Outsourcing and Market Thickness: The Case of U.S. Credit Unions

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Abstract

This paper examines the role of market size as a determinant of market transaction costs using microdata on the IT outsourcing of U.S. credit unions. Taking advantage of cross-vendor variation of client information, we distinguish the effects of two explanations on an observed positive relationship between outsourcing and market thickness: (1) market transaction costs are lower in thicker markets, and (2) economies of scale in an vendor's production make outsourcing more attractive in thicker markets. We construct an estimation strategy based on a model of a coalitional game, in which a trade-off between market transaction costs and scale economy determines credit unions' equilibrium outsourcing decisions. To measure market thickness, we exploit the variation of credit union size and location, which characterize their IT requirements and are determined mostly at the time of their openings. Our estimation results show that, even after controlling for the effect of scale economies, a sizable effect of market thickness remains to explain credit unions' outsourcing decisions, indicating a significant role that market thickness plays in reducing transaction costs. In particular, apart from the effects of scale economies, an an increase in market thickness in terms of credit union size by one standard deviation raises the credit union's outsourcing probability by 16 percentage points (from 30% to 46%) on average.

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1 Introduction

What determines firm boundaries? A series of works since Williamson[1] suggest that outsourcing is more costly than internal transaction when a transaction involves more relation-specific investments (Klein et al. (1978)). Many empirical studies support this hypothesis,[2] reporting a negative relationship between outsourcing and the degree of specificities associated with transactions. Hubbard (2001) further shows evidence that outsourcing replaces in-house production more often when more firms require similar inputs. The production for goods in such a thick market, by definition, incurs less specific investments, which is, in turn, considered to lower market transaction costs.

These studies on outsourcing, however, often abstract the role of production technology at upstream and downstream firms. In this paper, we explicitly control for the effects of production technology on procurement outcomes in testing whether market transaction costs is lower in thicker markets.

Production technology is considered as a main factor for firms' outsourcing decisions. Marshall (1920) and Stigler (1951) address that, in the presence of scale economies, thicker markets provide upstream firms with greater scale advantage, which would, in turn, make outsourcing more cost-efficient for downstream firms. Such a view has also been one interpretation on an empirical finding of a positive relationship between outsourcing and market thickness (Ciccone and Hall, 1996; Holmes,1999; and Ono, 2008).

In this paper, we untangle the above two channels of market thickness effects on outsourcing. In particular, we control for the effects of production technology on outsourcing. We then examine, free of the effects of production technology, to what extent outsourcing increases with market thickness. By doing so, we avoid overestimating the market thickness effects on transaction costs, if indeed scale economies give upstream firms more advantage. Of course, it is possible that some factors prevent downstream firms from taking full advan-

[1] See Williamson (1985) and Williamson (1975).

[2] For example, see Monteverde and Teece (1982) and Masten (1984).

tage of the scale economies at upstream firms.

We investigate our question by examining IT procurements of U.S. credit unions. Credit unions use either in-house or outsource*d data-processing (DP)* systems to manage financial transaction records. With the in-house DP system, credit unions perform DP in-house with their own IT staffs and hardware using licensed software. With the outsourced DP system, the entire DP system resides at a vendor's site, and vendors perform DP using their own IT staffs, their own hardware, and software they have developed.

Our data come from the National Credit Union Administration (NCUA) Call Report. It covers essentially all federally insured U.S. credit unions and provides various information at the credit union level, including their outsourcing decisions. Based on our data, about 30 percent of the credit unions outsource their DP, and the rest perform it in-house. Unlike other data used to study outsourcing, our data tell us not only credit unions' outsourcing decisions, but also with which vendors they contract. This allows us to observe the variation of credit union characteristics across vendors. That is, we can control for the scale of a vendor's production as well as other characteristics of its clients. No data used in the past research on outsourcing allows us to control for these variables. We take advantage of this novel feature of the data to control for the effects of outsourcing in reexamining the effects of market thickness to lower transaction costs.

Based on our field study, credit union size indicates various factors determining kind and complexity of DP required by each credit union. For example, small credit unions demand easy-to-operate systems to compensate for their lack of experts on information security and compliance. In contrast, while large credit unions are better staffed to handle security and compliance, they require a more flexible IT system, for example, to differentiate their financial products from others and to introduce new financial products in a timely basis. Vendors require specific investments to service credit unions of particular size, which would segment the DP market. Another factor that may segment the market may be location. For example, in order to perform customer relationship management (CRM), a part of DP often performed by core-processing vendors, vendors need knowledge specific to a client's local market such as the nature of local competition and community characteristics. By narrowing the service area, a vendor could save fixed costs, including the travel costs for face-to-face communications and promotions.[3]

Using size and location as two possible factors segmenting a DP market for credit unions, we measure market thickness by the densities of these two credit union characteristics. Because credit unions are regulated to operate in markets specified in an application process, credit unions' size and location are more or less determined prior to their outsourcing decisions. This makes the data on credit unions appealing for our analyses. Our first order observation shows that outsourcing has a clear positive association with credit union size density, while a simple correlation does not show a clear pattern with the spatial density. We explain more details in Sections 2 and 4.

In order to clarify the mechanisms behind outsourcing decisions, we present *a* model in which credit unions play a coalitional game. Credit unions perform DP either by themselves (i.e., in-house) or perform it with some other credit unions through an IT vendor (i.e., outsourcing). In our model, a vendor is a mere unit of a coalition comprised of multiple credit unions, and each of these credit unions bears a fraction of the total expense for DP procurement. In contrast, a credit union choosing in-house DP is a coalition of only itself and is solely responsible for the expense.

More specifically, we define two types of costs for procuring DP: (1) DP costs and (2) market transaction costs. DP costs represent the expense to process data including the expense for servers, that for security systems, and the salaries of system engineers. The DP costs of a credit union that performs DP in-house depend only on its own characteristics. In contrast, the costs of DP at a vendor depend on the characteristics of all the credit unions in the same coalition (vendor) such as their scale and similarity. Market transaction costs are incurred only when credit unions outsource DP. Transaction costs result, for example,

[3] According to Rapport (2010), some vendors participate in conferences held by local credit union leagues or hold conferences themselves to maintain lasting client relationships and to promote their new services.

from legal disputes and needs for monitoring[4] and represent all the expenses incurred to a coalition due to a lack of ability to write complete contracts between credit unions and vendors. in-house DP does not incur such costs, while it precludes a possibility for credit unions to take advantage of larger scale from a joint production. The tradeoff between the benefits of joint production (i.e., economies of scale) and market transaction costs determines each credit union's outsourcing decision.

We define an equilibrium of our model as a set of coalitions and an allocation of expenses in the coalition that satisfy the following three conditions. First, no vendors have an incentive to attract a member of the other coalitions. Second, no credit unions that outsources DP has an incentive to switch to in-house DP. Finally, every credit union outsourcing DP bears at least the incremental costs or additional expenses due to its participation in a coalition, *ceteris paribus*.

By exploiting the above equilibrium conditions, we estimate both a DP cost function and a market transaction cost function. A main obstacle of our estimation is the lack of price and cost data.[5] We overcome this difficulty by deriving necessary conditions for an equilibrium described only by characteristics of coalitions and credit unions and not by prices or costs. As we show later, such necessary conditions indicate that, in an equilibrium, every credit union should be choosing a procurement option (in-house DP or outsourced DP to a particular vendor) that incurs the lowest incremental cost, taking other credit unions' decisions as given. We apply these conditions into a conventional discrete choice framework and estimate the parameters by nested logit analyses.

In our estimation, the cross-vendor variation in the characteristics of clients allows us to identify the parameters of the DP cost function. The variation in outsourcing decisions across credit unions left unexplained by this estimated DP cost function identifies the parameters

[4] As Shi and Susarla (2010) stressed, IT systems often require modifications after an initial installment, which also incurs costly renegotiation or otherwise results in an inefficient level of service.

[5] While the data include some information of expenses as used in Knittel and Stango (2007), the DP costs are not reported separately from other operating expenses, and, more importantly, such accounting information does not reflect market transaction costs.

of the transaction cost function. The identification of the parameters for market transaction cost function relies on our assumption that DP technology is common for all the coalitions, including the credit unions performing DP in-house.

The contribution of our paper is summarized as follows. First, while examining market thickness effects on transaction costs, we explicitly allow a possibility that a positive relationship between market thickness and outsourcing is explained by production technology alone. Second, among many empirical studies on outsourcing, this paper is the first to incorporate explicitly a possibility for firms' outsourcing decisions to interdepend on each other. This complements theoretical literature on outsourcing that has already addressed such an interdependency (Grossman and Helpman (2002)).[6] Third, this paper contributes to the growing literature on the estimation of matching game. In particular, our paper adds an example of estimating coalition games to a work by Weese (2010) on Japanese municipalities mergers and that by Byrne (2010) on mergers among cable television companies in Canada.[7] Our paper is the first to apply the empirical framework of matching games to study a firm's make-or-buy decisions. Fourth, this paper proposes an empirical framework that allows us to examine the nature of market transaction costs based only on information on the match between downstream firms and upstream firms. In particular, our framework does not require cost data of any kind. Finally, our paper is the first to use a market thickness measure besides geographic density to explore the role of market thickness in determining transaction costs.

