

## **USE OF INFORMATION NETWORKS AND THEIR IMPACT ON ORGANISATIONAL STRUCTURES: FIRM-LEVEL EVIDENCE FROM JAPAN**

### **1. INTRODUCTION**

Although networking of computers is now rather routine, the impact on the firm remains poorly understood, largely owing to a lack of data on firms' use of IT in general and of networks in particular. Japan is an important exception, as the Ministry of International Trade and Industry (MITI) conducts a

survey of 23 000 Japanese manufacturing and distribution firms through its Basic Survey of Business Structure and Activities (BSBSA).<sup>1</sup> The survey includes a broad range of variables, such as basic financial indicators, employment characteristics, supplier relationships, and R&D expenditures, as well as use of information networks by type of application (see Box 2.1).

#### **Box 2.1. Surveying network use in Japan**

The Basic Survey of Business Structure and Activities (BSBSA) provides firm-level qualitative information on the use of information networks through three sets of questions.

The first set determines whether a firm has introduced intra-firm or inter-firm information networks or both.

The second set involves the types of information networks installed and their purpose, categorised on the following basis:

1. Ordering: use of networks to co-ordinate the purchase and delivery of products usually consisting of intermediary inputs or parts.
2. Production: networks are used to track the flow of production, optimise resources and identify problems.
3. Sales and inventory: tracking sales and inventory stocks by product category.
4. Distribution: intermediary and/or final product flow control, tracking by location and volume.
5. Technology: sharing technology information within and across different departments, or among related firms.
6. Accounting and finance: financial transaction co-ordination and analysis of internal accounting system.
7. Human resources: database system for personnel department.
8. Management planning: internal, cross-department project tracking and management planning system.
9. Marketing/customer information: information about customers and related marketing data.
10. Financial transactions: firm banking and other financial transactions.
11. Reservations and consumer information: on-line customer service, product information and product sales such as reservations.
12. General reference: retrieval system for general information such as phone numbers, employee bulletin boards, etc.
13. Other.

The third set identifies the ownership of information networks on the basis of seven groups: own firm or group, product suppliers, wholesalers, retailers, database providers, VAN (value added network) providers, and others.

## 2. NETWORK USE

Nearly two-thirds (64.6 per cent) of the firms surveyed had introduced an intra-firm information network (*i.e.* LAN) by 1991, and 43.8 per cent of the businesses surveyed had inter-firm networks. While the distribution of networks is relatively even across industries, the use of networks varies with firm size. Firms classified in the largest size class were nearly two to three times as likely to install an intra- or inter-firm network than those in the smallest size class. The differences based on the size of the firm are not surprising and are evident in other countries' surveys of advanced manufacturing technologies as well.<sup>2</sup> Three factors typically limit the diffusion of technology to small firms: the size of the initial capital investment, the need for in-house expertise, and the cost of adapting the technology to the firm's needs. Information networks are not an exception.

The importance of firm size in determining the adoption of networks persists regardless of the purpose of the network (Figure 2.1), although uses such as ordering, sales and inventory, and accounting tend to be cited by industries in all size classes, whereas uses for managing technology or for management

planning are more restricted. For example, large, high-technology industries, such as office equipment and computers, are much more likely to use networks for technology management (26.1 per cent) than traditional sectors comprised mainly of small firms, such as the food product industry (3.6 per cent).

The use of a network is related to an industry's position in the chain of production that stretches from the primary extraction of materials to the delivery of the product to the final consumer. Not surprisingly, upstream industries, such as primary metals, are not likely to need customer information, whereas downstream industries, such as retailers, need not concern themselves with production management. Inter-sectoral variations in the use of networks for production management, technology information management, and customer information management reveal that while IT networks are ubiquitous, their use is quite heterogeneous (Table 2.1).

