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# The Impact of Location and Dispersion on IT Investment Choices

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*Research-in-Progress*

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## Abstract

*This study is a spatially explicit examination of the role of distance from parent headquarters and local norms on the IT profile of a location at the establishment-level. Prior research has hypothesized that physical distance plays a key role in explaining differences in adoption rates of internet technology between urban versus rural establishments. Here, since distance is viewed as playing a key role, we explicitly test the effect of distance. In addition, instead to testing to adoption of a single technology, we examine the propensity to adoption similar aggregate technology portfolios. Doing so will help distinguish the extent of influence that flows from different channels of diffusion. Specifically, we ask: how is IT adoption affected by the interaction between firm attributes, spatial proximity and shared social structures? Using a database of the IT assets of 1,275 establishments from 461 firms, we develop a vector measure to capture the heterogeneity of an IT portfolio and use it to test our hypotheses. This paper presents the initial results of a quick approximation of the model.*

**Keywords**: IT adoption, IT portfolio, dispersion, diffusion.

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## Introduction

Although the effect of IT investment on organizational performance has been studied extensively, few studies have examined the factors that determine the mix of IT investments made by organizations. This study explores one aspect of this decision by examining the IT portfolios of branches of dispersed firms. The argument is that our perception of a firm's IT investment portfolio should be expanded from being a lumpy, holistic whole to a more fine-grained one, where local environmental characteristics interact with directives from parent firms to influence the assets held by individual establishments. The greater dispersion of firms today provides an opportunity to assert more strongly the value of such a perspective. Our research questions is: how is IT adoption affected by the interaction between firm attributes, spatial proximity and shared social structures? We argue that, over and above differences due to organizational level, geographical distance influences the adoption decisions of individual establishments. The high cost of transmitting detailed IT management knowledge across distances makes it difficult to replicate IT portfolios across establishments. In addition, the presence of legacy systems constrains the extent to which IT portfolios can be standardized across establishments. Thus, the mix of IT investments in a particular firm's establishment (i.e. branch) is related to its distance from its peer establishments.

## Conceptual Framework

### *Measuring an IT Portfolio*

Researcjers (e.g. Brynjolfsson & Hitt, 1996; Bharadwaj, Bharadwaj & Konsynski, 1999) have demonstrated that, by and large, IT benefits organizations. More recent studies (e.g. Brynjolfsson and Hitt, 2003; Wade and Hulland, 2004) examine complementary investments and contingencies that influence the value a firm earns from IT. Different types of IT have been found to have differential impacts on different firm performance measures (Aral and Weill, 2007). A corollary is that firm performance is affected by the heterogeneity of its IT portfolio, not just the gross amount of IT assets it possesses. This heterogeneity can be traced to differences in the adoption of IT by firms, which is influenced by factors such as the level of coordination costs (Dewan, Michael and Min, 1998), slack resources (Kobelsky, Richardson and Zmud, 2002), membership in professional associations (Swan and Newell, 1995), and industry concentration (Melville, Gurbaxani and Kraemer, 2007).

To date, there has been limited research on differences in firms' IT portfolios. Studies that examined the impact of different types of IT (e.g. Aral and Weill, 2007; Bresnahan and Greenstein, 1996; Chatterjee, Richardson, and Zmud, 2001) did not attempt to develop a composite measure of IT that assessed the heterogeneity of IT portfolios across firms. Instead, they restricted their analysis to examining how different types of IT individually led to a range of effects. Table 1 indicates the categories that were used in prior studies. The lack of a composite index to measure the heterogeneity of IT portfolios makes it difficult to extend IT value research into analyzing the differential, as well as the synergistic, contribution of the various types of IT to a firm's performance. Thus, a key objective of this study is to create an IT portfolio measure that incorporates the fact that IT is made of different types of components, since firms do not invest equally in each of these components. This will be used to measure the differences between firms' IT portfolios and related to firm-level covariates, such as the level of dispersion.

| Table 1. Categorization of IT Assets | | | |
|---|---|---|---|
| **Aral and Weill, 2007** | **Burke, et al, 2002[a]** | **Bresnahan and Greenstein, 1996[b]** | **Chatterjee et al., 2001[c]** |
| transactional | clinical IT | number-crunching | automate |
| informational | administrative | manufacturing | informate |
| strategic | strategic IT | business applications | transform |
| infrastructure | | database | |
| | | systems software | |
| | | communications/networking | |