The rest of the paper proceeds as follows. Section 2 provides an overview of credit unions' DP procurement decisions. Section 3 documents our data. Section 4 presents our model on the match between credit unions and vendors. Section 5 explains our estimation strategy. Section 6 reports the results of our estimation, and Section 7 concludes.

[6] In his empirical application, Fox (2008) studies matching between downstream firms (automobile assemblers) and upstream firms (suppliers of automobile parts) where the attractiveness of each match may depend on other firms' matches. Fox's paper only considers the parts that are outsourced. Our paper is different from his paper in this respect.

[7] There is large empirical literature on two-sided matching games. See Ho (2009), Fox (2008), and Park (2010) for examples of such studies.

2 Credit Unions and DP Procurements

2.1 Background

Credit unions are nonprofit cooperative institutions that provide financial services to their own shareholders called members. Membership is limited to a group, or multiple groups, each of which is defined by a common bond of occupation (e.g., navy, teachers), association (e.g., churches), or geographical area such as a well-defined neighborhood, community (e.g., county), and rural district.[8] While some credit unions offer minimal services (e.g., checking and saving accounts), others provide more advanced products such as variable rate loans, credit cards, and mortgages.

As cooperatives, most credit unions have a board of directors elected by members. These directors are often volunteers[9] and do not engage in daily operations. Instead, they designate daily operations to executive teams comprised of professional managers.[10] To give these managers an incentive to work for the benefit of members, bonuses are often linked to earnings, board evaluations, and loan growth (Bankston (2007)).

2.2 The Core Processing System

Information technology plays a crucial role in modern credit unions. Recording financial transactions, managing online banking and webpages, and securing data all require intense use of information technology. Among the various IT systems, a core processing system is essential, maintaining a credit union's fundamental functions as a financial institution. Its function includes recording members' information and financial transactions, processing loan applications, managing credit cards, and preparing documents to comply with regulation.

[8] http://www.ncua.gov/Resources/RegulationsOpinionsLaws/charter_manual/2003CharteringandFOMManual.pdf (as of May, 2011)

[9] Only one of the board members is allowed to be paid.

[10] According to Bankston (2007), the average base salary of the chief executive officers operating medium-size credit unions ($10 million to $19.0 million in total assets) was $72,947 in 2007. The salaries of the CEOs of very large credit unions ($1 billion or more in total assets) in the same year exceeded $400,000.

This core processing system is also a key for marketing. In particular, it is used to perform data analysis for better pricing strategies and promotions. This function is often called Customer Relationship Management (CRM) and is considered critical for a credit union's survival (Knittel and Stango (2007)).[11]

2.3 Procurement Forms

The core processing systems for most credit unions take one of the following two forms: a vendor-in-house system and an on-line service bureau system.[12] Credit unions choosing a vendor-in-house system manage their core systems by themselves. Typically, credit unions purchase software from vendors[13] and use it with their own hardware[14] maintained by their own IT professionals. Although their system is based on commercial software, some credit unions customize the software. In contrast, with on-line service bureau systems, credit unions outsource their DP to vendors. In this case, the entire system, including data storage, resides at a vendor's site. Vendors are responsible for maintaining both hardware and software. These credit unions access their data through terminals (often PCs) via the Internet.[15]

2.4 Outsourcing vs. In-house production

An obvious advantage of outsourcing over in-house production is greater scale economies. By outsourcing DP, credit unions can share various fixed costs, including those for hardware, IT professionals, data backup, and data security (eCU technologies (2005)). By relying on

[11] For example, calculating the return on investment (ROI) for a specific investment requires software and examination as to whether it is tightly aligned with the CU's particular product. The CU may also examine a specific product penetration and which specific members are responding. By doing so, many CUs decide whom to target, which members should benefit from waived fees, and which members should be let go (Source: Credit Union Magazine (March 1, 2005.) "CRM success depends more on strategy than software.")

[12] Other possible formats include a paper-based manual system and a credit-union-developed in-house system. In 2010, credit unions using these formats account for less than 2 percent of the credit unions in the U.S.

[13] The origin of the name "vendor-in-house" comes from this particular nature.

[14] In case of the so-called the turn-key system, vendors sell credit unions hardware that comes with preinstalled with their own account software. By using hardware that is chosen by vendors, credit unions can avoid incompatibility risk.

[15] Virtual Private Network (VPN) is often used to secure their transferred data.

vendors' scale, credit unions can benefit from the up-to-date systems in terms of both IT technology as well as regulations. In addition, outsourcing also allows credit unions to lower organizational costs due to bureaucracy and internal politicking.[16]

Outsourcing,however, is considered to incur additional costs and risks associated with market transactions. For example, based on a survey of companies including financial institutions,[17] Wright (2004) points to security, total dependence, and legal consequences as important risks firms face when outsourcing their information systems. In the case of DP transaction between a credit union and a vendor, the credit union may face security risks when it is hard to monitor its vendor's compliance with predetermined security standards. In addition, a credit union's total dependence on its vendor runs the risk of being held up. For example, a vendor may prioritize a large client's needs, and a small credit union might have to wait for a long time before a vendor fixes its system.[18] In another example, a vendor might limit adjusting its service or software for credit unions with specific needs. Finally, the costs to write and enforce contracts with vendors can be considerable. Credit unions may need to bear significant legal expense to check and negotiate the contents of contracts. Vendors also face such costs and risks. For example, a system development for a particular credit union may make its vendor vulnerable to the opportunistic behavior of the credit unions. These costs increase the total costs of outsourcing, which would discourage the realization of outsourcing contracts, while all such costs would be allocated between credit unions and the vendor in accordance with the price for DP.

Among factors determining the above benefits and costs of outsourcing, we take a closer look at the role of market thickness. With more credit unions requiring similar DP, the market transaction costs may become lower. For example, a specialist service to lower costs of contracting and monitoring could be supported by the large number of similar credit

[16] Several papers (Scharfstein, 1998; Shin and Stulz, 1998) have used such ideas to explain observed inefficiencies in internal capital markets. A model showing weakened incentives of agents for in-house production is formally formulated in Hart and Moore (1990); without having ownership of non-human assets, each agent in in-house production has less incentive to invest in human capital.

[17] The survey also asks firms in the health insurance industry and large retailers.

[18] Such temporal specificities are also pointed out in Pirrong (1993).

unions. At the same time, such a thicker demand may make it possible for vendors to enjoy greater scale economies and lower prices.

Considering credit union size as one factor characterizing required DP services, credit unions of a typical size (medium size in our sample) may enjoy the above benefits from being in a thicker segment of the market. Both very small and very large credit unions, which are in thin segments of the market, may face difficulties in finding reasonable specialist aids for contracting that meet their specific needs. The scale economy benefits for vendors to cover such markets would also be low. As we mentioned above, credit unions of different size categories require different DP needs, each of which would require some fixed costs. Credit union location is another factor characterizing required DP services. In a denser local market with more credit unions, more specialist services for contracting can be supported. Vendors may also find it more beneficial to cover these markets as they may enjoy more scale economies, applying location-specific knowledge to many credit unions.

In our empirical examinations, as a measure of market thickness, we use credit union densities in terms of the above two credit union attributes. Note that, as we show later in more details, credit union size is also used to represent the scale of in-house DP in our study. The in-house DP of a small credit union may suffer from its small size.[19] Note also that some may be concerned by that credit union characteristics, and therfore the market thickness measures based on credit union size and location may be affected by their outsourcing decisions. Credit unions, however, often have to operate within an initially defined market, as regulated non-profit organizations. In fact, an applicant for federal credit unions has to define their operations including the location and the territory as well as the field of membership in its early stage.[20]

[19] Small credit unions do not, however, contribute much to increasing a vendor's scale. Thus, it is not clear whether a vendor offers prices lower than the costs of in-house DP.

[20] http://www.ncua.gov/Resources/RegulationsOpinionsLaws/charter_manual/2003CharteringandFOMManual.pdf (as of May, 2011)

3 The Data and Descriptive Analysis

3.1 NCUA Data

Our main data source is the National Credit Union Administration (NCUA) Call Report in March 2010. The NCUA is the federal agency that oversees credit unions in the U.S. and requires all federally insured credit unions to report various information on a quarterly basis.[21] Our data set is based on this mandatory report and provides various information, including credit unions' locations, membership numbers, assets, and types of financial services offered. Most important to our study, the data also report whether or not credit unions outsource their DP and, if they do, the names of their vendors. We use this information to identify all credit union clients for each vendor.[22] This allows us to compare credit union characteristics across vendors. Dropped from our data are outlier credit unions including those with no more than 100 members and those that do not lend at all (See Appendix for details of our cleaning procedure.) This reduces the sample by 10% and leaves us with 7,149 credit unions.

3.2 Summary Statistics of the Credit Unions

Table 1 reports the summary statistics of the credit unions in our sample. Credit unions vary significantly in their size. The median-sized credit union serves 3,000 members, while the top 5 percentile serve more than 50,000 members, and the bottom 5th percentile, no more than 300 members. A similar tendency is found using total assets as an alternative measure for size. The size distribution is skewed, which is reflected in a mean about four times as large as the median. Larger credit unions also tend to have more assets per member and offer more kinds of financial products (see also Figure 1 showing the size distribution of credit unions by the number of product offerings.) Table 2 presents the percentage of credit

[21] According to the NCUA Website, more than 90 percent of the credit unions in the U.S. are federally insured.

