PCIC Personal Computing Industry Center
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Global Sourcing Choice and Firm Performance: Impacts of Firm Characteristics, Nature of the Activity and Strategic Motivation

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June 2011

The Personal Computing Industry Center is supported by grants from the Alfred P. Sloan Foundation, the U.S. National Science Foundation, industry sponsors, and University of California, Irvine (California Institute of Information Technology and Telecommunications, The Paul Merage School of Business, and the Vice Chancellor for Research). Online at http://pcic.merage.uci.edu.

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ABSTRACT

Offshore sourcing of IT development has grown rapidly in the past decade. Yet some firms are much more active than others in offshore sourcing, and some report greater success in offshore performance. This raises two questions. First, how can we explain differences in firm sourcing choices, even among firms operating in the same industry? Second, what factors influence the impact of offshore sourcing on firm performance?

We use data from a 2010 survey of U.S. software companies to analyze the factors that influence global sourcing decisions and the impacts of offshore sourcing on firm performance. We first examine the factors that shape sourcing choices for all firms, those that offshore and those that do not. We then focus on only those firms that offshore, examining both the determinants of offshoring and the performance outcomes of offshoring for firms with different strategies.

The most important contribution of this analysis is the finding that there are two types of offshoring strategic motivation, as identified through factor analysis. One is operational improvement and the other is international market expansion. These differences in strategy are significantly associated with the choice of sourcing options, and with the cost savings achieved from offshoring. It appears that firms motivated by cost reduction are more likely to use the outsourcing option rather than setting up their own captive development centers, while those motivated by market expansion are more likely to use captive development. Firms that go offshore for operations reasons report greater cost reduction than those that go for market access.

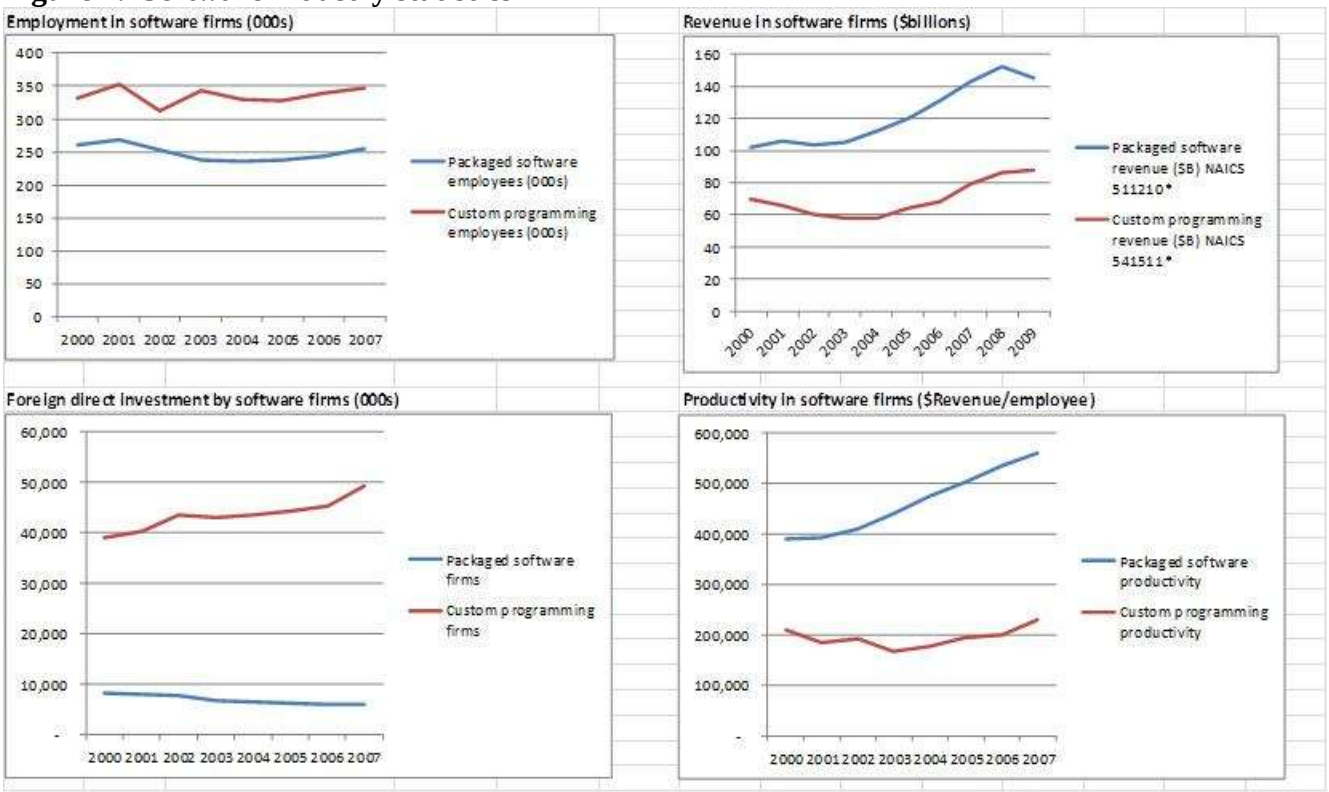
KEYWORDS
Sourcing choice, strategic motivation, offshoring, outsourcing, software industry, software development, modularity, maturity, productivity, firm strategy,

INTRODUCTION

The globalization of software, IT services and business processes by U.S. firms over the last decade has been well-documented through surveys (Lewin and Couto, 2007), case studies (Lacity and Rottman, 2008; Wilcocks and Lacity, 2006) and press accounts (Friedman, 2005). There has been great concern that the process of globalization is a threat to U.S. employment in leading high-technology industries such as software.

The U.S. software industry had about $240 billion in sales in 2009, up from $170 billion in 2000, and contributed a trade surplus of $27.2 billion (U.S. Census, 2010; Miles, 2010). Yet industry employment fell after 2000, and only returned to its previous levels in 2007 (Figure 1). Is this a result of offshoring, or greater productivity on the part of U.S. workers? On the productivity side, packaged software firms have steadily increased productivity (revenue/employee) while custom programming firms suffered a decline in productivity after 2000 and only returned to the earlier levels in 2007. On the globalization side, packaged software firms have steadily increased their foreign direct investment, reaching a position of $50.8 billion invested abroad in 2009 (U.S. Census, 2010; Miles, 2010). Both packaged and custom software firms have also outsourced development to foreign vendors.

Figure 1. Software industry statistics



Sources: U.S. Census (2010); Miles (2010).

Given the importance of the software industry in the U.S. economy, and given the extent of offshoring in the industry, it is important to know: (1) what motivates software firms to go offshore, and (2) to what extent is their actual performance is consistent with their motivations?

We use data from a 2010 survey of US software companies to analyze the factors that influence global sourcing decisions and the impacts of offshore sourcing on firm performance. Using the entire sample, we first test a model that estimates the impacts of firm and development activity characteristics on the extent to which software firms use any of the following sourcing options: onshore-inhouse, onshore-outsourced, offshore-inhouse, and offshore-outsourced. We find higher levels of international sales are associated with greater likelihood of inhouse and outsourced offshoring, while higher productivity is associated with lower levels of captive (inhouse) offshoring. Also, higher product modularity is associated with higher levels of onshore-inhouse sourcing. Lower process maturity is associated with lower use of offshore outsourcing, a surprising finding since it is sometimes argued that more mature processes are easier to outsource. Packaged software companies are more likely to use both inhouse and outsourced offshore development than custom software firms.

Next we look at the sample of firms who are actually doing offshore development and study factors related to the distribution of development effort among the four sourcing choices (measured as the proportion of full-time equivalent developers in each category). Here, degree of internationalization is associated with higher levels of inhouse-offshore. Greater productivity is associated with lower levels of inhouse offshoring but higher levels of offshore outsourcing. Greater product modularity is associated with lower levels of inhouse offshoring and has no relationship to offshore outsourcing. Process maturity has no measurable impact on sourcing choice. We also look at the impact of strategic motivation on sourcing choice. Using factor analysis, we identify two distinct offshoring motivations—operations and market access. We find that firms that go offshore primarily for operational reasons are more likely to outsource, while those that go to gain access to foreign markets are more likely to use inhouse (captive) development.

