THREE ESSAYS ON THE ECONOMICS OF OUTSOURCING OF GOODS & SERVICES: AN ANALYSIS OF B2B EXCHANGES, OFFSHORING & ALLOCATION OF PRODUCTION CAPACITIES

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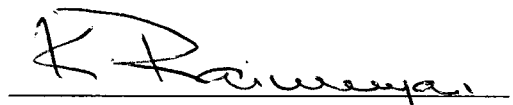

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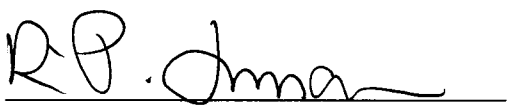

Graduate Group Chairperson

Dedicated to

Amma, Baba,

Ammamma, Tata,

Bamma, Tata,

And of course,

My dearest Poupee.

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ABSTRACT

THREE ESSAYS ON THE ECONOMICS OF OUTSOURCING OF GOODS & SERVICES: AN ANALYSIS OF B2B EXCHANGES, OFFSHORING & ALLOCATION OF PRODUCTION CAPACITIES

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Information technology is redefining organizations at the same time as the market for outsourced goods and services is growing at a furious pace. These rapid changes motivate us to analyze the impact that information technology can have on the boundaries of firms. A particularly important question is the effect of information technology on the allocation of production capacity, an issue that has hardly been addressed in the extant literature. The first essay examines the boundaries of manufacturing firms and investigates the impact that a business-to-business private exchange has on the scale of their operations. We demonstrate how the creation of a private electronic exchange can alter the productive capacity of a firm as well as the optimal allocations to competing firms. The second essay models competition in an oligopoly where firms offer vertically differentiated services. We computationally investigate the allocation of the share of production

at equilibrium among four production regimes, namely, in-house, on-shore, offshore and automation (utility). Furthermore, the analysis compares the equilibrium shares of allocation for three types of services: Quality Neutral, Context-Sensitive and Judgment-Intensive. Finally, the third essay empirically investigates how different characteristics of a firm result in the allocation of production to in-house, onshore and offshore sites. We build econometric models to determine factors that contribute to high quality of service by a multishore service provider and how information technology affects the channels of information used by different buyer (client) firms.

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1 Introduction

Sourcing has so far been regarded as a synonym for procurement. However, in the face of constantly changing competition due to globalization coupled with rapid innovations in technology, sourcing can no longer be viewed as a simple process of identifying suppliers to lower internal costs (Gottfredson et al. 2005). Instead, sourcing must involve an in-depth analysis of a supplier's leveraging power and how the supplier choice is going to affect the organization's growth, innovation, and synergy (AT Kearney 2001). Consequently, organizations are regarding sourcing as a strategic process that can transform value-chains and make organizations more flexible. Outsourcing, redefined as a strategic sourcing process, is the process of delegating or contracting out an internal process of a company to a specialized external provider to lower costs, focus on core competency, and improve the efficiency of the processes of the company. Outsourcing encompasses on-shoring, near-shoring (nearby country), co-sourcing (joint venture in offshore country) and third-party offshoring.

Historically the origins of outsourcing date back to a few thousand years ago. Initially, man was self sufficient and able to grow his own crops, gather his own food, skin hides for his clothing, etc. With the cropping up of communities, in which people specialized in different professions and engaged in trading of goods and services, came the early signs of outsourcing. However, for companies in the 1800s and 1900s being vertically integrated was the norm, with the company owning all the processes involved in converting raw materials to goods and/or services (Maynard 2004). For instance, Ford Motor Company owned everything from iron ore at the input level to the finished cars at

the output level. Companies even had their own in-house lawyers and tax accountants. With the onset of the industrial revolution which sparked the growth of services such as insurance, tax, accounting and legal began the first wave of outsourcing, in particular on-shore outsourcing. Outsourcing in the manufacturing sector followed, initially in low-tech items and later in high-tech components (Maynard 2004). Early offshoring activities were first observed among manufacturing companies in the 1950s when U.S. companies were offshoring shoe production to South America (Baldo 2003).

Although outsourcing is not a new concept the advent of the internet has transformed business to business procurement, as a result, sourcing has regained importance and is now perceived to be a strategic process in organizations. According to a report by Michael F. Corbett & Associates (2003), the global outsourcing market including the manufacturing sector was US $3.78 trillion in 2001 and was estimated to grow to $5.1 trillion by 2003[1].

In this thesis, the overarching theme across the three essays is the analysis of the impact of information technology (IT) on the boundaries of the firm, more specifically, on the allocation of production capacities. Pioneering work studying firm boundaries was conducted by Coase (1937) who questioned reasons for the existence of firms. He reasoned their existence in terms of the relative costs associated with performing the activities internally versus turning to the market for the same activities. Coase's theory has been extended by several researchers - transaction cost economics by Williamson (1979), incomplete contracts theory by Grossman, Hart and Moore (Grossman and Hart

[1] http://www.selltoindia.com/keyfindings.htm

1986, Hart and Moore 1990), and agency theory by Alchian and Demsetz (1972) and Jensen and Meckling (1976).

IT greatly reduces the costs of coordination. Hence, researchers in the area of Information Systems have been studying how IT affects the boundaries of the firm (Malone et al. 1987, Gurbaxani and Whang 1991, Clemons et al. 1993). There is substantial evidence corroborating the theory that an increase in the usage of IT in organizations is associated with large decreases in vertical integration. Hitt (1999) analyzed an 8-year panel data set consisting of firm structure and capital stock of technology. The results demonstrate that an increase in usage of IT has a strong association with a decrease in vertical integration but a weak association with an increase in diversification. Shin, in his forthcoming paper, provides further support of the benefits of IT which can be leveraged by diversified firms as well. He finds strong evidence for a positive effect of increased usage of IT on the profitability of highly diversified firms.

Other researchers have focused on the impact of IT on the emergence of hybrid governance structures in outsourcing relationships (Aron and Liu 2005). We, on the other hand, are interested in addressing the question of how IT affects firm boundaries via the allocation of production capacities. The first essay focuses on outsourcing in the manufacturing sector, whereas, the second and third essays concentrate on outsourcing of IT services. The methodology we use in this thesis ranges from analytical in the first essay, to simulation in the second essay, and experimental, in the last.

In the first essay, we analyze the impact of a business-to-business (B2B) market on the boundaries of a manufacturing firm by investigating how a private electronic exchange can redefine the productive capacity of a firm and the optimal allocations to

competing firms. We characterize the competitive environment of a large producer who uses a private electronic business-to-business market (PEM) for procuring his supplies. Further, we illustrate how the creation of a PEM can help the large producer to reduce his coordination costs by removing the 'cost pooling' mechanism which exists in a disaggregate procurement regime; and thereby, can force an increase in the procurement costs faced by his competitors. Most extant literature in B2B markets simplifies real-world markets by assuming homogeneity in production capacities and ignores production constraints. On the other hand, in this essay we model heterogeneity in production capacities and further increase the complexity and richness of the model by incorporating production constraints. The impact of production constraints on the equilibrium levels of firm profits and welfare are also investigated in the paper.

Dramatic improvements and cost reductions in telecommunications have not only resulted in the outsourcing of IT-enabled services, but also in the outsourcing of business processes and knowledge services. The primary reason for organizations outsourcing some of their services has been to refocus efforts on their core competencies (Dibbern et al. 2004). According to a report by OECD (2005), the global market for outsourced IT and business process services in 2001 is estimated at $260 billion. Of the total estimate, domestic outsourcing in the U.S. is estimated at $227 with the remaining $32 billion accounting for offshored services. Estimates for 2003 and 2004 for global outsourced IT (excluding software) services alone are $285 billion and $322 billion, respectively. Offshored IT and business process services are estimated to have been between $40 to $45 billion in 2003 (Gartner 2004).

In the second essay, we move away from extant literature which focuses on reasons for outsourcing, determination of processes to outsource based on risk and complexity, and optimal governance structures of outsourcing relationships, among others. Instead, we investigate the boundaries of firms by analyzing how production is allocated between multiple production regimes – in-house, on-shore, offshore and automated production (automated utility). The automated production or utility production regime is highly technology oriented and enjoys economies of scale. The regime involves negligible human intervention and hence, generates commoditized solutions but at very low costs. Most papers that study information systems outsourcing ignore the effect of competition on outsourcing decisions. We, however, explicitly model competition in an oligopoly in the domain of services characterized by vertical differentiation. We analyze the different equilibria that emerge for three types of services or process regimes, taking into consideration the relative cost and quality trade-offs of the four production regimes. The three types of services are Quality Neutral, Context Sensitive and Judgment Intensive.

In the Quality Neutral services market, the costs and qualities of the different production regimes are equidistant from each other. For Context Sensitive services, it is very important for firms to be close to local market conditions; hence when work is context sensitive, outsourcing the work results in a dramatic decrease in quality. On the other hand, for Judgment Intensive services, outsourcing to an Automated Utility results in drastically low quality of services. Although other outsourcing production regimes, on-shore and off-shore, which involve human intervention and judgment provide quality levels very close to in-house production.

End-customers in the model are heterogeneous and utility maximizers. Since the model is analytically intractable, we resort to the use of simulation to characterize allocation of production capacity in equilibrium. Apart from investigating the share of production allocated to the different production regimes for the three types of services, we also analyze the type of service that is most suited to a particular production regime. In addition, we compare the average quality of differentiated services provided by firms under the welfare maximizing solution to the profit maximizing solution, for the three types of services. The impact of market concentration, in other words, increased competition due to more firms in the market, on the allocation of production is also investigated.

Finally, in the third essay, we empirically investigate how technology impacts the boundaries of the firm and the allocation of production of services between on-shore and off-shore production regimes. We build econometric models to investigate how different aspects of the firm result in allocation of production to in-house, on-shore and offshore sites. Firstly, we investigate factors that contribute to the overall quality of output in multi-shore service production. Next, we examine the evolution of inter-organizational information flow and how the channels of information exchange differ between ad-hoc and contractual clients. Importantly, our observation of ad-hoc clients converting to contractual clients has also led us to analyze what affects buyer's sourcing decisions. In this essay, we are able to draw out by fine grained analysis how markets that we have analyzed in Essay two actually work in practice.

The research contributions outlined above are elaborated on in the following chapters.

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2 A Model of Market Power and Efficiency in Private Electronic Exchanges

2.1 Introduction

The promise of reduced costs arising from identifying more efficient suppliers of goods and services and from streamlining the procurement process – transaction, search, purchase – has resulted in the creation of two thousand or so business-to-business (B2B) e-marketplaces over the last decade. These e-marketplaces were established to drive far-reaching changes in the way firms buy and sell goods. However, according to a survey conducted by Day et al. (2003) only 43% of them survived up till July 2002 and Forrester Research estimated that only 180 of the 1500 or so e-marketplaces in existence during the boom will remain by 2003 (Day et al. 2003). The hardest hit e-marketplaces were independent exchanges which constituted about 92% of the e-marketplaces. Despite the dismal performance of business-to-business (B2B) marketplaces, firms have not abandoned these ventures as yet and are continuing to invest in building their B2B infrastructure - although with more scrutiny than before - since companies transacting in successful e-marketplaces do observe a reduction in their costs (McEwan 2001). For instance, Eastman Chemical, a multinational chemicals and plastics manufacturer that procures over US $500 million annually, reduced its procurement costs by between 5 and 15%, and its lead time in transaction completion from two weeks to 24 hours (Ng 2002). The new wave of investment in B2B marketplaces has been directed towards private

marketplaces and consortia as opposed to the earlier investments which favored independent public exchanges.

In 2002, according to an AMR Research survey more than fifteen percent of the Fortune 2000 companies already had private e-marketplaces and the number was estimated to grow by an additional 28 percent by the end of 2003 (Hoffman et al. 2002). Some of the private exchanges that exist today are operated by Cisco Systems, Inc., Eastman Chemical Co., General Electric Co., Hewlett-Packard Co., Intel Corp., and Wal-Mart Stores, Inc.'s Walmart.com (Braunstein 2001). Popularity of private e-marketplaces (PEM from hereon) generally stems from the following reasons: (a) proprietary information is protected from competitors, (b) competitive advantage is not disclosed and the firm's brand visibility is not lost, (c) and most importantly deeper integration and collaboration of business processes can be fostered among traders on a PEM which often enable firms to use it as a strategic tool to lock out competitors and lock-in buyers. Moreover, we believe firms can also use PEMs as a strategic tool to enforce asymmetric market power to gain a competitive advantage over their competitors. Often smaller firms form consortia to consolidate their purchasing volumes in order to try and increase their market power, large firms use PEMs as a strategic tool analogously – a phenomenon that we explore in this essay. For instance, according to a director at Ariba Inc. the goal of Covisint (consortium by large automotive companies) was to create a huge market cap through the consolidation of the different companies' purchasing and turn it into market power (Jaochim and Moozakis 2001). EnronOnline, on the other hand, was a private exchange created by Enron where gas, electricity, and other commodities were traded. Ownership of this exchange gave Enron access to significantly more market data than its

competitors and it used the private exchange as a means of attaining additional market power (Tauzin 2002).

With the current trend of adoption of PEMs, several issues arise about the nature and extent of strategic advantage that these PEMs confer on firms that run them. These questions are:

- What market conditions make PEMs viable?
- What impact do PEMs have on the nature of competition and market efficiency?

We develop a game theoretic model of a 'large firm' and a consortium of smaller firms in a market and analyze a firm's incentives to start a PEM and the viability of such an e-marketplace in competing against the consortium. Our analysis focuses on how a PEM may help firms acquire market power and set up incentives for collusion. We characterize the optimal equilibrium strategy of the firm that sets up the PEM as well the strategic response of the consortium of firms. Our analysis also incorporates the effects of a PEM, under different models of competition and collusion, on firms' profits, consumer surplus, and social welfare. The remainder of this essay is organized as follows. In Section 2.2, we review the related literature on B2B electronic markets and incentives of firms to create PEMs. Section 2.3 develops an analytical model of a two-tier supply chain; while in Section 2.4, we characterize and compare firm behavior under different models of competition. In Section 2.5, we analyze the implications of our results and draw out insights from the analysis. Section 2.6 concludes, and provides directions for future research.

2.2 Literature Review

Lucking-Reiley and Spulber (2001) categorize the effects of B2B e-commerce into 4 areas: (1) cost efficiencies from automation of transactions, (2) economic advantages of new market intermediaries, (3) consolidation of demand and supply through organized exchanges, and (4) changes in the vertical structure of companies. Early researchers in the field of Information Systems strived to predict the effect of information technology on the structure of organizations and markets (Malone et al. 1987, Gurbaxani and Whang 1991, Brynjolfsson et al. 1994) which has its roots in the seminal work of Coase on transactions cost theory (1937) that was later extended by Williamson (1975). The focus of these early studies was in determining whether information technology would tilt the production of goods and services towards vertical integration or markets; in other words, establishing the impact of information technology on the boundary of the firm. With the increasing use of markets, amplified by the explosion of B2B e-marketplaces, researchers have shifted their focus from studying changes in the vertical structures of firms to the other three effects of B2B e-commerce that Lucking-Reiley and Spulber identify.

Bandyopadhyay et al. (2005) characterize the equilibrium strategies of heterogeneous sellers competing in B2B exchanges via a sealed bid reverse auction. In their model, no individual seller can fulfill the aggregate market demand (thus, preventing Bertrand results) but the capacities of all the producers are greater than the aggregate demand. The essay demonstrates the strategic advantages that seller firms with low costs of production and large production capacities have over their competitors, and

discusses the resulting equilibria strategies. Further, it is shown that the ensuing competition can benefit the buyers through price reductions. Anand and Aron (2003) focus on a monopolist seller's pricing scheme under different types of demand uncertainty when he provides web-based group buying discounts. They analytically compare the seller's profits under the characterized optimal price and simple posted prices. Whereas, the question of how an intermediary can survive by attracting buyers and producers while at the same time maximizing his revenue is addressed by Yoo et al. (2002). Their paper formulates pricing schemes for the intermediary when there are network effects in the marketplace, where the value of a marketplace to a buyer depends on the number of producers and vice versa. Their results indicate that the optimal price for buyers (producers), and the fraction of buyers (producers) depend on the intensity of the network effects of both buyers and producers, and on the switching costs. Extant research has also addressed the effects on business-to-business exchanges of information transparency (Zhu 2004), and supply chain contracting in the presence of a spot market (Kleindorfer and Wu 2003), among others.

Most of the earlier research focused on public and independent e-marketplaces; hence, there is relatively little research on private e-marketplaces. However, with the collapse of the majority of these e-marketplaces and the rise of PEMs in the market, there is a growing need to characterize and analyze these e-marketplaces. Although, private e-commerce has been in existence for over 25 years, it was conducted through EDI and related technology which was accessible mostly to large firms and was technically limited to routine transactions (Turay and Aamir 2001). The effects of adoption of EDI have been studied by various researchers (Barua and Lee 1997, Riggins et al. 1994, Zhu

1999). Though private e-marketplaces may appear to resemble an EDI system, they differ significantly; the foremost reason being, an EDI system lacks the capability of conducting and transacting dynamic and simultaneous interactions among multiple parties (Le 2002).

Milliou and Petrakis (2004) investigate the firm's decision problem when quality investments made by the firm can spill over as benefits to its competitors in a public marketplace. Their analysis shows that there is a critical level of fixed costs under which the firm would benefit from creating its own marketplace, and gains from creating a private marketplace are strengthened with closer collaboration between the firm and its producer. Katsamakas (2003) develops a game-theoretic model of an intermediary and several buyers and sellers, and characterizes regions of parameters where no infrastructure is viable, only an intermediary is viable, only private marketplaces are viable, and where both can co-exist.

Our work differs from previous work since we focus on addressing a different issue - a fundamental one – as to how asymmetric production capacities of firms impact the incentives of a large firm to set up a PEM. We investigate the incentives of a firm with larger production capacity than its competitors to set up a PEM for procurement and employ it as a strategic device to drive market outcomes downstream.

2.3 Model

Our model is set in a two-tier supply chain: (a) suppliers of inputs to manufacturing sell to (b) producers/manufacturers of finished goods that in turn sell to

end consumers characterized by a downward sloping demand curve. The producers in our model compete in the same downstream market, thus the cost of their factors of inputs to production upstream is of strategic consequence. Each tier has multiple agents and the upstream market prior to the advent of an electronic market is defined by bilateral contracts between producers and suppliers. The downstream price and quantity supplied are determined by the downstream aggregate demand schedule.

A note on terminology, the manufacturers of inputs to production upstream are referred to as *suppliers*, the manufacturers of the end product are referred to as *producers*, and the end-customers are referred to as *consumers*.

2.3.1 Pre-Aggregation Marketplace

We begin by considering the implications of asymmetric supply capacities as manifest in a large producer in the upstream market. Consider a market where there are n producers and n suppliers, where the suppliers (as mentioned before) are located upstream and they produce an undifferentiated good such as metallic ore, industrial acids, steel, cement, etc. Of the n producers, there is one producer who has a large production capacity (in terms of his capacity constraints). The suppliers are homogeneous with respect to their production costs; the marginal production cost of the i^{th} supplier is denoted by $MC_i(q)$. We model the total cost function[2], $TC_i(q)$, which is twice differentiable in q over the domain of non-negative real numbers and is increasing and convex in q. The marginal and total production costs are given by:

[2] A frequently used and well studied modeling primitive.

$$MC_i(q) = kq \tag{1.1}$$

$$TC_i(q) = \int MC(q)dq = \frac{k}{2}q^2 + \alpha \tag{1.2}$$

An increasing marginal cost function is widely used in the extant economic literature. The increasing nature of marginal costs could be attributed to a variety of reasons such as increased wear and tear of machines at higher utilizations, capacity constraints, labor overtime, queuing effects of inputs to production, etc. (Anand and Aron 2004).

Each of the suppliers supplies equal quantities, which equal $\frac{1}{n}$ of the aggregate producer demand. If aggregate producer demand is q, the total and average costs faced by each supplier are given by:

$$TC_i\left[\frac{q}{n}\right] = \int_0^{\frac{q}{n}} (kq)dq = k\left[\frac{q^2}{2n^2}\right] \tag{1.3}$$

$$AC_i\left[\frac{q}{n}\right] = \frac{TC_i\left[\frac{q}{n}\right]}{q/n} = \frac{kq}{2n} \tag{1.4}$$

Since the suppliers are homogeneous, producers buy from the lowest price supplier, and the suppliers end up charging the producers a unit price equaling their average cost of production[3]. From (1.3) above it is clear that the total cost of producing a quantity q by n suppliers is given by:

$$TC(q) = n \times \left[\int_0^{\frac{q}{n}} (kq)dq\right] = \frac{kq^2}{2n} = \theta\frac{q^2}{2}, \text{ where } \theta = \frac{k}{n} \tag{1.5}$$

[3] Undifferentiated firms operate at zero profit equilibrium – a standard Bertrand result in such models.

The term $\theta = \frac{k}{n}$ is an **inverse measure of production efficiency**. Note that as θ increases, the cost of production goes up and the cost declines with declining θ.

Suppliers' cost structures are common knowledge. The producers compete in the same downstream market after procuring from the suppliers and face a common aggregate demand function. The downward sloping demand function reflects heterogeneous consumer valuations.