For example, the use of networks for ordering and production purposes is high in the automobile and supply industry, owing to the close links that exist between assemblers and parts manufactures. The adoption of production control systems is high in

◆ Figure 2.1. *Effect of firm size on network use*

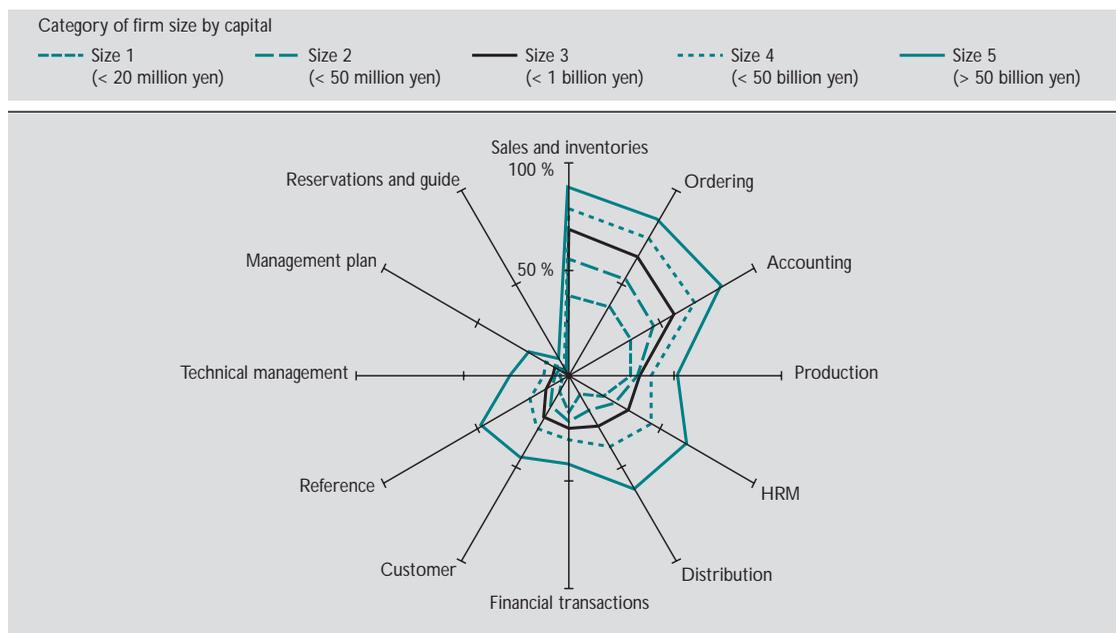


Table 2.1. **Distribution of network use by industry in Japan**

Percentage

	Sales and inventories	Ordering	Accounting	Production	Human resources	Distribution	Financial transactions	Customer	Reference	Technical management	Management planning	Reservation and guide
Food products	56.9	60.2	50.0	42.0	34.2	26.4	22.6	15.9	9.7	3.6	6.2	1.5
Textiles and apparel	55.4	50.0	45.5	45.9	27.6	26.0	19.5	8.3	6.1	5.6	7.2	0.9
Lumber, wood and paper	52.6	47.9	46.2	42.4	30.7	20.7	22.0	14.9	11.3	3.7	6.7	1.2
Chemicals excluding drugs	67.8	61.0	60.1	56.6	38.2	38.5	25.1	16.1	22.1	17.6	9.0	2.5
Drugs	71.8	59.7	59.7	58.8	42.6	45.8	33.8	26.4	38.4	15.7	12.5	1.9
Petroleum and coal product	67.2	59.0	59.0	62.3	41.0	44.3	27.9	16.4	37.7	27.9	6.6	4.9
Plastics and rubber	60.3	62.0	46.3	49.8	31.2	28.3	22.4	10.3	9.0	10.1	5.1	0.9
Stone, clay and glass	55.3	43.1	47.5	42.6	30.2	17.6	19.9	8.6	7.7	6.2	5.5	1.0
Primary metals	60.0	59.0	49.6	55.9	33.6	23.0	22.7	9.1	11.6	9.0	6.4	1.0
Metal products	52.7	49.9	47.5	50.0	31.7	18.0	20.3	8.2	7.1	7.8	4.8	0.6
General machinery	50.7	51.3	50.3	51.8	33.2	16.0	23.1	16.5	10.4	16.2	6.5	1.7
Office equip. and computer	57.1	60.8	53.7	62.1	36.1	27.4	28.7	16.1	17.6	26.1	9.5	5.3
Electrical machinery	48.8	59.9	49.5	57.4	34.2	18.6	21.8	10.4	11.9	15.1	4.5	1.5
Electronic supplies	63.2	65.6	55.3	68.4	41.1	29.3	24.6	9.6	14.0	21.6	8.1	2.1
Communication equipment	59.6	56.8	52.5	62.8	39.3	23.0	26.2	10.4	14.2	23.0	13.1	2.7
Electrical appliances	58.9	60.6	52.9	60.2	34.9	28.0	23.3	12.6	15.2	20.6	7.9	2.6
Automobiles and supplies	54.8	75.0	50.6	61.5	38.6	26.7	27.6	10.6	15.0	22.1	9.4	1.6
Other transport equip.	46.8	45.5	50.5	50.9	34.2	10.8	24.8	9.0	8.6	14.0	8.1	1.4
Optical precision machinery	54.1	55.4	51.0	56.7	34.4	20.4	26.8	8.9	13.4	17.2	2.5	0.6
Other precision machinery	61.0	61.5	52.0	56.5	35.0	20.5	24.0	16.5	13.0	17.0	7.0	1.5
Wholesale	72.8	67.0	58.3	16.2	28.8	33.3	27.4	27.6	16.4	5.1	9.1	2.0
Retail	73.8	65.7	62.1	8.7	36.9	27.3	26.4	47.4	21.1	5.8	12.1	7.6
Construction	36.6	33.2	47.2	31.5	27.2	8.5	22.6	17.4	12.8	13.2	8.9	1.7
Service	42.8	34.6	42.3	15.9	28.8	10.6	21.2	23.6	18.3	13.9	6.7	5.8
Average	63.1	60.3	53.9	35.1	32.6	26.9	24.8	21.7	14.5	9.1	8.3	2.5

Source: MITI (1994a), BSBSA.