Finally, we estimate a third model to examine how firm characteristics and strategic motives affect the performance of offshore development efforts (the extent of cost savings associated with offshoring). Here we find that firms with an operations strategy have significantly greater cost savings than firms that go offshore for market access, while firms that seek market access report greater success on qualitative measures related to competitive position, revenue from non-U.S. markets, software quality and customer service. This may reflect some self-reporting bias, but also suggests that offshore outcomes are influenced by firm strategy.

An important contribution of this analysis is the finding that there are essentially two types of offshoring strategic motivations, and that these differences in strategy are significantly associated with the choice of sourcing options, and with differences in offshoring-related performance. At a broader level, we test a conceptual model that relates sourcing decisions to firm characteristics, management strategies and product/process characteristics. We find that sourcing decisions depend highly on firm characteristics and management strategies, but are only weakly related to product/process characteristics, contrary to the previous conceptual and empirical research.

LITERATURE AND RESEARCH FRAMEWORK

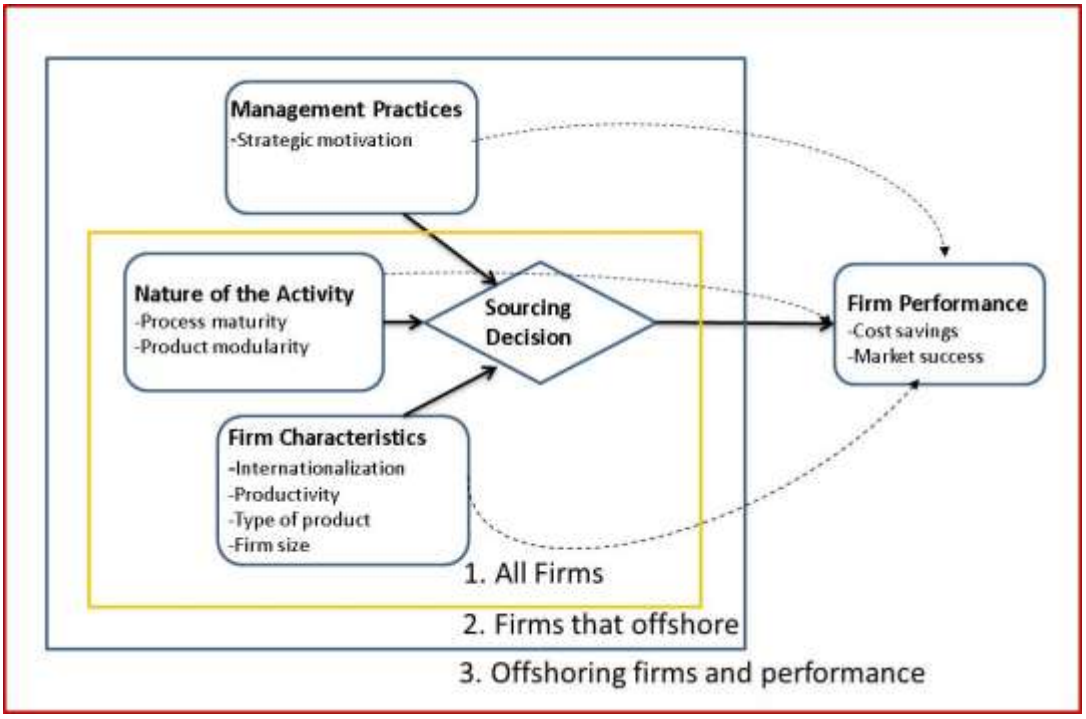
Until recently, economic globalization had been concentrated mostly in manufacturing industries as multinational corporations have created global production networks and trade flows have been dominated by manufactured goods. While this process has caused concern about the loss of jobs and industrial capabilities in the U.S., it has been argued that a shift from blue collar production work to white collar knowledge work is a natural progression for an advanced economy in the information age (Bell, 1973). Today globalization is rapidly expanding into knowledge activities as R&D, product design and engineering and software development are offshored to places such as China, the Philippines, Ireland, Israel and India.

U.S. firms may benefit from lower production costs by going offshore, but there may be a loss of jobs for professionals in the U.S. However, if offshoring is aimed at expanding markets, both U.S. companies and workers could benefit. A worse scenario is if firms go offshore and fail to reap the expected cost reductions or market expansion, in which case they are no better off, and U.S. jobs have been lost. This outcome is quite possible, as evidenced by the documented cases of offshoring efforts that have gone awry (e.g., Aron and Singh, 2005).

Most of the empirical research on offshoring focuses on operational activities in manufacturing and services such as assembly and test, product support and help desk/call center. Software development has an operations side too including coding and testing, implementation and maintenance and support. However, this research is concerned with the knowledge activities of software research, analysis and design which are more similar to R&D activities than to operational ones. Therefore, we look to the literature on the offshoring of R&D to frame our research.

Many factors have been posited to influence the offshoring of knowledge activities such as R&D (Thursby and Thursby, 2006; Lewin et al., 2009) and software development (Dibbern et al., 2004). In reviewing the literature, we have identified three sets of factors: firm characteristics, the nature of the activity being offshored or outsourced, and the management practices of the firms (Dibbern et al., 2004; Dedrick, Carmel and Kraemer 2010). The relationships among these are illustrated in Figure 2 and elaborated below. The figure also shows the factors and relationships studied in our three empirical models as identified in the introduction.

Figure 2. Conceptual framework



Source: Adapted from Dedrick, Carmel and Kraemer (2010).

Sourcing decision

The sourcing decision we are concerned with is whether software development is carried out in the home country of the parent firm (onshore) or in a foreign (offshore) location, and whether it is done by the firm (in-house) or by an outside firm (outsourced) (Sobol and Apte, 1995). The dimensions of the decision can be represented in a 2x2 matrix, with four potential sourcing options (Figure 3) (Metters, 2008). While sourcing decisions are made for each development project, at any point in time the firm as a whole can also be characterized as (1) engaged in offshoring or not; and (2) if engaged in offshoring, whether inhouse or outsourced.

Figure 3. Classic 2x2 sourcing decision matrix

	Onshore	**Offshore**
Inhouse	Inhouse onshore	Inhouse offshore
Outsourced	Outsourced onshore	Outsourced offshore

The use of outside service providers is considered superior for achieving efficiency, labor flexibility, and specialized expertise in software development, but involves external coordination costs to ensure performance (Dibbern et al., 2008). In contrast, the use of in-house staff is considered superior for exploiting firm-specific knowledge (DiRomualdo and Gurbaxani, 1998),

but setting up and maintaining an inhouse offshore operation can result in higher fixed costs and sacrifice labor flexibility compared to using an outside provider.

Firm characteristics

There are four characteristics of firms that have been shown to be related to the decision to offshore economic activities. The first is the ***internationalization*** of the firm or the extent to which the firm is already engaged in international sales. Firms with a higher proportion of international sales are likely to have sales, marketing and distribution activities offshore which provide a base for setting up software localization, support and maintenance services for the existing customer base or developing products for new markets. Market knowledge would enable the firm to find cost-effective local talent to enhance existing products and to develop new products for the host and similar markets (Bardhan, 2006).

> **Hypothesis 1**. Firms with higher international sales will conduct more software development offshore.

The second factor is the ***productivity*** of the firm. Research on internationalization and trade (Bernard et al., 2007) has shown that within an industry, firms that are more productive in terms of sales per employee are more likely to export. The research further shows that these firms are productive, not as a result of learning from exporting, but "because only the most productive firms are able to overcome the costs of entering export markets" (Bernard et al., 2007). It is likely that the same factors apply to software offshoring, which also involves significant start-up costs. The greater productivity of some software firms enables them to easier set-up and better manage offshore development. Thus, we hypothesize that firms with higher productivity will conduct more development offshore.

> **Hypothesis 2**. Firms with higher productivity will conduct more software development offshore.

The third factor is the ***type of software firm.*** This refers to whether the firm is primarily producing packaged software or custom programming services. Given that software is their intellectual capital, packaged software firms are unlikely to outsource whether onshore or offshore due to the risk of IP loss. They are likely to do captive software development offshore to access new markets and/or to better serve existing international markets. In contrast, cost-effective human capital is the core resource of programming services firms, and so they are likely to outsource offshore to acquire the most cost-effective talent.

> **Hypothesis 3a**. Packaged software firms will conduct more software development offshore.
> **Hypothesis 3b.** Packaged software firms will conduct software development through inhouse/ operations rather than outsourcing.