2.3.2 Aggregation Marketplace

We now formulate an aggregated marketplace, with the large producer creating his own buy-side PEM (for procurement from the suppliers) with all n suppliers. The benefit to the large producer is in terms of reduced coordination costs and the increase in market power over its suppliers. In the pre-aggregation case, we posit that one reason for the large producer not being able to avail of volume discounts is that each of its divisions or stores negotiated independently with the suppliers, or that due to lack of centralized purchasing, individual stores resorted to maverick purchasing while being unaware of prior negotiated contracts. This is a frequently encountered phenomenon and has been studied in extant research (Kaplan and Sawhney 2000, Wise and Morrison 2000). However, with the creation of the PEM by the conglomerate firm, due to reduced coordination costs the firm is able to demand volume discounts from the various suppliers. For example, Appleby's, a chain restaurant with approximately 400 company-owned stores, was able to demand volume discounts from its producers after it established a B2B exchange with centralized purchasing (Bowling and Maheux 2000).

The rest of the "$n-1$" producers could in response, create a consortium and demand similar volume discounts if their aggregate demand is greater than that of the large producer. However, the total cost of coordination will be in the order of n^2, for large numbers of producers, and/or large coordination costs[4]. Hence, the total costs (procurement costs and coordination costs) faced by the consortium are far greater than just the procurement costs even if they were to obtain volume discounts. A major problem faced by consortiums is that of governance and the difficulty of collaborative efforts with competitor firms. As asserted by the CEO of Ventro, an independent market maker for B2B exchanges, "The single biggest problem is that joint ventures are hard, joint ventures with many players are twice as hard, and joint ventures with many players who've been competitors for 80 years are nearly impossible" (Henig, 2000).

From hereon we will refer to the "n-1" producers as the "The Consortium" whereas the producer with the larger production capacity will be referred to as the "Large Producer." Consequently, P_L refers to the Large Producer and P_C to The Consortium (of producers). As under the pre-aggregation model, the total costs incurred by each of the n suppliers to produce the goods are as follows[5], where q_L and q_C represent the quantities supplied by the Large Producer and The Consortium, respectively:

[4] Each producer would have to coordinate with each of the other remaining "$n-2$" producers, on scheduling of orders, production, delivery, pricing, order fulfillment and align processes within their firms so as to be able to link their information systems to those of the suppliers. The number of connections in a network as we know from Metcalfe's Law, grows as the square of network, thus setting up a coordination cost in the order of n^2.

[5] Proof of these results can be found in the Appendix of Mathematical Proofs & Derivations, which is available upon request.

$$TC_1\left(\frac{q_L+q_C}{n}\right)=\ldots=TC_n\left(\frac{q_L+q_C}{n}\right)=\frac{k}{2n^2}(q_L+q_C)^2 \qquad (1.6)$$

However, with aggregation and increased market power, the Large Producer can command to pay an amount exactly equal to the cost of producing the quantity that he demands; therefore, the price he pays is given by:

$$c_{PL}=\frac{k}{2n}(q_L) \qquad (1.7)$$

As a result, the suppliers increase the price charged to The Consortium and the increased price faced by The Consortium, as compared to the pre-aggregation marketplace, is:

$$c_{PC}=\frac{k}{2n}(2q_L+q_C) \qquad (1.8)$$

2.4 Analysis

We model oligopolistic competition between n producers of whom $n-1$ are identical and are referred to as the "The Consortium", whereas one producer, referred to as the "Large Producer," has a larger production capacity[6] than The Consortium. We conduct our analysis for the general case with n homogeneous suppliers. We employ the traditional and well studied downward sloping demand schedule faced by the producers, as described by the function: $P(q)=\alpha-mq$. The producers face a constant quantity independent cost of value addition given by T. Therefore, the total cost of production faced by the producers is as follows: $CP(q)=TC(q)+T$, where T is the value addition cost, and $TC(q)$ is the total cost of inputs to production. Since T is a constant additive factor and uniform across all producers we normalize this to naught and consequently, for

[6] Production capacity under constraints of this producer are greater than that of the consortium.

the development of the game and the resulting competitive equilibrium we will deal with a total cost function that is equal to the cost of inputs to production. Since we are interested in analyzing the use of PEMs by the Large Producer as a strategic procurement mechanism to lower the cost of inputs to production, it is parsimonious modeling to isolate the factors that drive outcomes and analyze their impact on the equilibrium[7]. In the following sections, we develop the model and use the above demand structure to analyze the principal features of the resulting equilibrium and bring out the intuition that underlies the results. The analysis is conducted under different types of competition for the cases of before (pre-aggregation) and after (aggregation) the creation of a PEM. We begin with a discussion of the results under price competition, followed by quantity competition, and finally we comment on the results that obtain at collusive equilibrium.

2.4.1 Price Competition

Based on the above model setup and assumptions, we now proceed to derive the equilibrium strategies under price competition of the Large Producer and The Consortium under two market structures - before and after the creation of a PEM.

[7] We can ignore these additive manufacturing costs which by their very nature will not impact equilibrium or the results of comparative statics.

2.4.1.1 Pre-Aggregation

Recall, that in the pre-aggregation market structure, the undifferentiated suppliers charge the producers a price equal to their average cost[8] and produce identical quantities. Hence, the unit price paid by the Large Producer and The Consortium is as follows[9]:

$$c_{PL} = c_{PC} = \frac{k}{2n}(q_L + q_C)$$

At competitive equilibrium, in a game of price competition, the price the producers charge the consumers will be equal to the marginal cost faced by the producers. The reason being that for a homogeneous good, consumers buy from the lowest price producer; and if the marginal costs of the producers are equal, competition and price-cutting behavior of the firms would ultimately result in the price being brought down to the producers' marginal cost. This would hold good in the absence of production capacity constraints.

Asymmetric Capacity Constraints: The producer asymmetry that we model is driven by asymmetric production capacities induced by constraints. In a large number of industries ranging from Copper and Diamonds to synthetic fiber this is the norm. Firms have different productive capacities as a result of different historical endowments of natural resources and access to factors of production. We model the existence of such productive constraints as follows. Since the inverse demand function is given by: $P(q) = \alpha - mq$, the demand function is given by:

[8] It will be clear from inspection that this is the same as charging the total cost for a quantity produced – or the zero profit equilibrium consistent with Bertrand competition between undifferentiated suppliers.
[9] Proof of these results can be found in the Appendix of Mathematical Proofs & Derivations, which is available upon request.

$$Q(p) = \frac{\alpha}{m} - \frac{p}{m}.$$

Therefore, the maximum quantity that can possibly be demanded is $\frac{\alpha}{m}$. Suppose the production constraints are such that The Consortium can supply at most a fraction of maximum possible demand given by "f"and the Large Producer can supply at most "$1-f$". Consequently, the capacity constraints in production faced by the Large Producer and The Consortium (in its aggregate production capacity) are as follows[10], respectively:

$$x_L = (1-f) \times \frac{\alpha}{m},$$

and

$$x_C = f \times \frac{\alpha}{m}.$$

Now, the competitive dynamics change. Neither the Large Producer nor The Consortium can supply to the entire market; hence, *neither gains by reducing price below a certain level – resulting in a price competition with production constraints*. Both, the Large Producer and The Consortium solve the maximization problem (maximize their profits) and find a strategy that is a best response to the other's strategy. The results are similar to the results under quantity competition in the pre-aggregation scenario. To avoid repetition, please refer to Section 2.4.2.1 for details[11].

[10] Taken as a function of aggregate demand faced by the producers when price is zero.

[11] We choose to display the results under the case of quantity competition with homogeneous costs (pre-aggregation) instead of here, since it would make the comparison with the case of quantity competition with heterogeneous costs easier.

2.4.1.2 Aggregation

With the creation of a PEM, the Large Producer seeks to reduce his coordination costs by removing the 'cost pooling' mechanism inherent in the disaggregate procurement regime – i.e. the total cost of production is divided proportionally between the Large Producer and The Consortium; and thus increases his market power vis-à-vis the suppliers. Whereas, the market position of The Consortium worsens relative to the Large Producer, as the Large Producer is able to impose on The Consortium higher costs of procurement (from the suppliers), thereby, increasing The Consortium's marginal cost (and therefore their average costs as well).

As mentioned in Section 2.3, the average costs incurred by each of the n suppliers to produce the goods are as follows[12]:

$$AC_1\left(\frac{q_L+q_C}{n}\right)=\ldots=AC_n\left(\frac{q_L+q_C}{n}\right)=\frac{k}{2n}(q_L+q_C)$$

However, with aggregation and increased market power, the Large Producer pays an amount exactly equal to the cost of producing the quantity that he demands and his price is therefore given by:

$$c_{PL}=\frac{k}{2n}(q_L)$$

And, the price faced by The Consortium is:

$$c_{PC}=\frac{k}{2n}(2q_L+q_C)$$

[12] Proof of these results can be found in the Appendix of Mathematical Proofs & Derivations, which is available upon request.

Note that as in the pre-aggregation case, the Large Producer and The Consortium are constrained by production capacity. It is clear from the above that the price paid by the Large Producer is not greater than that of The Consortium, since $0 \leq q_L, q_C$. Therefore under price competition the Large Producer would price his good at the marginal cost of The Consortium which is higher than his own marginal cost. However, according to game theoretic rationality, The Consortium would solve the maximization problem of the Large Producer and thus determine the Large Producer's marginal cost[13]. Consequently, The Consortium would procure a lower quantity level such that their marginal cost is slightly less than the anticipated price set by the Large Producer; thus, permitting them to sell their entire capacity. The Large Producer too will anticipate this through Backward Induction and will therefore, price at the lowest possible level of The Consortium's marginal cost. In order to thoroughly investigate the feasibility and value of creating a PEM by the Large Producer, we must examine competition between the Large Producer and The Consortium under various models of competition. Hence, we now proceed to the analysis under quantity competition. We analyze the resulting games in the sections that follow.

2.4.2 Competition a la Cournot

In the previous section, we discussed the equilibrium strategies of the Large Producer and The Consortium under price competition. In this section, we extend our equilibrium analysis to Cournot competition or quantity competition under market

[13] Through Backward Induction.

structures with and without the existence of a PEM. We derive the optimal quantities and profits of the producers, as well as total welfare under the two market structures.

2.4.2.1 Pre-Aggregation – Quantity Procurement Characterized by Homogeneous Costs

We model competition a la Cournot with the Large Producer and The Consortium coordinating on optimal quantity to be produced. The suppliers charge each of the producers their average cost of producing the goods, thereby resulting in all producers facing the same marginal costs (refer to equation (1.4)).

The problem faced by both the Large Producer and The Consortium is to determine the profit maximizing quantity in the downstream market.

The Large Producer's problem is:

$$\arg\max_{q_L} \pi = \left[(\alpha - m(q_L + q_C)) - \frac{k}{2n}(q_L + q_C) \right] q_L$$

Whereas The Consortium's problem is:

$$\arg\max_{q_C} \pi = \left[(\alpha - m(q_L + q_C)) - \frac{k}{2n}(q_L + q_C) \right] q_C$$

Taking FOC we get:

$$q_L^*(q_C) = \left[\alpha - q_C \left(m + \frac{k}{2n} \right) \right] \left(\frac{3}{2nm + k} \right) \tag{1.9}$$

$$q_C^*(q_L) = \left[\alpha - q_L \left(m + \frac{k}{2n} \right) \right] \left(\frac{3}{2nm + k} \right) \tag{1.10}$$

The observations above lead us to our first result.

Proposition 1: The Unique Subgame Perfect Nash Equilibrium quantities for the Large Producer and The Consortium are as follows:

$$\Rightarrow q_L^* = \frac{2n\alpha}{3(2nm+k)}$$

$$\Rightarrow q_C^* = \frac{2n\alpha}{3(2nm+k)}$$

Now that we have calculated the optimal quantities of the Large Producer and The Consortium, we have to check whether the optimal quantities are indeed less than their respective capacity constraints. We now proceed to determine the conditions under which the optimal quantities are less than (or more than) the capacity constraints of the Large Producer and The Consortium. The following are the 4 cases that we analyze: (1) the calculated optimal quantities are less than the respective capacities for both the Large Producer and The Consortium, (2) the Large Producer's calculated optimal quantity is less than his capacity but The Consortium's optimal quantity is not feasible, (3) The Consortium's calculated optimal quantity is feasible but the Large Producer's optimal quantity exceeds his capacity constraint, and (4) calculated optimal quantities for both (Large Producer and The Consortium) are infeasible.

Recall from Section 2.4.1.1 that the production constraints faced by the Large Producer and The Consortium are fractions of the maximum possible demand and are given by:

$$(1-f)\times\frac{\alpha}{m},$$

and

$$f\times\frac{\alpha}{m}.$$

Case 1: Both optimal quantities are below the producers' capacity constraints.

For the optimal quantities of both the Large Producer and The Consortium to be below their respective capacity constraints, the following conditions must hold:

$$q_L^* \le (1-f)\times\frac{\alpha}{m}, \text{ and}$$

$$q_C^* \le f\times\frac{\alpha}{m}.$$

Lemma 1: The optimal quantities for the Large Producer and The Consortium will be less than or equal to their capacity constraints if the following conditions hold true:

$$\text{If } \frac{1}{3}\le f\le\frac{2}{3}, \text{ then } n,m,k,\alpha>0.$$

$$\text{If } f<\frac{1}{3}, \text{then } f\ge\frac{2nm}{3(2nm+k)}, \text{and } \alpha>0.$$

$$\text{If } f>\frac{2}{3}, \text{ then } f\le\frac{4nm+3k}{3(2nm+k)}, \text{and } \alpha>0.^{14}$$

Hence, the price at which the producers can sell in the consumer market is given by:

$$p^* = \alpha - m(q_L^* + q_C^*) = \frac{\alpha(2nm+3k)}{(6nm+3k)}.$$

The profits of the Large Producer are:

---

[14] For $f > 2/3$, the large producer's share falls to less than 1/3. In a case of a consortium made up of two producers, this implies that one of the consortium members has greater capacity than the large producer. A contradiction of modeling primitives.

$$\pi_{PL} = \left(p^* - c\left(q_L^*\right)\right)q_L^* = \frac{2n\alpha^2}{9(2nm+k)}$$

And the profits of The Consortium are:

$$\pi_{PC} = \left(p^* - c\left(q_C^*\right)\right)q_C^* = \frac{2n\alpha^2}{9(2nm+k)}$$

Suppliers are marginal and therefore operate at zero-profit equilibrium.

Consumer surplus is given by:

$$CS = \frac{8n^2m\alpha^2}{9(2nm+k)^2}$$

And total producer surplus is given by:

$$PS = \frac{4n\alpha^2}{9(2nm+k)}$$

Hence, total welfare is as follows:

$$W = \frac{4n\alpha^2(4nm+k)}{9(2nm+k)^2}$$

We derive the price charged and the profits received by the producers, consumer and producer surplus, and total welfare, along with the conditions that characterize them for Case 2 and Case 3, analogous to the case above and present the results in Table 2.1. Case 4, the case where the calculated optimal quantity exceeds the production constraint for both the Large Producer and The Consortium, is infeasible. See Appendix of Mathematical Proofs[15] for derivations of above results and results in Table 2.1.

[15] Available upon request.

Table 2.1: Comparing the two constrained cases of Cournot competition with homogeneous costs.

	Case2	*Case3*
Conditions	$f < \min\left\{\frac{1}{3}, \frac{2nm}{3(2nm+k)}\right\}$, and $n, m, k, \alpha > 0$.	$f > \max\left\{\frac{2}{3}, \frac{4nm+3k}{3(2nm+k)}\right\}$, and $k, n, m, \alpha > 0$.
Optimal Quantities	$q_L^* = \frac{\alpha[2nm(1-f)-kf]}{2m(2nm+k)}$, $q_C^* = f \times \frac{\alpha}{m}$	$q_L^* = (1-f)\frac{\alpha}{m}$ $q_C^* = \frac{\alpha[f(2nm+k)-k]}{2m(2nm+k)}$,
Price	$p^* = \frac{\alpha(2nm(1-f)+k(2-f))}{2(2nm+k)}$	$p^* = \frac{\alpha[k+f(2nm+k)]}{2(2nm+k)}$.
Profits	$\pi_{PL} = \frac{\alpha^2[kf-2nm(1-f)]^2}{8nm^2(2nm+k)}$ $\pi_{PC} = \frac{\alpha^2 f[2nm(1-f)-kf]}{4nm^2}$	$\pi_{PL} = \frac{\alpha^2[2nmf-k(1-f)](1-f)}{4nm^2}$ $\pi_{PC} = \frac{\alpha^2[2nmf-k(1-f)]^2}{8nm^2(2nm+k)}$
Consumer Surplus	$CS = \frac{\alpha^2[2nm(1+f)+kf]^2}{8m(2nm+k)^2}$	$CS = \frac{\alpha^2[2nm(f-2)+k(f-1)]^2}{8m(2nm+k)^2}$
Producer Surplus	$PS = \frac{\alpha^2[4n^2m^2-f^2(2nm+k)^2]}{8nm^2(2nm+k)}$	$PS = \alpha^2[2nmf-k(1-f)]\times \left[\frac{[2nm(2-f)+k(1-f)]}{8nm^2(2nm+k)}\right]$
Total Welfare	$W = \alpha^2[2nm(1+f)+fk]\times \left[\frac{[2nm(3nm+k)-f(nm+k)(2nm+k)]}{8nm^2(2nm+k)^2}\right]$	$W = \left[\frac{\alpha^2}{8nm^2(2nm+k)^2}\right]\times \left[\begin{array}{l} 4n^3m^3(4-f^2)+4n^2m^2kf(3-2f) \\ -5nmk^2(f-1)^2-k^3(f-1)^2 \end{array}\right]$

Remarks:

Under homogeneous costs, if either The Consortium's (Case 2) or the Large Producer's (Case 3) calculated optimal quantity is not feasible and the quantity is constrained by capacity, the competitor recalculates his optimal quantity. The recalculated optimal quantity for both the Large Producer and The Consortium is greater than the optimal quantity derived in Case 1. However, the increase in quantity by one producer is not enough to compensate the reduction in quantity of the other producer. Therefore, due to a reduction in quantities supplied, the price paid by the consumer increases[16], which in turn, decreases consumer surplus in Cases 2 and 3. When the constraint faced by The Consortium binds - as in Case 2 - the Large Producer makes the greatest profit. It is clear from Table 2.1 that the quantity supplied by the Large Producer as well as the price is greatest in Case2, thus making it the best regime for The Large Producer and the least profitable regime for The Consortium. Analogously, when the constraint faced by the Large Producer binds - as in Case 3 - The Consortium makes the greatest profit of the three regimes. Thus in the regime characterized by Case 3, The Consortium makes its greatest (relative) profit while the Large Producer makes least (relative) profits. In both regimes characterized by Case 2 and Case 3, the greater profits of the dominant player (the Large Producer and The Consortium, respectively), more than compensate for the lower profits of the other player. Hence, overall producer surplus is greater in Case 2 and Case 3 as compared to the unconstrained regime characterized by Case 1.

[16] Due to the downward sloping demand curve.

2.4.2.2 Aggregation - Quantity Procurement Characterized by Heterogeneous Costs

As stated earlier, after the creation of a PEM, the Large Producer avoids the 'cost pooling' inherent in the disaggregate procurement regime and thereby, increases his market power vis-à-vis the suppliers. Therefore, the Large Producer pays the suppliers a price that makes them marginal. As a result, the suppliers must charge The Consortium the residual costs of production for the additional quantity demanded by The Consortium (of smaller producers). If the suppliers charge less than this amount they will make a loss, thus violating the IR[17] constraint. The problem faced by both the Large Producer and The Consortium is the maximization of their profit functions with respect to the quantity they sell.

$$\arg\max_{q_L} \pi = p \times q_L - TC(q_L) = (\alpha - m(q_L + q_C)) \times q_L - \frac{k}{2n} q_L^2$$

$$\arg\max_{q_C} \pi = p \times q_C - TC(q_C) = (\alpha - m(q_L + q_C)) \times q_C - \frac{k}{2n} q_C (2q_L + q_C)$$

Taking FOC we get:

$$q_L^*(q_C) = \frac{n(\alpha - mq_C)}{(2nm + k)} \tag{1.11}$$

$$q_C^*(q_L) = \frac{n\alpha - q_L(nm + k)}{(2nm + k)} \tag{1.12}$$

The observations above lead us to our next result.

[17] Individual Rationality

Proposition 2: Under Subgame Perfect Nash Equilibrium the optimal quantities supplied by the Large Producer and The Consortium are as follows:

$$\Rightarrow q_L^* = \frac{n\alpha(nm+k)}{k^2+3nkm+3n^2m^2}$$

$$\Rightarrow q_C^* = \frac{n^2m\alpha}{k^2+3nkm+3n^2m^2}$$

Now that we have calculated the optimal quantities of the Large Producer and The Consortium, as before, we have to check whether the optimal quantities are indeed less than their respective capacity constraints. We now proceed to determine the conditions under which the optimal quantities are less than (or more than) the capacity constraints of the Large Producer and The Consortium. As before, the following are the 4 cases that we analyze: (1) the calculated optimal quantities are less than the respective capacities for both the Large Producer and The Consortium, (2) the Large Producer's calculated optimal quantity is less than his capacity but The Consortium's optimal quantity is not feasible, (3) The Consortium's calculated optimal quantity is feasible but the Large Producer's optimal quantity exceeds his capacity constraint, and (4) calculated optimal quantities for both (Large Producer and The Consortium) are infeasible.

