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AN EMPIRICAL STUDY OF THE IMPACT OF INFORMATION TECHNOLOGY EXTERNALITIES ON THE AUDIT PRODUCTION FUNCTION

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Extended Abstract

Introduction

Numerous studies have evaluated how a firm's IT choices affect its production efficiency (Alpar and Kim 1990; Banker et al. 1990; Lee and Menon 2000). However, there has been little attention paid to how the IT choices of one organization affect the costs of other organizations in its value chain. As IT expands the scope of interorganizational linkages in a connected economy, managers must consider how the IT choices of other firms can impact the costs of their firms. This creates a need for further research on the cost impact of the externalities created by IT investment decisions of informationally linked firms. A striking example of such externalities occurs in professional service industries, such as public accounting, where clients' decisions impact service costs.

In this study, we empirically evaluate the impact of IT externalities in the context of the relation between a leading international public accounting firm and its audit clients' IT choices. In particular, we seek to address the following three research questions: Do the IT choices of its audit clients affect its audit service costs? Do the IT choices of its clients affect its audit staff allocations? Is the impact of IT externalities on the costs of the auditing firm reflected in the pricing of its audit engagements?

Research Background

Impact of IT Choices on Operating Costs

Prior research has documented the impact of a firm's IT investment on its own production efficiency. For example, Alpar and Kim (1990) found that a 10% increase in IT spending of commercial banks resulted in a 1.9% reduction in total operating costs. Banker et al. (1990) found that fast food restaurants using point-of-sale technology are more cost efficient than those without such a technology. Lee and Menon's (2000) study of the healthcare industry also demonstrated that hospitals with greater IT investment intensity have more cost efficient operations. Some studies have examined the cost impacts of interorganizational information systems that extend beyond traditional organizational boundaries. Mukhopadhyay et al. (1995) analyzed benefits from Electronic Data Interchange (EDI) technology for the upstream firm in the value chain. For Chrysler Corporation's EDI links with its suppliers, the cost savings were estimated to be over \$100 per vehicle. Analyzing data from 31 grocery retail chain stores that implemented EDI technology with Campbell Soup Company, Lee et al. (1999) found that inventory management efficiency improved at the downstream firms after the EDI implementation. Although the EDI productivity studies traverse organizational boundaries, the EDI investment is typically a joint decision involving both the supplier and the customer. Prior research has not yet examined the impact of a unilateral choice of IT by a firm on the costs of its suppliers or customers.

Economics of Externalities

An externality appears when the environment of a firm is directly affected by the actions of another agent. In this study, we aim to first demonstrate the presence of IT externalities and evaluate their impact on operating costs. We also examine whether these IT externalities affect the optimal allocation of production resources. Further, we examine whether the cost impact of IT

externalities influences, in turn, the equilibrium price. That is, if a firm's production function is impacted by the IT choices of its customers (or suppliers), then its unit production cost is likely to be altered. Consequently, the change in its production may lead to a shift in its supply (or demand) function and result in a different equilibrium price and quantity. Depending on the competitive nature of the market, and characteristics of the demand and supply functions, the change in the equilibrium price may be different from the change in the production cost.

Research Context and Hypotheses

IT Externalities in a Public Accounting Firm

Our research site (referred to as the AUDITOR) is an office of a large international public accounting firm. In this study, we focus on how each client's IT choices affect its audit costs and prices. Auditing is a process to gather and evaluate evidence regarding assertions about clients' economic activities and related events (Messier 1997, p.8). The types of information systems (IS) that the clients have adopted and the way they have used their IS may have a significant impact on the work of the external auditors. The nature of the auditing task suggests that the following characteristics of the client's IS may affect the auditor's work:

- *IS Intensity* measures the computerization level of business activities at the client site. It is easier for auditors to access related information when a business function is computerized because the data is only a few clicks away (Wilkinson et al. 2000). However, online real-time applications and integrated IS are likely to increase the difficulty of the audit task. Also, transactions may be authorized by controls included in computer programs that are difficult for auditors to verify (Messier 1997, p. 229).
- *IS Complexity* refers to the complexity level of the client's computer systems. An IS can be complex for auditing purposes in various ways. The IS interface and functionality can be complex when the auditor is not familiar with the system. The control points can be complex when the IS is connected to another entity. Since a high level of IS complexity increases the audit task complexity, it may also diminish the auditors' judgment performance (Bonner 1994).
- *IS Assurance* is the level of assurance fostered by the scope and processes of the computer systems at the client site. The assurance level can be increased by superior IS documentation and IS security. Good systems documentation may allow auditors to understand the computer system quickly and determine the required audit process easily (Moscove et al. 1997). Also, a high level of IS security (data and transactions security) reduces the possibility of fraud.
- *IS Support* measures the support provided by the client's IS personnel. The IS personnel at the client site can impact the auditors' work in two ways. First, they can provide direct support for the auditor's questions regarding the systems. Second, they can facilitate the audit process indirectly by providing high quality maintenance of the IS.

