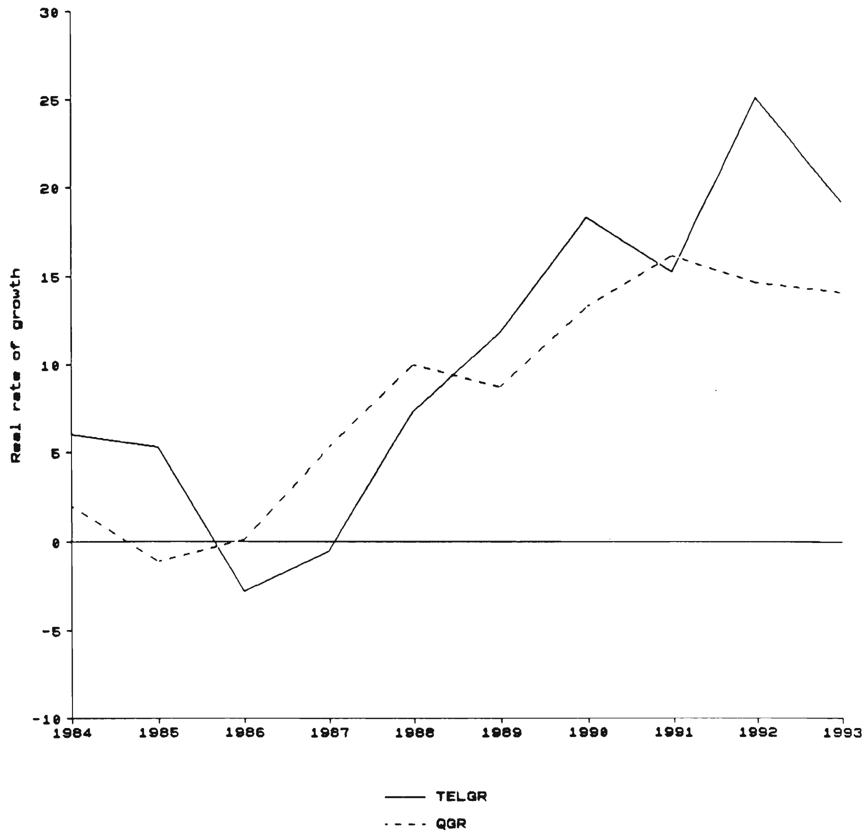


Figure V.3 Manufacturing firms' demand for telecommunications services, 1983–93

Figure V.4 The distribution of telecommunications demand by firm size, 1983, 1988, 1993

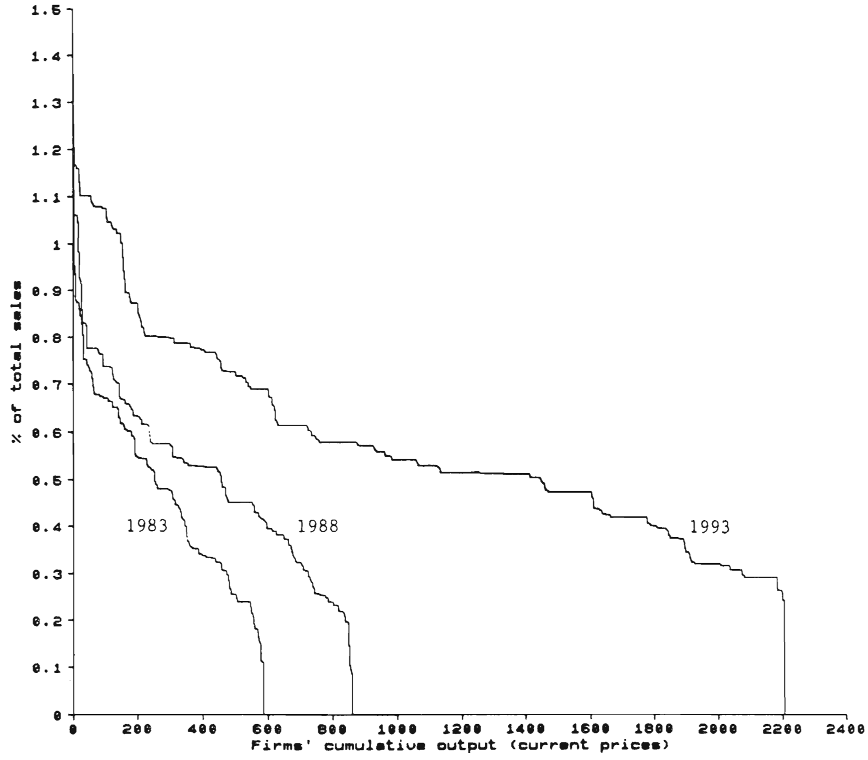


Figure V.5 Firms' demand for telecommunications services (by exit/entry), 1984–93