Case 1: Both optimal quantities are below the producers' capacity constraints

In order for the optimal quantities of the Large Producer and The Consortium to be below their respective capacity constraints, the following conditions have to hold:

$$q_L^* \le (1-f)\times\frac{\alpha}{m}, \text{ and } q_C^* \le f\times\frac{\alpha}{m}.$$

As before, we derive the price charged and the profits received by the producers, consumer and producer surplus, and total welfare, along with the conditions that characterize them for the first three cases and present the results in Table 2.2. As in the Pre-Aggregation Scenario[18], we find that under no conditions is it possible for both the Large Producer and The Consortium to have optimal quantities that exceed their respective production capacities. See Appendix of Mathematical Proofs for derivations of results in Table 2.2.

[18] In the derivation of Case 4 under pre-aggregation quantity competition.

Table 2.2: Comparing the different cases of Cournot competition with heterogeneous costs.

(a) Cases 1 and 2

	Case1	***Case2***
Conditions	If $\frac{1}{3} \le f \le \frac{2}{3}$, then $n, m, k, \alpha > 0$.	$f < \frac{n^2 m^2}{k^2 + 3nmk + 3n^2 m^2}$, and $n, m, k, \alpha > 0$.
	If $f < \frac{1}{3}$, then $f \ge \frac{n^2 m^2}{k^2 + 3nmk + 3n^2 m^2}$, and $\alpha > 0$.	
	If $f > \frac{2}{3}$, then $f \le \frac{k^2 + 2nmk + 2n^2 m^2}{k^2 + 3nmk + 3n^2 m^2}$, and $\alpha > 0$.[19]	
Optimal Quantities	$q_L^* = \frac{n\alpha(nm+k)}{k^2 + 3nkm + 3n^2 m^2}$	$q_L^* = \frac{n\alpha(1-f)}{(2nm+k)}$
	$q_C^* = \frac{n^2 m\alpha}{k^2 + 3nkm + 3n^2 m^2}$	$q_C^* = f \times \frac{\alpha}{m}$
Price	$p^* = \frac{\alpha(nm+k)^2}{k^2 + 3nkm + 3n^2 m^2}$	$p^* = \frac{\alpha(nm+k)(1-f)}{(2nm+k)}$

[19] For $f > 2/3$, the large producer's share falls to less than 1/3. In a case of a consortium made up of two producers, this implies that one of the consortium members has greater capacity than the large producer. A contradiction of modeling primitives.

Profits	$\pi_{PL} = \frac{n\alpha^2(2nm+k)(nm+k)^2}{2(k^2+3nkm+3n^2m^2)^2}$	$\pi_{PL} = \frac{n\alpha^2(f-1)^2}{2(2nm+k)}$
	$\pi_{PC} = \frac{n^3m^2\alpha^2(2nm+k)}{2(k^2+3nkm+3n^2m^2)^2}$	$\pi_{PC} = \left[\frac{\alpha^2 f}{2nm^2(2nm+k)}\right] \times [2n^2m^2(1-f)-2nmkf-k^2f]$
Consumer Surplus	$CS = \frac{n^2m\alpha^2(2nm+k)^2}{2(k^2+3nkm+3n^2m^2)^2}$	$CS = \frac{\alpha^2[nm(1+f)+kf]^2}{2m(2nm+k)^2}$
Producer Surplus	$PS = \left[\frac{n\alpha^2(2nm+k)}{2(k^2+3nkm+3n^2m^2)^2}\right] \times (k^2+2nkm+2n^2m^2)$	$PS = \frac{\alpha^2[n^2m^2-f^2(nm+k)^2]}{2nm^2(2nm+k)}$
Total Welfare	$W = \left[\frac{n\alpha^2(2nm+k)}{2(k^2+3nkm+3n^2m^2)^2}\right] \times (k^2+3nkm+4n^2m^2)$	$W = \left[\frac{[nm(1+f)+kf]}{2nm^2(2nm+k)^2}\right] \times \alpha^2[nm(3nm+k)-f(nm+k)^2]$

(b) Case 3

Case3

Conditions

$$f > \frac{k^2+2nmk+2n^2m^2}{k^2+3nmk+3n^2m^2},$$

and $n, m, k, \alpha > 0$.

Optimal Quantities

$$q_L^* = (1-f)\frac{\alpha}{m}, q_C^* = \frac{\alpha[f(nm+k)-k]}{m(2nm+k)}$$

Price

$$p^* = \frac{\alpha[nmf+k]}{(2nm+k)}$$

Profits

$$\pi_{PL} = \left[\frac{\alpha^2(1-f)}{2nm^2(2nm+k)}\right]\times \left[2n^2m^2f + 2nmkf - k^2(1-f)\right]$$

$$\pi_{PC} = \frac{\alpha^2[nmf - k(1-f)]^2}{2nm^2(2nm+k)}$$

Consumer Surplus

$$CS = \frac{n^2m\alpha^2(f-2)^2}{2(2nm+k)^2}$$

Producer Surplus

$$PS = \frac{n\alpha^2 f(2-f)}{2(2nm+k)}$$

Total Welfare

$$W = \left[\frac{n\alpha^2(2-f)}{2(2nm+k)^2}\right] \times [nm(2+f)+fk]$$

Remarks:

The results obtained under quantity competition in the Post-Aggregation Scenario (Table 2.2) are similar to those that we obtained under the Pre-Aggregation Scenario (Table 2.1) with some important differences which we analyze in the sections that follow. As before, the Large Producer's profits are greatest when The Consortium's production constraint binds. By analogous reasoning it is easy to see that The Consortium's profits are greatest when the Large Producer's production constraint binds. In both, Case 2 and Case 3, the greater profits of the Large Producer and The Consortium, respectively, more than compensate for the lower profits of the competitor producer. Hence, overall producer surplus is greater in Case 2 and Case 3 as compared to Case 1. However, it is worth noting that in the Post-Aggregation Scenario the Large Producer is better off and

The Consortium is Strictly Worse off (in each of these corresponding regimes respectively). We will explain the results and the underlying intuition in the next section.

Comparing the results under Case 2 to those under Case 3, we find that overall producer surplus is greater under Case 3 (Large Producer production constraint is binding). Consumer surplus is also greater under Case 3 than under Case 2. The reason for which lies in the fact that under Case 3 quantity supplied is greater, which in turn causes the price to be lower, and it ultimately translates into the consumer surplus being greater. Although, welfare is greatest under the unconstrained case, we find that welfare is lower under Case 2 than under Case 3, where the Large Producer's production constraint binds. The intuition behind the above result stems for the Large Producer acting as a pseudo monopolist with lower production costs than The Consortium under Case 2; thus, causing both consumer surplus and welfare to be lower than under Case 3.

We now turn our attention to how an electronic market may be used as a collusive tool by producers. Upstream procurement electronic exchanges may well enable collusion by allowing producers to signal costs and quantities supplied to a downstream. In fact, DeSanti (2000) in her address to the U.S. Chamber of Commerce stated that information sharing facilitated by B2B exchanges can lead to anti-competitive outcomes, by increasing the likelihood of collusion. For example, a B2B exchange can be a collusion enabler by enhancing the ability of producers to predict a competitor's prices from knowledge of its costs, or to project or monitor a competitor's output level. In the next section, we will proceed to investigate how tacit collusion between producers,

enabled by an electronic market, impacts the market outcomes such as price, producer profits, consumer surplus, and total welfare.

2.4.3 Equilibrium Under Tacit Collusion

Under collusion enabled by a PEM, the Large Producer and The Consortium can signal the exact quantities that they will supply to the end market by signaling their procurement quantities and prices. Further they can also commit to price fixing via a PEM by restricting output to drive pre-determined price outcomes[20]. Thus, the Large Producer and The Consortium act cohesively as a composite entity *producing monopoly quantities at monopoly prices*. Profit sharing within the composite is affected through a transfer. Hence, the problem becomes maximization of total profits, as given by:

$$\arg\max_{q} \pi = p^{*}q - TC(q) = (\alpha - mq)q - TC(q),$$

Where

$$TC(q) = \frac{k}{2n}q^{2}.$$

Taking FOC, we get:

$$\Rightarrow q^{*} = \frac{n\alpha}{2nm+k}, \text{ and}$$

$$\Rightarrow p^{*} = \frac{\alpha(nm+k)}{2nm+k}.$$

Hence, total profits are as follows:

$$\pi^{*} = \frac{n\alpha^{2}}{2(2nm+k)} \qquad (1.13)$$

[20] Since the demand schedule in the end market is common knowledge, this becomes possible.

Consumer surplus is given by:

$$CS = \frac{n^2 m\alpha^2}{2(2nm+k)^2} \tag{1.14}$$

And total welfare is as follows:

$$W = \frac{n\alpha^2(3nm+k)}{2(2nm+k)^2} \tag{1.15}$$

We will discuss the results and draw out the salient features that characterize each of the market structures discussed above and comment on the policy implications in the following section.

2.5 Discussion of Results

We proceed to analyze the nature of dominant strategies at equilibrium and to bring out the insights behind the principal findings. We compare the profits of the Large Producer and The Consortium under the pre-aggregation Cournot model (characterized by homogeneous costs of production) with the aggregation Cournot model (characterized by heterogeneous costs of production), in order to determine whether the PEM leads to higher profits for the Large Producer under all three cases (the unconstrained and constrained equilibria). The comparison leads us to Proposition 3.

Note: Henceforth, we shall use the following notation - PAC to refer to the pre-aggregation Cournot model, AC to refer to the aggregation Cournot model, and TC to refer to the model under tacit collusion.

Proposition 3: *In the Cournot game, under Subgame Perfect Nash Equilibrium, the following results hold:*

(1) *The Large Producer's profits post aggregation via a PEM are strictly greater than the pre-aggregation case under all three regimes*[21].

$$\pi_{PL}^{PAC} < \pi_{PL}^{AC}.$$

(2) The Consortium's profits post aggregation via a PEM are strictly less than the pre-aggregation case under all three regimes.

$$\pi_{PC}^{PAC} > \pi_{PC}^{AC}.$$

By creating a PEM, the Large Producer is able to break the 'cost pooling' arrangement that existed before the PEM, where the total cost of production is divided proportionally between the Large Producer and The Consortium. In the post-aggregation scheme, the Large Producer is able to pay for production at the lower end of the cost curve and thus ensures that cost of production at the higher end of the cost curve is imposed on The Consortium. The impact of the volume discounts is a rightward shift in the Large Producer's supply curve. The Consortium, which does not procure under a similar pricing scheme, ends up incurring a higher marginal cost of production thus experiencing a leftward shift in its supply curve.

[21] Where regimes refer to the three cases (constrained and unconstrained) of production capacity constraints.

Figure 2.1: Unconstrained Equilibrium: Ratios of Producer Profits: (1) The Large Producer's Profits: Aggregate Cournot Profits / Pre-Aggregation Cournot Profits & (2) The Consortium's Profits Aggregate Cournot Profits / Pre-Aggregation Cournot Profits[22].

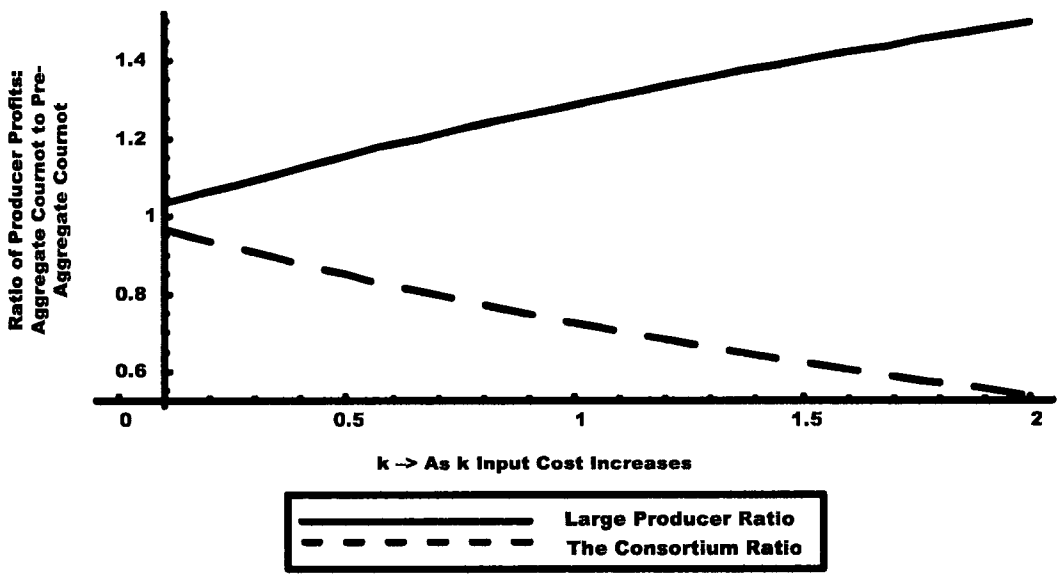


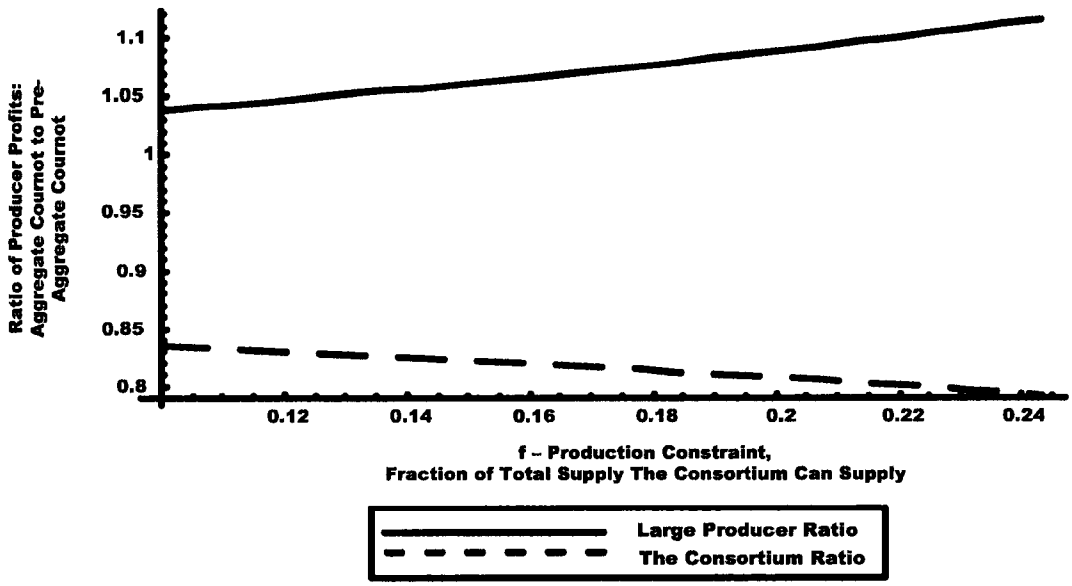
Figure 2.1 above provides a comparison of the profits after and before aggregation – the ratio of profits after aggregation to pre-aggregation is captured as a function of the production efficiency. Note that as k increases, the production efficiency decline results in higher costs of production for the same quantity produced. The benefit to the Large Producer of procuring through a PEM and thereby defeating the cost pooling efforts of The Consortium becomes evident with Figure 2.1. As production becomes more and more costly, the Large Producer is able to impose a greater burden on The Consortium and capture a larger fraction of the profits as evident in the increasing value

[22] Figure 2.1 was graphed with the following values: m=1 and n=3.

of the ratio of the two profits. Thus the value of the PEM to the Large Producer increases with the increases in cost of procurement. Finally it is clear that as the Large Producer becomes better off The Consortium's profit suffers under the PEM. Figure 2.1 shows how as costs of inputs rise The Consortium's profits decay, while the Large Producer's dominance increases.

Under production constraints though, it is no longer possible for the Large Producer and The Consortium to supply the market with optimal quantity. Here, the profits of both groups are impacted by their production constraints. Figure 2.2 and Figure 2.3 below capture the insight.

Figure 2.2: Constrained Equilibrium – Case 2: Ratios of Producer Profits: (1) The Large Producer's Profits: Aggregate Cournot Profits / Pre-Aggregation Cournot Profits & (2) The Consortium's Profits Aggregate Cournot Profits / Pre-Aggregation Cournot Profits[23].



[23] Figure 2.2 was graphed with the following values: k=1, m=1 and n=3.

Figure 2.3: Constrained Equilibrium – Case 3: Ratios of Producer Profits: (1) The Large Producer's Profits: Aggregate Cournot Profits / Pre-Aggregation Cournot Profits & (2) The Consortium's Profits Aggregate Cournot Profits / Pre-Aggregation Cournot Profits[24].

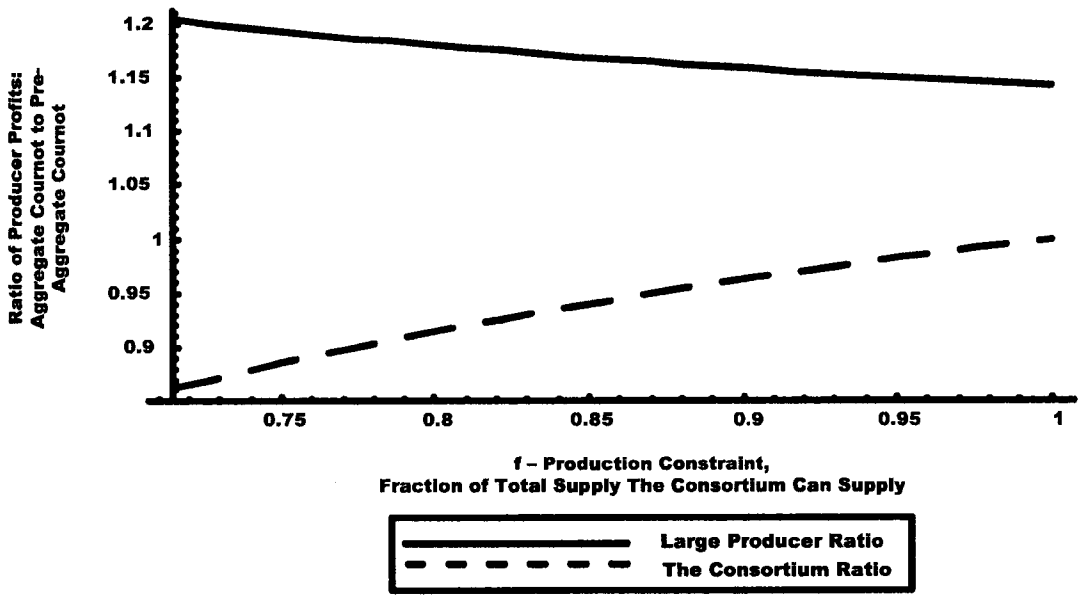


Figure 2.2 and Figure 2.3 provide a comparison of profits after and before aggregation as a function of f – the fraction of total supply The Consortium can supply. As the production constraint of The Consortium increases in Figure 2.2, one can observe the increasing value for the Large Producer of creating a PEM. When the production constraint of The Consortium is close to zero, the marginal costs for the Large Producer before and after aggregation are nearly the same. Hence, there is very little value in creating a PEM by the Large Producer, as can be observed by the profit ratio of the post and pre-aggregation scenarios being very close to 1. However, as the production

[24] Figure 2.3 was graphed with the following values: k=1, m=1 and n=3.

constraint of The Consortium increases, the difference in marginal costs for the Large Producer before and after aggregation grows, thus, enlarging the benefit of creating a PEM by the Large Producer. Figure 2.3, on the other hand, depicts the declining value of a PEM for the Large Producer as the production constraint of The Consortium tends to 1. The decline in value to the PEM is due to the fact that the production constraint of The Consortium is increasing, causing the production constraint of the PEM to decrease; and hence, although there is an increase in value of creating a PEM it is not enough to offset the decrease in value caused by the decreasing production constraint of the PEM.

The rankings of Total Quantity supplied, Producer Surplus, and Consumer Surplus are given by the inequalities below.

Proposition 4:

1. *Total Quantity Ranking: Total quantity supplied in the end-consumer market is highest under the pre-aggregation structure of Cournot competition, followed by the aggregate market structure of Cournot competition, and least under collusive equilibrium.*

$$Q^{TC} < Q^{AC} < Q^{PAC}.$$

2. *Producer Surplus Ranking: Total producer surplus is highest under a collusive structure (TC), next highest under the aggregation structure of Cournot competition, and least under the pre-aggregation structure of Cournot competition.*

$$PS^{TC} > PS^{AC} > PS^{PAC}.$$

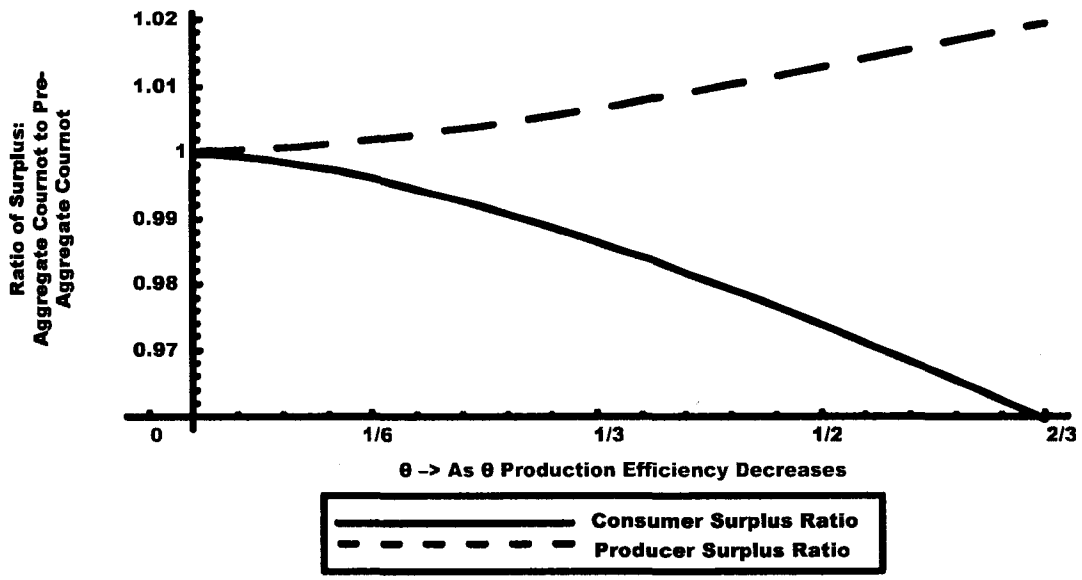
3. *Consumer Surplus Ranking: Consumer surplus is highest under the pre-aggregation structure of Cournot competition, next highest under the aggregation structure of Cournot competition, and least under collusive behavior.*

$$CS^{TC} < CS^{AC} < CS^{PAC}.$$

Collusion between producers allows them to restrict the quantity to the monopoly production level and therefore, it is clear why the total quantity supplied should be least under a regime of tacit collusion. Therefore, under the tacit collusion regime producer surplus[25] is greatest while consumer surplus is least. An interesting question that can be asked here is how does the PEM impact Producer and Consumer Surplus under competition a la Cournot? Figure 2.4, Figure 2.5 and Figure 2.6 provide a graphical comparison of the producer and consumer surplus after and before the advent of the PEM[26].

