

Product Diversity and Value of Information Technology:  
Evidence from the U.S. Banking Industry

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*Abstract prepared for Workshop on  
Information Systems and Economics*

September 11, 1998

Whether investments in information technology (IT) have resulted in improvement in productivity is a question that has attracted considerable attention (Brynjolfsson 1993). In this paper, we posit that benefits from information technology are contingent on the strategy of the firm. In particular, firms that choose to satisfy customer wants by offering a diverse range of products and services incur higher operating costs compared to firms with a focused strategy (Skinner 1974). Information technology alleviates the higher costs of managing more diverse operations. To the extent IT investment is positively associated with product diversity, it is also positively associated with operating costs. Therefore, to measure the value of IT, empirical research must explicitly recognize the interaction between product diversity and IT.

We develop these concepts in the context of the U.S. banking industry during the 1980s. This is a particularly interesting period to examine the impact of IT on banks' operating costs. The regulatory environment changed considerably with a relaxation of several constraints on the banking business activities. Moreover, IT in the banking industry advanced significantly, with increasing investment for strategic purposes rather than simply computerization of manual processes. "According to Salomon Brothers, US commercial banks were spending an estimated \$8.2 billion on hardware, systems software, applications software and systems-related telecommunications. IT spending was growing at 17.6% in 1985, nearly twice as fast as operating costs in the banking industry as a whole"

(McDougall 1988). For the sample analyzed in this study, information technology expenses accounted for approximately 10% of operating costs.

The evidence on the impact of IT on bank productivity during the 1980s has been mixed. A Touche Ross International survey (1985) reports that "senior executives we interviewed generally believed that technology has had little strategic impact in banking, despite massive investment by the industry." While Banker and Kauffman (1988) and Clemons and Row (1988) demonstrate value for specific banking technologies, Alpar and Kim (1990) and Markus and Soh (1992) obtain mixed results for the overall payoff from banks' expenditure on IT during this period.

The strategic use of information technology, such as pursuit of a more diverse market base or provision of very high quality of service, played a large role in separating the winners from the losers (Alper 1988). Friedman (1986), an Arthur Andersen partner, stated: "As (information) systems begin to be used to tailor product offerings, track customers' purchasing information and create electronic linkages with buyers, the differentiation value will become increasingly significant." Thus, operating costs may increase rather than decrease with IT investment, but it may provide strategic benefits such as differentiated products.

In this paper, we posit that product and network diversity lead to higher operating costs in the banking industry, but IT helps alleviate the potential diseconomies of scope. Managing different types of loan products and deposit customers imposes an additional informational and administrative burden. Berger, Hanweck, and Humphrey (1987) argue that the information gathered from serving a customer's deposits and loans can be reused for other lending decisions. "Before

lending decisions can be made, credit information must be gathered and analyzed.....If the information can be used to make unrelated types of loans to the institution's customers, it may serve as a source of economies of scope" (Clark 1988). Scope diseconomies may also result from a bank diversifying its operations over a broader network with a larger number of branches for a given scale of operations. Due to the fixed costs of maintaining the operations of each branch, ceteris paribus, a bank with more branches is likely to exhibit a greater operating inefficiency than another bank with a similar level of assets but with fewer branches.

Product and network diversity increase operating inefficiency by increasing the complexities of tasks and knowledge required to perform them. IT can be employed to alleviate these additional costs of diversity with judicious development of appropriate data bases and the development of new information-based products to tap potentially different markets (Wiseman 1985). For instance, Pirrie (1990), Director of Lloyds Bank, states: "Heavy investment is being directed towards the creation of an integrated customer database. This helps staff manage their core relationships and respond efficiently to operational needs.....New technology is facilitating improved productivity and increasing efficiency by reducing the room for processing errors."