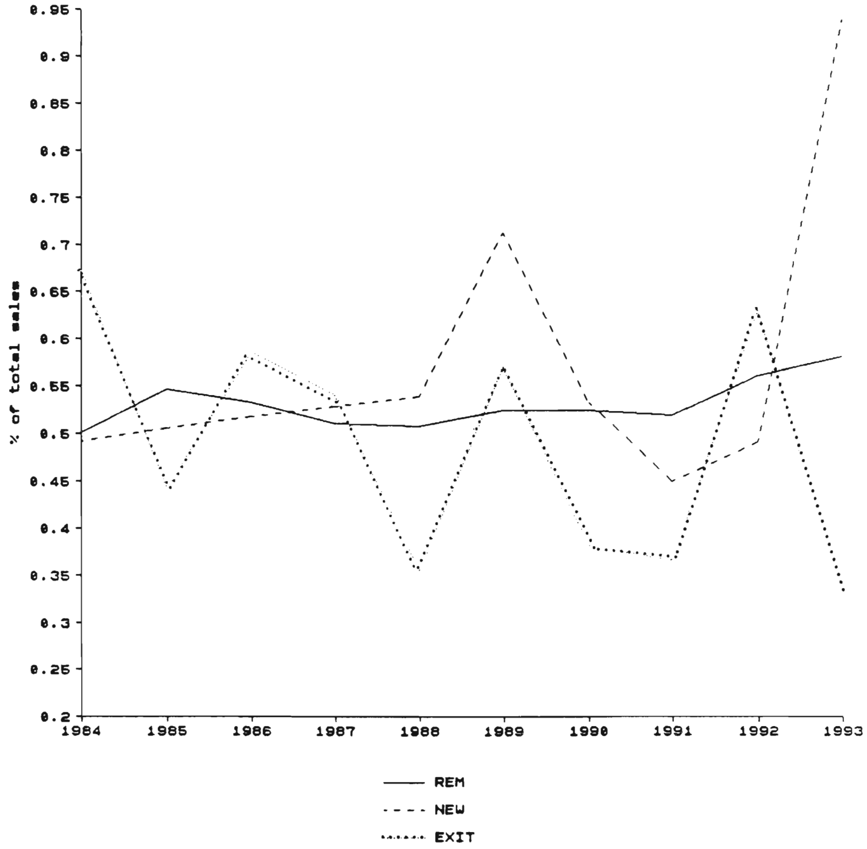


Figure V.6 Firms' growth rates vs. telecommunications intensity, 1983–93

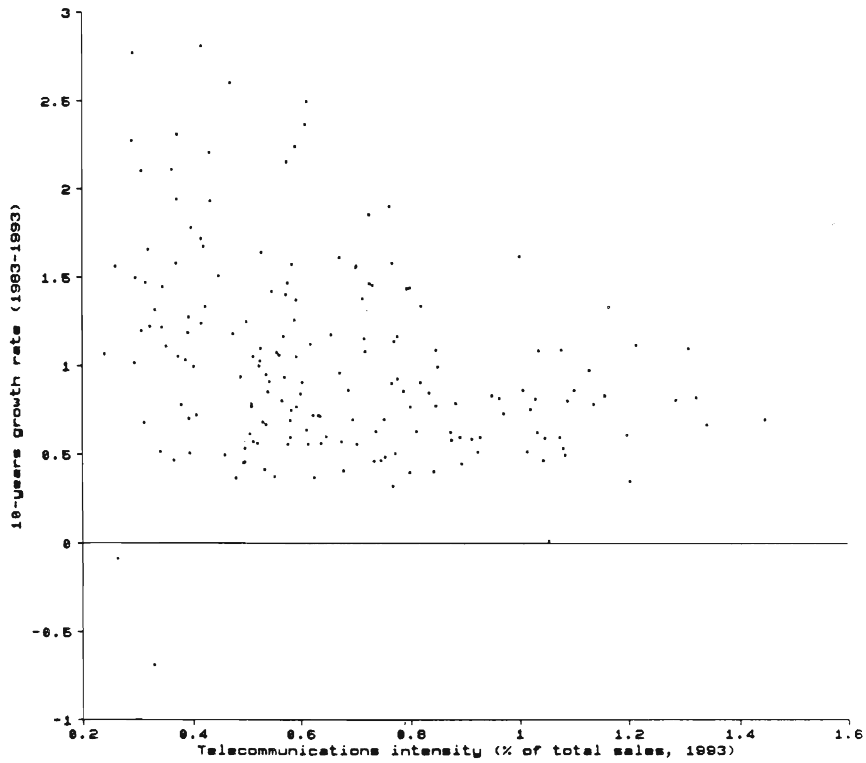


Figure V.7a Rate of return vs. telecommunications intensity, raw materials, 1993