[25] The sum of the profits of The Consortium and the Large Producer.
[26] As before, we compare the ratio of producer surplus after aggregation to pre-aggregation and the consumer surplus after aggregation to pre-aggregation.

Figure 2.4: Unconstrained Equilibrium: Ratios of Producer and Consumer Surpluses: (1) Producer Surplus: Aggregate Cournot Profits / Pre-Aggregation Cournot Profits & (2) Consumer Surplus: Aggregate Cournot Profits / Pre-Aggregation Cournot Profits[27].

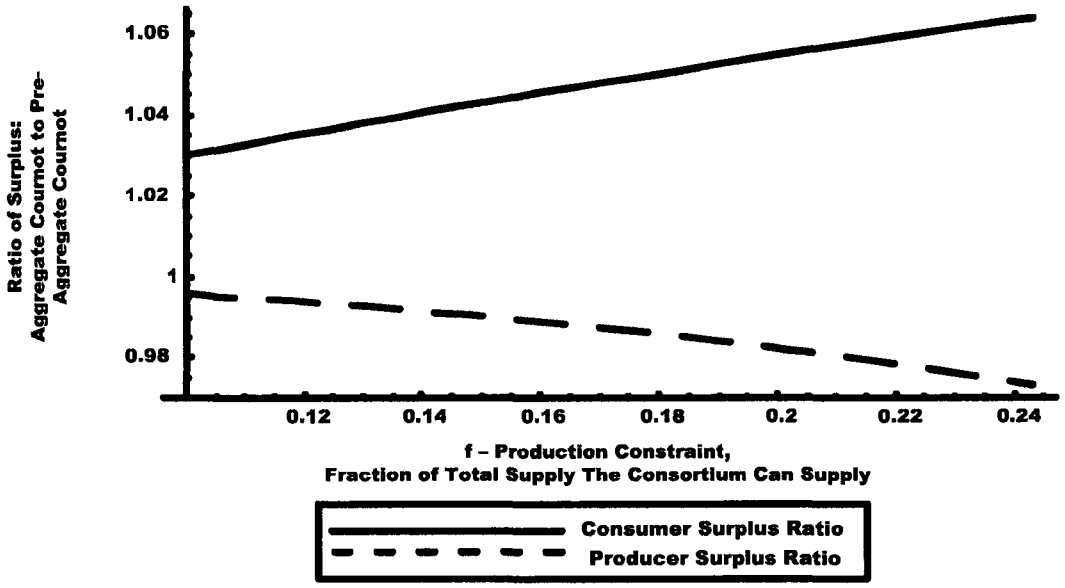


Recall from equation (1.5) and the discussion that followed it that $\theta = \frac{k}{n}$ is a measure of the inverse of upstream production efficiency - as θ increases production efficiency declines and vice versa. We compare producer and consumer surplus after and before aggregation as a function of θ and depict the ratios graphically in Figure 2.4 above. Notice that as production efficiency decreases (θ increases), the Large Producer imposes higher costs of inputs to production on The Consortium, causing the quantity

27
Figure 2.4 was graphed with the following values: m=1 and n=3.

supplied to be lower and the price to be higher. Therefore, producer surplus increases relative to consumer surplus[28] with declining production efficiency.

Figure 2.5: Constrained Equilibrium – Case 2: Ratios of Producer and Consumer Surpluses: (1) Producer Surplus: Aggregate Cournot Profits / Pre-Aggregation Cournot Profits & (2) Consumer Surplus: Aggregate Cournot Profits / Pre-Aggregation Cournot Profits[29].



[28] This is a comparative measure as can be seen from Figure 2.4.

[29] Figure 2.5 was graphed with the following values: k=1, m=1 and n=3.

Figure 2.6: Constrained Equilibrium – Case 3: Ratios of Producer and Consumer Surpluses: (1) Producer Surplus: Aggregate Cournot Profits / Pre-Aggregation Cournot Profits & (2) Consumer Surplus: Aggregate Cournot Profits / Pre-Aggregation Cournot Profits[30].

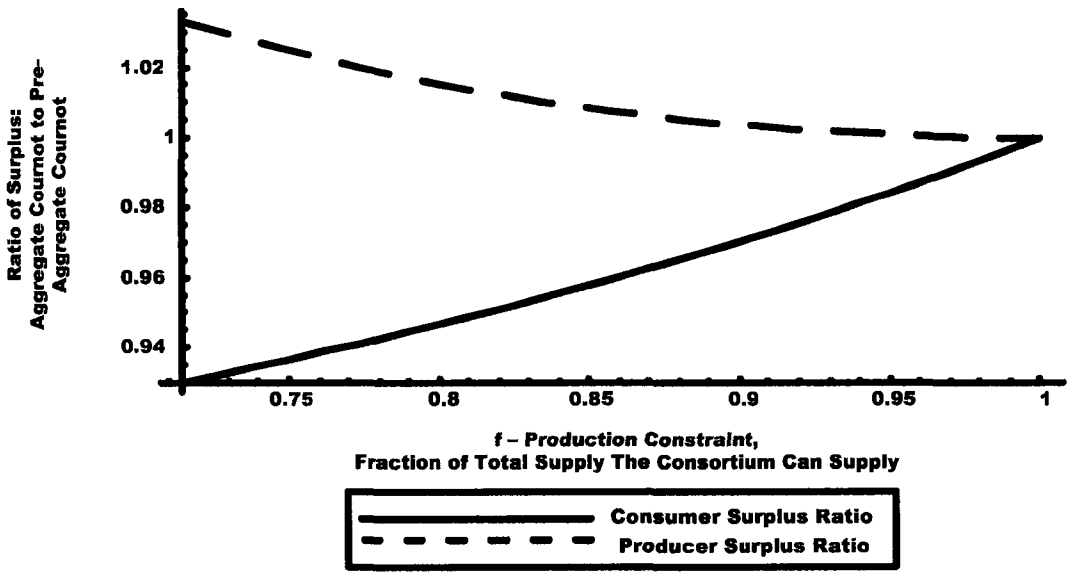


Figure 2.5 and Figure 2.6 depict the ratio of post-aggregation and pre-aggregation consumer and producer surplus as a function of the production constraint of The Consortium. In both the figures, we can observe that as the fraction of total quantity that can be supplied by The Consortium increases, the producer surplus ratio decreases, while the consumer surplus ratio increases[31]. As stated in Proposition 4, the rankings of producer surplus and consumer surplus follow a strict order, although the rankings are

[30] Figure 2.5 was graphed with the following values: k=1, m=1 and n=3.
[31] This doesn't mean that the actual Producer Surplus decreases, note that it is the comparative measure – the ratio – decreases.

reversed. We, therefore, proceed to explore how the above rankings affect total welfare, which leads us to our next result.

Proposition 5: *Welfare Ranking*: *The total welfare of the three market regimes – Pre-Aggregation Cournot, Tacit Collusion and Aggregate Cournot competition are as shown below.*

Condition	***Welfare Ranking***
Case 1: $\theta < 2.75632m$	$W^{TC} < W^{AC} < W^{PAC}$
Case 2: $5m > \theta > 2.75632m$	$W^{TC} < W^{PAC} < W^{AC}$
Case 3: $\theta > 5m$	$W^{PAC} < W^{TC} < W^{AC}$

Corollary 1: *Welfare under tacit collusion is strictly dominated by welfare under the PEM regime.*

How is welfare impacted by aggregation? To answer this we must comment on the role played by upstream production efficiency. Recall that as θ increases, production efficiency declines and vice versa. We now investigate the impact of Upstream Production Efficiency on the total welfare created in the market.

Production Efficiency and Welfare Ranking: Where upstream production efficiency is comparatively[32] higher i.e. $\theta < 2.75632m$, welfare under tacit collusion is less than the welfare under PEM-enabled aggregation which in turn is less than the pre-aggregation welfare. The intuition here is that when the suppliers upstream are efficient the producers

[32] Note that we analyze the impact of production efficiency on welfare for a given value of m the price elasticity of demand. The comparison holds for any given value –wlog – of m. We have not discussed the impact of the price elasticity of demand on welfare as it is a very well studied problem and the exposition on this topic can be found in any graduate level text book of economics.

would procure higher quantities and therefore, supply higher quantities in the end market at a lower price. While tacit collusion allows the producers to behave as a monopolistic cartel and therefore, produces the least welfare, the PEM enables the Large Producer to lower his costs of inputs to production and deliver a supply shock to The Consortium, thus raising their marginal cost of production. This in turn allows him to supply a lower quantity at a higher price to the end market thereby increasing his profits but lowering the welfare of the market. As the Production efficiency declines (or θ increases) to more moderate levels, given by $5m > \theta > 2.75632m$, we note that increasing costs of production upstream result in sub-optimal quantities being supplied by the two producers to the end market. The two producers, especially when asymmetric production constraints bind, maximize their profit by procuring sub-optimal quantities upstream even as they lower overall welfare. Finally, as production efficiency declines substantially, given by $\theta > 5m$, producers (both the Large Producer and The Consortium) are able to procure a more optimal quantity from the upstream suppliers by being able to coordinate via the PEM. In the absence of such coordination, competition between the producers results in the end market being over-supplied. While this serves to increase the consumer surplus (as can be seen from Proposition 5), there is a resulting decline in the total welfare. In this case, the pre-aggregation case produces the weakest welfare level and indeed, we find that even tacit collusion produces slightly higher welfare than the uncoordinated procurement scenario. However, tacit collusion results in too great a restriction of supply – since this results in monopoly output and therefore, the welfare produced in this case is dominated by the PEM-enabled aggregate Cournot competition. Thus we see that the welfare ranking in this case is given by: $W^{PAC} < W^{TC} < W^{AC}$.

2.6 Conclusions and Future Directions

We investigate the phenomenon of Private Electronic Markets and how these may be used as a strategic device by a large producer to counter a consortium of smaller producers. We also investigate the impact of the PEM in enabling tacit collusion amongst producers by allowing them to signal the quantities that they will supply to the market. Our findings are that the Large Producer can use the PEM to deliver a supply shock to The Consortium and move its supply curve leftward (and upwards). We find that as the cost of inputs of production increases, the PEM becomes a particularly effective mechanism for the Large Producer to grab an increasing share of the profits. When the upstream suppliers are aggregated via a PEM, the Large Producer captures a greater share of the profits as compared to a fragmented market. Moreover, as the demand curve becomes more inelastic, in other words, the slope of the demand curve, m, increases, the Large Producer's advantage in creating a PEM increases. We also find that when the upstream suppliers are highly efficient, the welfare (total efficiency) of the pre-aggregation fragmented markets is greatest while the market that features tacit collusion is the least efficient. As the production efficiency upstream decays, the PEM allows the Large Producer to procure a quantity (and therefore, supply that quantity to the end market) closer to the optimal quantity level thus producing the highest welfare under the Aggregate market regime. A key insight that emerges from this for policy makers is that when faced with highly efficient upstream suppliers, a large producer may well set up a PEM to diminish competition in his downstream end consumer market and thereby create significant welfare loss. Policy makers should enforce stringent measures to prevent the

formation of cartels and provide strong disincentives to discourage collusive behavior. In such markets they should also enforce interoperability mechanisms in electronic PEMs so that large producers do not exclude other producers to the detriment of overall welfare. In markets characterized by only marginal upstream efficiency, policy makers should discourage collusion but encourage initiatives for setting up PEMs that allow producers to purchase optimal quantities upstream.

In our model, we assume a fixed and constant cost of value addition faced by the producers. Instead if the cost of value addition is an increasing convex function in quantity, we would observe a decrease in the quantity supplied by the Large Producer. The reason being that although with the creation of a PEM by the Large Producer, his cost advantages for inputs to production relative to The Consortium push the Large Producer to increase the quantity produced, the increasing marginal costs of value addition cause him to decrease his overall production. In a similar vein, due to the increasing cost faced by The Consortium for value addition, the quantity supplied by The Consortium in the market decreases. Owing to the overall reduction in quantity supplied, which results in a price increase, the consumer surplus decreases. Another interesting point to note is the effect of The Consortium creating a PEM in place of the Large Producer. Under this scenario, The Consortium would enforce the cost pooling structure and deny the Large Producer a lower price in return for higher volumes. Further, it can be seen that the effect of who creates the PEM will only impact the sharing of profits and not impact the overall level of welfare. For a given quantity that is produced, the total cost of production is determined by the aggregate supply efficiency and not by the division of costs between the Large Producer and The Consortium. Finally, since both

parties will face the same aggregate demand curve, the quantity supplied to the market will not change. Thus a consortium owned PEM will act as an internal transfer measure. With technology costs declining persistently, how would reduced technology costs impact the creation of PEM? Our solution structure is robust to declining variable costs and constant fixed costs. However, under declining fixed cost there will be a difference to the equilibrium structure only when coordination costs also fall. Recall that the cost faced The Consortium to set up a PEM not only comprises fixed set up costs but more importantly coordination costs. Consequently, as long as coordination costs are much higher than fixed costs, the Large Producer will always be at a relative advantage compared to the consortium of producers. If, however, technology that enables collaboration such as – Wikipedia, CSCW platforms etc. – reduce coordination costs significantly, then we would not expect to see that a PEM to be run only by producers.

Finally, this research can be extended in a number of ways. It may be interesting to investigate how benefits of lower transaction costs impact the upstream suppliers' willingness to provide price discounts to the downstream firms. It would also be interesting to extend the model by incorporating a two sided exchange – one which can be used to procure products from the upstream suppliers as well as sell to end consumers. We have cited a number of different markets and firms where such PEMs operate - it would be a useful task to collect data from these firms and conduct an empirical study of the efficiency of PEMs. Finally, this model could also be extended by considering the impact of vertical integration – whereby the downstream producers acquire the upstream suppliers. From a policy standpoint it is worth investigating if this would lead to more intense price competition and therefore, result in greater welfare.

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3 Boundaries of the Firm in the Case of Multiple Outsourcing Options

3.1 Introduction

The information technology (IT) outsourcing continuum began with the era of automation, streamlining, application development, enterprise resource planning implementations, etc (Caplan 2004). Contracts were of short-term and work was very project specific. The second wave of change came about with the one-to-one players who were providing customized services for entire processes from end-to-end. These providers who came to be known as *Business Process Outsourcers* (BPO) were involved in long-term relationships and took over some of the managerial responsibility from their client organizations. For example, financial and accounting processes such as accounts receivable and payable, general ledger accounting and compliance routines in companies are very often outsourced to BPOs. The increase in demand in the domestic market for labor in the IT industry was resulting in shortages of labor and increasing labor costs. Around the same time, improvements in telecom capacity and the increased digitization of services, text, figures and other media made it possible for companies to offshore IT and BPO services to lower cost destinations (EvalueServe 2004). *Offshoring* provides companies with low-wage options, increased flexibility due to time zone differences, access to a larger pool of talent, and access to new markets. The later addition to the crop of outsourcing options came in the form of *outsourcing utilities* (OU), which provide standardized/commoditized services along industry verticals at much lower costs by

exploiting economies of scale through multi-processes. OUs use technology to automate processes and eliminate the need for human intervention. An example of an OU is a joint venture started by Barclays Bank, Lloyds TSB, HSBC, and Unisys which handles their check processing and allows these banks to enjoy huge reduction in costs by commoditizing the function of check processing.

The lure of cost reductions has resulted in companies racing to outsource and offshore their processes. However, the participants of the race have mostly been using outsourcing as a "quick-fix cost cutting" move without thoroughly analyzing the risks as well as opportunities that can be seized, such as enhanced capabilities and increased flexibility to expand a company's competitive advantage (Overby 2006). As a result of which the failure rate of outsourcing is as high as 40-70% causing several companies to bring back the processes in-house, as stated in a report in CIO magazine (Overby 2006). Yet, projections for outsourcing trends for the future are still very optimistic. According to a report by OECD (2005), the global market for outsourced IT and business process services in 2001 is estimated at $260 billion. Of the total estimate, domestic outsourcing in the U.S. is estimated at $227 with the remaining $32 billion accounting for offshored services. Estimates for 2003 and 2004 for global outsourced IT (excluding software) services alone are $285 billion and $322 billion, respectively; and offshored IT and business process services are estimated to have been between $40 to $45 billion in 2003 (Gartner 2004).

The global market for IT-enabled services is expected to be over $140 billion by 2008, according to a report by McKinsey & Co[33]. On other hand, according to Gartner

[33] http://www.bpoindia.org/knowledgeBase/

the global market size for BPO services is projected as $173 billion in 2007, of which $24.23 billion is forecasted to be offshored. The reason for such projections is that many firms have realized the savings and benefits of outsourcing through careful valuations and risk analysis. However, there have been several recent reports of corporations that migrated processes off-shore to gain cost benefits but had to suffer the attendant loss in quality of output. Corporations such as Lehman Brothers Inc. had to insource processes that they had migrated offshore as the output quality was unsatisfactory. These processes required domain expertise in addition to domain experience, thus making it necessary for the vendor to have an understanding of the business context of the buyer. Similarly Dell computers found that it had to insource some processes that it had migrated offshore due to the fact that these processes were embedded in the business context of its institutional buyers in the US and could not be executed offshore. In each case the buyer faced decidedly lower operating costs but they also had to settle for lower quality of execution. Careful analysis of service quality records suggest that such a loss in quality was not the result of opportunistic behavior by the vendor and nor was it because of poor transitioning of process by the buyer – the sub-optimal quality was solely because of the idiosyncratic nature of the work. The agents offshore needed to understand their buyers' markets, the culture of the buyer's end consumers and the historical issues that were relevant to servicing the buyer's internal users. These problems were solely because certain kinds of work cannot be easily migrated offshore without resulting in sub-optimal quality of work. For a more detailed discussion of idiosyncratic work, the reader is referred to Aron and Singh (2005). The authors suggest a three step-process for "right sourcing"- the process of choosing the right processes to offshore. They first suggest

ranking processes by value, followed by identifying and managing operational and structural risk. Operational risks refer to the possibilities of errors in processing information, delays in completion of work, etc., while structural risk deals with dangers of moral hazard and lock-in. Based on the level of operational and structural risk identified, the authors present a grid suggesting the most appropriate organizational form that a company should choose. If operational and structural risks are high, the authors suggest executing the process in-house; whereas if operational risk is high but structural risk is low, the company should outsource to a near-by vendor, while if the opposite is true, the company can consider offshoring with frequent audits. Aron and Singh discuss the importance of both location and organizational form when a company is deciding on its outsourcing strategy.

The objective of this essay is to investigate how firms allocate production of services between different wage regimes and production structures. Firms face the trade-off between quality and cost when they offshore processes. Reports in the trade and business press have suggested that firms that offshore the production of services can reap significant cost savings often at the cost of quality (of output). In this essay we investigate how firms make the choice of optimal quality and allocate production of processes between regimes characterized by widely varying production costs. The remainder of this essay is organized as follows. In Section 3.2 we provide some background on the modeling of our vertically differentiated model, which is followed by the contributions of researchers in the area of information systems outsourcing in Section 3.3. Section 3.4 presents an empirical survey of outsourcing strategies being adopted by companies. In Section 3.5, we formally outline our research questions and provide a

description of our model. Section 3.6 outlines the simulation methodology which is followed by results and analysis in Section 3.7. Section 3.8 provides managerial insights and our conclusions, along with directions for future work.

3.2 Background on Modeling

The objective of this essay is to analyze how firms allocate production of services between different wage regimes when there is a trade-off between quality and cost of service; and customers are heterogeneous in their preference for quality and price. Research literature closely related to our model characterization is the literature on vertical differentiation. Vertical differentiation models have been studied from an agent based market simulation perspective as well as a game-theoretic perspective. We begin with a discussion on the agent-based market simulation research and will then segue to related research on vertical differentiation.

3.2.1 Economic Models

Seminal work on vertical differentiation began with Hotelling (1929). In Hotelling's (1929) model two firms compete on location and price. The equilibrium strategy is for firms to choose the center of the market – "Principle of Minimum Differentiation." The reason for minimum differentiation is that Hotelling ignored the possibility that firms located near one another would engage in price competition which could result in fierce price wars. Gabszewicz and Thisse (1979) have extended Hotelling's model to include price competition analysis. Their findings demonstrate that

firms would engage in maximal differentiation, with either some consumers refraining from buying or all consumers buying one of two products.