Therefore, we specify the following hypotheses:

***H1: Information Technology (Main Effect):***

*Operating inefficiency of banking firms is positively related to the degree of information technology intensity.*

***H2: Product Diversity (Main Effect):***

*Operating inefficiency of banking firms is positively related to the degree of product diversity.*

***H3: Network Diversity (Main Effect):***

*Operating inefficiency of banking firms is positively related to the degree of network diversity.*

***H4: Information Technology - Product Diversity Interaction Effect***

*Higher information technology intensity reduces the additional costs of higher product diversity.*

***H5: Information technology - Geographic Diversity Interaction Effect***

*Higher information technology intensity reduces the additional costs of higher geographic diversity.*

We employ a two-stage estimation method to analyze a sample of data collected by Federal Reserve Bank under its Functional Cost Analysis program for each of the years 1982 through 1988. In the first stage, we estimate the operating inefficiency  $\theta_i$  for each bank  $i$  using Data Envelopment Analysis (DEA) for each of the seven years (Banker, Chanes, and Cooper 1984). There are two outputs of the banking production process: loans and deposits. These output metrics capture the principal activity of banks in providing services that enable customers to transfer claims over resources (Benston, Berger, Hanweck and Humphrey 1983, p.443; Lawrence and Shay 1986). Inputs comprise three categories of operating costs: labor, facility, and support. Labor costs include all employees' salaries, officers' salaries, directors' fees, and fringe benefits. Facility costs include occupancy depreciation, equipment depreciation and maintenance costs. Support costs include operating costs such as stationery, office supplies, postage, freight, legal fees, publicity and advertising, audits, travel, insurance, donations and gifts, and IT expenses (on-premise and off-premise computer expenses, telephone and telegraph, computer software expenses, and data service function expenses).

In the second stage, we estimate:

$$\ln\theta_i = \beta_0 + \beta_1 \text{INFTECH}_i + \beta_2 \text{PRODDIV}_i + \beta_3 \text{PRODDIV}_i * \text{INFTECH}_i + \beta_4 \text{NETWKDIV}_i + \beta_5 \text{NETWKDIV}_i * \text{INFTECH}_i + \beta_6 (1 / \text{TOTASSET}_i) + \varepsilon_i$$

We measure information technology intensity (INFTECH) as the ratio of IT expenses over total assets. The construct validity of our measure is demonstrated by its significant correlation (at the 1 percent level) with two additional measures of IT intensity employed by Alpar and Kim (1990) and Cron and Sobol (1983): the proportion of banking functions that have been computerized, and the ratio of the number of ATMs to the number of accounts serviced. The inverted Herfindahl index measures product diversity (PRODDIV) (Scherer and Ross 1990). Our measure of network diversity (NETWKDIV) is the total number of branches operated by a bank normalized by the bank's total assets (in million dollars).

Consistency of the DEA estimator (Banker 1993) combined with the consistency of the OLS estimator ensures that our two-stage estimation procedure provides consistent estimators of the elasticities ( $\beta$ ) of operating inefficiency with respect to IT and diversity measures, and their interactions. Based on our hypotheses, we expect that  $\beta_1$ ,  $\beta_2$  and  $\beta_4 > 0$ , but  $\beta_3$  and  $\beta_5 < 0$ . Also, the marginal percent impact of a percent increase in product diversity on operating inefficiency is given by  $\frac{\partial \ln\theta}{\partial \ln \text{PRODDIV}} = (\beta_2 + \beta_3 * \text{INFTECH}) * \text{PRODDIV}$ .

Thus, product diversity increases operating inefficiency to the extent  $\beta_2 > 0$ . However, if  $\beta_3 < 0$ , then additional IT intensity alleviates these costs of product diversity. Similarly, the marginal percent impact of a percent increase in IT intensity on operating inefficiency is given by  $\frac{\partial \ln\theta}{\partial \ln \text{INFTECH}} = (\beta_1 + \beta_3 * \text{PRODDIV} + \beta_5 * \text{NETWKDIV}) * \text{INFTECH}$ . Thus, IT intensity increases operating inefficiency to the extent  $\beta_1 > 0$ . However, if  $\beta_3$  and  $\beta_5 < 0$ , IT reduces

the adverse impact of product and network diversity. Thus, if  $\beta_3$  and  $\beta_5 < 0$  then the impact of IT on operating efficiency is less adverse for banking firms that have chosen the strategy of offering broad product and network diversity.