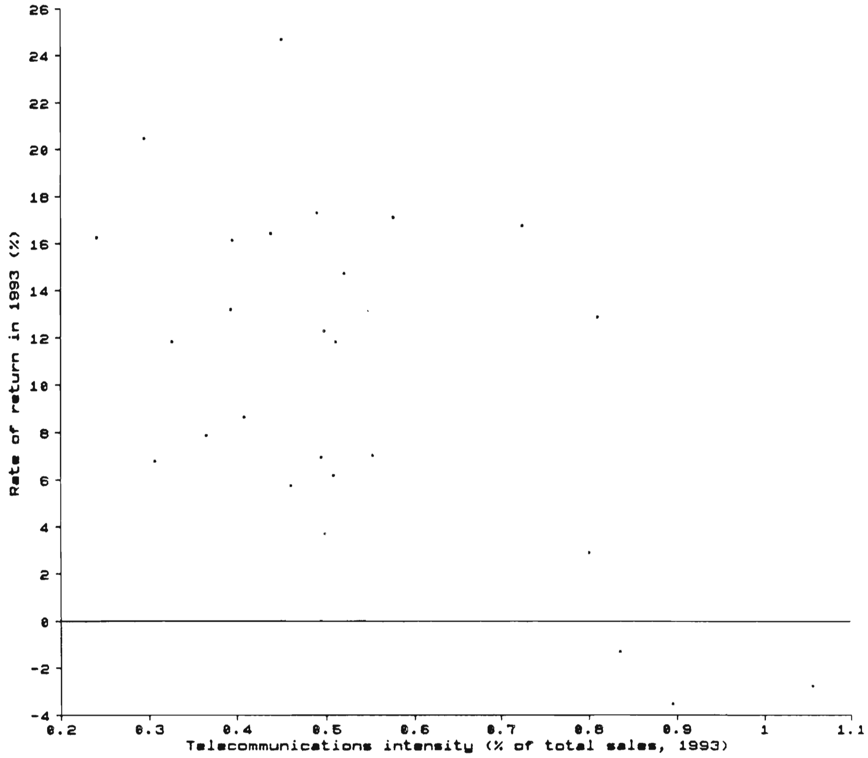


Figure V.7b Rate of return vs. telecommunications intensity, intermediate goods, 1993

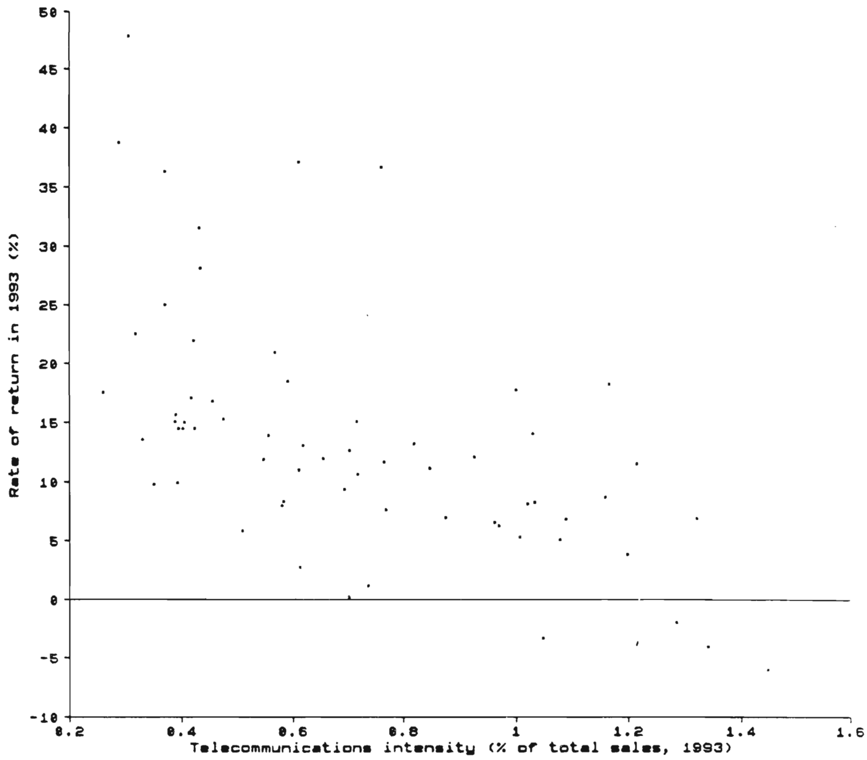


Figure V.7c Rate of return vs. telecommunications intensity, investment goods, 1993