The fourth factor is ***firm size***. Larger firms have greater resources to make investments offshore. They also have greater opportunity to benefit from economies of scale in production, sales and marketing that come from internationalization (Bernard et al., 2007). Thus, we hypothesize:

Hypothesis 4. Firms that are larger will conduct more software development offshore.

Nature of the activity

A second major group of factors involves the nature of the activity or product being considered for offshoring. These factors are consistent with the view that transaction costs associated with certain types of interactions can favor internalizing some activities, even when production costs are lower in market transactions (Williamson, 1979; Clemons et al., 1993). This is especially the case in skill-intensive industries where interaction between design and production is critical (Bernard et al., 2007). The impact of the nature of an activity on sourcing decisions has been well studied in the outsourcing literature and more recently in studies of offshoring (e.g., Sargent and Meares, 2006; Tanriverdi et al., 2007; Youngdahl and Ramaswamy, 2008).

In the sourcing literature, it is argued that ***mature processes*** are more likely to be moved offshore than newer processes. Firms will find it easier to offshore more mature processes, which are well known and understood and for which the development process is more predictable [Banker et al., 2006]. As software applications become more stable and mature, with fewer change requests, it is easier to move them offshore (Sargent and Meares, 2006). When a system is unstable or there are many change requests from the customer, it is more difficult to manage the software development process offshore, and therefore less likely to be moved.

> **Hypothesis 5**. Firms with higher process maturity will be more likely to conduct software development offshore.

Modularity is also related to offshoring and outsourcing in the literature. Modular activities are defined as those which can be performed independently, and then later integrated (Schilling and Steensma, 2001). When modularity is low, knowledge activities are difficult to separate from each other because the performance of one element depends on integration with another or because work at one stage in the process must be done in a way that it does not cause problems at the next stage. This situation calls for close and frequent communication to iterate and solve problems and makes offshoring more difficult. By contrast, when modularity is high, it is easier to carry out separate tasks in different locations. The relationship of sourcing decisions to modularity has been argued conceptually (Schilling and Steensma, 2001; Langlois, 2006; Sanchez and Mahoney, 1996), and modularity has been linked empirically to a greater likelihood of business process offshoring (Tanriverdi et al., 2007).

> **Hypothesis 6**. Firms with higher product modularity will be more likely to conduct software development offshore.

Management practices

We turn next to the managers' ***strategic motivation*** and how this might affect sourcing choices and firm performance. In characterizing business strategy, Porter (1996) argues that firms should focus on two key business objectives: operational effectiveness and strategic positioning. Firms that focus on operational effectiveness "get more out of their inputs than others because they eliminate wasted effort, employ more advanced technology, motivate employees better, or have greater insights into managing particular activities… operational effectiveness includes, but is not limited to efficiency" (Porter, 1996, p. 62). Those that focus on strategic positioning attempt to differentiate their products or services from those of their rivals in the market. Such strategic or market positioning is customer dependent, and thus firms can improve their performance by closeness to customers in existing markets and extending their reach to new markets or new customers (Porter, 1996).

The literature on firm globalization also indicates that managers might decide to go offshore for different strategic motivations. One is supply side or production oriented and aimed at reaching input markets (Bardhan, 2006). In the context of knowledge work such as software development, this would include inputs such as low cost labor, flexible labor, or large labor pools or highly-skilled talent). Another motivation is demand side or market oriented focused on the need to reach new markets, including the design of new products for specific customers or markets (Bardhan, 2006). Thus, firms might organize globally to optimize efficiency and economies of scale, or to increase responsiveness to markets or even create new markets.

We would expect that software firms will differ in their sourcing choices based on their strategic motivations (Dedrick, et al., 2010). Firms with a strong market focus would be expected to use captive software development to hire and retain employees loyal to the firm (helping to protect intellectual property), to attract talent with knowledge of local markets and to be seen as partners in local economic development and improve market access. In short, they are going offshore to build unique human resources that can help to better access local markets. Firms going offshore mainly to reduce costs would emphasize outsourcing to access cost-effective human resources with outsourcers that can provide flexible labor pools at whatever scale and skill-level needed. Here the emphasis is cost reduction more than developing human resources to help access markets.

We use the foregoing two orientations as a way of classifying a firm's sourcing motivation, and we expect that there will be differences in the offshoring strategies of software firms and in sourcing decisions as a result of the strategic motivation. Accordingly, we hypothesize:

> **Hypothesis 7**. Offshoring firms with a "market access" strategic motivation will make greater use of captive offshoring.
>
> **Hypothesis 8**. Offshoring firms with an "operations" strategic motivation will make greater use of outsourced offshoring.

Firm performance

The literature on offshoring and outsourcing is marked by mixed reports about firm performance as a result of offshoring. Some firms have gone offshore to reduce costs only to find that the savings are not what they expected (Lacity and Rottman, 2008; Rouse, 2009). Others have not been able to develop new products or increase international sales as they had hoped.

One explanation for the mixed performance is that many firms have gone offshore in an *ad hoc* manner without adequate consideration of sourcing strategies (Berry, 2006). Another is that firms have gone offshore or outsourced without adequate consideration of the obstacles and costs of overcoming these obstacles. Consequently, it is important to look at the relationship between strategic motivation, sourcing choices and firm performance. The performance improvements that have been expected from offshoring and outsourcing include reduced costs, access to highly skilled talent, faster product development, greater international sales, more revenue from new products and greater customer service levels (Dibbern et al, 2008; Lewin et al., 2010).

The distinctions in firm strategy between operational efficiency/effectiveness) and market access/positioning, or between supply side and demand side strategies, can be translated directly into corresponding strategies for offshoring. For example, operational efficiency is achieved by using offshoring to increase labor productivity, availability or flexibility and to lower labor costs. In contrast, market positioning involves using offshoring to extend geographic reach and local market access. We would expect that firms would be more likely to achieve high performance on dimensions consistent with their strategic motivations. For example, operations-focused firms should rank high on cost and labor savings, whereas market-focused firms should rank high on market success.

> **Hypothesis 9.** Offshoring firms with a "market access" strategy will achieve greater market success in offshore markets than offshoring firms that do not have a "market access" strategy.

> **Hypothesis 10.** Offshoring firms with an "operations" strategy will obtain larger cost savings than offshoring firms that do not have an "operations" strategy.

VARIABLES, DATA AND METHOD

In order to explore the hypothesized relationships, we designed a three part analysis. First, we look at all firms in the survey (354 firms) and examine the factors that distinguish firms that offshore software development from those that do not. These include characteristics of the firm and the nature of the development activity. Descriptives for these variables and others are shown in Table 1below. All measures are derived from the survey questionnaire (Appendix A) unless otherwise specified.

Table 1: Descriptive statistics for the variables

Categorical variables			**Count**	**Fraction**
SIC: 7371 - Computer programming services firms			102	40.2%
SIC: 7372 – Packaged software firms			152	59.8%
Continuous variables	**Mean**	**Standard Dev.**	**Min**	**Max**
International sales (fraction)	19.6%	21.9%	0.000%	96.0%
Productivity (revenue per employee - millions)	0.2	0.3	0.000	4.167
Firm size (number of employees)	490.9	1123.1	5	5000
Number of developers (FTEs)	141.7	503.0	1	4500
FTEs inhouse & onshore	91.7	358.9	0	4500
FTEs inhouse & offshore	37.1	216.4	0	3150
FTEs outsourced & onshore	2.2	7.6	0	70
FTEs outsourced & offshore	9.1	44.1	0	500
Fraction FTEs inhouse & onshore	73.1%	29.5%	0.0%	100.0%
Fraction FTEs inhouse & offshore	16.5%	25.7%	0.0%	100.0%
Fraction FTEs outsourced & onshore	3.6%	10.5%	0.0%	76.9%
Fraction FTEs outsourced & offshore	6.8%	13.6%	0.0%	80.4%

The dependent variable *sourcing choice* is the distribution of development effort among the four sourcing choices in Figure 2: inhouse onshore, outsourced onshore, inhouse offshore and outsourced offshore. It is measured as the fraction of full-time equivalent developers in each category as explained in detail in the Methodology section.

