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How Open Data Networks Influence Business Performance and Market Structure

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OPEN networks allow businesses to share computerized data with customers, suppliers, and other outside entities. Businesses investing in such data networks gain competitive advantage. A national data network provides virtually universal access, interconnecting most businesses and private citizens in a country. But establishing a national data network is very costly and must be justified through its economic, service, and social impact. In 1991, France—with its Teletel system—was close to having a national data network, whereas the U.S. was not. Using data from 619 businesses in France and the U.S., we analyze three claims:

- Open networks improve business productivity, efficiency, and quality of service.
- National open networks benefit small and medium-size firms as much as large firms.
- National open networks allow relationships among companies to be based on an electronic marketplace.

We found that firms using open networks were more efficient and profitable and had more stable relationships with their customers. The natural advantage that large firms have for exploiting new technology was moderated in France, since small and medium-size firms that use the national network gained the same advantages as large firms. However, even in France, the use of open networks by the general business population was still relatively low, thus arguing for a long diffusion constant for the beneficial effects of open networks.

National Vs. Industry-Specific Networks

Creating ubiquitous open networks interconnecting most businesses and citizens in a country costs many billions of dollars of public or private money. While policy makers call for this level of investment,[1] to date there is little empirical evidence to justify it—with much of the prior literature being theoretical, rather than empirical (e.g., [2, 7, 10]). This article provides some relevant data by examining how a cross-sectional sample of businesses use open data networks. We examine whether the use of these networks is associated with better productivity, efficiency, and quality of service, as well as with different types of relationships between firms and their customers. By comparing the use of networks in France, which had the best national data network in 1991, and in the U.S., we provide evidence about the possible effects of a national infrastructure as opposed to proprietary and uncoordinated networks.

A national data network is both ubiquitous and interconnected. A former

Do open national data networks make companies more competitive and more profitable? National networks generally increase network use and promote small-company participation in electronic commerce. But significant business benefits take time and lots of government investment before user companies see positive business results.

[1]Justifying funding in 1988 for the High Performance Computing and Communications Initiative, then Senator Al Gore (D-Tenn.) argued, "Properly harnessed and directed, massive computing power [including high-speed national data networks] can change the way America does business and conducts research. . . . We cannot afford to hesitate in crafting a blueprint to

Firms using open networks were more efficient and profitable and had more stable relationships with their customers.

head of DARPA and current CEO of Bellcore, the research arm of the U.S. regional telephone operating companies, George H. Heilmeier has argued that "building a national . . . information infrastructure is simply the entry fee for participation in the global economy. It is not enough for a nation's leading companies to participate by building their own private information networks. First-rank nations will see to it that homes, schools, and small businesses, as well as large corporations, have access to the global information system" [9]. Policy makers argue that such networks are necessary for reasons of both economic effectiveness and equity. As more entities have access to networks, the benefit to any entity increases. Fairness is an independent motivation for advocating national networks. To the extent that networks benefit their users, fairness argues that the benefits accrue to both small and large users.

Improved Performance

By electronically exchanging data with their customers or suppliers,[2] firms can handle transactions with fewer staff, ship orders more rapidly or with fewer errors, operate with smaller inventories [14], or improve coordination of complex processes [8].

As in many other domains of information technology investment [18], rigorously identifying whether open data networks improve important business outcomes is difficult. It is sometimes possible to establish that information technology investment has positive local effects on the tasks the technology was explicitly designed to support. In the case of data networks, for example, Mukhopadhyay [13] found that electronic data interchange (EDI) networks in the automotive industry decrease the error rates in transactions between suppliers and large manufacturers. However, identifying downstream effects of new information technology on productivity, profitability, or market share is more problematic [15]. Given the paucity of earlier evidence about the effects of open networks, one of our goals was to examine correlates of open data networks and firm performance.

However, the argument is not simply that open networks improve data transfer tasks and business performance, but that the ubiquity and interoperability of a national network add incremental value. A national network might provide incremental effects in three ways:

- By changing the effects networks have on firm performance
- By changing who uses networks
- By changing the relationships between firms and their customers

Diminished Natural Advantage

Generally, organizational size and wealth strongly determine the use of new technology and other innovations [19]. Larger organizations typically have spare resources in the form of both expertise and money to allow them to experiment with and deploy innovations. However, as a technology becomes more widely used and standardized, its price declines and the expertise to deploy it becomes available in the market and does not need to reside within the company that deploys it. Moreover, in the case of communication networks, the costs are shared across users. For these reasons, national scope should make open networks more available to small firms [4].