Competition under vertical differentiation has also been studied by Shaked and Sutton (1982). In their model, production costs are assumed to be zero and firms decide on the price level after they have observed the quality level chosen by their rival firm. Tastes of consumers are identical but their incomes are varied. Their findings show that in a duopoly, the two firms will choose distinctive qualities and both will enjoy non-zero profits at equilibrium because if they were to choose qualities close to one another then price competition would reduce their profits. They also demonstrate that if there are 3 or more firms, then competition in choice of quality drives all firms to set the same "top" level of quality permitted while prices and profits are zero. Moorthy (1988) has further extended the vertical differentiation model by incorporating costs of quality into the model and assuming convex increasing costs associated with higher quality levels. Consumers in his model also prefer higher quality to lower quality but differ in terms of their value for it and have the option of refraining from buying if no product is suitable. His results corroborate previous findings, where the equilibrium strategy for each firm in a duopoly is to differentiate its product from its competitor, though not maximally. In addition, the higher quality seller also chooses a higher profit margin. Consumer types are assumed to be uniformly distributed on [a,b], $0 < a < b$.

In all of the above models, authors either assume that the market is fully covered or that it is not fully covered. Wauthy (1996) on the other hand, makes no such explicit assumption, and shows that a covered or uncovered market is an endogenous outcome of the quality game. He demonstrates that the question of whether to cover the market or not

is at the core of the strategic decisions for firms, where the decisive factor for firms to cover the market or not is the distribution of consumers' tastes. He also analytically shows the different quality choices for firms for different ratios of the highest to lowest consumer preference values.

3.2.2 Agent-based Market Models

More recently researchers have turned to agent-based market models in order to study systems for which models cannot be solved analytically. Kephart et al. (2000), for instance, have shown that a market model in which buyers discriminate between sellers based only on product price is susceptible to price-wars between sellers, and prevents the sellers from converging to an equilibrium. Buyers in their model differ in terms of their maximum willingness-to-pay for a product. On the other hand, Sairamesh and Kephart (2000) study a vertically differentiated product or service where the buyers' utility depends on both price and quality. The sellers are assigned fixed quality levels of production with a linear cost function but are allowed to engage in dynamic price setting. Unlike in analytical models where sellers have perfect knowledge and are completely rational, as in reality the model assumes bounded rationality with sellers changing their prices based on learned information and past experience. Unsurprisingly, their results demonstrate that in a market with only price-sensitive buyers all pricing strategies lead to cyclical price-wars; whereas, in a market with only quality-sensitive buyers all pricing strategies eventually lead to the same price equilibrium.

Markopoulos and Ungar (2002) apply dynamic pricing to an electronic service market where sellers process requests at a finite rate and customers wait in line to obtain

service from a specific seller. The waiting time of customers is comparable to the quality of service. Customers arrive in the market based on an exponentially distributed inter-arrival time and each customer chooses a seller to buy service from by maximizing his expected utility. The utility of a buyer is a function of price paid and the waiting time. The impact on market performance and seller and consumer utilities is tested under two conditions of seller choice by customers – a customer can either (1) choose a seller at random and reject the seller's offer if the obtained information his regarding price and waiting time is not satisfactory, or (2) employ a shopbot to query the prices and waiting times of all the sellers and then make a choice based on maximized expected utility. Sellers dynamically set prices, whereby a seller instantly updates his price based on the number of customers in the seller's line. Hence, different customers in a seller's line can be quoted different prices. When buyers choose a seller at random, sellers pursue a pricing policy by which their expected cost remains constant, since customers are informed of the inter-arrival rate as well as the expected waiting time in the market. Therefore, if the waiting time is above a threshold, price is discounted, whereas if the waiting time is below, a price premium is charged. On the other hand, when buyers use shopbots sellers follow a greedy pricing policy. If a seller has the shortest queue, he will choose a price slightly below the price at which a buyer is indifferent between choosing the seller and his competitor with the next shortest queue. The results demonstrate that if sellers use dynamic price setting in the presence of shopbots, it results in price-wars and a drastic fall in profits. Therefore, sellers are better off colluding on prices when customers use shopbots to query information from all the sellers. In addition, when overall system

load is low total market welfare increases with the use of shopbots and dynamic pricing, however, total welfare decreases with the increase in system load.

So far the theory on vertical differentiation has mainly focused on duopoly competition. Although oligopoly competition for three competing firms has been analytically solved by Shaked and Sutton (1982), they ignore production costs by assuming costs to be zero. So far a model with three competing firms that face increasing costs of production as quality increases has not been solved. Further, as the number of competing firms facing non-zero production costs increases in the model formulation the problem becomes analytically intractable[34]. Our research brings together two important elements of this problem (1): Allocation of production capacities to various production regimes with varying quality of output and (2) how such allocation is driven by vertical competition in markets. We do not restrict the discussion to a simplistic duopoly or monopoly and nor do we restrict the choice of production to a single choice – i.e. the make-or-buy decision. Further, our work also differs from the agent-based modeling approach where researchers assume the quality levels of sellers to be fixed and only vary price. In our model, firms have the ability to choose different levels of quality as well as dynamically alter price based on their competitors' pricing strategies.

[34] As can be inferred from Shaked and Sutton's seminal work in this area, most notably in their paper cited above.

3.3 Information Systems Outsourcing Literature: The State of Praxis

In the early phases of the outsourcing continuum, researchers were concerned with determining reasons for outsourcing and understanding which processes should be outsourced. Researchers addressing the questions of why to outsource and whether a company should outsource pointed out the advantages of outsourcing such as reduced costs and availability of greater specialization but at the expense of disadvantages such as the threat of moral hazard, switching costs, lock-in and price renegotiation. Research examining the question of which processes to outsource, has mainly been descriptive in nature and does not have a theoretical foundation (Dibbern et al 2004). Clemons and Reddi (1994), and Bakos and Brynjolfsson (1993), move away from the questions of why and what to outsource, and move towards analyzing the elements of the outsourcing relationship, such as determining the optimal number of outsourcing suppliers. Snir and Hitt (2004) and Croson and Jacobides (1999), also focus on vendor selection but examine ways of distinguishing high-quality vendors from low-quality vendors when vendors differ in their quality capabilities, through the use of a pilot-project and a penalty scheme, respectively. On the other hand, Whang (1992) focuses on the contract structure and through the use of a game-theoretic model suggests a payment scheme that aligns the incentives of the vendor with the firm and results in the same effort level by the vendor as in-house development. In spite of the surge in the number of BPO providers in recent years, academic research has continued to remain under the umbrella of general outsourcing issues for the most part without addressing BPO specific questions/issues.

Most of the research in this area of outsourcing has been initiated by practioners in the community (Dibbern et al. 2004). Considerably less research has been performed in terms of empirical studies by researchers, to which Aron and Liu (2005a, 2005b) and Aron et al. (2005) have made major contributions. Their research focus is on finding optimal governance structures to monitor and control the work of vendors in the wake of moral hazard and operational risk which are present in offshoring activities. The authors not only present analytical models of hybrid governance forms but also corroborate the predictions of their models with surveyed BPO contracting data from different countries.

Most of the research papers, however, limit their analysis to the outsourcing relationship between an individual firm and a vendor, while ignoring the impact of competition on the outsourcing decisions of firms. In this essay, we model oligopoly competition and investigate the boundaries of firms when there are different sourcing options: In-house development, Onshoring, Offshoring and Automated Utilities. We also incorporate the demand side effects of end-customers; and examine the impact of consumer valuations on the outsourcing decisions of firms. For purposes of analysis, we resort to simulations instead of the traditional game-theoretic modeling construct, since the number of firms and the complexity of the problem makes it analytically intractable.

3.4 Survey Findings

The various production & process regimes and parameters used in our model are motivated by findings from a survey[35] we conducted of senior management of Fortune

[35] The surveys were conducted under the aegis of The Fishman Davidson Center For Service Operations and Knowledge@Wharton publicaiton respectively.

500 corporations on their reactions to the costs and benefits associated with outsourcing and offshoring of processes. In particular, we wanted to ascertain from these executives as to what the principal factors were in the decision to execute services in-house or to outsource them (and off-shore them). In addition we were also interested in investigating how executives would react to the idea of procuring services from a 'Service Utility' – a firm that would automate the production of services[36]. Our survey revealed that there were essentially four options that executives faced when it came to producing goods and services in-house. These are as follows: (1) *The Make Option*: Source these services in-house (2) *Onshoring*: Outsource these services to a third-party provider in the same labor regime (3) *Utility*: Source automated services from the provider of a Service Utility and (4) *Offshore*: Source these from a firm located in a lower wage regime.

We surveyed the trade-offs faced by executives and indeed it is findings of this survey that motivated the model. Executives were asked to identify all the principal means of sourcing services from different production regimes from a menu of choices (multiple responses were allowed in order for them to choose all the different sourcing structures that they thought were important). Table 3.1Table 3.1below provides a summary of the results. It is apparent that there is a clear consensus that the four options mentioned above are the principal means of sourcing as seen by these respondents in the survey[37].

[36] There are indeed several such utilities today. A well studied example is Unisys Corporation's Check Processing utiliy.

[37] A total of 120 responses were received. Figures have been rounded off to the nearest whole number.

Table 3.1: Principal Production Regimes for Sourcing Services

Principal Production Modes	Percentage of Respondents in Agreement
In-house	94%
Outsourced to an Onshore Provider	83%
Source from a Utility - Automation	72%
Outsourced to an off-shore provider	86%
Outsourced to an offshore captive service center	11%
Outsource to an Onshore JV	7%
Outsource to an offshore JV	7%
Outsource to an offshore utility	3%
Other	9%

We asked executives about their perceptions of quality of output from each of the modes of production below. Their responses are ranked whereby the mode of production with the highest quality of output was given the Rank 1 while the least productive quality mode was ranked 4. The results[38] are shown in Table 3.2 below.

[38] Based on 81 responses. The percentages do not sum to unity since there were 5 other options for mode of production – as shown in Table 3.1 above that are not shown here. Strictly speaking the ranking of the lowest quality regime was therefore, 9 (including the 5 remaining options which are not shown here).

Table 3.2: Production Quality Ranking of Production Regimes

Production Regime	Rank 1	Rank 2	Rank 3	Rank 4	Mean Quality Rank
In-house	85%	1%	0%	1%	1.1
Outsourced to an Onshore Provider	6%	81%	1%	2%	2.0
Source from a Utility - Automation	0%	1%	11%	89%	3.9
Outsourced to an off-shore provider	5%	10%	79%	2%	2.8

It is clear from the above that there is a consensus amongst respondents on the *Quality Hierarchy of Production Regimes.* The In-house production option is considered to be of greatest quality followed by outsourcing to an onshore provider followed respectively by offshore outsourcing and sourcing from automated utility.

We also asked respondents to identify the principal barriers to sourcing different kinds of services from each of the regimes identified above. Their responses indicated that the barriers to sourcing had to do with the kinds of processes that needed to be executed. Respondents identified two specific kinds of processes which we discuss below.

Context-Sensitive or Idiosyncratic Processes: These are processes where the processing agents need to be seeded with the knowledge about the firm's end consumers, their markets and how these markets work. Agents need to have an understanding of how these processes relate to specific market contexts and the historical context of the firm's products and services, as well as the nature of the engagement between the firm and its customers. Executives felt that offshoring such processes would run the risk of loss of context in transition and in the distancing of the operations from the context of business.

Judgment-Intensive Processes: These are processes, where human agents need to make judgments on specific decision situations. It is not possible to specify all states of the world that are likely to arise in the execution of such processes and human agents are called upon to make decisions using their expertise and with reference to a broad set of rules. The decisions may call for interpretation of rules, disambiguation of business situations and resolving conflicting claims on courses of actions. Executives in the survey felt that automating these processes – by seeding an automated system with a set of rules – is likely to lead to lower operational flexibility and eventually, to lower quality.

The bulk of work that went into producing services did not fall under either category above. However, most executives expressed that a significant chunk of the processing would fall under the above two categories. Based on this we asked them to identify which production regimes were most suitable for sourcing (producing) the three different kinds of processes above. Their responses are summarized in the table below with the most suitable regime being awarded the first rank while the least suitable being awarded the last rank. Their responses[39] are tabulated in Table 3.3, Table 3.4 and Table 3.5 below.

[39] Based on 66 responses. In one case – in Table 3.3 – there was an ambiguous response that was omitted and the totals do not sum to unity.

Table 3.3: Context-Sensitive or Idiosyncratic Processes

Production Regime	Rank 1	Rank 2	Rank 3	Rank 4
In-house	65	1	0	0
Outsourced to an Onshore Provider	1	65	0	0
Source from a Utility - Automation	0	0	18	48
Outsourced to an off-shore provider	0	0	48	17

Table 3.4: Judgment-Intensive Processes

Production Regime	Rank 1	Rank 2	Rank 3	Rank 4
In-house	59	6	1	0
Outsourced to an Onshore Provider	4	59	3	0
Source from a Utility - Automation	0	0	0	66
Outsourced to an off-shore provider	3	1	62	0

Table 3.5: Normal Processes – Bulk of Process Work

Production Regime	Rank 1	Rank 2	Rank 3	Rank 4
In-house	59	6	1	0
Outsourced to an Onshore Provider	4	59	3	0
Source from a Utilty - Automation	0	0	0	66
Outsourced to an off-shore provider	3	1	62	0

Again there is consensus in the Quality Hierarchy of Production of the three kinds of processes. It is clear that for all three kinds of processes, In-house produces the best quality followed respectively by onshore Outsourcing, offshore outsourcing and sourcing from an utility (through automated production).

We have based our model on the above findings. We have created a quality hierarchy of production of different production regimes and investigate how firms make their decision to allocate production under different regimes given the quality hierarchy discussed above.

3.5 Model

The focus in the literature on information systems (IS) outsourcing has been on determining which processes to outsource when risks of moral hazard and contract renegotiation are present, differentiating the high quality from the low quality vendors, studying the contract structure, and identifying the optimal governance structure to utilize in outsourcing contracts. The boundaries of the firm in IS outsourcing literature have largely been studied as a static equilibrium model while ignoring the impact of competition.

Research Questions

This essay addresses the issues of process types and their relation to production regimes, the quality capabilities of production regimes and the cost capabilities of production regimes and most importantly how these impact the share of production allocated to different production regimes.

More specifically the following research questions are dealt with in this essay:

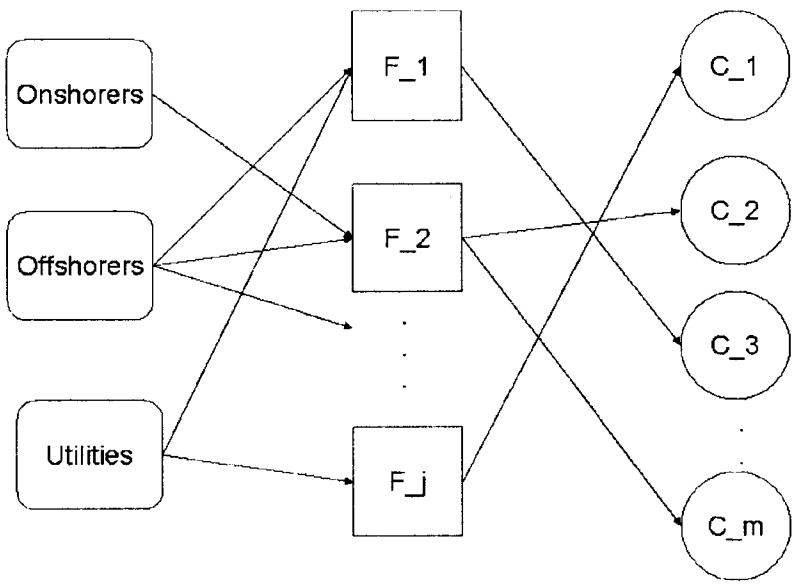
1. What is the impact of consumer valuation of quality on the share of production allocated to different production regimes?

2. What is the optimal sourcing frontier for context-sensitive services? How does market valuation of quality impact the allocation of production of context-sensitive services?

3. What is the optimal sourcing frontier for judgment-intensive services? How does market valuation of quality impact the allocation of production of judgment-intensive services?

4. What factors impact on the trade-off between automation and human production of services?

Figure 3.1: Displays the two-tier market model comprising 3 types of service vendors, firms, and customers.

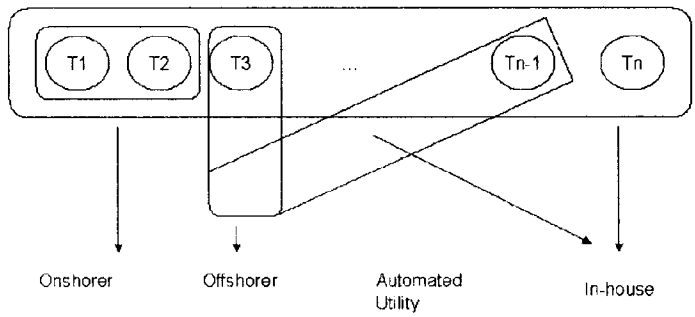


Our goal is to study the boundaries of a firm in a two-tier model (see Figure 3.1). The upstream market comprises a heterogeneous group of vendors – Onshore providers, Offshore providers and Automated Utilities - who differ in their quality of service and costs. Firms (F_j) engaged in servicing customers decide whether to use in-house development capabilities or to outsource; and if the latter then which vendors to

outsource to. In the downstream market, firms compete to sell their differentiated services to the same set of heterogeneous customers (C_m) who differ in their preference for quality and willingness to pay for it. We track the influence of heterogeneous downstream customer demand on the dynamically evolving back-end differentiation decisions of firms via simulation.

The model consists of three groups of service vendors, Onshorers, Offshorers, and Automated Utilities but for purposes of our model we assume that each group operates as a single entity. The service vendors, however, differ across groups in their levels of quality of service. The Automated Utilities are scale players and are more efficient producers of standard process volume; whereas, the one-to-one Outsourcers (Onshorers and Offshorers) are less efficient producers of basic processes and more efficient custom producers. Offshorers provide more efficient custom solutions than Automated Utilities but their solutions are lower in quality as compared to Onshorers, due to the context distancing factor associated with offshoring services. Although, due to lower wages in offshoring countries, the costs of Offshorers are much lower than the costs experienced by Onshorers. Highest quality can only be obtained through In-house development at substantially higher costs. Since we are interested in studying the dynamics of downstream consumer demand on the outsourcing decisions of firms, we assume that the service vendors operate at zero profit equilibrium or constant profit given by marginal cost plus switching costs, which we normalize to naught. Therefore, the price that vendors charge the firms is equivalent to their costs. The cost function of the different vendors is linear in their quality and given by $c_i = k \times q_i$, where i represents the vendor who can be any one of IH-In-house, O-Onshorer, OS-Offshorer, U-Automated Utility.

Figure 3.2: Displays the assignment of tasks either to in-house development services or to the 3 different groups of service vendors. In this particular assignment, no tasks are allocated to the BTU.



In order to provide service to downstream customers, each firm has a set of tasks that it has to complete. Firms can either perform the tasks In-house or outsource one or more tasks to one of the 3 groups of upstream vendors, depending on the quality level the firm seeks. Figure 3.2 illustrates the assignment of tasks across the sourcing options for the case where a firm must complete a set of n tasks. According to the distribution in Figure 3.2, the firm outsources the first two tasks to the Onshorer, the third and n-1^{th} tasks to the Offshorer, and the rest of the tasks to In-house development with no tasks being outsourced to the Automated Utility.

The quality of service provided by the firms to end-customers is a function of the allocation of the tasks. The overall quality of service offered by a firm is proportional to the number of tasks outsourced to the various vendors and given by:

$$q_j = \frac{q_{IH} \times n_{IH} + q_O \times n_O + q_{OS} \times n_{OS} + q_U \times n_U}{n},$$

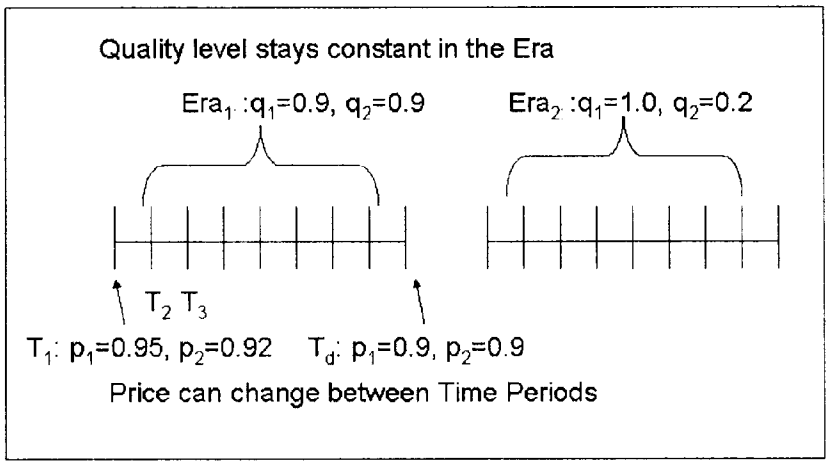
where n represents the number of tasks that needs to be completed in order to provide service downstream, and q_i and n_i represent the quality of services of the different sourcing options and the number of tasks allocated to the particular option, respectively.