Internationalization is measured as the proportion of international sales to worldwide sales of the firm. *Productivity* is defined as the firm's worldwide revenues per full-time employee. This measure is commonly used in studies of firms in international trade (Bernard et al., 2007).

The *type of software firm* is a categorical variable defined as either packaged software or programming services, and is based on the firm's SIC classification. SIC code 7371 includes computer programming services firms whereas SIC code 7372 includes packaged software firms.

Firm size is measured as the number of full time employees/1,000 in the firm worldwide. Firm size has been shown to be positively related to internationalization (Bernard et al., 2007), offshoring (Lewin et al., 2009) and outsourcing (Dibbern et al., 2004) in previous research.

Process maturity is measured as a single factor based on survey responses indicating agreement (on a scale of 1 to 5 where "5" meant strongly agree) with the following characterization of their development processes: our software development processes are mature; our software is well documented; we can easily measure the performance of our software development process; and

there is seldom any change in our development process. The higher the score the greater the process maturity.

Similarly, *product modularity* is measured as a single factor based on responses indicating agreement (on a scale of 1 to 5 where "5" meant strongly agree) with the following characteristics of the software: making changes to one part of our software affects many other parts (reverse coded, as this is the opposite of modularity) and; our software is easily divided into discrete modules. Modularity has been shown to be related to sourcing choices in previous research (Tanriverdi et al., 2007).

In the second analysis, we focus on the subsample of firms that perform at least some software development offshore (149 firms). We examine differences in strategic motivation as the explanation for sourcing choices. We focus on market and cost strategies, which are derived from the results of a principal component analysis of manager's motivations for offshoring. Respondents were asked to rate how important (scale ranging from 1 'unimportant' to 5 'important') in the past two years each of the items was as a business rationale for conducting software development outside the U.S. The analysis resulted in two orthogonal factors which we labeled market strategy and operations/cost strategy. The loadings, Eigenvalues and percent variance explained are shown in Table 2 below. The two factors explain 75% of the variance in the sample and are not intercorrelated.

Table 2. Strategic motivation factor: principal components analysis with varimax rotation

Questionnaire items	**Market focus**	**Operations focus**
Need to be close to our customers	0.898	0.012
Gain access to local markets	0.897	-0.040
Reduce labor costs	-0.202	0.823
Need for labor force flexibility	0.156	0.843
Eigenvalue	1.688	1.379
% of variance	41.89	34.77

N = 149

In the third analysis, we look at the relationship between the strategies above and the firm's performance as a result of offshoring. The measures for the two offshoring strategies (market access and labor cost/flexibility) were described above. We measure two aspects of performance: cost savings and market success. *Cost savings* are measured in quantitative terms as the estimated "percent cost savings achieved by the firm from conducting software development outside the U.S over the past two years." *Market success* is measured qualitatively as a factor score on five-point Likert-scale items, which asked respondents to indicate "the extent to which the following increased or decreased as a result of locating development outside of the U.S.": competitive position, revenue from non-U.S. markets, speed of product development and customer service levels (Table 4 below). The factor explains 42% of the variance in the sample and is not intercorrelated with the cost savings factor.

Table 4. Market access factor: principal components analysis

Questionnaire items	Market Access Performance
Competitive position	0.691
Revenue from non-US markets	0.493
Speed of product development	0.680
Software quality	0.661
Customer service levels	0.698
Eigenvalue	2.107
% of variance	42.13

N = 142

Data

The data for the analysis is from a cross-sectional survey of U.S. software firms and from Compustat (firm size). Survey data were collected via a telephone survey conducted for us by Abt SRBI (New York) from January 28 to April 12, 2010. The respondents were selected from firms with SIC codes corresponding to computer programming services (7371) and packaged software and computer integrated systems design (7372). Firms in the computer services (7379) SIC code were specifically excluded as we wanted to focus on software development activities rather than IT services. Details about the questionnaire items are provided in Appendix A.

The survey resulted in 254 completed cases with a response rate of 19.9 percent. Of the firms surveyed, 104 had no offshore development and were asked a short set of questions to compare them with the 150 firms that did have offshore development. Firms that conduct any offshore development completed the full survey. The full telephone survey took about 20 minutes to complete. Most of the respondents (64.6%) were high level executives directly involved in software development (Table 1). It is not surprising that so many high level executives participated because most of the companies in the survey were small and medium-sized. Other executives who participated in the survey were indirectly involved in software development activities through marketing and sales, business development, operations or customer services. A few, generally from the smaller companies, were the highest level executives such as Chairman, CEO, President, GM or Principal. The smallest group of executives was in IT and functional support.

Table 4. Respondents

Respondent category	Number	Percent
SVP, VP, Director or Manager of software/product development, CTO	164	64.6
Other Product Executives (marketing, sales, business development, innovation, operations, customer service)	41	16.1
CEO, President, GM, Principal, Chairman	26	10.2
CIO or other IT manager	8	3.2
Other C-level Executive (finance, controller, HR, legal)	15	5.9
Total	254	100

Methodology

One advantage of this survey-based research is that it was designed with the research question in mind, and therefore translation from survey measures into variables is very straightforward. Because the translation is so easy, many studies can employ simple estimators such as correlational studies, ANOVA and linear regression. More complex estimators are generally reserved for situations in which data collection is less than ideal. However, even when data collection is ideal, a simple estimator such as linear regression may not be appropriate.

Inference based on the linear regression model (*i.e.*, ordinary least squares) rests on a number of assumptions about the data and the underlying process. In our research setting most of these assumptions are noncontroversial, such as independence between observations. Two assumptions, however, warrant more explanation. First, linear regression assumes that the dependent variable can obtain any real number, but our dependent variables are fractions that are bounded between zero and one. Second, linear regression assumes that the effect change has the same meaning no matter where the dependent variable happens to be within its range, but in our case it is reasonable to assume that a change from 1% to 2% is quite different than a change from 49% to 50% or a change from 98% to 99%. Since these two assumptions are violated, estimation results based on ordinary least squares regression may be invalid.

Fortunately, these assumption violations have been addressed in previous work on the statistical properties of probabilities. Probabilities are bounded between zero and one, and changes in a probability have different meanings at different points within the range. Logistic regression estimates how explanatory variables affect the underlying probability of an event occurring based on observations of successes and failures. The equivalent for our study would be the "probability" that a particular FTE of development was sourced in a particular way (*e.g.*, inhouse and offshore). In our data the fractions represent the underlying "probabilities" so we do not need observations for each FTE.

Logistic regression gets its name from how the effects of explanatory variables are modeled. The underlying probability is transformed using the logit function

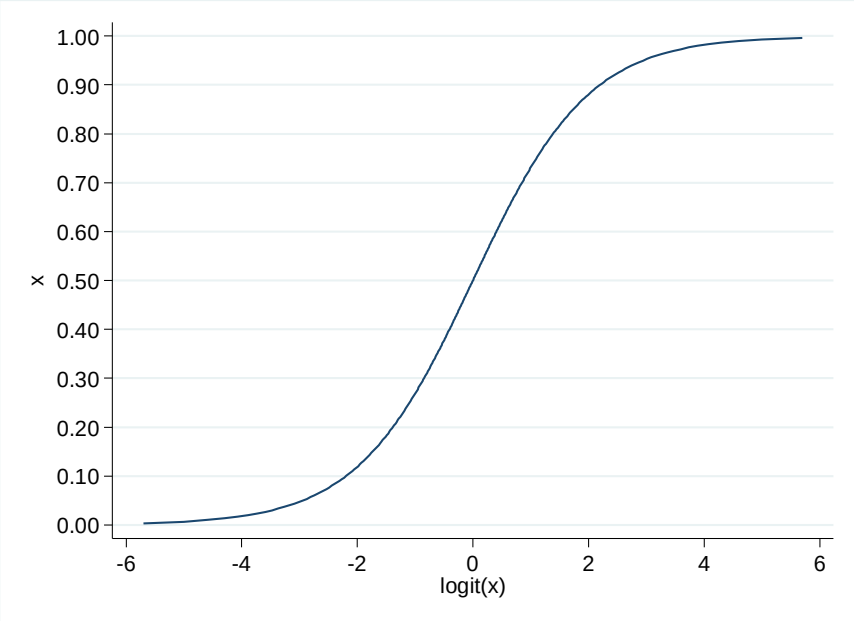
$$\mathrm{logit}(x) = \ln\left(\frac{x}{1-x}\right) \tag{1}$$

and ordinary least squares is used to deduce the effects of each explanatory variable on the transformed probability. The logit transformation has the desirable property that it is more "difficult" (requires a larger change in explanatory variables) to get the first few percent or last few percent of probability, as illustrated in Figure . Translating this into our fractions, it is "difficult" to start using a particular sourcing method.