In the U.S., where data networks were comparatively rare and incompatible in 1991 when the study was conducted, communication applications had to be written on an industry-specific or even firm-specific basis. In contrast, in France, the national Teletel videotex system provided a relatively ubiquitous data network and display standard. Interviews with several Teletel business users indicated that the Teletel system greatly facilitates development of communication-intensive data applications [4].

More Electronic Marketplaces

How firms use networks generally depends on their individual competitive strategies and on the maturity and ubiquity of their networks. In general, firms competing on the basis of product and service distinctiveness are likely to use networks to establish proprietary links to their customers, while firms competing on the basis of price might use networks to lower costs and to broaden their customer base. Similarly, early in the evolution of networks, when few firms use them, entry and exit costs are likely to be high and the networks are likely to be used to establish propri-

[2]The phrase "open data networks" is used analogously to the phrase "interorganizational networks" [8], but we recognize that organizations can use networks to connect to individuals, households, or other entities as well as to other organizations.

etary relationships with customers. As network use becomes more pervasive, customers are likely to use networks to generate competition among suppliers [10]. Because national networks lower switching costs and connect many more parties, customers can more easily shop among suppliers to best meet their product, price, or service needs. The ubiquity of national networks means that suppliers have access to national and mass markets, rather than being restricted to niche markets.

Research Strategy

Few empirical studies have looked at the impact of open data networks, particularly the role of national networks. Here, we examine propositions about the use of open networks through our cross-national survey of 619 firms that differ in the degree to which they then used open networks. To examine the role of open networks across a wide range of industries, we focused on sales and order processing among firms in the tangible goods industries—wholesale, retail, and manufacturing. Sales and relationships with customers are important elements of success in all business. Moreover, since sales and order fulfillment functions are often initial targets of automation, this domain is a likely site for examining the effects of open networks across a range of industries.

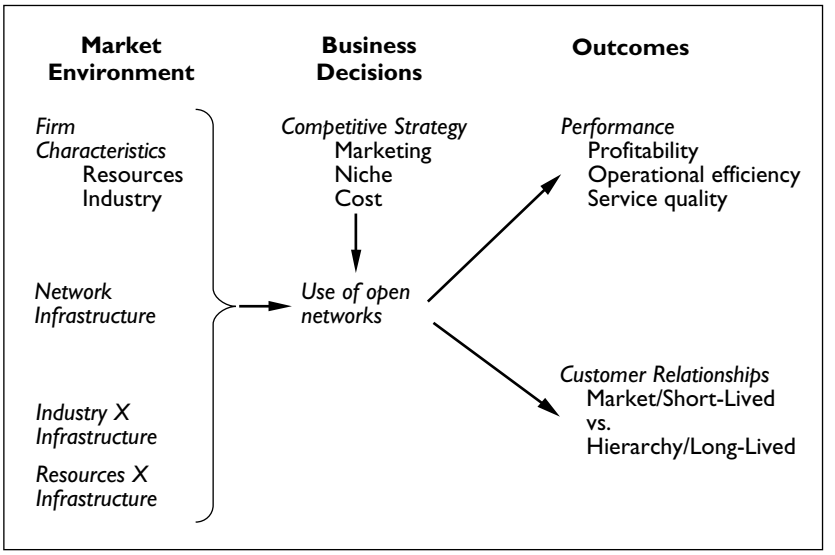

Figure 1. A model of open network use

To test propositions about national networks, we compared firms in France, where the Teletel videotex system provided a rudimentary national data network, with firms in the U.S., where networks were isolated and industry specific.

France's national data network—Teletel, the French videotex system—provides a national data network for businesses as well as information services for consumers. Teletel consists of widespread deployment of the Minitel data terminal, an electronic telephone directory, and more than 17,000 information and communication services and business applications. In 1992, there were more than six million Minitel terminals in France, with a growth rate of approximately 10% per year. About 20% of French households had Minitels, and about 80% of businesses had at least one Minitel. About 40% of the nonretired French population had access to Teletel, either at work or at home [5]. Although a minority of services are password protected, any member of the public can access most services on a nonsubscription basis; either the customer or the service provider is billed on a use-sensitive basis.

Whereas Teletel began as a mass-market service, growth is shifting from mass-market entertainment and information services to business-oriented information services and internal operation applications. In 1990, nearly 50% of the services were business-oriented. At that time, about 15,000 companies had created their own internal videotex services.