[a] *This study used a sample of hospitals.* [b] *Software was also differentiated based on who wrote it: in-house, third party, consultants, etc.* [c] *This is borrowed from Zuboff (1988)*

## *Impact of Firm Dispersion on IT Portfolios*

Today, firms are trading in a greater number of markets, establishing production units in more locations, and obtaining supplies from an increasingly scattered set of vendors (Karmarkar and Mangal, 2004). As they move closer to their input sources and markets, or strive to take advantage of operational cost differentials across locations by locating production plants or service outlets in low-cost locations, they are becoming increasingly dispersed. At one level, the greater need for communication between scattered parent units and their branches could lead to greater investment in IT to overcome the distance barrier. At another level, however, this increased dispersion impacts the level of communication, control and coordination that takes place within firms, possibly weakening ties between branches and their parents. Corporate decisions may not be transmitted accurately or in a timely fashion to scattered units, since the transaction costs of transferring knowledge increase with the number of locations across which the knowledge is being shared (Adams & Jaffe, 1996). Since dispersed establishments may find it difficult to interact with one another, the reduced level of communication could lead to increased heterogeneity across individual establishments belonging to a single firm. This heterogeneity could be manifested in, for example, hiring policies, IT investment decisions, or financial practices.

*H1: Branches of geographically concentrated firms will have more homogenous IT investment portfolios relative to branches of dispersed firms.*

Would the IT investment decisions of a branch office be more representative of the decisions made by its headquarters or by its neighboring establishments? At a more granular level, it is possible that the relative impact of these influences is moderated by the type of establishment. The decision-making and information processing needs of different types of establishments, such as manufacturing plants, sales offices and service centers, vary. For example, sales sites could be more focused on transaction-processing, while regional headquarters' would spend more time on control and coordination. Thus, different types of IT investments would have varying degrees of relevance for different types of sites.

*H2: Hypothesis 2 will be moderated by the branch's function: over and above the effects of their distance from each other, branches with similar functions will have more similar IT portfolios than those in different functions.*

*H2a: Branches of geographically concentrated firms that have the same function will be the most similar in their IT portfolios*

*H2b: Branches of geographically dispersed firms that have different functions will be the least similar in their IT portfolios*

In addition to the decreased influence of parent units, the decisions that dispersed establishments take may be affected to a greater extent by the decisions of their neighboring peers (Legendre, 1993; Rogers, 1995). Spatial proximity promotes face-to-face communication as well as the exchange of specialized knowledge, which diffuses through learning-by-doing and is thus highly localized (Busch & Reinhardt, 2000). In this respect, operational decisions on investments in technology could be seen as matters requiring a deep understanding of the objects to be procured, as well as the need to observe these technologies in actual use.

*H3: Branches of firms that are more dispersed will have IT portfolios more alike their local peers than those of their peer branches in other locations.*

# Research Model and Data

This study aims to discern the relationship between the diversity of firm IT investments and the level of firm dispersion. Firms invest in different types of IT, ranging from software applications and networking equipment to data storage and computer processors. This diversity implies that studies that look at IT investment broadly, such as this, require a measure that can aggregate this variety of assets without losing some sense of how they vary across firms. Although this may obscure the differing impact of various explanatory variables on the individual components of this measure, it is useful in this study since the focus is on examining the heterogeneity of a firm's IT portfolio. We term this measure "*IT Profile*" and define it as a vector representing the variety of IT in an organization.

## *Data*

The data for the study is from Harte-Hanks, a marketing firm which has created a dataset[1] of the IT assets and attributes of a range of firms and their establishments. The IT variables in the dataset are recorded at a very granular level: e.g. the number of servers, routers, PCs, LAN nodes, storage, types of software installed, software vendors used, etc. There is also information on the level at which IT purchase decisions are made (parent or local) and the number of IT employees. Demographic attributes include revenue, number of employees, and various location indicators: zip code, metro statistical area (MSA), county, state, and longitude/latitude. Certain criteria (for example, firms had to be based in the US, be in the manufacturing or service industries, have more than 500 employees, and not be non-profits or government organizations) were used to create a database of 1,275 establishments from 461 firms.