One drawback of the logit transform is that zero maps to negative infinity and one maps to positive infinity. We do observe zeros and ones in our data, so we cap our logits at -7 and 7 then use an econometric technique known as Tobit regression to estimate our models.[1] Tobit regression treats each -7 as "-7 or lower" and each 7 as "7 or higher."

[1] The limits of -7 and 7 are equivalent to fractions 0.0009 and 0.9991, respectively.

Figure 4: Logistic curve



EMPIRICAL RESULTS

We first present the results for all firms in order to identify the factors that differentiate between firms that offshore and those that do not. Then we present the results only for the firms that offshore at least some development activity, and look at the factors that influence their choice of captive offshoring versus outsourced offshoring. Finally, we examine the relationship between firm strategy or motives and offshoring performance.

Offshoring vs. non offshoring firms

The results in Table 5, 6 and 7 rely on logit-transformed dependent variables and use Tobit estimation to deal with zeros and ones in our data. For each firm we observe the fraction of development work sourced in each of the four modes: inhouse onshore, outsourced onshore, inhouse offshore, and outsourced offshore. In essence, our estimator treats zero (no use of that mode at all) as "somewhere to the left of -7" on the horizontal scale of Figure 3 and one (all development sourced from that mode) as "somewhere to the right of +7" on the same scale.

The most significant factor determining whether firm sourcing choice is their level of international sales. The effect of international sales is unambiguously toward more offshore development with an emphasis on captive (inhouse) development at the offshore location. Firms with higher scores on process maturity source less development from offshore outsourcing vendors. Firms with high software modularity tend to do development onshore and in-house.

Firms doing packaged software perform significantly more development offshore, both captive and outsourced, and independent of how much of that software is sold internationally.[2] Larger

[2] An interaction of international sales and the packaged software firm dummy is insignificant (results omitted for brevity).

firms are more likely to employ inhouse offshore ("captive") software development. Greater productivity is associated with lower inhouse offshore development.

Table 5: Development Sourcing (all firms, using logit transforms with limits)

	Model I(a)	Model I(b)	Model I(c)	Model I(d)
Estimation Method	Tobit			
Dependent Variable	Logit of Inhouse & Onshore	Logit of Outsourced & Onshore	Logit of Inhouse & Offshore	Logit of Outsourced & Offshore
Observation	Firm			
International sales (fraction)	-7.096*** (1.835)	0.839 (3.623)	11.314*** (2.309)	7.262*** (2.521)
Productivity (revenue per employee)	0.454 (2.613)	5.270 (5.008)	-7.072** (3.383)	3.275 (3.660)
Process maturity	0.457 (0.366)	-1.011 (0.736)	-0.087 (0.467)	-1.206** (0.531)
Product modularity	0.637* (0.383)	-0.562 (0.755)	-0.781 (0.486)	-0.666 (0.545)
Packaged software (dummy)	-2.930*** (0.790)	-0.613 (1.549)	2.717*** (1.026)	2.622** (1.138)
Employees / 1000	-0.457 (0.299)	0.176 (0.611)	0.923** (0.359)	0.321 (0.421)
Intercept	7.094*** (0.833)	-12.984*** (1.901)	-9.858*** (1.137)	-12.496*** (1.408)
R^2	0.280	0.039	0.308	0.183

Note: Standard errors in parentheses. * indicates $p < 0.10$, ** indicates $p < 0.05$, and *** indicates $p < 0.01$

Results for offshoring firms

For the subsample of firms that report offshoring activity, we have survey data on strategic motivation for offshoring and on performance impacts of offshore development. There is a clear effect of international sales driving development away from onshore inhouse development and toward captive offshore development. Consistent with the results for all firms, offshoring firms with higher productivity use less inhouse offshore development. However, in this case they are more likely to use outsourced offshore development. Packaged software firms source less of their development from onshore inhouse developers, although there is no tendency towards another sourcing option.

Firms with a market-access strategy employ more in-house offshore development while firms with an operational strategy shift away from onshore in-house development work and towards offshore outsourcing. Controlling for the above factors, firm size has no significant effect on sourcing decisions.

Table 6: Development Sourcing (offshoring firms, using logit transforms with limits)

	Model II(a)	Model II(b)	Model II(c)	Model II(d)
Estimation Method	Tobit			
Dependent Variable	Logit of Inhouse & Onshore	Logit of Outsourced & Onshore	Logit of Inhouse & Offshore	Logit of Outsourced & Offshore
Observation	Firm			
International sales (fraction)	-1.629* (0.868)	0.334 (3.632)	5.014*** (1.602)	1.060 (1.955)
Productivity (revenue per employee)	1.089 (1.316)	2.247 (5.517)	-6.483*** (2.426)	5.192* (2.959)
Process maturity	0.134 (0.195)	-1.240 (0.872)	0.331 (0.361)	-0.702 (0.446)
Product modularity	0.344 (0.207)	-0.407 (0.875)	-0.643* (0.383)	-0.198 (0.463)
Market access strategy	-0.209 (0.188)	0.004 (0.804)	0.795** (0.348)	-0.412 (0.422)
Operations strategy	-0.693*** (0.197)	0.018 (0.866)	0.293 (0.366)	0.924** (0.455)
Packaged software (dummy)	-0.917** (0.440)	-1.057 (1.823)	-0.111 (0.817)	0.184 (0.983)
Employees / 1000	-0.060 (0.148)	0.196 (0.632)	0.435 (0.270)	-0.203 (0.335)
Intercept	1.576*** (0.477)	-10.795*** (2.229)	-3.192*** (0.876)	-6.306*** (1.106)
R^2	0.256	0.062	0.242	0.178

Note: Standard errors in parentheses. Excluded group for firm size is >5000 employees. * indicates $p < 0.10$, ** indicates $p < 0.05$, and *** indicates $p < 0.01$

Offshoring and firm performance

Table 7 reports the performance changes reported by offshoring firms as a result of using offshore development. We decompose performance into two dimensions, qualitative market success and quantitative cost savings.

Each dimension of performance is associated with one of the two offshoring strategies. Namely, a market access strategy is associated with qualitative market success while an operations strategy is associated with cost savings.

Table 7: Performance (offshoring firms)

	Model VII(a)	Model VII(b)
Estimation Method	OLS	
Dependent Variable	Market success	Cost savings
Observation	Firm	
International sales (fraction)	0.207 (0.446)	0.958 (7.509)
Productivity (revenue per employee)	0.111 (1.288)	-4.033 (17.299)
Process maturity	0.269 (0.110)	0.295 (2.352)
Product modularity	0.035 (0.108)	-0.356 (2.442)
Market access strategy	0.195* (0.116)	-2.947 (1.847)
Operations strategy	0.103 (0.123)	9.963*** (1.619)
Packaged software (dummy)	0.283 (0.225)	-3.374 (4.968)
Employees / 1000	0.139 (0.086)	-1.967 (1.194)
Intercept	-0.374 (0.283)	25.141*** (5.348)
R^2	0.180	0.310

Note: Standard errors in parentheses. * indicates $p < 0.10$, ** indicates $p < 0.05$, and *** indicates $p < 0.01$

DISCUSSION

This study has examined factors that influence software firms' sourcing decisions. Table 8 summarizes the predicted and actual outcomes for the hypotheses. Among all firms, the results show that degree of internationalization and firm size are associated with greater likelihood of firms going offshore versus not going offshore, and firms selling packaged software are more likely to go offshore than software service firms.

Firms with higher productivity have a tendency toward offshore outsourcing and a tendency away from captive offshore development. Modularity is weakly associated with in-house onshore development in contrast to other studies which found a strong association with offshore sourcing (Taniverdi et al., 2006). Surprisingly, process maturity is associated with less offshore outsourcing. This suggests that some firms who choose offshore outsourcing may be motivated by the opportunity to leverage outsourcing vendors' maturity rather than investing in improving their own development processes.