[22] While some vendors have non-credit union clients (e.g., commercial banks, hospitals), they often offer a different service line for such clients. We consider only DP for credit unions.

Table 1: Summary statistics of credit unions characteristics

		Mean	S.D	5th	25th	50th	75th	95th
N. of members	All CUs	12.1	51.4	0.3	1.2	3.0	9.0	50.6
(in thousands)	CUs w/ in-house DP	14.1	60.0	0.3	0.9	2.4	9.8	61.9
	CUs outsourcing	7.3	19.1	0.8	2.1	4.0	8.2	21.0
Assets	All CUs	118.3	610.5	0.9	5.8	19.0	68.0	500.2
(in millions)	CUs w/ in-house DP	142.7	720.1	0.7	4.0	13.9	72.0	679.4
	CUs outsourcing	61.9	176.0	3.5	12.8	28.9	62.8	190.6
Assets per member	All CUs	7.1	4.6	2.1	4.3	6.3	8.7	14.2
(in thousands)	CUs w/ in-house DP	6.8	4.0	1.9	4.0	6.0	8.5	13.9
	CUs outsourcing	7.7	4.6	3.1	5.1	6.8	9.0	14.9
N. of financial products	All CUs	5.9	3.3	1.0	3.0	6.0	9.0	11.0
	CUs w/ in-house DP	5.5	3.5	1.0	2.0	5.0	9.0	11.0
	CUs outsourcing	6.9	2.6	2.0	5.0	7.0	9.0	11.0

Notes: Authors' calculations based on NACU data. The total sample size is 7,149. Among them, 4,992 credit unions choose in-house production, while 2,157 credit unions outsource. Financial products include auto loans, credit cards, fixed rate mortgages, adjustable rate mortgages, hybrid/balloon mortgages, home equity loans, home equity lines of credit, share certificates, IRAs, and money market shares.

unions offering each financial product. Starting with checking and saving accounts, credit unions increment their product offerings from a basic product, such as auto loans, to a more sophisticated product, such as variable rate mortgages.[23]

Among credit unions in our data, about 30 percent outsource their DP, while the rest perform DP in-house. The size of credit unions is distinctly different between those performing DP in-house and those outsourcing DP, suggesting that size is a key factor for a credit union's outsourcing decision. While the credit unions performing DP in-house are smaller than those outsourcing DP in terms of their average size, their sizes are more diverse. The standard deviation of the size of the credit unions performing DP in-house is three times as

[23]Most basic services after saving and checking accounts seem to be auto loans (99 percent of credit unions in our data offer auto loans,) then share certificates, and then IRAs. Variable rate mortgage seems to be the most sophisticated among the products we observe. Only 9 percent of credit unions in our data offer this product.

Table 2: Percentage of credit unions offering each financial product products

Loan products	(%)	Share products	(%)
Auto loan	97.7	Share draft certificate	80.2
Home equity	60.7	IRA	67.7
Fixed-rate mortgage	57.9	Money market	46.3
Credit card loan	54.0		
Home equity line of credit	49.9		
Business loan	28.3		
Adjustable-rate mortgage	26.2		
Balloon/hybrid mortgage	25.7		

Notes: Authors' calculations based on NACU data.

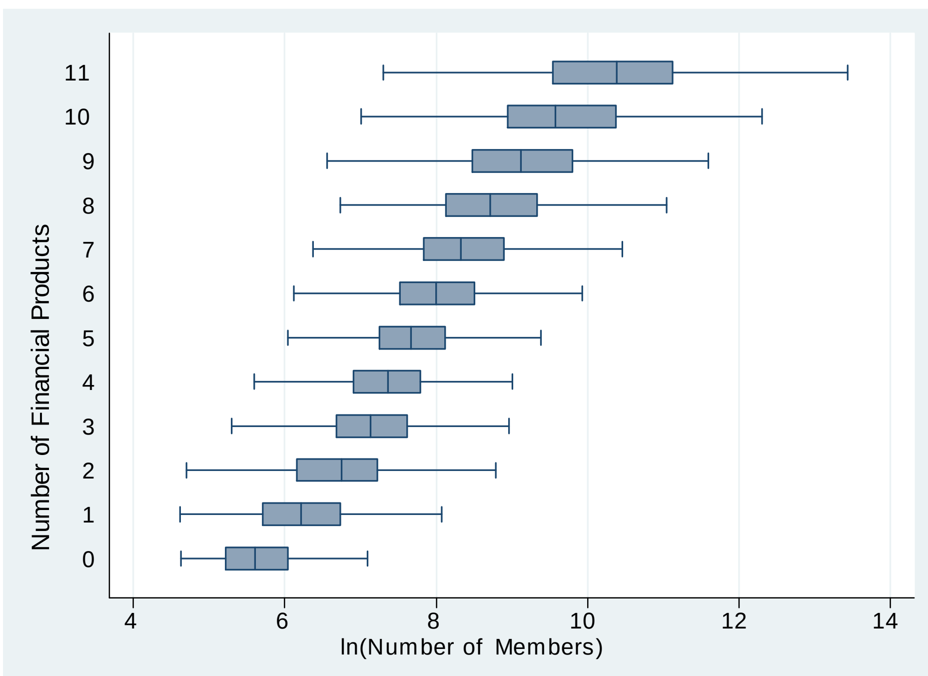

Figure 1: Size distribution of credit unions by the number of financial products

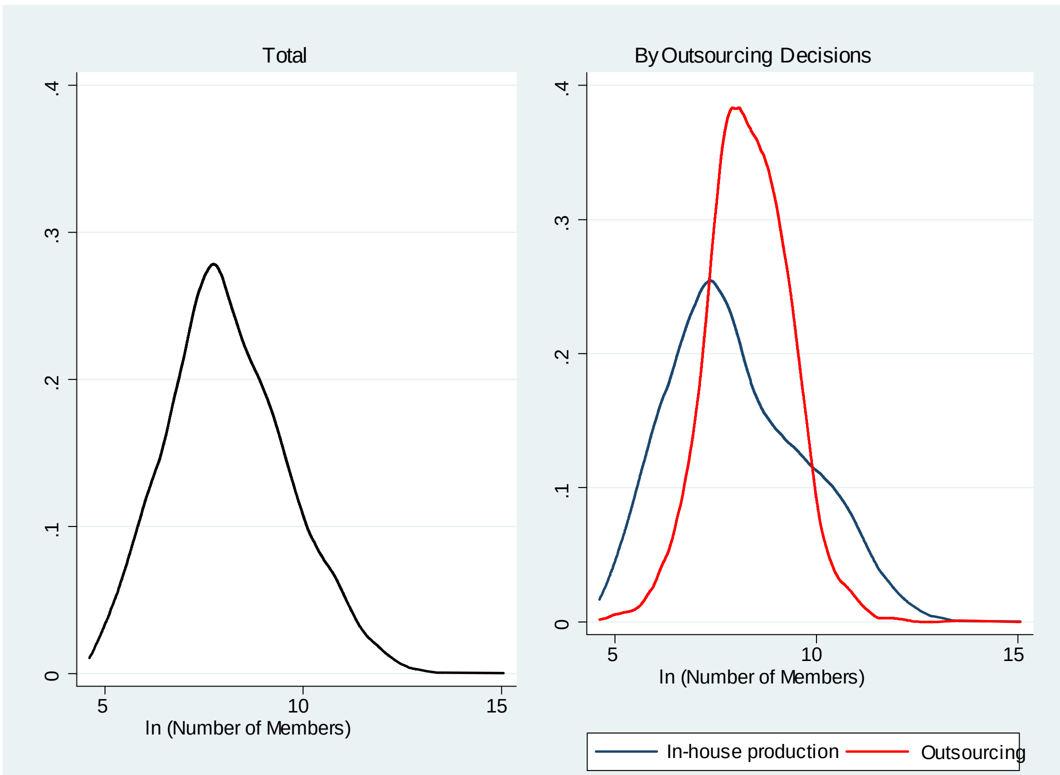

Figure 2: Size distributions of credit unions

large as that of credit unions outsourcing their DP in terms of both the number of members and assets. Figure 2 presents the size distribution of the credit unions based on kernel density estimates for the logged number of members. The left panel for all credit unions shows a more diverse distribution as compared to the right panel for the credit unions outsourcing their DP. The same tendency was found with the distributions in terms of asset size. This possibly reflects lowered transaction costs for medium-sized credit unions, which are in a thicker segment of the market. We test if such is the case after we control for the role of production technology.

To measure the thickness of a market segment, we use the kernel density of credit union size. While we use the word "segment" for exposition, in reality, the DP market does not exhibit discrete segments. The market is rather continuous in the sense that diversifying the kinds (size and location) of credit unions to service is possible even though it may increase fixed costs. We consider that a vendor chooses a range of credit union diversity rather than making a discrete choice on a market "segment." Using the density around each credit union (both in terms of size and location), we can capture the potential savings of fixed costs with continuous measures.