## *Variables*

IT Profile: This measures the heterogeneity of each establishment's IT portfolio. First, the IT assets are categorized into different classes, such as storage, networking and processing for hardware, and development, security and transaction processing for software. They are then summed up and normalized within each category for each establishment. Following that, each establishment's IT portfolio is represented as a vector. A vector measure was chosen as it allows multi-dimensional distance to be calculated. This enables the comparison of different portfolios by taking into account their differences across multiple asset types. In this preliminary study, only the software assets were coded and analyzed. The coding scheme used Table 1 as the starting point and was supplemented by additional codes based on the data available. Thus, the software portfolio was represented as a vector in this form: *{communication, development, information processing, infrastructural, security, manufacturing, standard office applications, transactional}*.

Dispersion: The first step was to calculate the great circle distance of each establishment from its parent. This measure was selected as it takes into account the earth's curvature, making it more accurate than traditional Euclidean distance. In addition, an employment-weighted measure of distance was also used. This separates the effects of size from distance: larger establishments (i.e. those with many employees) would be likely to be managed more closely, irrespective of their distance from their parents, compared with smaller establishments that were nearer their parents. The former would thus probably be closer to their parents in terms of the composition of their IT portfolio compared to the latter. Finally, firm dispersion was computed using the Ellison-Glaeser dartboard index (Ellison & Glaeser, 1997). This index measures whether establishments are more concentrated across states then would be hypothesized by

[1] This dataset has been used in prior IS research, e.g. Forman, Goldfarb and Greenstein (2005) and Chen & Forman (2006).

looking at state populations and the establishments' size distribution. In other words, this index compared the proportion of sites of firm *x* in region *i* with the proportion of sites of all firms in region *i*.

### *Method of Analysis*

The analysis will proceed in the following way. After measuring the dispersion of each firm, the sample will be divided into "concentrated" and "scattered" firms using a median split. Next, the difference between the IT portfolios of sites within each of the two categories was assessed. The difference between two portfolios will then be calculated as a dissimilarity measure using multidimensional scaling (MDS). Although the distance between 2 vectors can be calculated by this formula: distance = $\sqrt{(x_1 - y_1)^2 + (x_2 - y_2)^2}$, where *x* and *y* are the vector's dimensions, there are difficulties as the number of dimensions increases. Multidimensional scaling, on the other hand, is designed to handle such a scenario. MDS creates a matrix of the distance between each observation; in our case, this is equivalent to the amount by which the IT portfolio of each site differs from that of other sites. Then, the mean difference within each group is calculated, and the hypotheses would be tested using a set of ANOVAs.

For H2 and H3, the dissimilarity matrices were created for sites categorized by function, level of firm dispersion (concentrated or scattered), and location.

## Current Status

To obtain an initial assessment of the model's intuition, we calculated the IT profile of each establishment by summing up the amount of hardware it possessed in each category, and then dividing it by the number of employees it had. Thus, if an establishment had five servers, three desktop PCs, two LAN hubs, and seven printers, and 34 employees, its IT profile would be (17/34) = 0.50. A "Net Profile", an aggregation of networking-specific IT hardware, was also computed. "Industry IT Profile" is a weighted average of the IT profile of firms sharing the same 3-digit NAICS code, while "IT Profile of Neighbors" is a weighted average of the IT profile of firms located in the same metro statistical area (MSA). Similar measures were computed for the net profile. As a preliminary study, ordinary least squares (OLS) regression was used to assess the overall intuition of our model. Controlling for the level of IT investment in an industry, the models we are testing are:

> *Establishment IT Profile = f(Parent IT Profile, Industry IT Profile, IT Profile of Neighbors, Distance from Parent)*

The normality of the variables was tested with QQ plots, with variables that were non-normal being log-transformed to meet the requirements of OLS regression. The control variables were dummy-coded and included industry (manufacturing or service), region (North-Central = 1, North-East = 2, South = 3, West = 4), and locus of purchasing decision (parent = 1, establishment = 0). Interaction effects of these variables were also tested. The OLS regression results are presented in Table 2. The Durbin-Watson statistic is near 2, indicating that first-order autocorrelation is not a problem with the data. The variance explained (adjusted $R^2$) is 41% for IT profile and 16% for the latter. Overall, the IT profile of individual establishments is significantly affected by the IT profile of their parents, their industries, and their neighbors. The same applies for their net profile. The region a site is located in does not have a significant effect on its IT and net profiles, while the locus of decision-making does: establishments where IT investment decisions are made by the parent firm possess more IT than where decisions are made locally.