Research Hypotheses

In an audit team, audit managers are the supervisors and final reviewers of audit engagements while staff execute the plans, perform audit procedures and prepare working papers. The total audit cost for an audit is the sum of the wages paid to the two categories of audit staff. The work hours required for each category depend on the client's IS and other characteristics. As a result, considering the different wage rates for audit managers and staff, the proportions of audit costs for the two levels are likely to change with the client's IS characteristics.

For a client with a higher level of IS Intensity resulting from more business functions utilizing integrated online computerized systems, financial and other data can be transmitted conveniently via computerized systems without paper-based audit trails (Kanter 2001). In such settings, the audit manager must expend more effort to review the design and structure of the client's IS and make careful decisions trading off risk and effort (Tucker 2001). However, the staff's work hours may decrease because of easier access to well-structured information via computerized systems. Since the wage rate of audit managers is the higher than that of staff, the total audit cost may increase as a result of the increase in the effort of the audit manager. Therefore, we posit:

H1a: Ceteris paribus, the higher the level of a client's IS intensity, the higher is the proportion of audit manager cost in the total audit cost for the client and the lower is that of audit staff cost in the total audit cost.

H1b: Ceteris paribus, the higher the level of a client's IS intensity, the higher is the total audit cost for the client.

Since increased complexity of a client's computerized information systems can increase the number and ambiguity of the information cues the auditors need to process in their tasks, the audit task complexity increases and the work effort of all team members is likely to increase proportionally. When the client's IS is very complex, the staff need to spend more time in understanding and performing related audit procedures and the managers need to plan more carefully for the client. Therefore, we hypothesize:

H2a: Ceteris paribus, the level of a client's IS complexity is not significantly associated with the cost share of either audit managers or staff.

H2b: Ceteris paribus, the higher the level of a client's IS complexity, the higher is the total audit cost for the client.

When high-quality systems documentation and high-level systems security are provided, the task of all types of professionals is made easier. For instance, operation manuals allow staff to become familiar with the systems quickly. Data flow diagrams and process specifications depicting IS help promote efficient plan execution by audit staff. Therefore, an increase in IS assurance may result in a proportional decrease in the costs of each of the two levels of audit professionals, thus not affecting their cost shares. Consequently, we posit:

H3a: Ceteris paribus, the level of a client's IS assurance is not significantly associated with the cost shares of either audit managers or staff.

H3b: Ceteris paribus, the higher the level of a client's IS assurance, the lower is the total audit cost for the client.

Many studies have documented that strong IS support can improve the performance of accounting information systems (Montazemi 1988). As the staff work directly with the client's IS, good support from the client's IS professionals may reduce the juniors' work. Also, when there are more IS professionals to maintain the client's systems, the staff may find it easier to perform the detailed audit tests of the systems. Given that the effort of staff may be reduced with relatively more IS professionals at the client, the managers' cost share may increase to balance the decrease in the staff's cost share. The total audit cost is expected to decrease due to substantial cost reduction for audit staff. Hence, we hypothesize:

H4a: Ceteris paribus, the greater a client's IS support, the higher is the proportion of audit manager cost in the total audit cost for the client and the lower is that of audit staff cost in the total audit cost.

H4b: Ceteris paribus, the higher the level of a client's IS support, the lower is the total audit cost for the client.

If the client's IT choice has an impact on the audit costs, then the next issue we want to examine is whether the difference in the audit cost is reflected in a commensurate difference in the audit price. The demand for audit services by large companies is relatively inelastic with respect to price because they are either required statutorily or have strong economic incentives to be audited by a public accounting firm (Wallace 1980). In contrast, the supply of audit services is relatively elastic for a large public accounting firm since its total audit staffing level is quite flexible at the margin. In such market conditions with relatively inelastic demand and relatively elastic supply, the supplier can adjust the price of the offering to fully reflect the change in the production cost, provided it is aware of the full extent of the cost change. Therefore, we expect:

H5: A client's IT choices (IS intensity, IS complexity, IS assurance, IS support) generate similar impacts on audit price as on audit costs.

Empirical Analysis

Data Description

We collected data pertaining to the AUDITOR's 100 largest clients for the fiscal year 2000. We collected data on the AUDITOR's actual work hours for the audit managers (*MGRHRS*) and staff (*STAFFHRS*). We also gathered the wage rates for the two levels

(*MGRRATE* and *STAFFRATE*). We collected the price data (*PRICE*), which is the actual fee charged, for the audit performed for each client. To collect information on the client's IT choices, an AUDITOR's senior partner asked the audit managers who worked with those clients to fill out a questionnaire. The items included in the questionnaire were motivated by our discussions with auditors at different ranks about client's IT that may impact their auditing tasks. We used factor analysis to derive three orthogonal variables for the IT characteristics of each client. The items captured in each variable are shown in Table 1.