It is relatively easy to create Teletel services, and many service bureaus aid in their development. Reports based on interviews with several Minitel users indicated that the Teletel system greatly facilitates development of communication-intensive business applications. Common commercial applications include inventory control, order entry, electronic catalogues and product listings, electronic mail, and online company directories.

In 1991, the U.S. had a collection of isolated data networks, offering no widely available videotex service for the mass market. Videotex systems in the U.S. were limited to the estimated 5%–10% of households with both home computers and modems. In 1992, approximately three million people subscribed to some form of online computer service geared to home consumers [1]. Online databases, such as Mead Data Central and Dialog, succeeded by appealing to the business and scientific niche markets. The general public had virtually no access to any of these business or scientific networks. While there were some national data networks, such as the Internet, Bitnet, and Tymnet, they were fragmented, serving different client communities. Businesses subscribing to one network could not easily exchange data with businesses subscribing to another except through electronic mail gateways.

While many business applications used open networks, they were typically industry specific or firm specific. Perhaps the most common use of open networks in U.S. industry was EDI, the standard many manufacturers and their suppliers used for ordering, billing, and inventory control. Except for the rare special-purpose network designed for mass market access (e.g., the banking industry's automatic teller

Table 1. Sample attributes

		U.S.	Teletel	French general	Total
N		225	193	201	619
Industry	*Manufacturing*	99	55	67	221
	Wholesale	87	69	61	217
	Retail	18	39	46	103
	Other	21	30	27	78
Number of Employees	*6-20*	44	46	52	146
	21-100	50	53	49	153
	101-500	61	42	52	157
	> 500	70	52	48	170

machine network), industry-specific networks connected only a relatively small number of well-defined entities (e.g., Chrysler and its 17,000 suppliers).

Figure 1 shows the model underlying our analyses. Although establishing causation in a cross-sectional survey is impossible, we assume that some variables, such as firm resources and the availability of a national network, are likely factors in deciding how firms use open networks. (In the short run, it is unlikely that network use would lead to changes in firm resources.) We also treat a firm's competitive strategy as a possible influence on network use, although the availability of networks may change competitive strategies and the way firms attempt to deal with their customers [16]. Other variables, including firm performance, firm efficiency, and customer relationships, are more plausibly seen as outcomes of using open networks.

Since industries may systematically differ in their use of networks, we treat the industrial sector in which a firm is located as an important control variable. To use a telephony example, no catalog retailer could survive in the U.S. without a national 800 number, whereas for a manufacturer, the need for an 800 number is by no means critical. A regression analysis is used to identify characteristics of firms and their business environments that predict their use of open networks, holding constant these characteristics of the business environment.

The research model is not meant to describe all factors affecting network use, but rather to incorporate those variables for which we had measurements from the study. Price is an example of a variable that certainly determines network use but is not in the model. The study had no direct measure of the amount of money firms paid for their open data networks, primarily because such cost estimates are nearly impossible to obtain and the accounting of this number differs substantially across firms.

The analyses tested the effects of open data networks in general and national networks specifically, as well as the effects of competitive business strategies. We tested four propositions:

- Open data networks improve firm performance. In particular, we tested the extent to which firms using open networks are more profitable, operate more efficiently, and provide customers with better service.
- National networks diminish the natural advantages of large firms. Firms with greater resources use open networks more. However, a national network promotes use by firms and reduces the correlation between firm resources and network use.
- National networks promote electronic marketplaces. If a national network infrastructure is available, firms using the network have more marketlike, transaction-based relationships with their customers. If a national infrastructure is unavailable, firms using open networks have more hierarchical relationships with customers.
- Competitive strategies influence corporate use of open networks. In particular, aggressive market-oriented firms use open networks more than firms that compete by reducing costs.

Survey Methods

We compared three samples of French and U.S. firms by industry and firm size, using a Teletel sample, a French general sample, and a U.S. general sample.

The Teletel firms represent a random sample, stratified by number of employees, of the 4,585 commercial[3] firms identified by France Telecom as using Teletel for at least one business application. Before sampling, the nature of the application was not known, nor was it known whether the application was strictly internal (e.g., allowing company field representatives to access an online price list) or involved people outside the firm (e.g., allowing customers to order from a firm). We determined the number of employees in a firm and its four-digit Standard Industrial Code (SIC) from the International Dun and

[3]The commercial classification is based on the French industrial classification known as APE codes. Since the French APE codes do not map directly to U.S. SIC, 13% of the Teletel sample was in banking, finance, real estate, or services, rather than in the wholesale, retail, or manufacturing sector.