Table 8. Summary of support for hypotheses

Hypothesis		Prediction	Result	Conclusion
1	Firms with higher international sales will conduct more software development offshore.	+	+	Supported
2	Firms with higher productivity will conduct more software development offshore.	+	+ or -	Partial support
3a	Packaged software firms will conduct more software development offshore.	+	+	Supported
3b	Packaged software firms will conduct offshore software development through inhouse/ operations rather than outsourcing.	In-Off > Out-off	No difference	Not supported
4	Larger firms will conduct more of their offshore software development offshore.	+	+	Supported
5	Firms with higher process maturity will outsource offshore more software development work.	+	-	Rejected
6	Firms with higher product modularity will outsource offshore more software development work.	+	NS	Not supported
7	Offshoring firms with a "market access" strategy will use captive offshoring over outsourced offshoring.	In-Off > Out-Off	In-Off > Out-Off	Supported
8	Offshoring firms with an "operations" strategy will use outsourced offshoring over captive offshoring.	Out-Off > In-Off	Out-Off > In-Off	Supported
9	Offshoring firms with a "market access" strategy will achieve greater market success in offshore markets than other offshoring firms.	+	+	Supported
10	Offshoring firms with an "operations" strategy will obtain larger cost savings than other offshoring firms.	+	+	Supported

Among the firms that do development offshore, we found that international sales again push development to captive centers. The tendency for packaged software firms to employ offshore outsourcing vendors is weaker but still present as a negative association with in-house onshore development. Firms with higher productivity are still associated with more offshore outsourcing and less offshore captive development.

The inclusion of the two strategies or motives for offshoring causes nearly every other explanatory variable to lose significance. In other words, firm strategy provides the single best explanation for a firm's offshoring mix. Firms with an operational focus source less of their development from onshore inhouse developers and more from offshore outsourcing vendors.

It is clear from this analysis that firms go offshore for different motivations or strategies. It is also clear that firms achieve (or at least report) performance that is consistent with their strategies. Firms with a market-access strategy employ more captive development while firms with an operational strategy employ less onshore in-house development, and use more outsourced offshore development.

Each of the strategies supports its own measure of success without inflicting a significant penalty on the other measure. That is, firms with an "operations" strategy report greater cost savings and no impact on qualitative market access goals as a result of offshoring, and firms with a "market access" strategy report greater qualitative market success with no significant impact on cost savings.

CONCLUSION

Implications

There is a clear difference between software firms that employ offshore development and those that do not. Firms that offshore are larger, have more international sales and are more likely to sell packaged software rather than programming services. Furthermore, these differences probably exist even before offshoring begins. For instance, the fact that packaged software firms have a productivity advantage overall (Figure 1) and are more likely to go offshore suggests that higher productivity is a driver rather than a result of offshoring. This is because only the most productive firms are able to overcome the costs of entering offshore export markets. There is a large literature in international trade, which documents this finding for goods-producing firms (Bernard, et al., 2007).

We find that firms going offshore for market reasons generally achieve market success even though they are less likely to achieve cost savings. Firms going offshore for operational reasons are more likely to save money, but no more likely to achieve market success. It is interesting that firms achieve what they set out to accomplish in offshoring, but do not report any improvement on the other dimension. This may be related to location decisions. Firms seeking market access may be more likely to offshore to larger markets such as Western Europe, where costs are similar to U.S. costs, while those seeking operational advantages may offshore to lower cost locations such as India or China where the market for paid (not-pirated) software is limited. This is a question for further research.

At a broader level, we test a conceptual model that relates sourcing decisions to firm characteristics, management strategies and activity characteristics. We find that sourcing decisions depend highly on firm characteristics and management strategies, but are only weakly related to activity characteristics, contrary to the previous conceptual (Baldwin, 2000; Sturgeon, 2002).and empirical (Tanriverdi et al., 2007) research. Specifically, we find that neither product modularity nor process maturity are consistently or strongly related to sourcing choice in the software firms that we studied.

Limitations

As with all survey-based data, there are potential concerns about response bias—namely that firms identified as following one or another strategy would respond in line with their beliefs about the strategy. However, there are several features of the survey that mitigate this concern. First, respondents were never asked directly about their offshoring strategy. In fact, the phrase never appeared in the questionnaire. Instead, they were asked about the importance of a number of factors in the company's business rationale for conducting software development outside the U.S. We derived the strategies used in the analysis analytically as explained in the methods section.

Second, the respondents were mostly high level software executives who were in a position to know the facts about their firm's offshoring experience. Together, these considerations suggest that the responses are valid indicators of the firm's actual experience.[3]

Also, this was a cross-sectional study with data collected in 2010 when the economic downturn beginning in 2008 might have skewed firms towards greater use of offshoring and outsourcing for software development than would be the case without the great recession. While the recession might have affected the number of firms choosing to offshore, there is no reason to believe that it affected their choice of captive or outsourced offshoring.

References

Aron, R. and Singh, J.V. (2005). "Getting Offshoring Right." *Harvard Business Review*, 83(12), 135-143.

Baldwin, C. Y., K. B. Clark (2000). *Design Rules: The Power of Modularity*. MIT Press, Cambridge, MA.

Bardhan, A. (2006) Managing Globalization of R&D: Organizing for Offshoring Innovation, *Human Systems Management* 25(2): 103-114.

Bernard, Andrew B., J. Bradford Jensen, Stephen J. Redding and Peter K. Schott. 2007. "Firms in International Trade." *Journal of Economic Perspectives*, 21(3): 105-130.

Berry, J. (2006) *Offshoring Opportunities: Strategies and Tactics for Global Competitiveness*, Hoboken, NJ: John Wiley and Sons.

Cusumano, Michael A., and Richard W. Selby. *Microsoft Secrets: How the World's Most Powerful Software Company Creates Technology, Shapes Markets, and Manages People*. New York: Free Press, 1995.

[3] Beyond these considerations related to our specific survey, perceptual measures are widely accepted in organizational research (Lawrence and Lorsch, 1986) as valid measures, and have begun to appear in leading IS journals since the mid-nineties (e.g., Tallon et al., 2000). Moreover, various studies indicate that qualitative survey responses by knowledgeable professionals are good surrogates for objective measures on topics ranging from IT strategy (Venkatraman and Ramanujam, 1987), to performance (Delone and McLean, 1992); to IT business value (Tallon et al., 2000), to IT productivity (Grover et al., 1998), to business and IT strategic alignment (Broadbent and Weil, 1993).

Dedrick, J., Carmel, E., and Kraemer K.L. (2010) A dynamic model of offshore software development, *Journal of Information Technology*, 25 (Advanced online publication on January 12, 2010).

Dedrick, J., Kraemer, K.L., Carmel, E., and Dunkle, D. (2010). Strategic orientation in the globalization of software firms. Fourth Annual Global Sourcing Workshop, Zermatt, Switzerland.

Dibbern, J., Goles, T., Hirschheim, R., and Bandula, J. (2004) Information systems outsourcing: a survey and analysis of the literature, *Database for Advances in Information Systems* 34(4): 6-102.

Dibbern, J., Winkler, J., and Heinzl, A. (2008) Explaining variations in client extra costs between software projects offshored to India, *Management Information Systems Quarterly* 32(2): 333-366.

DiRomualdo, A., and Gurbaxani, V. (1998) Strategic Intent for IT Outsourcing, *Sloan Management Review* 39(4): 67-80.

Friedman, T. (2005). It's a Flat World After All. New York Times Magazine. April 3. http://www.nytimes.com/2005/04/03/magazine/03DOMINANCE.html accessed December 28, 2010.

Hoch, Detlev J., Cyriac R. Roeding, Gert Purkert, and Sandro K. Lindner. *Secrets of Software Success: Management Insights from 100 Software Firms Around the World.* Boston: Harvard Business School Press, 2000.

Lacity, M. C. and Willcocks, L. P. (2001). *Global Information Technology Outsourcing: In Search ofBusiness Advantage*, Chichester: Wiley.

Lacity, MC, and Rottman, JW (2008) *Offshore Outsourcing of IT Work*, England: Palgrave Macmillan.

Lewin, AY, Massini, S., and Peeters, C. (2009) Why are companies offshoring innovation? The emerging global race for talent, *Journal of International Business Studies* 40(6): 901-925.