the electronics supplies industry, probably because process control is a critical element in the fabrication of high-precision microelectronics parts such as semiconductors. The drug industry relies on networks for sales and inventory and customer information for managing highly diversified product lines and maintaining close contact with institutional customers such as hospitals.

Whether a network is used for internal purposes only or for external purposes as well is directly related to its purpose. Internal networks are more frequently used for managing production, keeping track of sales and inventory, accounting, human resource management, management planning, and marketing and customer information. Inter-firm networks are used for ordering, distribution, technology management, financial transactions, and reservations and customer information. Likewise, whether the network is owned by the firm or by a third party varies, depending on industry sector and network use. In manufacturing and distribution, for example, networks are usually managed by the firm itself, but when the network is used for financial transactions, reservation and consumer information, and general reference, third parties such as database providers often own the network.

Finally, networks generally have multiple applications in order to achieve synergism, as seen in the tendency for firms to develop complementary clusters of network use. The main clusters are: *business operations*, with strong links between ordering, production, and sales and inventory uses; *business support*, with complementary accounting and labour management uses; and *marketing*, involving customer and reservation and consumer information network applications. Technology management and management planning are network functions with links to each of these three groups and effectively act as hubs. Table 2.2 incorporates 12 network uses into the major groups, and indicates whether the function tends to be associated with internal or external networks.

### 3. THE IMPACT OF IT ON ORGANISATIONAL STRUCTURE

A growing body of research has identified the link between the adoption of information technologies and corresponding changes in the structure of organisations. These changes range from shifts in human capital requirements (Griliches, 1969; Berndt *et al.*, 1992) to changes in decisions about whether to “make” or “buy”, as information technology lowers the transaction costs of outsourcing what was previ-

ously produced internally (Brynjolfsson *et al.*, 1994). Some have even suggested that a complete re-engineering of the business process is required to fully take advantage of IT innovations (Hammer and Champy, 1993).