The ubiquity of national networks means that suppliers have access to national and mass markets, rather than being restricted to niche markets.

Bradstreet database. For the approximately 30% of the Teletel sample not listed in the D&B database, we used an interview to determine number of employees and industry (based on descriptions of a firm's primary and secondary products).

The French general sample and the U.S. sample were drawn as random samples from the International and the U.S. D&B databases and stratified to reflect the size and industry (four-digit SIC codes) distributions of the Teletel sample. The French general sample was selected by replacement—that is, if a firm was included in the Teletel sample and it was randomly selected for the French general sample, it was included in both samples. There were 31 (out of 201) such firms. To have sampled without replacement would have underestimated the true business use of Teletel in French business.

Each of the samples was stratified with respect to size. There were four size categories:

- From 6 to 20 employees
- From 21 to 100 employees
- From 101 to 500 employees
- More than 500 employees

Since pretest interviews showed very small firms used virtually no networking technology beyond the telephone, the sample excluded firms with fewer than six employees.

Because of differential nonresponse rates across industries and countries and occasional administrative problems, the comparability of the three samples is only approximate. Table 1 shows the distribution of the three samples across industry and size. We sought to concentrate on manufacturing, retail, and wholesale because the survey concentrated on the order-fulfillment process; computers are frequently first used to automate order fulfillment. Questions relating to order processing make sense in the context of a concrete good. To control for these differences among samples, four industrial categories—manufacturing, wholesale, retail, and other—are included as controls in all the following analyses.

Data were collected through telephone interviews. The controller or other senior financial manager of each firm selected for the sample was sent a letter explaining the project. After approximately one week, an interviewer called to arrange the interview. Interviewers made up to 10 calls back before discarding a firm. The effective response rate was 69%. At appointment time, the interviewer administered a 15-minute–to-30-minute, computer-assisted survey. After answering questions about general firm operations, competitive strategy, and financial performance, the financial manager was asked to recommend the most senior manager in the firm who could best answer questions about the firm's sales and order-fulfillment procedures. This individual was contacted for an additional telephone interview. If financial managers were comfortable answering questions about operations, they were given the second interview; 87% of financial managers completed both halves of the survey, most from smaller firms in all three samples and from French firms.

The survey was originally in English, translated into French, and translated back into English to ensure comparable wording. Interviews were conducted, over three months in France and five months in the U.S.

The following paragraphs give an overview of the measures from Figure 1 and their internal reliabilities if appropriate:

Industry. Based on a firm's four-digit SIC code, firms were classified into one of four industry groups: wholesale, retail, manufacturing, and other. Industry was used as a control variable in all analyses.

Network infrastructure. National network infrastructure was determined by the sample: Teletel, French general, and U.S. All firms in France had the Teletel network available to them, although only the Teletel firms were known to be using it for business applications. In addition, firms in France had other open networks available, including firm specific and industry networks. In the U.S. sample, firms had access to non-interconnected data networks and no coherent national data network. The clearest case for demonstrating the importance of a national infrastructure would occur if the French general and Teletel sample were similar to each other and different from the U.S. sample in the variables predicting network use and in the variables predicted by network use. Interpretation is clouded by differences in the two French samples.

Firm resources. To provide an estimate of firm resources, two highly correlated variables were combined—company sales and number of employees in 1990. Data on employees came from D&B or from the interview if not available from that source. Data on sales came from the financial managers' interview or from

Table 2. Predicting use of open networks

	Structural main effects	Structural main effects + interactions	Structural main effects + interactions + strategy
N	619	619	610
Adjusted R^2	.14	.17	.19
Independent Variables			
Intercept	.22	–.21	–.23
Infrastructure			
U.S.	.02	.06	.09
Teletel	.58***	1.24***	1.20***
French general	.00	.00	.00
Industry			
Manufacturing	–.43***	–.11	–.11
Wholesale	–.24**	–.02	–.03
Retail	–.12	.40*	.33
Other	.00	.00	.00
Firm resources	.27***	.40***	.34***
Firm resources X infrastructure		***	**
U.S.		–.09	–.03
Teletel		–.26**	–.26***
French general		.00	.00
Infrastructure X industry		***	***
Marketing orientation			.06*
Firm resources X marketing orientation			.08*

Note: For variables with one degree of freedom, the table entries represent standardized beta weights and their significance levels. For variables with more degrees of freedom, the table shows significance levels only.
*** p <= .001
** p <= .05
* p <= .10

D&B if the respondent refused to answer. Because both measures are not normally distributed, we took the log of each variable before creating this scale. The log of each variable was standardized, with a mean of 0 and a variance of 1; results were then averaged to create the scale (reliability $\alpha = 0.75$).