We assume that time is discrete, although this is not an essential assumption. In any time period, t, each customer chooses at most one firm to buy service from. Each customer, C_m, has a utility function, $U_m(s_m, p_j, q_j)$, which is a single-valued function of the price and quality of the service offered by a particular firm, F_j, in addition to the customer's taste preference, s_m. A customer chooses the service offered by the firm whose price-quality pair maximizes his utility. The utility function is concave function given by:

$$\max_j U_i(s_m, p_j, q_j) = U \times s_m \times \sqrt{q_j} - p_j, \text{ where } q_j, s_m \in (0,1]$$

where U represents customers' value for quality, s_m defines the taste parameter of the customer, q_j and p_j, are the quality and price charged by Firm j. The utility function is such that all customers prefer higher quality at a given price, but a customer with a larger value of the taste parameter, s_m, is willing to pay more for higher quality. The formulation is consistent with standard models of vertical differentiation (Tirole, 1988) and has been widely used in extant research.

Figure 3.3: Example of a two era duopoly model.



Time is broken into eras and each era consists of several time periods (see Figure 3.3). Customers visit firms during each time period and buy service from the firm that maximizes their utility. We do not assume that firms provide services that cover the entire market. Therefore, customers will only buy service if their maximum utility is positive; otherwise, they refrain from buying service for that time period. Firms change their task allocation only at the beginning of each era; as a result, for all the time periods in that particular era, the various quality levels chosen by firms remain constant. Price is the only variable that firms can change during a particular era. In other words, at the beginning of each time period in an era, firms decide whether to change price and if so, what level to price their service at. The distinction between eras and time periods can be thought of as short-term decisions versus medium-term decisions. In the short-term, it is relatively easy to change price but not the assignment of tasks. At the beginning of each era, every firm evaluates the profitability of the chosen quality level. If the profits obtained at the chosen quality level satisfy a particular criterion, the firm continues at the

same quality level. However, if the profits do not meet a particular criterion, a new task assignment is sought, resulting in a new quality of service provided by the firm. Figure 3.3 demonstrates an example of quality and price choices of a duopoly model for two eras. In the first era, both firms coincidentally choose the same quality level of 0.9 and compete on price during the era. In the first time period, $Firm_1$ picks a price of 0.95 and $Firm_2$ picks a price of 0.92. Since both firms provide the same level of quality but the price of $Firm_2$ is lower, all customers who have positive utility for the particular levels of quality and price choose the lower price firm, $Firm_2$. In the following time period, $Firm_1$ charges a price lower than $Firm_2$ and captures $Firm_2$'s entire market. $Firm_2$, in turn, retaliates by decreasing its price further. Thus begins a price war between the two firms which ultimately results in the firms pricing at their marginal cost by the end of the first era. Since both firms make zero profits in the first era, the two firms choose different outsourcing strategies in the second era, as illustrated in Figure 3.3. Pricing and quality decisions are made simultaneously by firms without the knowledge of current decisions of competitor firms. The firms do, however, have knowledge of past decisions made by their competitors.

3.6 Simulation Methodology

Economic analyses of e-markets assume that firms have complete knowledge of their competitors' costs, current chosen quality levels and prices. In reality, however, individual firms do not possess such complete knowledge; on the other hand while their knowledge is limited they are nonetheless capable of gathering and learning information with time based on past behavior of their competitors. Consequently, in this essay, we do

not assume that firms possess any knowledge of current quality levels and prices of their competitors but provide them with the ability to react to previously garnered information.

The marketplace we model is dynamic and non-stationary. The fact that firms are learning about an environment of which they are a part, and learning about the environment and other players who are simultaneously learning about the firm itself makes the model non-stationary. These characteristics make the model far too complex and intractable for analytical analysis and force the firms to engage in active learning in order to determine the quality level of service to offer. Next, we describe the vendor choice strategy and the pricing strategy employed by firms.

3.6.1 Vendor Choice Strategy – Learning Model

In this essay, a genetic algorithm (GA) (Holland 1970a, 1975, 1980) is used to model learning by firms. GAs were developed as robust methods for adaptive search, learning and optimization in complex problem domains. GAs are based on the theory of evolution and survival of the fittest. The algorithm maintains a population of possible strategies where over time strategies that perform well are retained, whereas those that perform poorly are replaced. Such a model favors adaptive learning since the population of strategies evolves over time and newer strategies are created from existing fit strategies. Replacement takes place through two processes, known as crossover and mutation, from existing strategies where the selection process favors the fitter or better performing strategies. Therefore, strategies that have been more successful in the past are more likely to become more frequently represented in the population of strategies. Crossover exchanges subparts of two chromosomes (strategies) that are selected

probabilistically based on the fitness of the strategies. The process of mutation randomly changes the value of some bits in the chromosome so as to promote exploration or sampling of strategies from different parts of the strategy space. Mutation can reinstall useful information that has been lost or introduce useful information which was never present. The process of mutation is especially important in environments that are constantly changing.

The first application of GAs to economic models has been carried out by Miller (1986). Axelrod (1987), in his many experiments to find strategies for the iterated prisoner's dilemma game, has used a GA to see if successful strategies can be found. Most of the strategies were variants of the very successful yet simple strategy – Tit-for-Tat. GAs have also been used extensively to find trading rules in financial markets (LeBaron, 2001) and for discovering bidding strategies in auctions (Andreoni and Miller, 1995). Arifovic (1994) employs a GA to find optimal production strategies for a set of firms. In her model each of the competing firms uses a GA to evolve a set of production strategies for the next period. The simulation results show that the adaptive market model converges to the rational expectations equilibrium. A Cournot oligopoly game is studied by Vriend (2000) in which firms compete by individually setting their quantity levels and the market price is determined based on the aggregate quantity produced. Vriend compares the outcomes of population level learning to individual learning. In the population level learning, a GA maintains a single production rule for every firm. Hence, new rules for a firm are created from successful rules of competitor firms. In individual learning, on the other hand, each firm uses a GA to maintain a set of production strategies and new strategies are formed based on the firm's own successful strategies. The author

finds that the population level learning systematically results in the aggregate output being close to the socially optimal level whereas the individual learning does not. The underlying commonality in the above studies is the question of whether adaptive agents are able to converge to a particular stable equilibrium in environments with multiple equilibria or are able to find a stable equilibrium in economies in which it is difficult to analytically find equilibrium strategies.

A GA starts off with a randomly generated population of chromosomes, where a chromosome encoded as a bit string represents a possible strategy. The fitness of an individual strategy is evaluated with respect to a given objective function. Once the strategies in the population set are evaluated, a new set of strategies are generated. There are several different methods of generating a new population. Two of the methods are: (1) generational approach - where an entirely new set of strategies can be generated and used to replace the previous set, or (2) steady-state approach - where a certain percentage of the fittest strategies is retained to populate the new population with the rest of the new strategies (termed offspring) being generated through crossover and mutation from highly fit individual strategies. Therefore, offspring strategies share some of the characteristics from the two parents from which they are created. The method of parent strategy selection for crossover is based on relative fitness proportion. Mutation is applied after crossover to randomly chosen bits of the chromosome string. The evaluation-selection-reproduction cycle is repeated until a satisfactory solution is found.

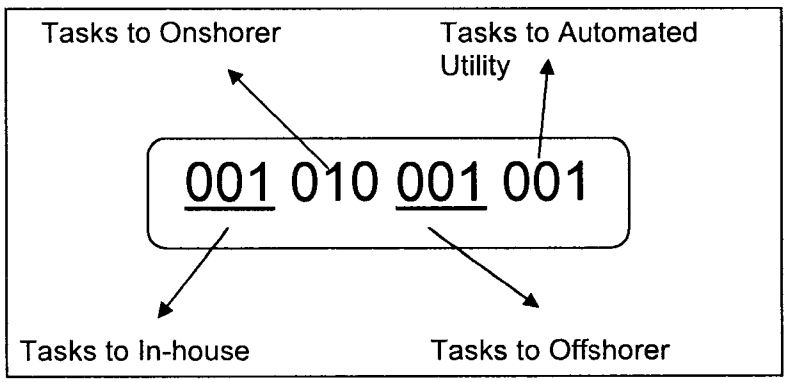
The stopping criterion of the GA we model is based on Herbert Simon's (1955, 1972) pioneering work on the theory of satisficing, according to which economic agents are boundedly rational and make decisions through "satisficing" rather than maximization

when faced with uncertainty and incomplete information. Satisficing is defined as the state of satisfaction when the outcome is comparable to an aspiration level. The satisficing approach has been considerably used in the literature in different forms and various types of models. In fact, Lant (1992) empirically tests the hypothesis of firms being boundedly rational where competing firms learn by forming aspirations based on past experiences. Krider and Weinberg (1997) study the competitive dynamics among retail firms that are modeled as boundedly rational agents which only search for better solutions if certain goals are not being met. Similar to our model, Stewart et al. (2004) employ a GA to solve a constrained optimization problem which uses aspiration levels to determine whether a solution is good enough. Pseudo-code for the algorithm can be found in Appendix. For a more detailed explanation of GAs please refer to Holland (1992) and Beasley et al. (1993a, 1993b).

In our model, each firm uses a GA to maintain a list of strategies which evolves using the steady-state approach, based on the past behavior of competitor firms as well as the firm's own previously used strategies. A chromosome or strategy for the firm is a possible assignment of tasks to the different sourcing options whether In-house, Onshorer, Offshore, or Automated Utility. Every strategy in the list is represented as a binary string in the GA. See Figure 3.4 for the representation of a strategy. Each sourcing option is represented by the number of bits required to represent the total number of tasks that need to be completed in order to provide service to downstream customers. Hence, if the total number of tasks is n, each sourcing option is represented by $b = ceiling[\lg(n+1)]$ bits (in a binary string). Further, since each sourcing option requires b bits and there are 4 different sourcing options, the length of the chromosome is $b \times 4$. Figure 3.4 depicts the

case where the number of tasks to be completed by a firm is 5. Since the number of bits needed to represent 5 tasks is 3, *b* in the figure equals 3 and the length of the chromosome equals 12. According to the task allocation in Figure 3.4, 2 tasks are outsourced to Onshorers and one task each is assigned to the other sourcing options.

Figure 3.4: Representation of a chromosome (strategy) in the GA, with 4 sourcing options and 5 tasks that need to be completed. Each sourcing option is represented by 3 bits.



The fitness of a strategy is equivalent to the profits earned by the firm when the particular strategy is used. An important issue with this representation is that a randomly generated strategy can result in an assignment of tasks which is less than or more than the total number of tasks that needs to be assigned; hence, resulting in infeasible strategies. The research literature suggests two ways of dealing with infeasible strategies. In the first method, the population of strategies is allowed to maintain both feasible and infeasible solutions and any time an infeasible solution is chosen, a very large penalty is assigned to it. The reason for the large penalty is to prevent the particular strategy from being chosen for selection while generating the new population of strategies. The second method

transforms the infeasible strategy to a feasible one. We choose the second method like Beasley and Chu (1996)[40]. Table 3.10 in Appendix contains the parameter values of the GA which are based on values suggested in the machine-learning literature or taken from similar experiments.

3.6.2 Pricing Strategy

According to Baker et al. (2001) in their article in the Mckinsey Quarterly Journal, firms can learn a lot of information about buyer demand by adjusting prices by small amounts. Despite the numerous theoretical models in the academic literature, the article states that forecasting customer demand and formulating a price model is a very difficult and complex task. Hence, most firms especially those in the service sector resort to simple pricing strategies or rules of thumb. Furthermore, the pioneering work of Herbert Simon (1955, 1972) illustrates that firms conform poorly to traditional theories of "rational decision-making."

In our model, firms can change their quality strategy (assignment of tasks) only at the beginning of an era. Recall that an era comprises a fixed number of time periods. However, prices can be changed at the beginning of every time period. Any time a new quality level is chosen, a firm must choose a new price. Although, the firms can retain the same price as the immediately preceding time period (assuming the quality level is the same) if the profits obtained by the firm satisfy a specific criterion.

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[40] When the sum of the assigned tasks in an infeasible strategy is more than the total number of tasks, we randomly choose one of the sourcing options and decrease the assignment by one task (only if it is possible to do so). The number of decrements equals the total number of tasks that the strategy is over the maximum number of tasks. An increment is performed if the infeasible strategy is under the maximum number of tasks. The increment operation is carried out until all tasks are assigned to one of the sourcing options.

Firms in our model use a heuristic pricing strategy which is a modification of the derivative pricing algorithm described in Kephart and Greenwald (1999). In time period t, in era e_s, if no other firm is providing service at the same quality level as the firm, the firm experiments by increasing its price. If the price increase results in an increase in profits, the firm increases price again in the following time period, t+1; on the other hand, if profits drop, price is decreased. In other words, the firm incrementally changes price in the same direction as before as long as profits increase and if profits drop, the direction of price change is reversed. Unlike in the derivative pricing algorithm where the increment is randomly chosen from a uniform distribution, firms in our model use a reasonable heuristic. The increment used by firms in time period t is the average of the difference in prices of firms in the previous time period, t-1. If two or more firms provide service at the same quality level, the firms never experiment with price increases and only engage in under cutting their rivals. Firms never price below their marginal cost. Consequently, if the price decrement results in a price lower than a firm's marginal cost the firm charges a price equal to its marginal cost.

In some instances, a firm experimenting with price increases might find that the increase has resulted in a decrease in profits and so in the following period the firm decreases its price. However, the decrease might be large causing the price to dip below marginal cost and so the firm ends up charging a price equal to its marginal cost. Since the firm faces no competition from another firm at the chosen quality level, the firm would experiment with increasing price yet again. The price increment rule might once again result in the firm charging a price too high for the quality level it is offering.

Therefore, the firm makes zero profits yet again and experiments with a price decrement in the following time period. As a result, a firm might be caught oscillating between charging a price equal to its marginal cost and a price too high for its quality level. In such cases, the firm uses the following heuristic. The firm charges a price such that a consumer with a taste parameter s_m is indifferent between the firm and the competitor who provides the highest utility for the consumer.

When the quality level chosen by a firm changes, the firms have 4 different pricing options to choose from: (a) price at the maximum mark-up on costs of the firms in the last time period of the previous era, (b) price at the minimum mark-up on costs of the firms in the last time period of the previous era, (c) price at the average mark-up on costs of the firms in the last time period of the previous era, or (d) price at the geometric mean of the mark-up on costs of the firms in the last time period of the previous era. Each firm chooses a different pricing strategy so as to preclude an intrinsic bias of emergent collusive behavior.

3.6.3 Simulation Protocol and Model

As stated previously, there are four sourcing options: In-house development, Onshorer, Offshorer and Automated Utility. We run simulations with 4 firms, each of which must complete 10 tasks in order to provide service to downstream customers. A firm does not change the level of quality it offers or the price it charges for a particular quality level, if a satisfaction criterion is met. The satisfaction criterion is that the firm

makes roughly one-fourth of the total profits made by firms in the market[41]. Each customer chooses only one firm to buy a unit of service from in each time period. Customer preferences for quality, s_m, are uniformly distributed between 0 and 1, $s_m \in (0,1]$[42]. The number of customers in the market is 500. For purposes of comparison, we keep the customer preferences constant across all simulation runs and process regimes.

The cost function of vendors is given by $c_i = k \times q_i$, as stated previously in Section 3.5. In the simulation model, we assume $k = 1$, and the quality level offered by vendors is $q_i \in (0,1]$ In the first era of every simulation run, we assign firms with an initial strategy different from the strategy of its competitors, from then on, the firms choose a strategy based on the GA. The mark-up price firms use in the very first time-period in the first era is a mark-up of 18.6%[43], then onwards, firms use the pricing strategy outlined in Section 3.6.2. Each era is made up of 30 time-periods.

We analyze the allocation of production capacities of the four firms across the different sourcing options for three different types of services as outlined in Section 3.4 – Survey Findings. The three types of services discussed are (1) Quality Neutral, (2) Context-Sensitive and (3) Judgment-Intensive. We rename *Normal Processes* as *Quality Neutral* processes to include processes that don't fall into either of the other categories. In

[41] The exact percentage of profits that we use for the satisfaction criterion is 22% which closely tracks to a "normative equitable distribution of profits". It is obvious that using 25% will require exact convergence with all four competitors garnering identical profits and will therefore, not result in a converged solution space.

[42] If more than one firm provides a customer with the same utility, the tie is broken randomly by the customer.

[43] Mark-up price chosen based on the weighted average gross returns on several industries as seen from S&P 500 index. It is obvious on inspection that the starting point does not impact the eventual solution.

the Quality Neutral Process Regime the quality levels offered by the different sourcing options are as follows[44]: $q_{IH} = 1.0, q_O = 0.75, q_{OS} = 0.5, q_U = 0.25$.

Context Sensitive Services are those services where processing agents need to be close to the firm's consumers and have a deep understanding of the market context. Hence, for these services even the next best alternative to In-house development results in a great decay in quality. The particular quality levels parameters for the different sourcing options are as follows: $q_{IH} = 1.0, q_O = 0.48, q_{OS} = 0.32, q_U = 0.16$. Finally, for Judgment Intensive Services where human interpretation is required and human agents need to make judgments on specific decisions, the use of the Automated Utility results in very low levels of quality. However, the difference in quality between In-house development and other options involving human judgment is small. In the Judgment Intensive Process Regime the quality levels offered by the different sourcing options are as follows:

$$q_{IH} = 1.0, q_O = 0.8, q_{OS} = 0.6, q_U = 0.1.$$

We also experiment by changing the value of U/k, which can be defined as the value creation parameter or the value to cost ratio. Recall that U in the customer utility function is the parameter which captures the value of quality for customers and k in the vendors' cost function represents the cost parameter.

3.7 Results and Analysis

Convergence is observed in all simulation runs and the results illustrate that adaptive firms are able to converge to a stable quality and price strategy. In dynamic

[44] The actual values are less relevant. It is the separation that is important. It is clear that this quality hierarchy regimes tracks to the survey responses quite closely.

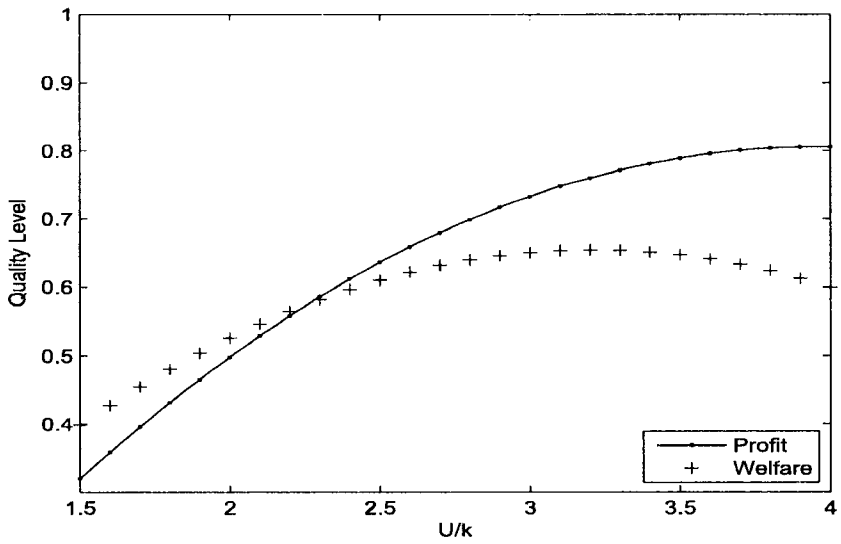
learning models, convergence is path-dependent and our results show that there is no unique strategy solution for firms. Therefore, for each process regime for which we demonstrate the results, we have taken an average of the top five solutions that maximize the profits of the firms and the average of the top five solutions that maximize overall welfare based on 500 different sets of runs.

3.7.1 Average Quality Comparison

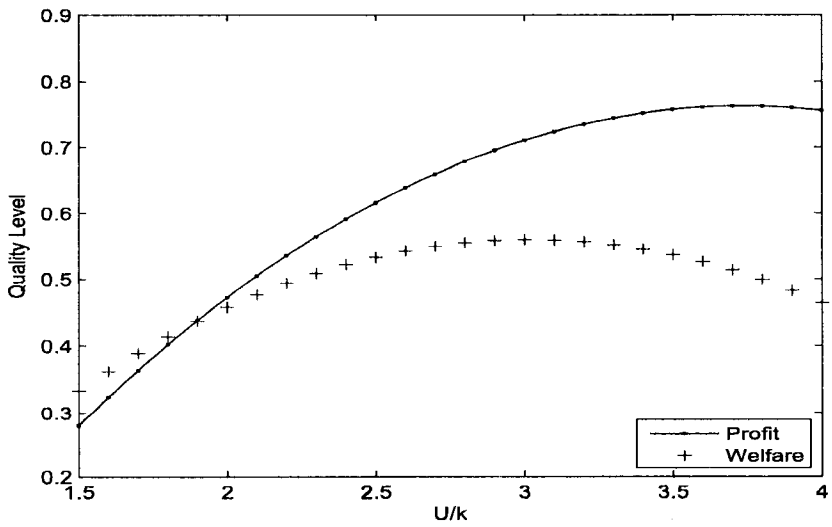
Figure 3.5(a) compares the mean quality at equilibrium in the Quality Neutral Process Regime under the profit maximizing solution and the welfare maximizing solution for different values of the value/cost (valuation) ratio. The graph illustrates the general trend of the relationship based on the values obtained for different customer valuations ranging from 1.5 to 4.0 in increments of 0.1. Low values of the valuation ratio refer to commodity services that customers don't value very much, whereas high values of the valuation ratio refer to highly valued services by the customers. As illustrated in the graph, as the valuation ratio increases, the mean quality at equilibrium in both the welfare and profit maximizing solutions increases. Further, as the valuation increases we find that the profit maximizing solution tends to over invest in quality.