The BSBSA database on worker characteristics and supplier relationships can be used to explore the impact of information technology networks on organisational structure. Organisational changes associated with the adoption of information technology networks were identified in the following six categories:

- PLAN: changes in the percentage of persons engaged in business planning;
- R&D: changes in the percentage of persons engaged in research and development;
- IP: changes in the percentage of persons engaged in information processing;
- SALE: changes in the percentage of persons engaged in sales and distribution;
- BC: changes in the percentage of persons engaged in production (“blue-collar”);
- OUT: changes in the probability of increased outsourcing of total production.

Changes in these (dependent) variables were explained through a series of regression analyses that control for firm size and industry while allowing the various types of network use categorised in Table 2.2 to vary as dummy explanatory variables. (See Appendix for the description of coefficients, the magnitude of changes, and the statistical significance of these coefficients.) The major findings from this analysis are:

- In general, the use of information networks complements white-collar jobs and substitutes for blue-collar jobs. Although the data do not allow the identification of different skill levels, the coefficients for PLAN and R&D, which represent changes that increase the use of skilled occupations, are significant and positive, suggesting an upward skill bias. This is especially true for those firms that use networks for the management of technology, where the impact on R&D personnel is particularly large.
- Compared to other occupations in PLAN and R&D, the impact on information personnel (IP) is not as important, suggesting that the adoption of IT causes broad job reallocations,

Table 2.2. **Breakdown of uses of information networks**

	Intra-firm networks	Inter-firm networks
Business operations	<ul style="list-style-type: none"> <li>- Production control</li> <li>- Sales and inventory control</li> </ul>	<ul style="list-style-type: none"> <li>- Ordering system<sup>1</sup></li> </ul>
Business support	<ul style="list-style-type: none"> <li>- Accounting system</li> <li>- Human resource management</li> </ul>	
Marketing	<ul style="list-style-type: none"> <li>- Customer information mgt.<sup>1</sup></li> </ul>	<ul style="list-style-type: none"> <li>- Reservation and guide system</li> </ul>
Hub functions	<ul style="list-style-type: none"> <li>- Management planning</li> </ul>	<ul style="list-style-type: none"> <li>- Technology information mgt.</li> </ul>
Other network uses		<ul style="list-style-type: none"> <li>- Distribution management</li> <li>- Financial transaction<sup>1</sup></li> <li>- General reference<sup>1</sup></li> </ul>

1. Network uses likely to be owned by a third party.

Source: Adapted from Motohashi (1996).

rather than simply the creation of IT-related jobs.

- While the impact for white-collar workers is generally positive, the use of networks, regardless of purpose, has a negative impact on blue-collar jobs. Those firms that adopt a network for both business support functions (BS2: accounting system, labour management) and management planning had a significant reduction in their blue-collar work force.
- A number of network functions such as business operation (BO1,2), distribution (DIST) and technology management (TECH) are more likely to be related to outsourcing than to business support functions. When business operations are broken down into individual components, the ordering function is particularly important for outsourcing. This finding confirms the notion that IT networks have a positive impact on a firm's proclivity to outsource.

#### 4. CONCLUSIONS

Firm-level data describing the use of computer networks by Japanese businesses both within and across firms show the distribution of computer networks and their effect on the organisational structure of firms. The data lead to the following conclusions:

- *The use of networks is relatively evenly distributed across industries.* Unlike other technologies, information technology is a "general-purpose technology" that can be used to manage operations of a manufacturing plant, provide logistics support for distribution sectors like retail trade, and track customer service for service sectors.

- *The probability of using a computer network is directly related to the size of the firm.* While the reason for this difference can not be determined from the data, other research suggests that the cost of acquiring and implementing the technology is an important factor (US Bureau of the Census, 1993a).
- *Different network uses are complementary.* Firms that use information networks for one function (e.g. production management) are likely to use other network functions (e.g. cost accounting) as well. This underscores the finding that the adoption of information technologies tends to have a pervasive effect and is rarely limited to a single application.
- The adoption of computer networks is associated with a shift in the occupational mix of the firm that favours white-collar jobs at the expense of blue-collar jobs. Rather than simply leading to a greater demand for information-processing jobs, IT networks tend to have a wider impact, positively affecting R&D personnel and managers while creating less demand for blue-collar production workers.
- *Firms' willingness to outsource some production activities increases with the adoption of computer networks.* The use of a network to streamline business operations is positively correlated with the probability of outsourcing. This might be explained by the fact that the use of information technology lowers transaction costs, thereby favouring "buying" to "making".