Inefficiency scores on the results of the second stage estimator are reported in Table 1. As hypothesized, main effects of IT, product diversity and network diversity are all positively associated with operating inefficiencies, and their interaction terms are negatively associated with operating inefficiency. Table 2 reports the values of the marginal percent impact of IT on operating inefficiency given by the expression  $(\hat{\beta}_1 + \hat{\beta}_3 * PRODDIV + \hat{\beta}_5 * NETWKDIV) * INFTECH$ , estimated at the mean values of INFTECH and at several different values of PRODDIV and NTEWKDIV. We find that the marginal impact becomes smaller than 10%, the average ratio of IT expense to operating costs, and even negative for higher values of PRODDIV and NETWKDIV. This indicates that IT intensity becomes considerably more valuable for banking firms with a high level of product and network diversity.

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Table 1: Regression Results Relating Operating Inefficiency to Information Technology Intensity,  
Product Diversity and Network Diversity  
(Coefficient Estimates with Significance Levels in Parentheses)

Year	1982	1983	1984	1985	1986	1987	1988
INFTECH	234.06** (6.56)	126.69** (3.59)	143.00** (3.91)	206.50** (4.94)	195.58** (4.58)	122.25** (2.71)	121.54** (2.59)
PRODDIV	0.71** (12.88)	0.49** (9.27)	0.54** (9.04)	0.57** (9.07)	0.45** (7.44)	0.40** (6.59)	0.46** (7.36)
INFTECH× PRODDIV	-76.88** (-5.48)	-37.89** (-2.75)	-38.88** (-2.56)	-59.10** (-3.45)	-47.45** (-2.70)	-30.49* (-1.73)	-38.27* (-2.00)
NETWKDIV	2.39** (3.36)	2.99** (3.86)	4.10** (4.45)	3.61** (3.02)	4.58** (5.04)	2.86** (3.35)	2.29** (2.75)

INFTECH× NETWKDIV	-281.93* (-2.18)	-151.23 (-0.96)	-349.51* (-1.91)	-951.89** (-3.32)	-929.19** (-4.66)	-570.60** (-2.77)	-207.67 (-1.50)
1/TOT ASSET	-1.91** (-2.75)	-5.80** (-7.04)	-8.52** (-8.95)	-5.54** (-5.40)	-6.22** (-6.93)	-1.54* (-1.82)	-3.63** (-3.90)
Adj. R <sup>2</sup>	0.34	0.30	0.36	0.27	0.31	0.23	0.26

INF TECH = Information technology intensity.

PRODDIV = Product diversity.

NETWKDIV = Network diversity.

\* : Significant at 0.10.

\*\* : Significant at 0.01.

Table 2: Estimates of the Marginal Percent Impact on Operating Inefficiency of  
a Percent Increase in Information Technology Intensity  
(Estimated at Mean Value of INFTECH)

Value of PRODDIV	Value of NETWKDIV	1982	1983	1984	1985	1986	1987	1988
<b>Mean</b>	<b>Mean</b>	<b>0.139</b>	<b>0.119</b>	<b>0.136</b>	<b>0.115</b>	<b>0.167</b>	<b>0.102</b>	<b>0.085</b>
5th Percentile	5th Percentile	0.407	0.232	0.263	0.348	0.356	0.221	0.182
1st Decile	1st Decile	0.332	0.212	0.241	0.306	0.329	0.201	0.167
1st Quartile	1st Quartile	0.221	0.159	0.191	0.220	0.264	0.159	0.127
Median	Median	0.131	0.115	0.137	0.122	0.184	0.110	0.083
3rd Quartile	3rd Quartile	0.050	0.076	0.083	0.028	0.093	0.059	0.045
9th Decile	9th Decile	-0.021	0.042	0.035	-0.075	0.002	0.005	0.007
95th Percentile	95th Percentile	-0.075	0.021	0.001	-0.143	-0.078	-0.047	-0.016

PRODDIV = Product diversity  
NETWKDIV = Network diversity