The left panel of Figure 3 shows the predicted outsourcing probability based on kernel regression of outsourcing decisions on a size density; the graph is based on the size density in terms of the number of members, while we observe the same tendency with the size density in terms of assets. Clearly, the density of credit union size is positively associated with outsourcing probability. The right of the figure shows the predicted outsourcing probability based on kernel regression of outsourcing decisions on a spatial density; we use the number of credit unions within 60 miles of each credit union as a spatial density. The figure does not show a clear pattern between the spatial density and outsourcing decisions; the same was true with slightly different measures such as the number of credit unions within 30 miles and within 90 miles. It is possible that geography does not matter much for DP transactions. Unlike the industries studied in Hubbard (2001) and Pirrong (1993), the DP

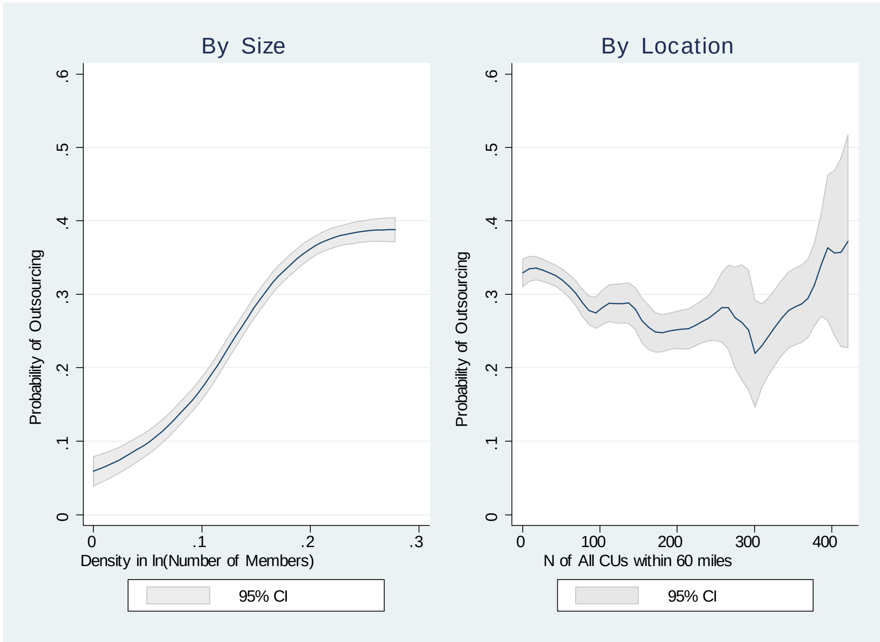

Figure 3: Predicted probability of outsourcing

transactions studied in our paper may not require considerable area-specific investments as vendors perform DP remotely.

3.3 Summary Statistics of the Vendors

Table 3 reports the summary statistics of the 19 vendors in our sample.[24] On average, a vendor serves 44 credit unions that have the total of 190,000 members. The DP market for credit unions is concentrated. The largest vendor (FISERV) services more than 50 percent, and the four largest vendors (FISERV, HFS, JACK HENRY and CU*ANSWERS) cover 75 percent of the credit unions outsourcing their DP. The Herfindahl-Hirshman Indice is about 0.3, whether it is based on the number of clients, the total number of members, or total assets.

Among the vendors, however, some are small, servicing as few as eight credit unions. Such vendors may be overcoming their small scale by specializing in credit unions of a particular

[24]See Appendix for the full list of these 19 vendors.

Table 3: Summary statistics of vendors

	Mean	Std. Dev.	5th	25th	50th	75th	95th
Number of clients	119.8	259.3	8.0	17.0	43.5	112.0	1135.0
Total number of members	875.1	1,902.9	11.2	49.4	192.2	1,008.0	8,213.9
Total assets	7,414.5	16,022.2	41.1	315.0	1,463.5	8,209.3	69,023.6

Notes: Authors' calculations based on the NACU data. The total sample size is 18. The total number of members is in thousands, while the total assets are in millions of dollars. Number of clients is the number of credit unions a vendor services. Total sizes is the sum of the number of members of its clients. Adjusted Herfindhal-Hirschman Index is the product of the number of clients and Herfindhal-Hirschman index. This Herfindahal-Hirschman Index is based on the number of members.

kind. To measure such specialization, we quantify the similarity among credit unions served by the same vendor by the fraction of "similar" credit union pairs of all possible pairs among them. We also calculate such an index in terms of credit union locations. We define a pair of credit unions "similar" in terms of size if the larger of the pair does not exceed twice the size of the smaller, and "similar" in terms of location if the distance between the pair is less than 60 miles.[25]

The two panels in Figure 4 plot the relationship between vendors' scale and these similarity measures. The negative correlation shown in the left panel indicates that a smaller vendor's clients are less diverse in terms of size.[26] Such a clear pattern does not, however, seem to exist between vendor scale and the spatial proximity of credit unions as shown in the right panel. Yet the panel does show that some vendors do concentrate in certain geographic areas. By specializing in supporting credit unions in a certain area, a vendor may be able to reduce area-specific fixed costs.

Figure 5 shows the spatial distribution of the credit unions contracting with CU*ANSWERS and HFS, which are clustered in different areas. This contrasts with the fairly dispersed dis-

[25] We use the longitude and latitude corresponding to each credit union's zip code to calculate distances.

[26] To check if this negative correlation is due to a statistical artifact, we regress the similarity measure on vendors' sizes as well as their numbers of their clients. The coefficient for vendors' sizes is still negative and significant, while the coefficient for the number of clients is not statistically significant even at the 10 percent level.

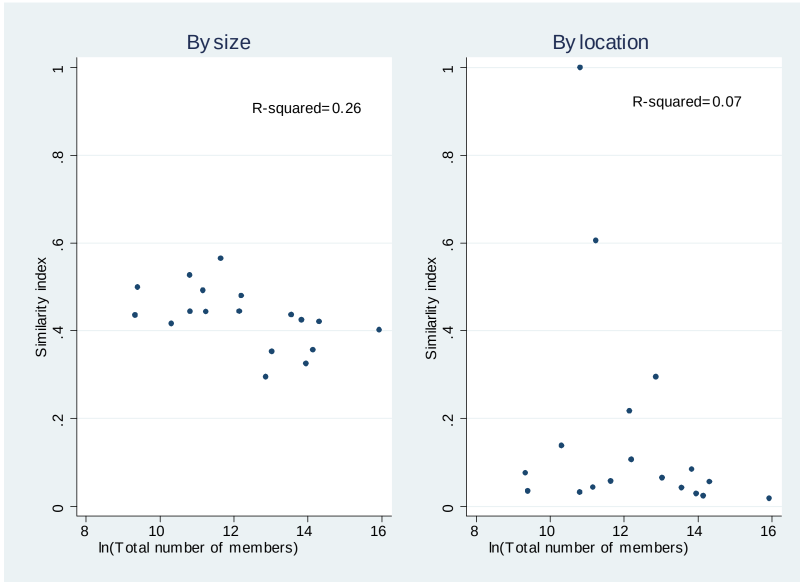

Figure 4: Relationship between a vendor's scale and the similarity of its clients

tribution of all 4,992 credit unions outsourcing DP. Table 4 shows location quotients of vendors (i.e., the ratios of an area's share of the credit unions using a particular vendor to that of all credit unions) for each area, which takes one when the spatial distribution of a vendor's credit unions is proportional to that of overall credit unions. This does not seem to be the case for most vendors. The credit unions using CU*ANSWERS are concentrated in the East-North Central area four times as much as all credit unions outsourcing. While the East-North Central area represents only 18 percent of all the credit unions outsourcing DP, it represents 74 percent of the credit unions contacting with CU*ANSWERS. Analogously, the credit unions using JACKHENRY are concentrated in New England four times as much as overall credit unions. Such geographical clustering may reflect economies that a vendor achieves by specializing in a particular area. This seems to suggest that vendors have at least some incentive to specialize in terms of location, possibly to limit fixed entry costs.