Metters, R. (2008). A typology of offshoring and outsourcing in electronically transmitted services. *Journal of Operations Management*. 26(2) 198-211.

Miles, T. (2010), Software and IT services industry data. Washington D.C., Office of Technology and Electronic Commerce, Manufacturing and Services, Department of Commerce. Powerpoint presentation.

National Research Council (2006) *Software, Growth, and the Future of the U.S. Economy*, Washington DC: National Academies Press.

Oza, N., and Hall, T. (2005) Difficulties in Managing Offshore Software Outsourcing Relationships: An empirical Analysis of 18 High Maturity Indian Software Companies, *Journal of Information Technology Case and Application Research* 7(3): 25-41.

Porter, M. (1986) *Competition in Global Industries*, Boston, MA: Harvard Business School Press.

Porter, M. (1996) What is strategy? *Harvard Business Review* 74(6): 61-77.

Rouse, AC (2009) Is there an 'information technology outsourcing paradox?' in R. Hirschheim, A. Heinzl, and J. Dibbern (eds.) *Information Systems Outsourcing: Enduring themes, new perspectives and global changes*, Heidelberg: Springer. pp. 129-146.

Sahay, S., Nicholson, B., and Krishna, S. (2003) *Global IT Outsourcing: Software Development Across Borders*, Cambridge, UK: Cambridge University Press.

Sturgeon, T.J. (2002). Modular Production Networks: A New American Model of Industrial Organization, *Industrial and Corporate Change*,11:3: 451-496.

Tallon, P., Kraemer, K.L., and Gurbaxani, V. (2000) Executives perspectives on the business value of information technology, *Journal of Management Information Systems* 16(4): 145-173.

Tanriverdi, H., Konana, P., and Ge, L. (2007) The choice of sourcing mechanisms for business processes, *Information Systems Research* 18(3): 280-299.

Thursby, J. and Thursby, M. (2006) "Why Firms Conduct R&D Where They Do." *Research Technology Management* 49, no. 3 http://www.proquest.com/ (accessed January 10, 2011).

U.S. Census (2010). Firms and establishments: 2000-2007 County business patterns databases, and Census services annual survey and quarterly services survey. Washington, DC.

Williamson, OE (1975) *Markets and Hierarchies: Analysis and Antitrust Implications*, New York: Free Press.

Willcocks, L.P. and Lacity, M.C. (1995) Information systems outsourcing in theory and practice, *Journal of Information Technology* 10(4): 203-207.

Willcocks, L.P. and Lacity, M.C. (2006) *Global Sourcing of Business and IT Services*, England: Palgrave Macmillan.

Appendix A: Shortened version of questionnaire items

Offshoring choice

This dependent variable is constructed from responses to the following five related questionnaire items. The steps in construction of the variable are described in Appendix B.

Q8 How many full-time equivalent (FTE) software developers do you have in all of your company's/business unit's in-house locations? Include both employees and contract workers. By software developers we mean anyone involved in analysis, design, coding, testing, implementation or maintenance.

Q9 If you outsource software development, please give your best estimate of how many full-time equivalent software developers are employed by your outsourcing providers on your behalf?

Q10 Do you have software development activities outside of the U.S. through your own subsidiaries, joint ventures, or in an outsourcing relationship?

Q12 Out of a total of 100%, what percent of your in-house software developers (including contractors) are located outside the U.S.?

Q13 And, again, out of a total of 100%, what percent of your outsourced software developers are located outside the U.S.?

Strategic motivation

On a scale of 1 to 5 where "1" means "unimportant" and "5" means "important", please rate how important in the past two years the following have been in your company's/business unit's business rationale for conducting software development outside the U.S.

Reduce labor cost	1	2	3	4	5
Need for labor force flexibility	1	2	3	4	5
Need to be close to our customers	1	2	3	4	5
Gain access to local markets	1	2	3	4	5

Offshore Performance

Market success

To what extent have the following increased or decreased as a result of locating development outside the U.S.?

Competitive position	1	2	3	4	5
Revenue generated from new products	1	2	3	4	5
Speed of product development	1	2	3	4	5
Software quality	1	2	3	4	5
Customer service levels	1	2	3	4	5

Cost savings

What percent cost savings has your company/business unit achieved from conducting software development outside the U.S.?

Process Maturity

On a scale of 1 to 5 where "1" means "strongly disagree" and "5" means "strongly agree", please indicate the extent to which you agree or disagree with the following statements.

There are many exceptions to development rules and procedures in our company. (Reverse coded)	1	2	3	4	5
Our software development processes are mature.	1	2	3	4	5
Our software is well documented.	1	2	3	4	5
We can easily assess performance of our software development process.	1	2	3	4	5
There is seldom any change in our development process.	1	2	3	4	5

Product Modularity

On a scale of 1 to 5 where "1" means "strongly disagree" and "5" means "strongly agree", please indicate the extent to which you agree or disagree with the following statements.

Making changes to one part of our software affects many other parts. (Reverse coded)	1	2	3	4	5
Our software is easily divided into discrete modules.	1	2	3	4	5

Appendix B: Construction of Variables

Sourcing Choice

Construction of the dependent variable starts with the number of inhouse FTEs from **Q8** and the number of outsourced FTEs from **Q9** in Appendix A.

Then **Q10** asks if the respondent has any development work offshore.

*If **Q10** is yes, **Q12** asks what fraction of the **Q8** inhouse developers are offshore. From this we calculate FTEs inhouse-onshore and inhouse-offshore for those firms that have some offshoring.*

*If **Q10** is yes, **Q13** asks what fraction of the **Q9** outsourced developers are offshore. From this we calculate FTEs outsourced-onshore and outsourced-offshore for those firms that have some offshoring.*

*If **Q10** is no, then all of the FTEs from **Q8** and **Q9** are considered onshore with zero FTEs offshore.*

We then used the FTE counts to calculate fractions in each of the above four sourcing options. For example:

$$fraction_{inhouse,onshore} = \frac{FTE_{inhouse,onshore}}{FTE_{inhouse,onshore} + FTE_{outsourced,onshore} + FTE_{inhouse,offshore} + FTE_{outsourced,ofshore}} \quad (2)$$

These fractions were then translated into logits using Equation (1). If a fraction is zero then its logit would be $-\infty$. We coded such entries as -7 (the most negative uncensored logit was -6.557). Similarly, if a fraction is one then its logit would be $+\infty$. We coded such entries as +7.

Maturity Factor

Table B1. Principal Components Analysis

Questionnaire items	**Maturity**
Many exceptions to development rules	-0.484
Development processes are mature	0.825
Software is well-documented	0.749
Easily assess process performance	0.737
Seldom changes to development process	0.526
Eigenvalue	2.295
% of variance	45.91

N = 252

Modularity Factor

Table B2. Principal Components Analysis

Questionnaire items	**Modularity**
Changes to software affect many parts	-0.791
Software easily divided into modules	0.791
Eigenvalue	1.252
% of variance	62.58

N = 250

Appendix C: Alternative specifications

For completeness and to demonstrate that our results are not driven by the logit transformation nor the Tobit estimator, we provide versions of Model I and Model II using classic ordinary least squares (OLS) regression as well as OLS estimates of logit-transformed dependent variables without the correction of a Tobit estimator. The results are qualitatively similar in all specifications, but the results reported in the main paper are best justified on theoretical grounds.

The results in Table C1 are based on classic OLS linear regression. Higher international sales are associated with more captive offshore development, with a one-standard-deviation increase in international sales increasing the fraction of development performed in captive centers by 0.088. This increase is mirrored by decreases in onshore development.

Our measure of process maturity is associated less offshore outsourcing, indicating that some firms who choose offshore outsourcing may be motivated by the opportunity to leverage vendors' maturity. Firms with higher revenue per employee outsource more of their development work.

Packaged software firms tend to perform about 14% more development offshore than programming service firms. Smaller firms tend to develop in-house and onshore while larger firms tend to develop at captive centers (in-house and offshore).