Network use. The network-use scale (reliability $\alpha = 0.81$) consists of 16 items describing the extent to which a firm uses data networks to communicate with individuals and firms beyond its own business. A factor analysis showed that these 16 items loaded heavily on a network-use scale. Use of fewer items would have made the scale less robust. For example, respondents described whether their data networks were open to outsiders, whether they could communicate with customers by computer, and the percentage of orders from large- and average-size customers received by computer. These items were standardized to a mean of 0 and a standard deviation of 1.

Competitive strategies. Our scales for competitive strategy were based on earlier work [3, 11, 12, 21]. Items in the scales were intended to measure the extent to which firms compete by distributing a wide range of goods and services, by selling to niche vs. mass markets, and by being the low-cost producer in a market. Firms with product/marketing orientations focus on rapid development of new products and advertising them aggressively. Firms with niche orientations focus on developing new specialized markets for their products, rather than selling to the mass market. Firms with a cost orientation compete by trying to be the lowest-cost producers in a market.

Firm performance. The firm-performance measures include variables directly connected to order fulfillment—order processing efficiency, quality, and speed—and a broad measure of firm profitability. We include three measures of order processing efficiency:

- Orders per employee—the number of orders in 1990 divided by the number of employees expressed in quintiles.
- Employees per order—the respondent's estimate of the number of people handling an order as it is processed, not counting production staff.
- Cost per order—the respondent's estimate of the direct cost of processing an order.

Service quality. We included four measures of service quality:

- Returns
- Back orders
- Errors

Table 3. Percentage of orders entering by different routes

Route	U.S.	Teletel	French general
Mail	21[a]	32[b]	36[b]
Telephone	43[a]	24[b]	19[b]
Fax	12[a]	20[b]	22[b]
Person	18[a]	28[b]	31[b]
Electronically	4[a]	9[b]	3[a]

Note: Numbers within a row with different superscripts differ significantly from each other at the 0.05 level.

Table 4. Percentage of time tasks are done electronically

Task	U.S.	Teletel	French general
Order from suppliers	6[a]	14[b]	10[a]
Customer track orders	2[a]	6[b]	3[a]
Communicate with customers	6[a]	7[a]	3[b]
Distribute documentation to customers	4[a]	7[b]	4[a]
Employees check inventory	69[a]	90[b]	77[c]
Employee-employee communication	11[a]	26[b]	14[a]
Find corporate phone numbers	11[a]	22[b]	23[b]

Note: Numbers within a row with different superscript are significantly different from each other at the 0.05 level.

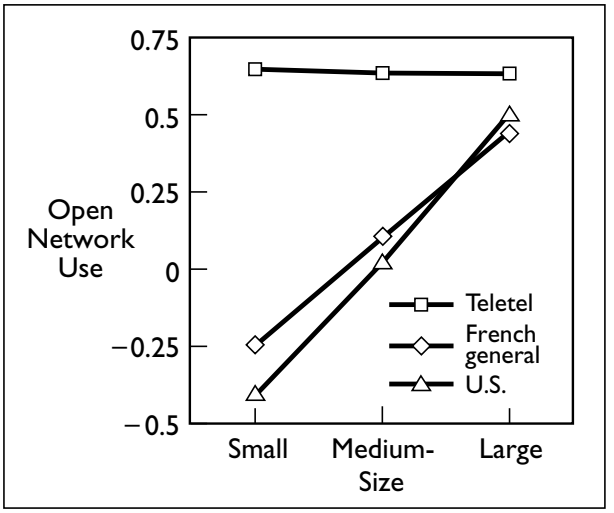

Figure 2. Association of firm resources and use of open networks by sample

These three are respectively the percentage of all orders returned for any reason, have items that are back ordered after once being in stock, and are in error for any reason.

- Order processing speed, that is, the time an order is in house before being shipped

Profitability. Profitability is the respondent's estimate of the firm's profits or losses, expressed in quintiles. It should be noted that profitability is difficult to model adequately. Many factors affect profitability, such as pricing, volume, and competition.