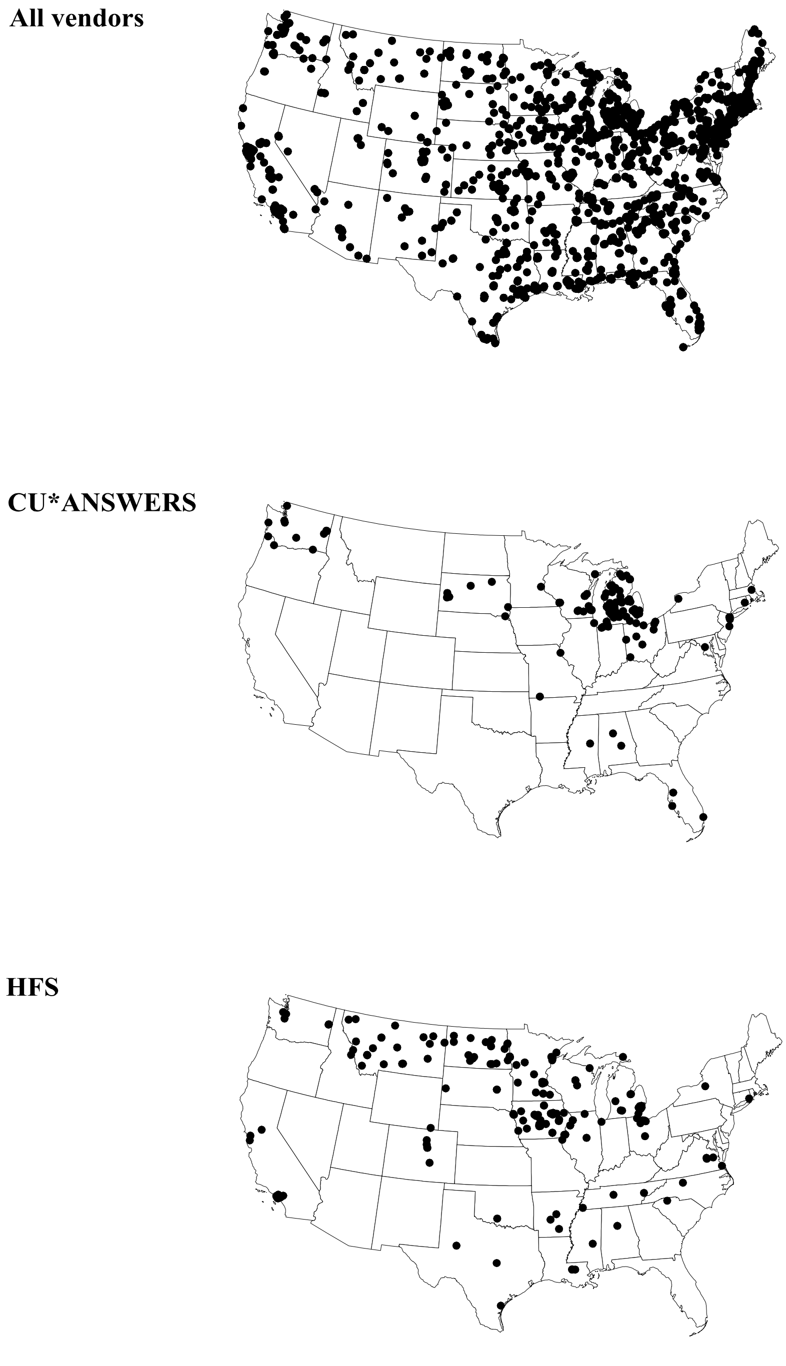

Figure 5: Geographical distributions of credit unions for selected vendors

Table 4: Location Quotient in terms of the count of credit unions

Region	New England	Middle Atlantic	South Atlantic	E. N. Central	W. N. Central	E. S. Central	W. S Central	Mountain	Pacific
AMIS		8.02							
CBS			6.36			1.01			0.73
CONNECTICUT-ONLINE	5.69	3.59		0.19			0.31		
CU*ANSWERS	0.17	0.29	0.21	3.98	0.49	0.28			0.95
CU NATION		2.00	3.76			1.63	1.14		
DATAMATIC				5.41					
EPL			0.76	0.16	0.11	7.20	0.53	1.74	1.51
ESP	0.76	0.52	0.24	2.44			2.35	0.64	0.92
FIDELITY	0.67	1.36	0.85	0.92	0.72	0.25	1.72	1.88	0.89
FISERV	0.92	1.50	1.35	0.73	0.55	1.05	1.10	0.67	1.21
HFS	0.06	0.04	0.22	0.81	3.55	0.33	0.50	3.18	1.04
INTECH	0.48				5.01	0.27	0.37	4.08	0.39
JACK HENRY	4.06	0.17	1.30	0.89	0.42	0.72	0.38	1.24	0.78
OPEN SOLUTIONS	2.00	0.07	1.14	2.03	0.27	1.05	0.49	0.71	0.84
SHARE ONE	0.69		0.88	0.32	0.45	5.38		2.35	1.67
SHARETECH		1.72		3.09			1.30	1.43	
SYSTRONICS				0.21	6.26		1.32		
TOTAL1							9.10		

Notes: Authors' calculations based on NACU data. The total sample size is 7,149. The nice area divisions we used are those defined by the U.S. Census Bureau. The New England division includes Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont; the Middle Atlantic division includes New Jersey, New York, and Pennsylvania; the East North Central division includes Illinois, Indiana, Michigan, Ohio, and Wisconsin; the West North Central division includes Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota; the South Atlantic division includes D.C. Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, and West Virginia; the East South Central division includes Alabama, Kentucky, Mississippi, and Tennessee; the West South Central division includes Arkansas, Louisiana, Oklahoma, and Texas; the Mountain division includes Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming; the Pacific division includes Alaska, California, Hawaii, Oregon, and Washington

4 The Model

In this section, we construct an equilibrium coalition model in which every credit union performs DP either by itself (i.e., in-house) or by forming a coalition with some other credit unions (i.e., outsourcing). A trade-off between scale economy and market transaction costs determines each credit union's outsourcing decision in an equilibrium.

4.1 Primitive

The economy consists of N credit unions. Let $j \in \{1, \ldots, N\}$ denote credit union j. A $K \times 1$ vector $\mathbf{x}_j \in \mathbb{R}^K$ represents credit union j's characteristics that are observable to econometricians. Define a vendor as a coalition that involves more than one credit union. Let $\mathcal{A}_i$ denote a set of credit unions that belong to vendor i. For notational convenience, we also use $\mathcal{A}_0$ to denote a set of credit unions that choose in-house production.

4.2 Cost Function

We specify that DP outsourcing incurs two type of costs: (1) DP costs and (2) market transaction costs. DP costs represent essential expenses to process data such as those for hardware and salaries of IT professionals. Market transaction costs represent any expense that arises due to a credit union's lack of ability to write complete contracts. Examples include legal expense and monitoring costs. Any costs that arise regardless of the needs of contracts are categorized in DP costs.

Let $C(\mathcal{A}_i)$ denote the DP costs for jointly processing the data of the credit unions in $\mathcal{A}_i$. We specify $C(\mathcal{A}_i)$ as

$$C(\mathcal{A}_i) \equiv FC_{DP} + f(\mathcal{A}_i)' \boldsymbol{\beta} - \sum_{j \in \mathcal{A}_i} \epsilon_{ij}, \tag{1}$$

where FC_{DP} is the fixed costs, and $f(\mathcal{A}_i)$, with a slight abuse of notation, is a $L \times 1$ vector of summary statistics of the credit unions in $\mathcal{A}_i$. $\boldsymbol{\beta}$ is a $L \times 1$ parameter vector, and $-\epsilon_{ij}$ is random components of costs unobservable to econometricians.[27] Let τ_j denote the market transaction costs incurred by credit union j's transaction in a market. We specify τ_j as a linear function of observable characteristics of credit union j, given by

$$\tau_j \equiv FC_{TC} + \mathbf{z}_j' \boldsymbol{\gamma}, \tag{2}$$

where FC_{TC} is fixed costs, $\mathbf{z}_j$ is a vector of observable characteristics of credit union j, and γ is a parameter vector. Some characteristics of credit union j may appear in both $\mathbf{x}_j$ and $\mathbf{z}_j$. The total cost to process jointly the data of all the credit unions in $\mathcal{A}_i$ is the sum of DP costs and market transaction costs of these credit unions, which is written as

$$C(\mathcal{A}_i) + \sum_{j \in \mathcal{A}_i} \tau_j. \tag{3}$$

In contrast, in-house DP does not incur market transaction costs and incurs only DP costs, which depends solely on the characteristics of the credit union.[28] We write the total costs of credit union j choosing in-house DP (i.e., $j \in \mathcal{A}_0$) as[29]

$$C(\{j\}). \tag{4}$$

Note that these specifications for costs reflect our assumption that both vendors and credit unions have access to the same technology and hence the same DP cost function $C(\cdot)$, which serves as an important identification assumption as we explain details later.

[27]The minus sign before ϵ_{ij} is put for notational convenience.

[28]It is possible that in-house DP production also incurs the costs, which would not arise in a joint production. Examples of such costs include ones due to bureaucracy or internal politicking. In our model, τ_j represents market transaction costs net of such costs.

[29]The summary statistics of the characteristics of a credit union may be different from the characteristics themselves. For example, the variance of total asset is zero when $\mathcal{A}$ is a singleton.