Table C1: Development Sourcing (all firms, using raw fractions)

	Model I(e)	Model I(f)	Model I(g)	Model I(h)
Estimation Method	Ordinary Least Squares			
Dependent Variable	Fraction Inhouse & Onshore	Fraction Outsourced & Onshore	Fraction Inhouse & Offshore	Fraction Outsourced & Offshore
Observation	Firm			
International sales (fraction)	-0.396*** (0.106)	-0.048 (0.047)	0.426*** (0.082)	0.018 (0.057)
Productivity (revenue per employee)	-0.110 (0.150)	0.145** (0.066)	-0.226* (0.117)	0.191** (0.081)
Process maturity	0.019 (0.021)	0.000 (0.009)	0.006 (0.016)	-0.025** (0.011)
Product modularity	0.036* (0.021)	-0.012 (0.009)	-0.010 (0.017)	-0.014 (0.012)
Packaged software (dummy)	-0.136*** (0.044)	-0.007 (0.019)	0.083** (0.034)	0.060** (0.024)
Firm size (employees/1000)	-0.037** (0.103)	-0.002 (0.008)	0.028** (0.013)	0.011 (0.009)
Intercept	0.943*** (0.044)	0.022 (0.020)	0.047 (0.079)	-0.013 (0.024)
R^2	0.249	0.052	0.254	0.172

Note: Standard errors in parentheses. * indicates $p < 0.10$, ** indicates $p < 0.05$, and *** indicates $p < 0.01$

The results in Table C2 reflect a standard OLS regression except that the dependent variable has been transformed using the logit function in (1). Because a zero would map to negative infinity and a one would map to positive infinity, we coded these values as -7 and +7, respectively. These endpoints have higher absolute values than any non-zero, non-one value in our dataset.

The interpretation of a coefficient is the horizontal change in Figure 3 a unit change in the independent variable. For example, the fraction sourced inhouse and onshore by a packaged software firm (SIC 7372) is 1.878 units to the left of a comparable programming services firm while the fraction sourced by a packaged software firm from offshoring outsourcing vendors is 0.888 units to the right. The mean fraction of onshore inhouse development is 0.731 on the vertical scale, which is equivalent to 1.000 on the horizontal scale. A shift of 1.878 units to the left yields a horizontal measure of -0.878 and a matching fraction of 0.294. Table C2 reports effects that are qualitatively similar to those in Table C1 except that the effect of revenue per employee is weaker.

Table C2: Development Sourcing (all firms, using logit transforms)

	Model I(i)	Model I(j)	Model I(k)	Model I(l)
Estimation Method	Ordinary Least Squares			
Dependent Variable	Logit of Inhouse & Onshore	Logit of Outsourced & Onshore	Logit of Inhouse & Offshore	Logit of Outsourced & Offshore
Observation	Firm			
International sales (fraction)	-5.038*** (1.232)	-0.091 (0.890)	6.267*** (1.101)	2.466** (0.997)
Productivity (revenue per employee)	0.202 (1.750)	1.722 (1.264)	-3.507** (1.564)	1.915 (1.416)
Process maturity	0.299 (0.243)	-0.224 (0.175)	0.017 (0.217)	-0.455** (0.196)
Product modularity	0.454* (0.250)	-0.185 (0.180)	-0.366 (0.223)	-0.264 (0.202)
Packaged software (dummy)	-1.878*** (0.509)	-0.129 (0.368)	1.218*** (0.455)	0.888** (0.428)
Firm size (employees/1000)	-0.338* (0.200)	0.388 (0.144)	0.438** (0.179)	0.116 (0.162)
Intercept	5.017*** (0.517)	-6.195*** (0.373)	-5.783*** (0.462)	-6.609*** (0.418)
R^2	0.280	0.041	0.310	0.185

Note: Standard errors in parentheses. * indicates $p < 0.10$, ** indicates $p < 0.05$, and *** indicates $p < 0.01$

Table C3 returns to classic OLS regression applied to the subsample of firms that perform at least some development offshore. For this subsample, we have survey data on strategies, obstacles and performance relative to onshore development. The obstacle factor was not statistically significant in any of our specifications, perhaps due to the fact that our subsample consists entirely of firms who "overcame the obstacles" and initiated offshore development.

The familiar effect of international sales pushing development to captive centers is again evident, as is the tendency for packaged software firms to employ offshore outsourcing vendors. Also, firms with high productivity tend toward offshore outsourcing and away from captive offshore development. The inclusion of the two strategies causes nearly every other explanatory variable to lose significance in the OLS regression. Firms with an operational focus source more of their development from offshore locations.

Table C3: Development Sourcing (offshoring firms, using raw fractions)

	Model II(e)	Model II(f)	Model II(g)	Model II(h)
Estimation Method	Ordinary Least Squares			
Dependent Variable	Fraction Inhouse & Onshore	Fraction Outsourced & Onshore	Fraction Inhouse & Offshore	Fraction Outsourced & Offshore
Observation	Firm			
International sales (fraction)	-0.264** (0.119)	-0.013 (0.041)	0.358*** (0.112)	-0.082 (0.080)
Productivity (revenue per employee)	0.043 (0.181)	-0.021 (0.063)	-0.351** (0.170)	0.328*** (0.121)
Process maturity	0.017 (0.027)	-0.012 (0.009)	0.022 (0.025)	-0.027 (0.018)
Product modularity	0.037 (0.029)	-0.020* (0.010)	-0.004 (0.027)	-0.013 (0.019)
Market access strategy	-0.037 (0.026)	-0.002 (0.009)	0.042* (0.030)	-0.004 (0.017)
Operations strategy	-0.107*** (0.027)	0.001 (0.009)	0.063** (0.025)	0.043** (0.018)
Packaged software (dummy)	-0.109* (0.060)	0.003 (0.021)	0.035 (0.057)	0.071* (0.040)
Firm size (employees/1000)	-0.018 (0.020)	0.001 (0.007)	0.020 (0.019)	-0.003 (0.014)
Intercept	0.771*** (0.066)	0.027 (0.022)	0.185*** (0.062)	0.017 (0.044)
R^2	0.295	0.103	0.240	0.245

Note: Standard errors in parentheses. Excluded group for firm size is >5000 employees. * indicates $p < 0.10$, ** indicates $p < 0.05$, and *** indicates $p < 0.01$

The results in Table C4 reflect a standard OLS regression except that the dependent variable has been transformed using the logit function in (1). Because a zero would map to negative infinity and a one would map to positive infinity, we coded these values as -7 and +7, respectively. These endpoints have higher absolute values than any non-zero, non-one value in our dataset. The interpretation of a coefficient is the horizontal change in Figure 3 from a unit change in the independent variable. This transformation leaves intact international sales' impact on captive development and revenue per employee's impact on shifting offshore development toward offshoring. However, the effects of product modularity have vanished.

Firms with an operational focus source less of their development from onshore inhouse developers and more from offshore outsourcing vendors. Packaged software firms develop less from onshore inhouse developers, but it is not clear to where they shift this work.

Table C4: Development Sourcing (offshoring firms, using logit transforms)

	Model II(i)	Model II(j)	Model II(k)	Model II(l)
Estimation Method	Ordinary Least Squares			
Dependent Variable	Logit of Inhouse & Onshore	Logit of Outsourced & Onshore	Logit of Inhouse & Offshore	Logit of Outsourced & Offshore
Observation	Firm			
International sales (fraction)	-1.618* (0.885)	0.020 (1.046)	4.141*** (1.299)	0.368 (1.287)
Productivity (revenue per employee)	1.034 (1.342)	0.705 (1.587)	-5.244*** (1.970)	3.726* (1.953)
Process maturity	0.129 (0.199)	-0.359 (0.235)	0.266 (0.292)	-0.476 (0.289)
Product modularity	0.337 (0.211)	-0.225 (0.250)	-0.465 (0.310)	-0.143 (0.308)
Market access strategy	-0.201 (0.191)	0.010 (0.226)	0.588** (0.280)	-0.241 (0.279)
Operations strategy	-0.679*** (0.201)	0.032 (0.237)	0.326 (0.295)	0.644** (0.292)
Packaged software (dummy)	-0.876*** (0.448)	-0.157 (0.530)	-0.028 (0.657)	0.278 (0.651)
Firm size (employees/1000)	-0.064 (0.151)	0.063 (0.179)	0.317 (0.222)	-0.160 (0.220)
Intercept	1.553*** (0.486)	-6.028*** (0.575)	-2.742*** (0.713)	-4.913*** (0.707)
R^2	0.256	0.066	0.244	0.179

Note: Standard errors in parentheses. * indicates $p < 0.10$, ** indicates $p < 0.05$, and *** indicates $p < 0.01$