Figure 3.5: Mean Quality at Equilibrium under the Profit and Welfare maximizing solutions in the (a) Quality Neutral Process Regime, (b) Context Sensitive Process Regime, and (c) Judgment Intensive Process Regime.

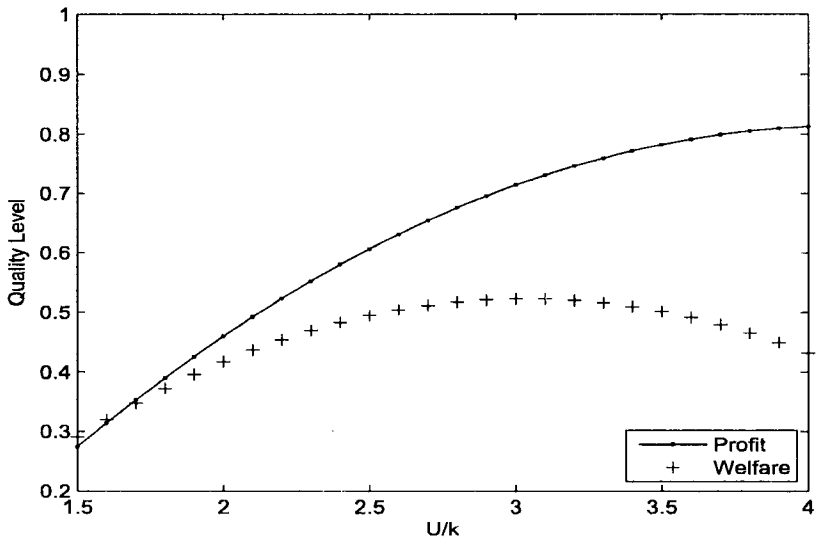
(a) Quality Neutral Process Regime



(b) Context Sensitive Process Regime



(c) Judgment Intensive Process Regime



Since firms are concerned only with profit maximization and not about social welfare, by over-investing in quality they leave more of the market uncovered. The correlation between the valuation ratio and the mean quality in the profit maximizing solution is 0.959, whereas with the welfare maximizing solution the correlation is 0.776, corroborating our trend analysis. The results appeal to the intuition that underlies competition in markets characterized by vertical differentiation. At low valuation ratios, since customers' value for services is so low firms make more profits by under investing in quality and leaving part of the market uncovered; while as valuation increases, customers are more willing to pay for quality, and so to maximize their profits firms start to over invest in quality to capture customers who highly value the service and leave out the lower part of the market that values it less – less profitable customers. Firms tend to over invest in quality under the profit maximizing solution as compared to the welfare maximizing solution as customer valuation increases even in the Context Sensitive and

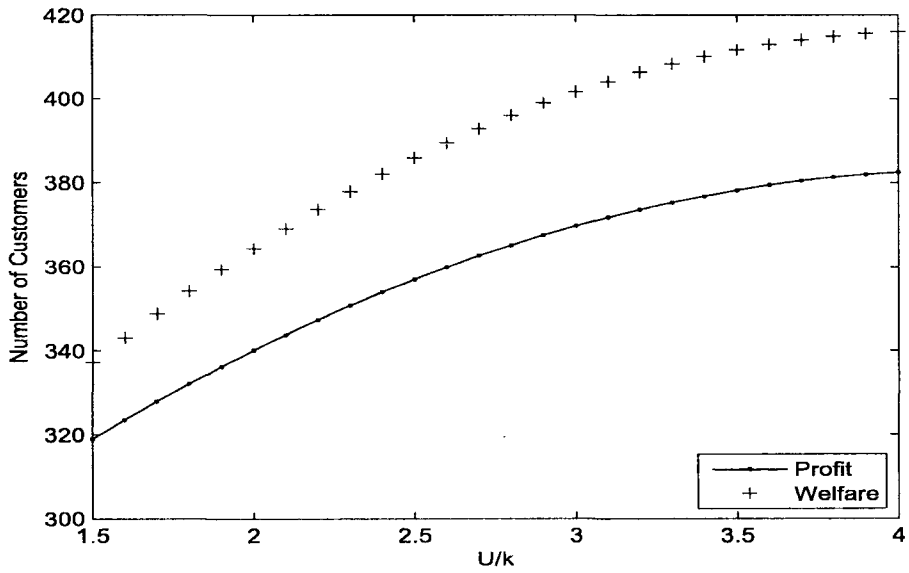
Judgment Intensive Process Regimes (see Figure 3.5(b) and Figure 3.5(c)). The correlations between customer valuation and the mean quality in the market under the profit and welfare maximizing solutions for the three process regimes are shown in Table 3.6: Correlations between customer valuation and the mean quality at equilibrium under the profit and welfare maximizing solutions under the three process regimes. Figure 3.6 compares the number of customers served under the profit and welfare maximizing solutions in the three different process regimes. As illustrated in the figures, the profit maximizing solution always leaves more of the market uncovered as compared to the welfare maximizing solution.

Table 3.6: Correlations between customer valuation and the mean quality at equilibrium under the profit and welfare maximizing solutions under the three process regimes.

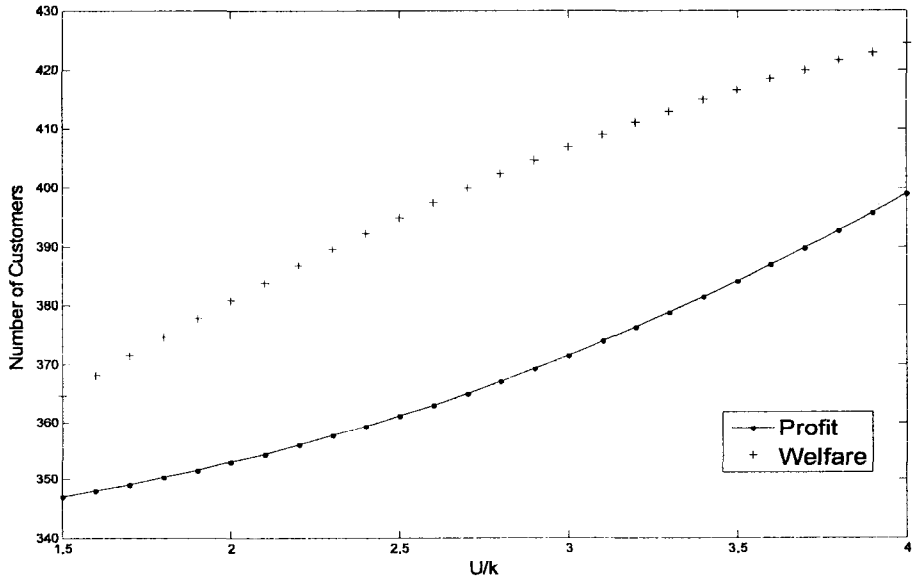
	Quality Neutral *Welfare*	Quality Neutral *Profit*	Context Sensitive *Welfare*	Context Sensitive *Profit*	Judgment Intensive *Welfare*	Judgment Intensive *Profit*
Correlation with U/k	0.776	0.959	0.549	0.942	0.591	0.969

Figure 3.6: Number of Customers Served under the Profit and Welfare maximizing solutions in the (a) Quality Neutral Process Regime, (b) Context Sensitive Process Regime, and (c) Judgment Intensive Process Regime.

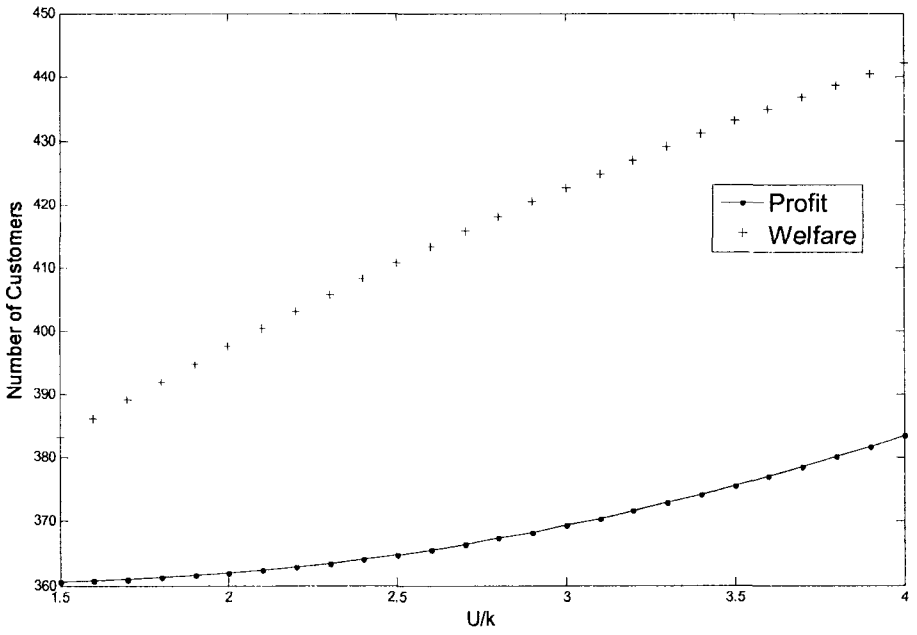
(a) Quality Neutral Process Regime



(b) Context Sensitive Process Regime



(c) Judgment Intensive Process Regime



3.7.2 Production Allocation in Process Regimes

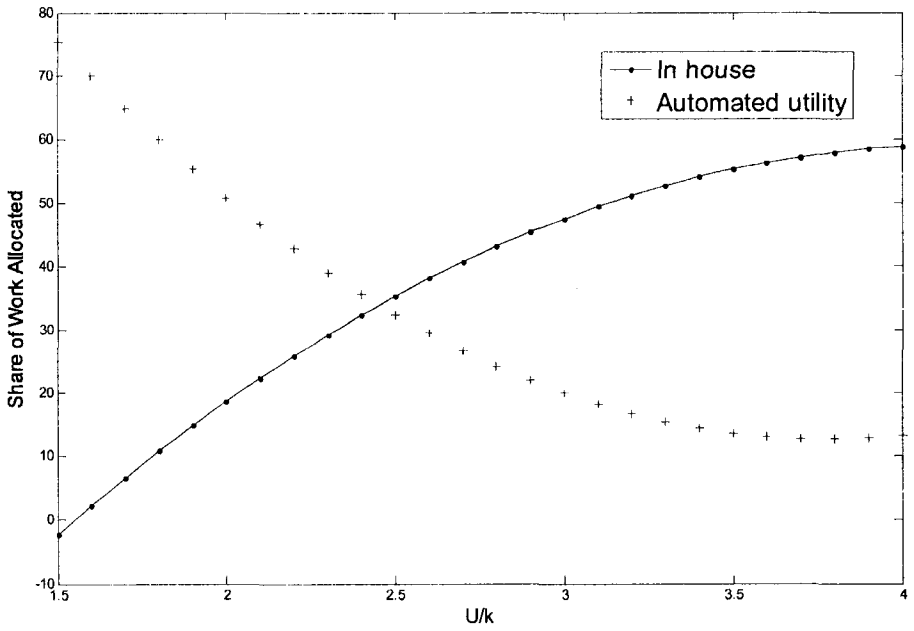
3.7.2.1 Quality Neutral Process Regime

In Figure 3.7 we compare the share of production allocated to the Automated Utility and retained In-house as a function of the valuation ratio. As valuation increases, the share of production retained In-house increases, while the share allocated to the Automated Utility decreases dramatically. The two shares of production allocated possess an inverse relationship as also illustrated by the negative correlation between the shares shown in Table 3.7 as -0.979. We have also run a regression of the share of production allocated to the Automated Utility as a function of customer valuation (U_k) and obtain the following.

$$Share_{AU} = \beta_0 + \beta_1 \times U\_k + \varepsilon,$$

where β_0 is 1.005, β_1 is -0.248 and the adjusted R-square is 0.883. The negative coefficient of β_1 further corroborates the relationship that as customer valuation increases the share of production allocated to the Automated Utility decreases. On the other hand, when we run a regression of the share of production allocated to In-house production as a function of customer valuation we find that β_1 has a positive value of 0.244, indicating that as customer valuation increases the share allocated increases. The adjusted R-square we obtain is 0.928.

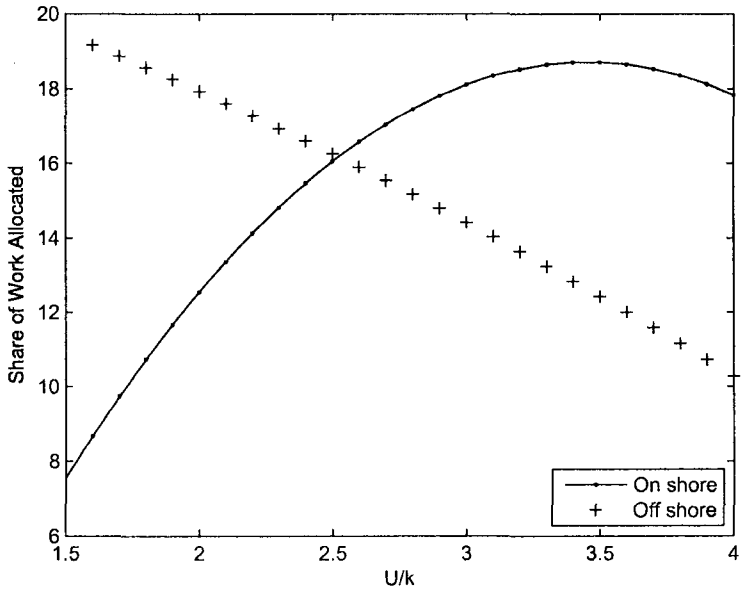
Figure 3.7: Share of Work Allocated (%) to In-house Production and the Automated Utility in the Quality Neutral Process Regime.



When comparing the share of production allocated to the Onshorer and Offshorer in Figure 3.8, we observe that as valuation increases the onshoring option dominates in the high valuation region. When the valuation ratio is low, since customers' willingness to pay for quality is limited, firms are forced to resort to the cheaper, lower quality option

– which turns out to be offshoring. The negative correlation of -0.463 between the shares of production allocated to the Onshorer and Offshorer indicates that while the share allocated to the Offshorer decreases as customer valuation increases, the share allocated to the Onshorer increases. Therefore, an important result is that as customer valuation increases a greater share of work is allocated to onshore production as compared to offshore production.

Figure 3.8: Share of Work Allocated (%) to the Onshorer and Offshorer in the Quality Neutral Process Regime.



Regression analysis of the share of work allocated to domestic production, which is the sum of in-house and onshore production, as a function of customer valuation yields a positive coefficient for customer valuation, 0.207. Note that the positive coefficient of customer valuation in the regression analysis of domestic production is lower than the coefficient in the regression analysis of only in-house production. The reason for the lower coefficient is due to the dilution of the domestic production advantage with the

addition of onshore production which tends to decrease slightly at very high levels of customer valuation due to the lower quality of service offered by the Onshorer.

Table 3.7: Correlations between the 4 production regimes in the Quality Neutral Process Regime.

	In-House	*Onshore*	*Offshore*	*Utility*
In-House	1			
Onshore	0.840	1		
Offshore	-0.717	-0.463	1	
Utility	-0.979	-0.907	0.579	1

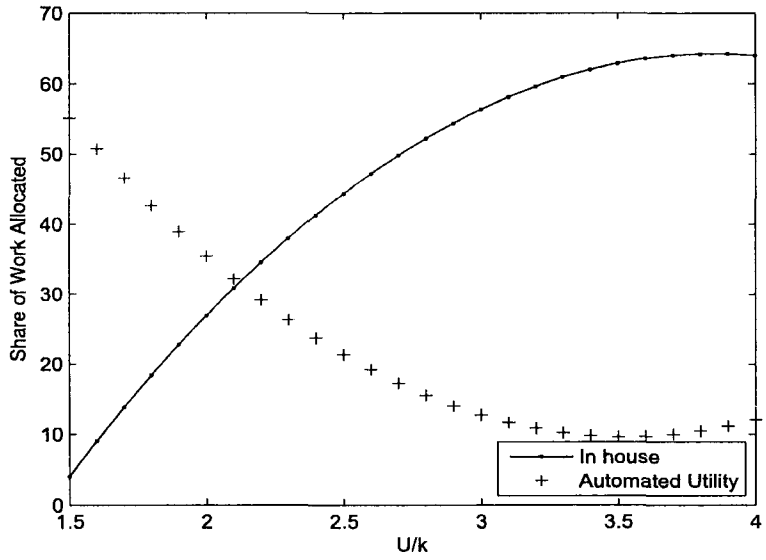
3.7.2.2 Context Sensitive Process Regime

In the context sensitive process regime, the difference between In-house production and the next best quality alternative is huge; hence, in this regime, it is extremely important for firms to be close to the market. Many kinds of processes such as fixed income pricing research, legal research and supplier coordination in supply chains fall under this category.

Table 3.8: Correlations between the 4 production regimes in the Context Sensitive Process Regime.

	In-House	*Onshore*	*Offshore*	*Utility*
In-House	1			
Onshore	-0.042	1		
Offshore	-0.938	0.079	1	
Utility	-0.972	-0.153	0.860	1

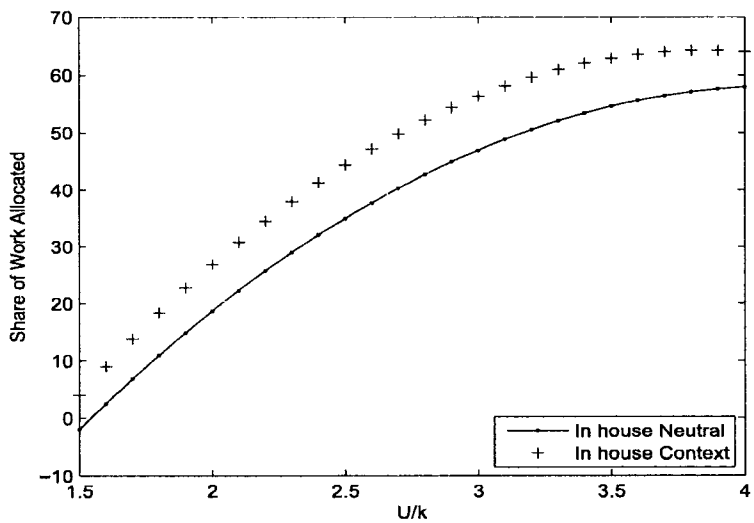
Figure 3.9: Share of Work Allocated (%) to In-house Production and the Automated Utility in the Context Sensitive Process Regime.



In Figure 3.9 we graph the share of work allocated to the Automated Utility and In-house production as a function of the valuation ratio. As valuation increases, the share of production retained In-house increases, while the share allocated to the Automated Utility decreases. Consequently, we observe a negative correlation between the share of work allocated to In-house production and the Automated Utility. Findings are further corroborated by the regression analysis of the share of work allocated to in-house production and the Automated Utility as a function of customer valuation. The coefficient of customer valuation is positive with a value of 0.240 in the regression of In-house production and has a value of -0.172 in the regression of production allocated to the Automated Utility. The adjusted R-square values of the share of work allocated to In-house production and the Automated Utility are 0.897 and 0.818, respectively. Although the coefficient of customer valuation in the regression analysis of In-house production is

slightly smaller by 0.004 in the Context Sensitive Process Regime than in the Quality Neutral Process Regime, the intercept in the Quality Neutral Process Regime has a higher negative value of -0.301 as compared to -0.211. The smaller intercept value in the Quality Neutral Process Regime decreases the overall share allocated to In-house production as compared to the share allocated in the Context Sensitive Process Regime. Figure 3.10 compares the share allocated to In-house production in the two regimes. We observe that a greater share of work is allocated to In-house production for all customer valuations in the Context Sensitive Regime than in the Quality Neutral Regime owing to a drastic decrease in the quality of outsourced service in the former regime.

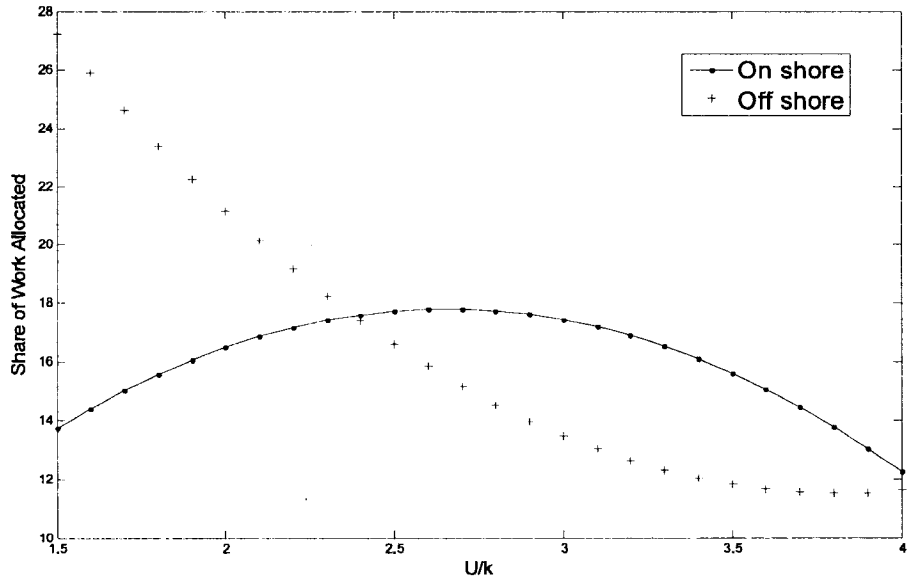
Figure 3.10: Share of Work Allocated (%) to In-house Production in the Quality Neutral and Context Sensitive Process Regimes.