4.3 Profit Function

Consider a credit union j that belongs to a vendor i. Let p_{ij} denote a fee or transfer that credit union j owes to vendor i. We allow the prices to be different across the credit unions even when they outsource their DPs to the same vendor. Vendor i's profit is written as

$$\sum_{j \in \mathcal{A}_i} p_{ij} - C\left(\mathcal{A}_i\right) - \sum_{j \in \mathcal{A}_i} \tau_j. \tag{5}$$

4.4 Equilibrium

We characterize an equilibrium of this economy by equilibrium coalitions, $\{\mathcal{A}_i^*\}_{i=0}^{M^*}$, and equilibrium prices, $\left\{\{p_{1j}^*\}_{j \in \mathcal{A}_1^*}, \{p_{2j}^*\}_{j \in \mathcal{A}_2^*}, \cdots, \{p_{M^*j}^*\}_{j \in \mathcal{A}_M^*}\right\}$, such that

1. $\{\mathcal{A}_i^*\}_{j=0}^{M^*}$ is a partition of $\{1, 2, \ldots, N\}$,

2. For any vendor $i' \in \{1, \ldots, M^*\}$,

$$\sum_{j \in \mathcal{A}_{i'}^*} p_{i'j}^* - C\left(\mathcal{A}_{i'}^*\right) - \sum_{j \in \mathcal{A}_{i'}^*} \tau_j \geq 0 \tag{6}$$

3. For any pair of vendors i' and $i'' \in \{1, \ldots, M^*\}$ with $i' \neq i''$, and for any credit union $j'' \in A_{i''}^*$,

$$\begin{aligned} & \sum_{j \in \mathcal{A}_{i'}^*} p_{i'j}^* - C\left(\mathcal{A}_{i'}^*\right) - \sum_{j \in \mathcal{A}_{i'}^*} \tau_j \\ \geq \; & \left(\sum_{j \in \mathcal{A}_{i'}^*} p_{i'j}^* + p_{i''j''}^*\right) - C\left(\mathcal{A}_{i'}^* \cup \{j''\}\right) - \left(\sum_{j \in \mathcal{A}_{i'}^*} \tau_j + \tau_{j''}\right) \end{aligned} \tag{7}$$

4. For any vendor $i' \in \{1, \ldots, M^*\}$ and for any credit union $j'' \in A_0^*$,

$$\begin{aligned} & \sum_{j \in \mathcal{A}_{i'}^*} p_{i'j}^* - C\left(\mathcal{A}_{i'}^*\right) - \sum_{j \in \mathcal{A}_{i'}^*} \tau_j \\ \geq & \left(\sum_{j \in \mathcal{A}_{i'}^*} p_{i'j}^* + C\left(\{j''\}\right) \right) - C\left(\mathcal{A}_{i'}^* \cup \{j''\}\right) - \left(\sum_{j \in \mathcal{A}_{i'}^*} \tau_j + \tau_{j''} \right) \end{aligned} \tag{8}$$

5. For any vendor $i' \in \{1, \ldots, M^*\}$ and for any credit union $j' \in A_{i'}^*$,

$$\begin{aligned} & \sum_{j \in \mathcal{A}_{i'}^*} p_{i'j}^* - C\left(\mathcal{A}_{i'}^*\right) - \sum_{j \in \mathcal{A}_{i'}^*} \tau_j \\ \geq & \left(\sum_{j \in \mathcal{A}_{i'}^*} p_{i'j}^* - p_{i'j'}^* \right) - C\left(\mathcal{A}_{i'}^* \setminus \{j'\}\right) - \left(\sum_{j \in \mathcal{A}_{i'}^*} \tau_j - \tau_{j'} \right) \end{aligned} \tag{9}$$

6. For any vendor $i' \in \{1, \ldots, M^*\}$ and for any credit union $j' \in A_{i'}^*$

$$p_{i'j'}^* \leq C\left(\{j'\}\right). \tag{10}$$

The first condition means that, in an equilibrium, every credit union must process its data either by itself or jointly with other credit unions by contracting with one of the vendors. The second condition means that, for any vendor, the total payment of the credit unions in a given vendor must exceed the total costs in an equilibrium. The third and fourth conditions mean that, in an equilibrium, no vendor can increase its profit by attracting a credit union that is not currently its client. Here we assume that, in order for a vendor to attract clients of other vendors, the vendor should not charge more than the fees that the credit unions are currently charged. The fifth condition means that no vendor can increase its profit by terminating a contract with one of its clients. The sixth condition means that no credit union outsourcing its DP in an equilibrium has an incentive to switch to in-house production. Note that this equilibrium defined here prohibits only particular types of deviation, unlike the core, which prohibits any kind of deviation. We do not use the core as an equilibrium concept because coordination failure may actually occur in this market.[30]

4.5 Minimum Incremental Cost Condition

By combining these six equilibrium conditions, we obtain two inequality conditions:

$$
\begin{aligned}
\forall j' \;&\in\; A_{i'}^{*} \text{ with } i' \neq 0 \text{ and } \forall i'' \in \{1,..,M^{*}\} \text{ with } i'' \neq i' \\
&\begin{cases} C\left(\mathcal{A}_{i'}^{*}\right) - C\left(\mathcal{A}_{i'}^{*} \setminus \{j'\}\right) \leq C\left(\mathcal{A}_{i''}^{*} \cup \{j'\}\right) - C\left(\mathcal{A}_{i''}^{*}\right) \\ C\left(\mathcal{A}_{i'}^{*}\right) - C\left(\mathcal{A}_{i'}^{*} \setminus \{j'\}\right) + \tau_{j'} \leq C\left(\{j'\}\right) \end{cases} \qquad (11)
\end{aligned}
$$

$$
\begin{aligned}
\forall j' \;&\in\; A_{0}^{*}, \\
&C\left(\{j'\}\right) \leq C\left(\mathcal{A}_{i'}^{*} \cup \{j'\}\right) - C\left(\mathcal{A}_{i'}^{*}\right) + \tau_{j'} \;\; \forall i' \in \{1,..,M^{*}\}. \qquad (12)
\end{aligned}
$$

Inequality condition (11) implies that, if a credit union j, which outsources DP to vendor i in an equilibrium, were to switch to vendor i'', the costs saved at vendor i' are smaller than the incremental costs at vendor i''. The condition also implies that if instead credit union j' were to perform DP in-house, the costs saved at vendor i' would be smaller than the costs of in-house DP net of the market transaction costs, which is not incurred for in-house DP. Inequality condition (12) implies that, if credit union j', which performs DP in-house in an equilibrium, were to outsource DP to vendor j', the additional costs at vendor j' plus the market transaction costs would be greater than the in-house costs of credit union j. These inequality conditions imply that, in an equilibrium, every credit union, whether it outsources or performs DP in-house, should be choosing the option with the lowest incremental cost, taking all other credit unions' choices as given.[31] Any set of coalitions that violates this condition cannot be an equilibrium, because at least one credit union has an incentive to deviate from it.

These inequality conditions are appealing for the following two reasons. First, they

[30] Note that this equilibrium concept still contains the core as a special case.

[31] Note that, for in-house production, its incremental cost is equal to its DP cost.

allow us to estimate the model without having access to price data, which is proprietary for most cases, if not all. Second, we do not have to specify a bargaining mechanism between vendors and credit unions. The above inequalities only require that equilibrium prices fall between the lowest and the second lowest incremental cost among all the possible options. The difference between these two incremental costs is the surplus to be allocated between a credit union and its vendor. The equilibrium conditions of this model do not specify how to allocate this surplus. This feature of the condition is valuable, because the information on surplus allocation is not available in much data including ours.

5 Estimation

We estimate the parameters of both DP cost and transaction cost functions by applying the inequality conditions (11) and (12) to the data. In particular, we use the fact that these conditions are observationally equivalent to the optimal conditions of the conventional discrete choice framework.[32]

5.1 Nested Logit Estimation

Suppose we have data from N credit unions, some of which outsource their DP to one of M vendors. We estimate the parameters of the model by maximizing the likelihood that the observed coalitions are stable. Inserting (1) and (2) to the inequality conditions (11) and

[32] Note that these equilibrium conditions do not exactly correspond to the optimal conditions of the conventional discrete choice framework. In our model, the inequalities (11) and (12) are not optimal conditions of credit unions' decisions, but equilibrium conditions. Incremental costs themselves are not necessarily equal to the amount corresponding credit unions bear in an equilibrium. Rather, they merely represent the lower bound of such amount.

(12) and multiplying them by -1, we have

$$
\begin{aligned}
\forall j' &\in A_{i'} \text{ with } i' \neq 0 \text{ and } \forall i'' \in \{1, .., M\} \text{ with } i'' \neq i' \\
&\begin{cases}
-\left(f\left(\mathcal{A}_{i'}\right) - f\left(\mathcal{A}_{i'} \backslash \{j'\}\right)\right)\boldsymbol{\beta} + \epsilon_{i'j'} \\
\qquad \geq -\left(f\left(\mathcal{A}_{i''} \cup \{j'\}\right) - f\left(\mathcal{A}_{i''}\right)\right)\boldsymbol{\beta} + \epsilon_{i''j'} \\
-\left(f\left(\mathcal{A}_{i'}\right) - f\left(\mathcal{A}_{i'} \backslash \{j'\}\right)\right)\boldsymbol{\beta} - FC_{TC} - \mathbf{z}_j'\boldsymbol{\gamma} + \epsilon_{i'j'} \\
\qquad \geq -FC_{DP} - f\left(\{j'\}\right)\boldsymbol{\beta} + \epsilon_{0j'}
\end{cases} \\
\forall j' &\in A_0 \text{ and } \forall i' \in \{1, .., M\} \\
&\begin{cases}
-f\left(\{j'\}\right)\boldsymbol{\beta} - FC_{DP} + \epsilon_{0j'} \\
\qquad \geq -\left(f\left(\mathcal{A}_{i'} \cup \{j'\}\right) - f\left(\mathcal{A}_{i'}\right)\right)\boldsymbol{\beta} - FC_{TC} - \mathbf{z}_j'\boldsymbol{\gamma} + \epsilon_{i'j'}.
\end{cases}
\end{aligned} \tag{13}
$$

These inequality conditions coincide with the optimal conditions of the conventional discrete choice model. In our specification, a random component that influences a credit union's choice enters linearly the cost specification for each option Thus, while each credit union's choice is influenced by other credit unions' decisions, the random components influencing other credit unions' decisions are cancelled out in the above inequality conditions. As a result, a random component influencing the credit union's choice is only the one associated with its own costs for each choices.