Customer relationships. Two variables were designed to measure the extent to which firms have either relatively transient, marketlike relationships or more stable, hierarchical relationships with their customers. Customer longevity is the number of years the largest customer has been ordering from the company. Repeat ordering is the percentage of both large and regular customers who place more than two orders a month. A high score on these variables indicates less marketlike relationships and more stable, hierarchical relationships between firms and their customers. If a supplier faces a competitive market, customers do not show strong loyalty; instead, they search the market for the best prices and, as a result, do not do business with any firm for long, decreasing the number of customers that place multiple orders during the year.

Control variables. Because the way in which firms process orders depends on the average price of an order, the average price of an order was included as a control variable in analyses predicting customer relationships and operational efficiency.

Here we describe path analyses based on ordinary least squares regression. We use network infrastructure, industry, firm resources, competitive strategy, and firm interactions to predict the extent to which a firm uses open networks. We then use these variables, along with the control variables, network use, and the interaction of network use and network infrastructure to predict customer relationships and firm performance.

Results

How do open networks affect firm resources and network infrastructure? The first column in Table 2 shows the statistical main effects of industry, network infrastructure, and firm resources on network use. In terms of our predictions, firms with more resources—more employees and more sales—use open networks more. The effects of a national network infrastructure are mixed. While the Teletel sample used open networks more than the U.S. sample, the French general and U.S. samples did not differ from each other.

Table 3 and Table 4 show this network-use phenomenon more concretely. Table 3 shows the proportion of orders coming into firms through several routes, including electronically (either by computer or by Teletel). While the Teletel sample has more electronic ordering than the U.S. sample, it also has more electronic ordering than the French general sample, which does not differ from the U.S. sample. The two French samples use text-based ordering, that is, mail and fax, more and phone ordering less than their U.S. counterparts. Electronic ordering is a minority strategy in all samples.

Table 4 shows the percentage of occasions on which respondents reported using data networks for other business functions. The items in the top section of

Table 5. Regression of network use on outcomes

	Profits	Orders per employee	Cost per order	Errors	Customer longevity	Reorders
N	360	376	381	561	319[a]	556
Adjusted R^2	.27*	.48***	.27***	.05***	.12**	.09***
Independent Variables						
Network usage	.09*	.21***	.06	–.02	.18**	.13**
Intercept	.36	–.47	–.23	–.32	.14	1.18
Infrastructure	–	–	*	***	**	***
U.S.	–.47	–.27**	–.34**	1.34**	–.60	–.91***
Teletel	–.27	–.23***	–.58**	.10	–.54*	–.08
French general	.00	.00	.00	.00	.00	.00
Industry	–	***	**	–	**	–
Manufacturing	–.10	–.34**	.09	.33	.52	–.08
Wholesale	–.32	–.63**	.59**	.10	–.27	–.11
Retail	–.24	–.82	.13	.16	–.34	–.52**
Other	.00	.00	.00	.00	.00	.00
Firm resources	.73***	–.12	.47***	.03	.15*	.05
Firm resources X infrastructure	–	–	**	–	–	*
U.S.	–.26*	.06	–.38**	–.04	.10	.13**
Teletel	–.13	.00	–.02	.03	–.06	.12
French general	.00	–.00	.00	.00	.00	.00
Infrastructure X industry	–	*	–	–	*	–
Marketing organization	–.05	.07	–.05**	–.03	–.05	.03
Firm resources X market orientation	–.05	–.07	–.07	.04	.06	–.01
Cost of average order	NA	–.47***	.32***	NA	NA	NA

Note: For variables with one degree of freedom, the table entries represent standardized beta weights and their significance levels. For variables with more than one degree of freedom, the table shows significance levels only.

a Of the 356 firms reporting they had large customers who differed from a typical customer
*** p<= .001
** p <= .05
* p <= .10
– p > .10

Table 4 represent external communication with customers or suppliers and are included in the open-network scale. The items in the lower section represent internal employee communication. The data shows that across a number of tasks, the Teletel sample is more likely to use data networks than either the U.S. sample or the French general sample, which generally do not differ from each other.

The second column in Table 2 provides partial support for the prediction that a national network reduces the advantage large firms have in using open networks (see Figure 2, which plots the overall fitted regression model and shows that the leveling of the firm resource effect on network use occurs only for the Teletel sample). That is, the effect of firm resources as a function of firm size is virtually eliminated for the Teletel sample.