## 5. LIMITATIONS, UNANSWERED QUESTIONS AND FURTHER RESEARCH

Although the data give insight into the diffusion and use of computer networks in Japan, they have various limitations. A major limitation is the fact that the data reflect the situation as of 1991, prior to the rapid growth of the Internet, which has given small and medium-sized businesses a relatively inexpensive means of obtaining access to both intra- and inter-firm networks. This may change the size bias associated with the use of computer networks. MITI plans to release data from the second survey conducted in 1994 which should begin to shed light on this question.

Another issue is the difficulty of generalising these findings to countries other than Japan. A number of observers (Brynjolfsson, 1996) argue that a decentralised and flexible organisational structure is essential to reap the full benefits of computer networks in a firm, but Japanese firms are considered to be hierarchical and less flexible in hiring, firing, and reassigning work to accommodate a major reorganisation and to have relatively low computer (PC)

penetration rate (Negroponte, 1994; Vadon, 1996). For this reason, it could be argued that the organisational changes witnessed in Japan might offer a more conservative indication of what is happening in other countries. To evaluate this hypothesis, data from other countries and comparative analysis are needed.

This analysis also links the use of computer networks with a greater tendency to outsource production. It is likely that a significant portion of this outsourcing activity is going to foreign firms. As the Internet grows to form an international network of computers, this phenomenon will undoubtedly grow, further "informationalising" the globalisation process. Some Japanese firms already use the Internet to solicit bids from suppliers scattered throughout the world, and some German firms claim that they are losing lucrative market niches because the Internet makes it easier for customers to compare prices and find more competitive suppliers (Norman, 1996). From an international viewpoint, IT should increase competition and lead to an equalisation of wages across countries (Forge, 1995). Further work needs to be done in this respect.

## Appendix

### Regression results of labour demand equations by occupation and network use

	BO1	BO2	BS1	BS2	DIST	TECH	CUST
PLAN			+		+		
R&D		++			++	++	
IP	-				+	+	+
SALE	+	+		+		—	++
BC	—			—	—		

Note: Symbols represent the magnitude of changes for each coefficient: > -0.1 per cent (—); -0.1 to 0 per cent (-); 0 to 0.1 per cent (+); > 0.1 per cent (++). Only those coefficients of statistical significance at the 5 per cent level are provided.

Source: Motohashi, 1996.

A number of network use variables are dummy variables where:

- BO1 is 1 when a firm adopts one or two out of the three business operation group networks.
- BO2 is 1 if a firm adopts all three business operation group networks.
- BS1 is 1 if a firm adopts one or two out of the two business support group networks and uses the network for management planning.
- BS2 is 1 if a firm adopts both of the business support group networks and management planning use.
- DIST is 1 if a firm uses the network for distribution purposes.
- TECH is 1 if a firm makes use of the network for management of technology.
- CUST is 1 if a firm uses the network for customer information management.

## NOTES

1. This census survey was carried out for all firms, except those with fewer than 50 employees or less than ¥ 30 million in capital, whose main business is in manufacturing or distribution. ("distribution" refers to wholesalers and retailers.) The BSBSA also covers firms in the "other service" industry, but the survey particular to this group is not a census, contrary to a complete enumeration (with cut-off points) for manufacturing and distribution. In addition, the sample size of the "other service" industry is too small to permit a 3-digit level of industry classification. Aggregate results and a 1991 questionnaire for the survey are published in MITI (1994a). The detailed results on information network use are provided in Motohashi (1996).
2. Surveys on the adoption of advanced manufacturing technology, including information technology applications, show a strong correlation between technology adoption and firm size (see Dunne, 1994; and Baldwin *et al.*, 1995).