We estimate the parameters of the model by the nested logit (McFadden (1978)). The model has two branches. One branch consists of in-house production only, while the other branch consists of the alternatives of M vendors. We allow some correlation between the random components associated with costs to outsource DP, while we assume these random components are independent of the random component associated with the costs of in-house production. We specify a vector of random components $\{\epsilon_{0j}, \epsilon_{1j}, \cdots, \epsilon_{Mj}\}$ as a random draw from the following generalized extreme value distribution:

$$
F\left(\epsilon_{0j}, \epsilon_{1j}, \cdots, \epsilon_{Mj},\right) = \exp\left(-\exp\left(-\epsilon_{0j}\right) - \left(\sum_{i=1}^{M} \exp\left(-\frac{\epsilon_{ij}}{\rho_1}\right)\right)^{\rho_1}\right). \tag{14}
$$

In our implementation, $f(\mathcal{A})$ consists of measures for the scale of a vendor's DP operation and for the similarity of the vendor's clients. As proxies for a vendor's scale, we use the sum of the number of its clients' members, the sum of its client's assets, and the number of clients. To specify $f(\mathcal{A})$ using these variables, it would be ideal to use a flexible specification such as high-order polynomials. Here we at least include the squared term of the number of clients. As a proxy for the diversity of a vendor's clients, we use the indices introduced in Section 3.3. For the definitions of these variables, see Table 8 in the Appendix.

To specify the market transaction cost function, as elements of z_j, we use the three market thickness measures described in Section 3. We also include credit unions' sizes and state fixed effects. Larger credit unions may require more complex contracts, which may increase transaction costs. Market transaction costs may also depend on state-specific factors such as local credit union leagues, legal systems, or regulation.

5.2 Identification

Identification of the parameters of the DP cost function, β, comes from the cross-vendor variation of client characteristics. Our equilibrium condition indicates that a credit union outsourcing their DP should be contracting with the vendor with whom its incremental cost would be the lowest, taking all other credit unions' choices as given. The nested logit method estimates the value of β, so that, taking other credit unions' choices as given, every credit union's observed vendor choice is most consistent with the equilibrium conditions. Once the DP cost function is esimtated, it is used for a comparison between the minimum possible DP costs from outsourcing and the in-house DP costs, which is a part of the nested logit procedure. This part relies on the assumption that the DP function is common between joint productions (vendors) and in-house productions. The variation in outsourcing decision left unexplained by cost comparison between outsourcing and in-house DP is used to estimate the market transaction cost function (i.e., the parameters for market thickness measures, γ) as well as the difference between the constant terms of the DP cost function and market transaction cost function (i.e., $FC_{DP} - FC_{TC}$).

Note that to identify market transaction cost function we also rely on our assumption that the market transaction costs for a particular credit union depend only on the credit union's characteristics. Note also that, in the estimation of DP cost function, we cannot identify all the elements of the costs. In particular, we cannot identify the parmeters of the vendors' characteristics that do not affect credit unions' outsourcing decisions, because such characteristics are irrelevant from the cross-vendor variation in their incremental costs[33]. This, however, does not influence our estimates for the parameters for market thickness measures.

6 Results

Table 5 reports our main estimation results. The DP production technology is controlled by the variables included to capture DP costs, which are estimated based on credit unions' vendor choice. The estimated DP cost function is then used to infer the in-house production costs. The outsourcing decisions left unexplained are then examined along with their association with the variables that capture market transaction costs. The first two columns are based on our base specification, where the second column includes state fixed effects for transaction costs. The third and fourth columns use only the number of members as a measure of credit union size as a specification of transaction costs. All estimation results support the use of nested logit over multinomial logit.

In our base model, after controlling for the effects of production technology, the parameter

[33]For example, suppose that the first element of $f(\mathcal{A}_i)$ is the sum of the total assets of all the credit unions in A_i. Then we have

$$f(\mathcal{A}_i) - f(\mathcal{A}_i \backslash \{j'\}) = \begin{bmatrix} \sum_{j \in \mathcal{A}_i} x_{j1} \\ \vdots \end{bmatrix} - \begin{bmatrix} \sum_{j \in \mathcal{A}_i \backslash \{j'\}} x_{j1} \\ \vdots \end{bmatrix} = \begin{bmatrix} x_{j'1} \\ \vdots \end{bmatrix},$$

where the first element of x_j (i.e., x_{j1}) is the asset of credit union j. We cannot identify β_1 because the resulting regressor x_{j1} does not vary across vendors. We can, however, identify β_1 if we take the logarithm of the sum of the assets (i.e,. $\ln\left(\sum_{j \in \mathcal{A}_i} x_{j1}\right)$).

Table 5: Nested Logit Estimates

	(1)	(2)	(3)	(4)
Market Transaction Cost (γ):				
Density measures [R Market thickness]				
N of members	-0.439^{**}	-0.469^{**}	-0.791^{**}	-0.853^{**}
	(0.070)	(0.073)	(0.051)	(0.051)
Assets	-0.563^{**}	-0.586^{**}		
	(0.079)	(0.083)		
Location	0.088^{**}	-0.095^{*}	0.099^{**}	-0.083^{*}
	(0.029)	(0.049)	(0.029)	(0.049)
Size of a Credit Union				
ln(N of members)	2.364^{*}	1.854^{*}	3.497^{**}	2.244
	(1.222)	(1.031)	(1.716)	(1.549)
ln(Assets)	0.584^{*}	0.600	-0.730^{**}	-0.627
	(0.344)	(0.381)	(0.321)	(0.277)
DP Cost (β):				
Vendor scale				
ln(Total N of members)	2.240^{*}	1.772^{*}	3.394^{**}	2.162
	(1.230)	(1.035)	(1.730)	(1.564)
ln(Total assets)	1.161^{**}	1.128^{**}	-0.303	-0.225
	(0.387)	(0.429)	(0.354)	(0.305)
ln(N of clients)	-59.786^{**}	-50.801^{**}	-53.597^{**}	-34.019
	(20.785)	(18.494)	(26.382)	(23.406)
$[ln(\text{N of clients})]^2$	14.753^{**}	12.536^{**}	13.216^{**}	8.391
	(5.112)	(4.547)	(6.494)	(5.764)
Within vendor similarity of CU characteristics				
% of CUs similar in N of members	0.958	0.810	1.607	1.044
	(1.508)	(1.301)	(1.498)	(1.112)
% of CUs similar in assets	-5.911^{**}	-4.977^{**}	-6.619^{**}	-4.301
	(2.392)	(2.101)	(3.189)	(2.932)
% of CUs within 60 miles	-44.397^{**}	-38.144^{**}	-40.547^{**}	-26.299
	(14.453)	(13.269)	(18.720)	(17.611)
Constant ($FC_{DP} - FC_{TC}$)	81.588^{**}	69.798^{**}	74.768^{**}	48.007
	(27.581)	(24.928)	(35.767)	(32.944)
State fixed effects on choices b/w outsourcing and performing DP in-house	No	Yes	No	Yes
Dissimilarity parameters in Nested logit in the second branch	0.366^{**}	0.311^{**}	0.323^{**}	0.208^{**}
	(0.126)	(0.112)	(0.161)	(0.143)
Log likelihood	-7828.794	-7535.024	-7854.763	-7560.804

Notes: Authors' calculations based on NACU data. State dummies are suppressed. The total sample size is 7,149. Estimates with ** and * are statistically significant at the 5 percent and the 10 percent level, respectively. For the dissimilarity parameter ρ_1, we test $H_0 : \rho_1 = 1$.

estimates of market thickness measures in terms of credit union size show negative and statistically significant (at the five percent level) relationship with credit unions' outsourcing decisions. This is consistent with the view that credit unions in thicker markets face less market transaction cost. Results were mixed for the market thickness measure in terms of credit union location. One factor that may contribute to the negative effects of such measure is the spillover of IT knowledge between credit unions. It is possible that such a spillover occurs, for example, through some conferences at state credit union leagues. If such spillover effects are, somehow, greater for in-house DP than for outsourced DP, it would lower outsourcing probabilities in the area with greater concentration of credit unions. With the specification that includes state fixed effects, we obtain negative and statistically significant coefficients. This seems to suggest that the spatial density of credit unions does reduce market transaction costs. In a spatially dense area, it is possible that service to lower such costs is readily available.

Table 6 reports the marginal effects of the market thickness on the probability of outsourcing. In our specification, these effects are considered to result from the lowered market transaction costs by greater market thickness. Based on the estimates in the second column of Table 5, when density in terms of a credit union's number of members increases by one standard deviation, the probability of outsourcing increases by 8.4 percentage points on average. The effect is large considering that the average predicted outsourcing probability is 0.302. The marginal effects of density in terms of asset are slightly larger. As compared to these effects, the magnitude of the effect of spatial density is smaller. An increase in the spatial density by one s.d. change increases the outsourcing probability by only 1.6 percentage points.

To make it easier to interpret the marginal effects of market thickness in terms of credit union size, we also estimate the model, including just one credit union size density. The results are shown in the last two columns of Table 5 . Based on these estimates, the one standard deviation increase in market thickness measure in terms of the number of members raises the probability of outsourcing by 16 percentage points, representing almost the sum of the effects the two density measures for credit union size.