How do open networks affect competitive strategies? The third column in Table 2 (structural main effects plus interactions plus strategy) adds the product/marketing-orientation scale to the structural variables examined earlier, showing that the more a firm has a product/marketing orientation, the more it is likely to use open networks. Surprisingly, a cost-reduction orientation is unrelated to the use of open networks, causing us to drop this variable from the model. These findings suggest that firms are using open networks to make it easier for customers to do business with them, rather than to increase their internal efficiency.

How do open networks affect firm performance? Here, we test the hypothesis that greater use of open networks is associated with better firm performance. Table 5 shows the results of the multiple regression analyses, controlling for variables suggested by the earlier analysis to be associated with network use.

Firms are using open networks to make it easier for customers to do business with them, rather than to increase their internal efficiency.

Results show a marginally significant association of network use with profits in the expected direction. Firms using open networks more were more profitable in 1990.

Network use was also associated with one measure of the efficiency with which orders are processed. As shown by the second column (orders per employee) in Table 5, use of open networks was significantly associated with the number of orders firms handled per employee. On the other hand, more direct measures of ordering efficiency—estimates of cost and personnel to process a typical order—did not show associations with open network use, once the average cost of an order was included as a control variable. The third column (cost per order) shows the results for the estimated costs to process a typical order. The results for number of employees who handle a typical order were also not significant.

No associations between network use and any measures of service quality included in the study. In particular, firms using open networks more did not have fewer shipping order errors (as shown in the fourth column, $\beta = -0.02$, $p > 0.65$), back orders ($\beta = -0.03$, $p > 0.45$) or returns ($\beta = 0.03$, $p > 0.45$) and were not quicker in shipping orders ($\beta = 0$, $p > 0.90$).

How do open networks affect a firm's relationships with its customers? We presented two competing hypotheses for the effects open networks might have on relationships between firms and their customers. One is that open networks promote hierarchies, using open networks for competitive advantage by binding their customers to the firm. The competing argument is that ubiquitous open networks promote electronic markets; customers use open networks to shop among suppliers, so relationships between them tend to be short-lived and market-based.

Our study found that the hierarchy/market continuum translated into customer loyalty. The data supports the hierarchy hypothesis over the market hypothesis. The fifth column (customer longevity) in Table 5 shows that firms using open networks more extensively have customers that have traded with them for a longer time. The sixth column (reorders) shows their customers trade with them more frequently.

The effects of open networks may depend on a particular firm's and a particular industry's expertise using networks. One might expect that open networks would be most likely to lead to a market relationship most when the networks are widely deployed in an industry and when the deploying firms have had substantial experience with them. However, additional analyses (not reported in Table 5) show that the association of open networks with measures of customer loyalty did not differ for industries with more extensive network use or for firms that used open networks for a longer time.

Conclusions

The survey's results support a weak form of the national infrastructure hypotheses—that a national infrastructure increases network use in general and promotes technological participation of small firms by reducing their capital and expertise disadvantages. These hypotheses are consistent with the data from the Teletel sample. Firms in the Teletel sample used open networks more intensively and for more different business functions than their U.S. counterparts. Moreover, the association of firm resources on use of open networks was virtually eliminated in the Teletel sample. However, contrary to the strong form of the national network hypotheses, the U.S. and the French general samples did not differ in terms of overall use of open networks or the effects of size and resources on use.

The results for the Teletel sample have two alternate interpretations, one substantive and one methodological:

Early adopters. The substantive interpretation is that the Teletel sample consists of early adopters of technology and that their behavior provides a forecast of how less advanced firms will operate in the future when open networks are more ubiquitous, barriers to their use are reduced, and experience with them is more common [20]. When the study was done, open networks were not used extensively, even in France and even among the Teletel firms, as shown in Table 3 and in Table 4. Truly national data networks (analogous to the U.S. telephone network) did not yet exist. If the firms in the Teletel sample are indeed lead users, one would expect that once data networks are widely deployed, small firms will be able to exploit open networks almost as easily as large firms, just as they did in the Teletel sample. Given the positive association of network use with firm efficiency and profitability, one implication is that a national network infrastructure could promote competitiveness of small and medium-size firms, which are responsible for much of the growth in the world economy. Future longitudinal or cross-sectional research com-

Early adopters of technology may not be representative of companies of similar size; it may be dangerous to use their behavior as a basis for forecasting network investment and use.

paring eras, countries, or industries with differential diffusion of open networks should test this interpretation.