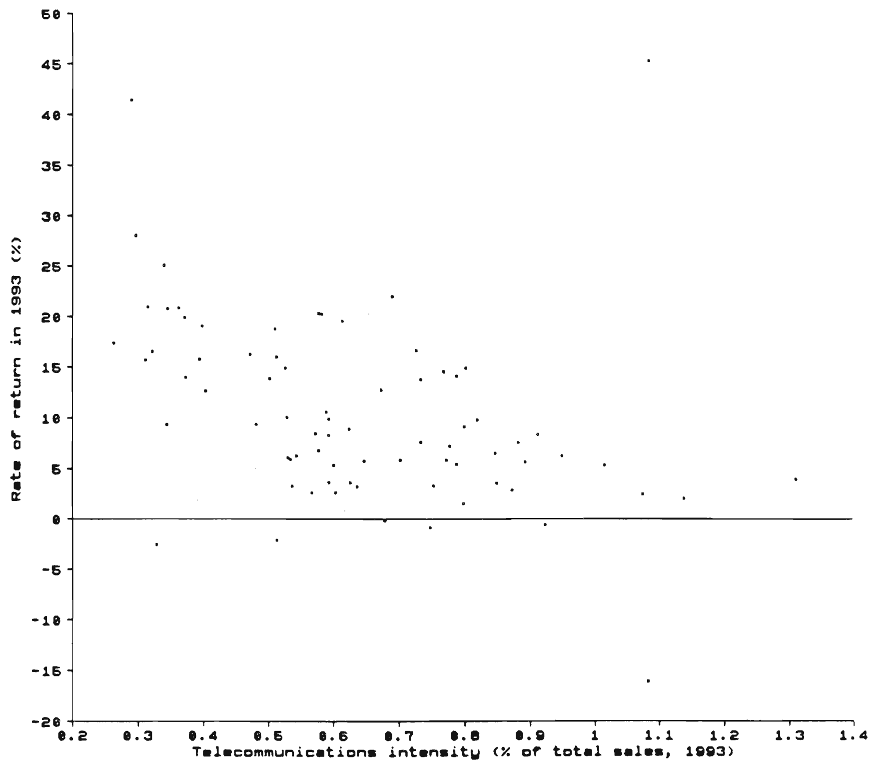
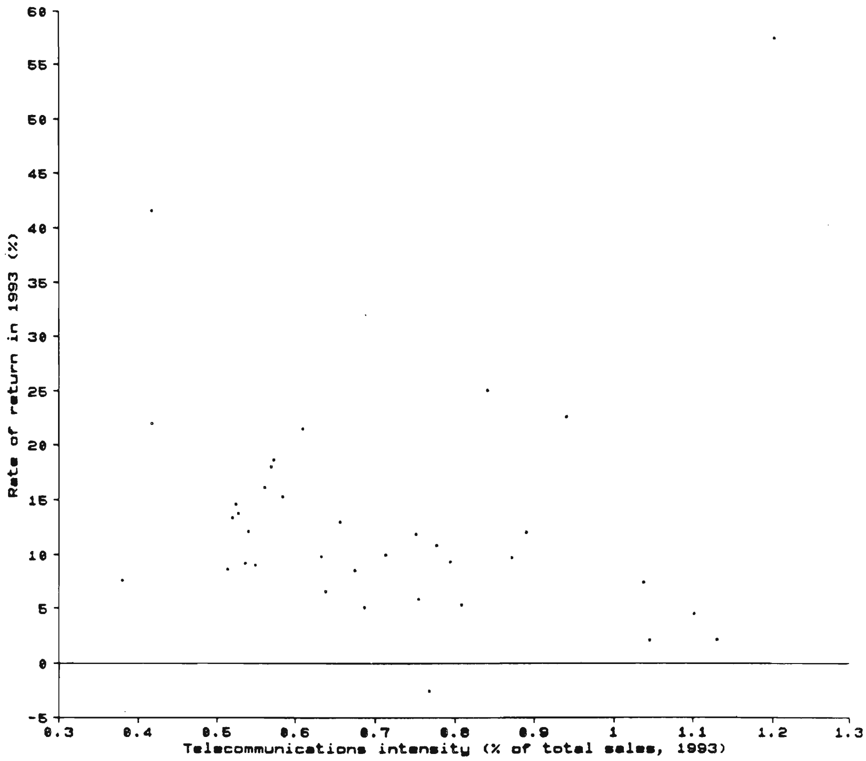


Figure V.7d Rate of return vs. telecommunications intensity, consumer goods, 1993



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