Although distance by itself is significantly and positively associated with only the net profile of establishments, distance weighted by employment is, on the other hand, significantly and negatively related to both IT and net profile. This is an interesting finding and is robust to the addition of various controls: region, manufacturing/service and locus of purchase decisions. The positive relationship between distance and net profile is reasonable, as establishments located further away from their parents will be expected to invest more in networking technology to enhance the communications between both parties. However, the negative relationship between employment-weighted distance and both IT and net profiles is more difficult to explain. It implies that between two establishments of the same size, the one that is nearer to its parent will have less IT (which is understandable), or that between two establishments equidistant from their parent, the one that is larger in size will have less IT (which is surprising).

| Table 2. Regression Results for Establishment Site IT and Net Profiles | | |
|---|---|---|
| **Dependent Variable** | **Establishment IT Profile** | **Establishment Net Profile** |
| **Variables** | Beta [p-value] | Beta [p-value] |
| Enterprise IT/Net Profile- per employee | .131 **[.000]** | .085 **[.000]** |
| Average IT industry profile | .511 **[.000]** | .310 **[.000]** |
| Average IT metro area profile | .083 **[.000]** | .053 **[.000]** |
| Distance of Site from Parent- employment-weighted | -.035 [**.000**] | -.024 [**.000**] |
| Regions: 1, 2, 3, 4 | .045 [.146] | -.007 [.847] |
| PC purchase decisions- parent (1) or local (0) | .215 [**.000**] | .055 **[.086]** |
| service =1, else =0 | .157 [**.000**] | -.058 [.274] |
| interaction: region x manufacturing | -.026 [.359] | -.015 [.663] |
| interaction: region x service | -.048 [.232] | .022 [.648] |
| interaction: purchase decision x manufacturing | -.069 [**.050**] | .057 [.176] |
| interaction: purchase decision x service | -.154 [**.000**] | .054 [.218] |
| **Adjusted R Squared** | .416 | .166 |

## Conclusion and Further Research

The results of the interim model here indicate that distance, dispersion and decisions of neighbors do affect the IT investment decisions of establishments. Although more definite conclusions on the impact of dispersion on IT investment can only be made when additional analyses are carried out, the preliminary results here point out that this is a fruitful line of research and is worth exploring further.

The study contributes in a few ways. First, the use of a vector measure to analyze IT portfolios is novel and opens up a range of questions worth investigating. For example: a) what factors are related to firms having particular portfolios? These could be used to create a contingency theory of IT portfolios; b) how do firms' IT portfolios change over time, and do they move in certain trajectories? This supports the call for researchers to treat IT systems historically (Markus, 2000), especially pertinent with projects taking longer to complete and often being constrained by prior choices; c) what are the consequences of different type of IT portfolios? Here, different aspects of firm performance could be examined as an extension of Aral & Weill (2007).

A limitation of the study the type of data used. The Harte-Hanks dataset is dissimilar from other IT investment data, in that there are no measures of "value" or "cost". What it records is how much of each type of IT (e.g. LAN servers, mainframes, PCs, routers, etc.) an establishment has and the types of software it uses. This leads to a possible confound: if a firm buys more of a certain piece of IT, is it because of lower prices or because of its business needs? In other words, disentangling the effect of changing prices from requirements-driven investments becomes difficult. One possible method of overcoming this could be to include a technology price index in the regression models. Some future directions for this study include the use of spatial data analysis, since distance has been shown to have an impact on the variables of interest, and the use of distance-based dispersion measures, such as Geocon (Busch & Reinhardt, 1999) or Holmes & Stevens' (2004) Gini-based measure.

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