Unmeasured variables. A methodological interpretation of results for the Teletel sample is less informative about public policy. According to the methodological interpretation, the Teletel sample differs from the U.S. sample and the French general sample on some uncontrolled or unmeasured variables, and sample differences in degree of network use result from these hidden differences. While the samples were matched on many relevant dimensions (e.g., industry at the four-digit SIC code level, country, and firm size), the French general sample and the Teletel sample may still differ on other relevant dimensions. It is possible, for example, that Teletel firms use open networks and other technological innovations more because they have a more technologically sophisticated work force. This technological preeminence gives them a competitive advantage we attribute erroneously to the availability of a national infrastructure. This technological preeminence argues that early adopters of technology may not be representative of companies of similar size and that it may be dangerous to use their behavior as a basis for forecasting.

This research presents evidence that firms using open networks operate more efficiently, at least for order processing. That is, firms that can communicate beyond their own structures through data networks handle orders with less labor, whether the firm is large or small, is in France or in the U.S., or uses Teletel or a proprietary data network, Although the results are consistent with the hypothesis that use of open networks leads to efficiencies, no causal order can be established from this cross-sectional data. Surprisingly, we found no effects of using open networks on the quality of order-processing service—the elapsed time in which orders are processed and the errors associated with them—although such a relationship has been identified by other researchers (e.g., [14]).

Our data also address the controversy about whether data networks change customer-supplier relationships. Economic theory leads to the hypothesis that by lowering the costs of finding and transacting business with suppliers, open networks encourage market relationships between firms. Yet our data show that the more a firm uses open networks, the more stable are its relationships with its customers; a typical customer trades with such firms more frequently and for a longer duration.

From the cross-sectional data, we cannot tell whether open networks encourage customer loyalty or whether firms deploy open networks primarily when they have loyal customers. In either case, the association of open networks with customer loyalty is inconsistent with the electronic market hypothesis. Together with the finding that firms with a marketing-oriented competitive strategy use open networks more, the data suggest that firms use networks as a competitive tool to tie their customers to the firm. (See also [17] for case study material leading to similar conclusions.)

However, using networks for marketing-oriented competitive strategy may be a temporary strategy that changes as networks become more ubiquitous or as customers grow more sophisticated in their use. The theoretical literature on this topic often assumes widespread adoption of these networks, whereas adoption is slow and fraught with much uncertainty.

While our research supports the hypothesis that open data networks are valuable to firms, it raises questions about the role of a national infrastructure. Does a national infrastructure make it easier for small firms to reap the advantage of networks? Will it lead to electronic marketplaces? Answers depend on the degree to which the French Teletel experience approximates a ubiquitous national data network. Our observations suggest that 1991 was too early to see strong effects from a national data network.

If our analysis and interpretation of the data are correct, what does our study of networks in France and the U.S. imply for national policy? The U.S. is deploying a dramatically expanded national network. Debate has centered around the focus of the network, the role of government, and the role of existing communications companies in developing the network. Based on our findings and our background research, we offer three recommendations:

- Strong central support is needed for a network. For example, the French videotex system, Teletel, succeeded partly because the French government provided strong direction, guidance, and capital in its development.
- While home use of Teletel has been the most successful videotex application undertaken in any

country, we think it unlikely that any special-purpose Minitel-like terminal will take hold in the U.S. Previous videotex efforts in the U.S. were unsuccessful, and audiotex now plays a similar role to videotex in France. While the functionality of audiotex is more limited than that of videotex, most audiotex residential services either do not need the increased functionality or compensate by using human intermediaries. For example, in France, Teletel is used extensively for mail-order applications, while in the U.S., 800 numbers are used for mail-order sales. Eventually, the demand for more complex services will exist in the residential market and will probably require more bandwidth than the current Minitel or the ordinary telephone. In the U.S., the terminal of choice for these services will probably be a PC or its descendant. Thus, in the shorter run, we recommend that the U.S. focus on applications in education, health care, and business. Organizations in these areas likely already have the computers and modems necessary to interconnect to the network or are in a position to acquire the needed equipment.

- Firms with the most resources in the U.S. already use data networks. An appropriate role for the government would be to encourage smaller organizations to take advantage of the Internet. This assistance might be provided through government-sponsored network consulting firms that would show small businesses, local schools, and citizens how to use the network and what kind of applications they might benefit from.

Our research points to the value and importance of concerted long-range planning by government and private industry. The Teletel experiment began in the early 1980s as part of a large-scale effort that successfully propelled French telecommunications from a far follower to one of the two or three world leaders, along with Germany and the U.S. In less than 20 years, ordinary French businesses came to be on a par with ordinary U.S. businesses in network use, something that would not have happened without massive government intervention and capital. ◻

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