Now, let us look at the estimates of DP cost function. As we explained above, by incroporating DP cost function in our analysis on outsourcing, we try to prevent its effects from being mixed with the effects of market thickness on transaction cost. While the parameters for vendor scale measures are rather difficult to interpret, our results in Table 5 clearly indicate that, for a given vendor scale, a vendor can lower DP cost by servicing more similar credit unions, *ceteris paribus*. The similarity measures both in terms of credit union size and location obtain negative and significant coefficients. This suggests that there are fixed costs for vendors to expand the type of credit unions they serve, and thus DP production is more efficient when a vendor specializes in a narrower and denser range of the market. Thus, credit unions in a denser market segment may have an incentive to outsource not only because of lower market transaction costs, but also because of greater scale economies at vendors.

Then, do we overestimate the effects of market thickness on transaction costs if we do not control for production technology? To answer this question, we also perform logit analyses on credit unions' outsourcing decisions without controlling for DP production costs and compare the coefficients of market thickness with those in Table 5. We find no evidence for underestimation; the coefficients for market thickness in the simple logit analyses are not statistically different from those in the nested logit where we control for the effects of DP production technology. This indicates that, at least for the DP market for credit unions, higher density does not necessarily lower a firm's incremental costs for outsourcing net of market transaction costs.

Table 6: The Average marginal effects on the probability of outsourcing

Market Thickness		
N. of Members	Assets	Location
0.084	0.106	0.016

Notes: The reported effects are the average change in the probability of outsourcing across the sample. Each credit union's predicted probability is calculated by taking other credit unions' observed choices as given.

7 Conclusion

This paper tests the effect of market thickness on market transaction costs by looking at the make-or-buy decisions of U.S. credit unions' IT procurement. In particular, we explicitly take into account the effect of market thickness on production costs to isolate its impact on market transaction cost. With the presence of fixed costs in servicing each market segment, scale economies at vendors would be greater in a denser market segment. This may also induce a positive correlation between market thickness and outsourcing decisions.

We take advantage of the data that allow us to observe within-vendor characteristics of their clients. This, combined with the information about which credit unions are choosing in-house production, is used to distinguish the effects of market transaction costs on their outsourcing decisions from that of scale economies at vendors. We characterize DP market segment by credit union size and location and measure the degree of market thickness based on these segments.

Our results show a strong negative relationship between market transaction costs and market thickness measured in terms of credit union size and in terms of credit union location. This was found even after taking into account the effect of production technologies. In fact, we found evidence for vendors' preference to serve similar credit unions, which implies the existence of the effect of scale economies on outsourcing. To the best of our knowledge, this paper is the first to isolate the effect of market thickness on market transaction costs by explicitly taking into account its effects on production costs.

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A Appendix: Data Cleaning Procedure

The NCUA call report (also referred to as the Freedom of Information Act (FOIA) 5300 data) collects the data of all federally-chartered and state-chartered credit unions that are federally insured as well as some non-federally insured credit unions. In March 2010, 7,631 credit unions reported to the NCUA. The non-federally insured credit unions not included in this data are fewer than 500.[34]

The information that the call report collects includes how credit unions procure their core-processing systems. Of the 7,631 credit unions in the NCUA call report, included in our study are 95 percent (7,267 credit unions) performing their core-processing either by an in-house system using licensed software or by completely outsourcing the system.[35] In the latter case, the call report collects the name of a data-processing vendor. The call reports also collect the name of a software company in the former case, while we do not use such information in our analysis in this paper as we focus on examining credit unions' procurement for data-processing service. After cleaning vendor name records, we exclude 75 credit unions that use a very small vendor or do not report their vendor's name. We further exclude 43 credit unions of rather atypical characteristics (e.g., fewer than 100 members; no loan outstanding). This leaves us with 7,149 credit unions.

We also made corrections to reported procurement types for one percent of credit unions. While a core-processing system of the most credit unions falls straightforwardly into the above-mentioned two procurement categories as defined by the NCUA,[36] some credit unions

[34] http://www.ncua.gov/About/FAQ.aspx#4 (downloaded in August, 2010)

[35] Thirty-one credit unions reported their procurement types as fully in-house (i.e., the credit union developed, and generally maintains, the software onsite. The credit union has responsibility for the hardware and software systems.) but also reported software company. We consider that their actual procurement type is "in-house with licensed software" and includ them in our study.

[36] The in-house system using licensed software is referred to as a vendor in-house system and is defined as "Vendor provides, and maintains the software program(s) required to track member data. This type of product is also called "turnkey" and in many cases is a complete accounting package (share, loan, general ledger, subsidiaries, teller operations, cash operations, etc.). In most cases, the credit union will install and maintain the hardware to run the software at its office(s). The vendor generally maintains control over software programming and provides updates, patches, fixes, and new releases on a regular or predetermined basis. In some cases, clients may request the vendor to customize the software for their particular needs." The system that is completely outsourced is referred to as a vendor online service bureau and is defined

misreport their procurement types when their core-processing is performed by small Credit Union Service Organizations (CUSOs) with which they are affiliated.[37]

Unlike most data-processing vendors, small CUSO core-processing vendors, such as CUONLINE and CUSOURCE, use software developed by other companies.[38] In such cases, we found that some credit unions report their procurement type as "in-house with licensed software," which we correct as "complete outsourcing."[39]

as "Hardware and software systems reside at the vendor's location with the exception of those systems a credit union requires in order to access and transmit data to the vendor. Most, if not all, data processing occurs at the vendor's site. Service bureau vendors generally provide reports (paper, electronic, microfiche, or other) on a regular basis. Connection is made to a service bureau through dial-up connections, private lines, the Internet, frame relay, or other WAN services. The service provided may be real-time (transaction post upon data entry) or batch processing (data is accumulated throughout a predetermined time period and then transmitted to the vendor for processing at predetermined intervals)."

[37] CUSOs are subsidiaries of credit unions and are permitted by NCUA regulations to perform certain financial and operational services that cannot be legally offered by credit unions. A typical goal of the CUSOs is to reduce costs by performing a service for multiple CUs. The permitted CUSO services include the sale of securities and insurance products, mortgage origination, data processing, and trust services.

[38] Large CUSO core-processors such as CU*Answer use their own developed software.

[39] Note that such credit unions also tend to report a software company as a data-processing vendor instead of their CUSO core processor. Our field research, based on trade magazines and correspondences with industry experts from Callahan & Associates, suggests that CUSO core-processors using licensed software cooperate with software companies as business partners, and the CUSO core-processors using the same software company's software do not generally compete over clients. As knowledge sharing and cooperation would occur through a software company for these small CUSO core-processors using licensed software, we use the total scale of credit unions processing data under the same company's software rather than the scale of the CUSO as the scale of data-processing operation.

Table 7: List of the DP Vendors

Name	# of Clients	Total Members	Total Assets
AMIS	18	494	315.0
CBS	13	11.2	41.1
CONNECTICUT ONLINE	29	383.7	4,583.2
CU*ANSWERS	140	1,008.0	8,209.3
CU NATION	8	12.0	70.8
DATAMATIC	9	29.8	246.3
EPL	69	452.5	3,147.9
ESP	31	113.1	827.0
FIDELITY	53	1,137.7	9,329.5
FISERV	1,135	8,213.9	69,023.6
HFS	201	1,374.6	13,191.6
INTECH	49	187.2	1,605.5
JACK HENRY	145	1,624.0	13,202.2
OPEN SOLUTIONS	112	764.1	7,066.3
SHARE ONE	17	69.9	562.2
SHARETECH	14	48.8	255.7
SYSTRONICS	76	197.3	1,321.5
TOTAL1	38	75.5	461.6

Notes: Total members are in thousands, while total assets are in millions of dollars.

B Appendix: Definitions of the Regressors

Table 8: Definitions of Regressors

Size of a vendor		
ln (total # of members)	$\ln\left(x_{mj} + \sum_{j' \in \mathcal{A}_i} x_{mj'}\right)$	The total number of the members belonging to one of vendor i's clients
ln (total assets)	$\ln\left(x_{aj} + \sum_{j' \in \mathcal{A}_i} x_{aj'}\right)$	The total assets of the credit unions that are the clients of a vendor j
N of clients	$\lvert\mathcal{A}_i\rvert$	The total number of vendor i's clients
Percentage of CUs		
similar in # of members	$\frac{1}{\lvert\mathcal{A}_i\rvert} \sum_{j' \in \mathcal{A}_i} 1\left(\frac{x_{mj'}}{x_{mj}} \in [0.5, 2]\right)$	The percentage of vendor i's clients whose size, measured by the number of members, is more than half but less than twice of the size of credit union j
similar in assets	$\frac{1}{\lvert\mathcal{A}_i\rvert} \sum_{j' \in \mathcal{A}_i} 1\left(\frac{x_{aj'}}{x_{aj}} \in [0.5, 2]\right)$	The percentage of vendor i's clients whose size, measured by assets, is more than half but less than twice of the size of credit union j
within 60 miles	$\frac{1}{\lvert\mathcal{A}_i\rvert} \sum_{j' \in \mathcal{A}_i} 1\left(dist\left(j, j'\right) \leq 60\right)$	The percentage of vendor i's clients whose location is within a radius of 60 miles of credit union j

Notes: x_{mj} and x_{aj} denote the number of members and total assets of credit union j respectively. A_i denotes the set of vendor i's clients.