Table 1 Client IT Variables Derived from Factor Analysis

Variable Name	Item Name and Description
<i>IS Intensity</i>	<i>COMPUTERIZATION</i> Proportion of business functions that utilize computer systems
	<i>INTERGRATION</i> Proportion of computerized information systems that are integrated
	<i>ERP</i> Proportion of business functions that utilize Enterprise Resource Planning (ERP) software
<i>IS Complexity</i>	<i>CUSTOMIZATION</i> Proportion of computerized information systems that are customized
	<i>DATASERVER</i> Size of data servers
	<i>NETWORK</i> Network connectivity between the headquarter and branches
	<i>ECOMMERCE</i> Whether the client engages with electronic commerce activities
<i>IS Assurance</i>	<i>DOCUMENTATION</i> Auditor's rating of the completeness of IS documentation
	<i>WEBSITE</i> Whether the client has an official web site

In addition, we collected data on the number of IS professionals and computer users at the client site to construct the variable *ISSUPPORT*, measured as the number of IS professionals divided by the number of computer users. Since the prior research literature in auditing has identified various client characteristics (O'Keefe et al. 1994), we control for these previously identified client characteristics to examine how the clients' IT choices impact audit costs and prices including:

- *ASSETS*: client's total assets, to measure client size.
- *PUBLIC*: coded 1 if client's shares are publicly traded, and 0 otherwise.
- *BUSRISK*: client's inventory plus receivables normalized by total assets, to measure financial risk.
- *SUBSIDIARY*: number of subsidiaries of the client, to measure operational complexity.

Estimation Model

Recognizing that the cost for each client's audit is determined by the client's IT and business characteristics, and comprises two categories of audit professionals, we specify a translog cost equation. Since the AUDITOR optimally assigns its auditors to each client audit given the relative wages of each professional level, we also employ Shephard's Lemma (Shephard 1970) to derive two cost share equations to incorporate endogeneity of these variables. Since the cost shares sum to one, only one of the two cost share equations is used for estimation to avoid a singular disturbance covariance matrix. In addition to the cost model, we specify a price equation to relate the logarithm of the audit fee to the client's IT and business characteristics. The final model consists of a system of three equations. Since the error terms of the three equations are likely to be correlated, consistent and efficient estimators are obtained via seemingly unrelated regressions (SUR) estimation (Zellner 1962).

Estimation Results

We observe from our estimation results that the impacts of the client's IT characteristics on the cost share of managers and staff generally exhibit the expected signs. The level of the client's IT Intensity is significantly and positively associated with the audit manager cost share. IS Complexity does not have a significant impact on either cost share. The costs of professionals increase proportionally with the IS complexity. The coefficients of IS Assurance are also not significant at conventional levels. IS Support has a significant positive impact on the audit manager cost share.

Both IS Intensity and IS Complexity have a significant positive impact on the total audit cost, supporting research hypotheses H1b and H2b. A 0.1 point increase in the score for the client's IS Intensity results in a 1.89% increase in the total audit cost. A 0.1 point increase in the score for the client's IS Complexity results in a 2.06% increase in the total audit cost. As expected, both IS Assurance and IS Support have a negative impact on the total audit cost, but neither impact is statistically significant. The coefficients of the four IT variables in the price equation show values that are similar (in the same direction and smaller in magnitude) to those in the cost equation. A 0.1 point increase in the client's IS Intensity score results in a 1.22% increase in the audit price. A 0.1 point increase in the client's IS Complexity score results in a 1.96% increase in the audit price. The results from statistical tests also supported our research hypothesis H5 regarding the relationship between the impact of IT externalities on audit costs and audit prices.

Conclusion

In this paper, we proposed a novel perspective on externalities created by IT investments, and presented an empirical evaluation of the impact of IT externalities. Our results confirmed that some IT choices by audit clients impact audit staff allocations and audit costs for a public accounting firm. The level of the client's IS intensity increases the audit managers' cost share, but decreases the audit staff's cost share. The level of the client's IS complexity has no significant impact on the two cost shares, but the total audit cost increases with both IS intensity and IS complexity. In the market for auditing services, the impact of IT externalities on the audit cost is almost fully passed on to the client in the form of a corresponding impact on the audit price. Thus, the results indicate that the client eventually bears the audit cost impacts of its IT choices.

Our study represents the first step in investigating questions related to externalities in the study of the impact of IT investments. We find evidence indicating that IT externalities impact costs, cost shares and prices in the context of a public accounting firm. The next steps will involve verification of similar relationships in other industries and detailed exploration of the process and mechanisms that support those externality relationships. In any case, our analysis and results underscore the importance for managers to assess IT externality impacts when conducting business with other organizations in their value chain.

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