We also compare the share of production allocated to the Onshorer and Offshorer in the Context Sensitive Process Regime in Figure 3.11. The trend line in the graph indicates that firms tend to outsource more work to the Offshorer than the Onshorer when

customers value the service less, in other words, at low customer valuation ratios. The reason for a lower share being allocated to the Offshorer at higher customer valuations is that although the Offshorer's costs are low they do not compensate for the very low level of quality offered by the Offshorer; and at higher customer valuations customers are willing to pay for higher quality levels unlike at lower valuations. Contrary to the Quality Neutral Process Regime where the correlation between the shares allocated to In-house production and the Onshorer is high and positive, 0.840, in the Context Sensitive Process Regime the correlation has a low but negative value, -0.042. The negative correlation is due to the drastic drop in quality between the in-house and onshore options, where the Onshorer is able to provide service at a very low quality level of 0.48 as compared to the in-house quality level of 1.0.

Figure 3.11: Share of Work Allocated (%) to the Onshorer and Offshorer in the Context Sensitive Process Regime.



We also observe a negative correlation of 0.938 between the share of work allocated to In-house production and the Offshorer. The negative correlation indicates that as the share of In-house production increases with an increase in the valuation ratio, the low quality of outsourcing work causes firms to move work away from outsourcing (both onshore and offshore) to In-house production. In other words, in a context sensitive regime it is very valuable for firms to understand local market conditions, firms' competitors and customers, and as the market tends to increasingly value these factors, outsourcing becomes a less alternative option. For example, investment banks considering outsourcing back-office services experience dilution in quality whether they outsource to domestic outsourcers or to offshore vendors. However, in context sensitive markets outsourcing to offshore vendors has a greater effect on the dilution in quality than does outsourcing to domestic vendors. Offshore vendors that provide research and

computational analysis of Mergers and Acquisitions targets for instance, are at a significant disadvantage compared to their clients or even onshore outsourcers as they do not have a sufficiently deep understanding of the client's markets or the market situation of the target corporations. Similarly, offshore firms can only provide a restricted set of services in the domain of supplier coordination in long and complex supply chains without an understanding of the business context of the buyer and its suppliers.

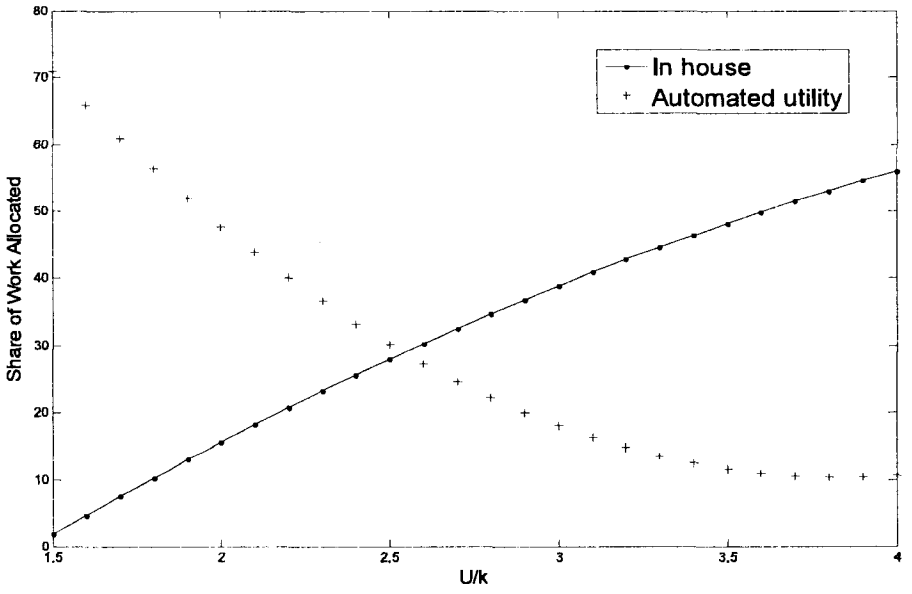
When we run a regression of the share of work allocated to domestic production as a function of customer valuation we obtain a value of 0.234 for the coefficient of customer valuation, indicating that as customer valuation increases so does the share of work allocated to domestic production. Therefore, an important result is that as customer valuation increases a greater share of work is retained domestically and not offshored. Although, the coefficient of customer valuation is greater when we regress the share allocated to In-house production as a function of customer valuation, which is 0.240, as compared to the regression of the share of domestic production. The effect is a dilution of the domestic production advantage as customer valuation increases due to the decrease in the share allocated to the Onshorer offering very low levels of quality.

3.7.2.3 Judgment Intensive Process Regime

In this regime production by human agents is favored where sourcing options involving human agents produce high quality. In-house production does not have a very big quality advantage over the Onshorer and the Offshorer. The Automated Utility, however, has a huge quality disadvantage as compared to the other sourcing options. For instance, in equity research it is possible in theory to create an algorithm and define

information that feeds into a computational model of a stock from such sources as Bloomberg and Lexis-Nexis. However, in such cases the research often lacks depth for there are several aspects of a firm's performance (and therefore its stock price) that require judgment and interpretation by a human agent. In the absence of human-intervention the resulting research is shallow and often of little strategic consequence.

Figure 3.12: Share of Work Allocated (%) to In-house Production and the Automated Utility in the Judgment Intensive Process Regime.



Consistent with the other two process regimes, we find that as the entire customer segment starts to value service more, causing the valuation ratio to increase, the effect is an increase in the share of work allocated to In-house production while a decrease in the share allocated to the Automated Utility (see Figure 3.12). Figure 3.12 illustrates the inverse relationship between the shares allocated to the two production regimes where the correlation between the two shares is -0.953 (see Table 3.9). The regression analysis of

the share of work allocated to the Automated Utility and In-house production as a function of customer valuation results in the coefficient of customer valuation equal to -0.241 and 0.217, respectively. The coefficient of customer valuation (0.217) in the regression of the share allocated to In-house production is smaller than the coefficient in the Context Sensitive Process Regime (0.240). The smaller coefficient indicates that the share allocated to In-house production increases less in the Judgment Intensive Process Regime than in the Context Sensitive Process Regime because as customer valuation increases there are other high quality but lower cost options available in the Judgment Intensive Regime such as the Onshorer and Offshorer.

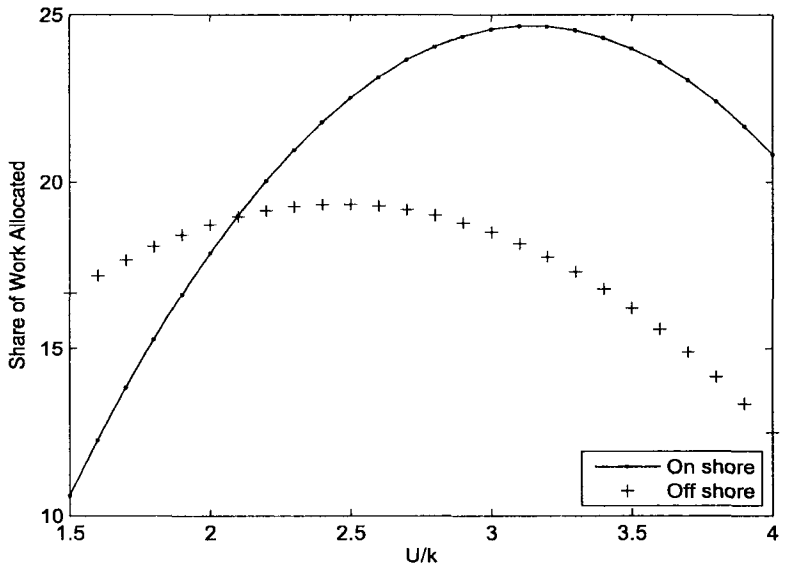
Table 3.9: Correlations between the 4 production regimes in the Judgment Intensive Market Regime.

	In-House	*Onshore*	*Offshore*	*Utility*
In-House	1			
Onshore	0.611	1		
Offshore	-0.467	0.1815	1	
Utility	-0.953	-0.809	0.213	1

Figure 3.13 compares the share of production allocated to the Onshorer and the Offshorer as a function of customer valuation. The graph demonstrates that offshoring is a cheaper option for lower customer valuations but as customer valuation increases the Onshorer has a clear advantage over the Offshorer due to his superior quality level; leading to an important result that far more jobs are lost to the Automated Utility than to the Offshorer. The regression analysis of domestic production as a function of customer valuation results in the coefficient of customer valuation equaling 0.258. Unlike in the

Context Sensitive Process Regime where the inclusion of the share allocated to the Onshorer dilutes the domestic production advantage, in the Judgment Intensive Process Regime the inclusion increases the share allocated to domestic production due to the higher quality of service provided by the Onshorer.

Figure 3.13: Share of Work Allocated (%) to the Onshorer and Offshorer in the Judgment Intensive Process Regime



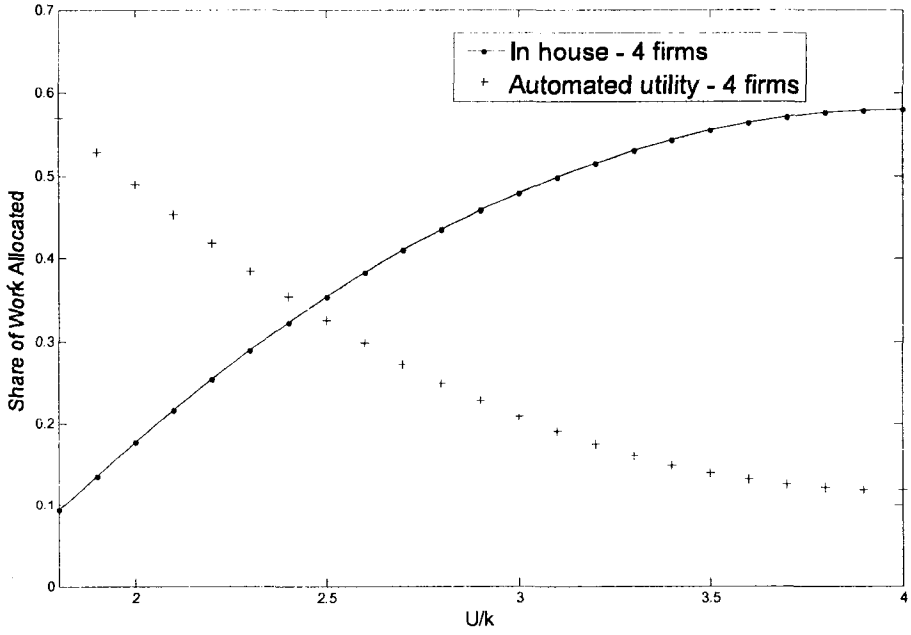
3.7.3 Market Concentration

In order to investigate how the shares of allocation across the different production regimes generalize when the number of competing firms is increased, we also run simulations with 5 competing firms and 6 competing firms in the Quality Neutral Process Regime. As illustrated in

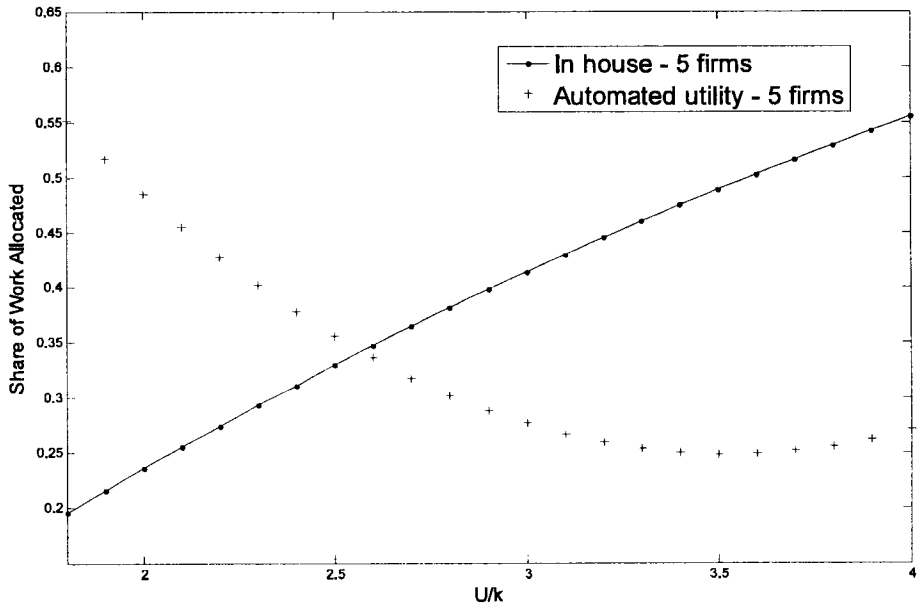
Figure *3.14*, the inverse relationship between the share of work allocated to In-house production and the Automated Utility holds regardless of the number of competing firms in the market. We observe that for low values of customer valuation the share allocated to the Automated Utility is higher than that allocated to In-house production, but as customer valuation increases the share allocated to the Automated Utility starts to decline whereas the share allocated to In-house production increases. Although the share allocated to the Automated Utility decreases, as the number of competing firms in the market increases the total share allocated to the Automated Utility increases.

Figure 3.14: Share of Work Allocated (%) to In-house Production and the Automated Utility in the Quality Neutral Process Regime with (a) 4 Competing Firms, (b) 5 Competing Firms, and (c) 6 Competing Firms.

(a) 4 Competing Firms



(b) 5 Competing Firms



(c) 6 Competing Firms

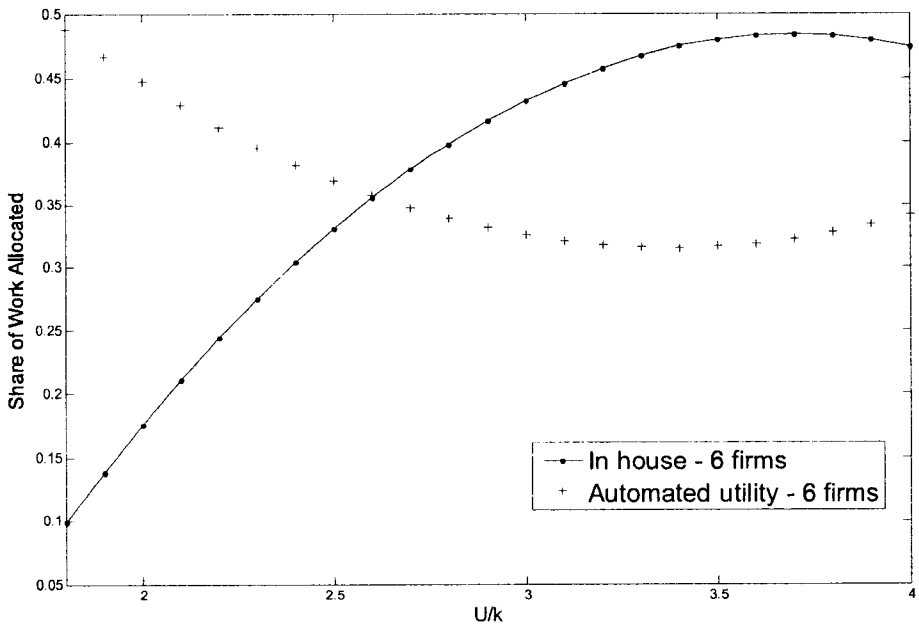
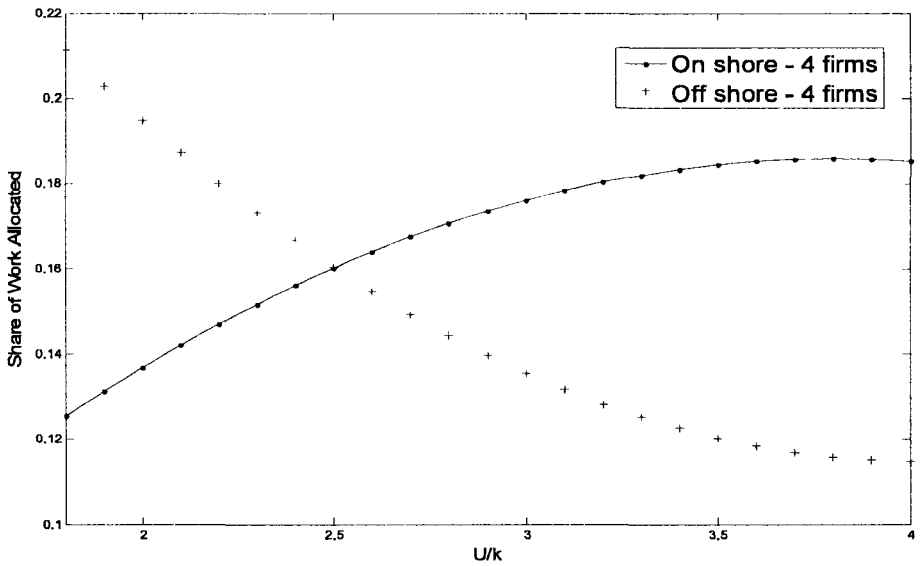


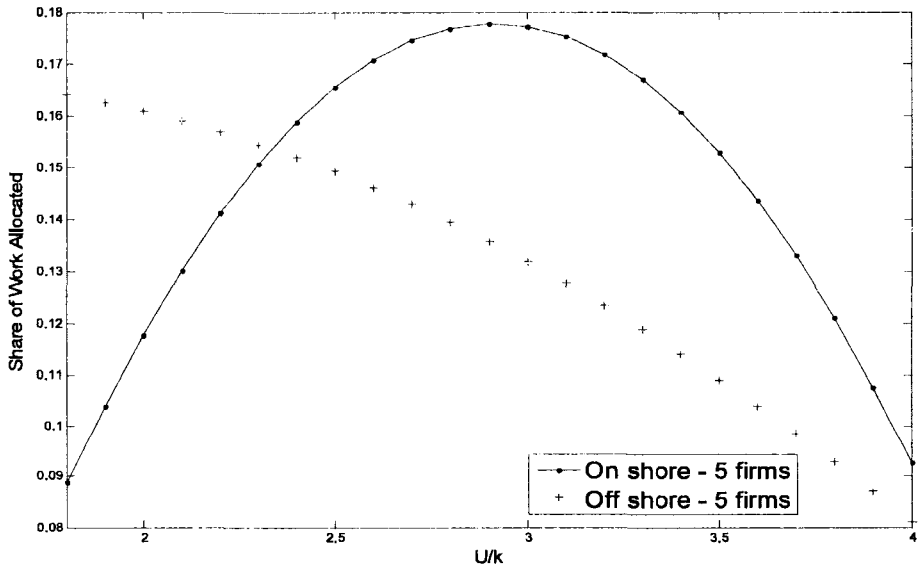
Figure 3.15 depicts the effect of the number of competing firms on the share of allocation to the Onshorer and Offshorer. The figure demonstrates a consistency in a greater share being allocated to the Offshorer than the Onshorer when customer valuation is low but as customer valuation increases a greater share is allocated to the Onshorer. However, we also observe that as the number of competing firms in the market increases the total share allocated to the Onshorer for high values of customer valuation tends to decrease. The share of work allocated to domestic production, In-house production plus the Onshorer, as a function of customer valuation for different market concentrations is shown in Figure 3.16. The graph illustrates that for low customer valuations the greater the market concentration, the higher the share allocated to domestic production, but as customer valuation increases, higher market concentration results in a decrease in the share of work allocated to domestic production. Additionally, regardless of the level of market concentration the share allocated to domestic production is always higher than the share allocated to the Offshorer; a result which corroborates our finding that the loss of jobs is due to automation of services and not due to offshoring.

Figure 3.15: Share of Work Allocated (%) to the Onshorer and Offshorer in the Quality Neutral Process Regime with (a) 4 Competing Firms, (b) 5 Competing Firms, and (c) 6 Competing Firms.

(a) 4 Competing Firms



(b) 5 Competing Firms



(c) 6 Competing Firms

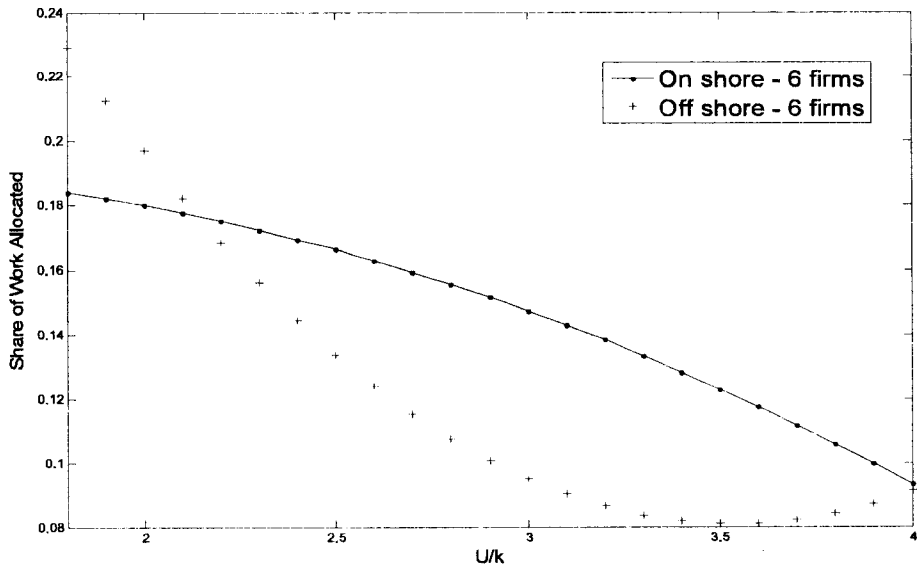
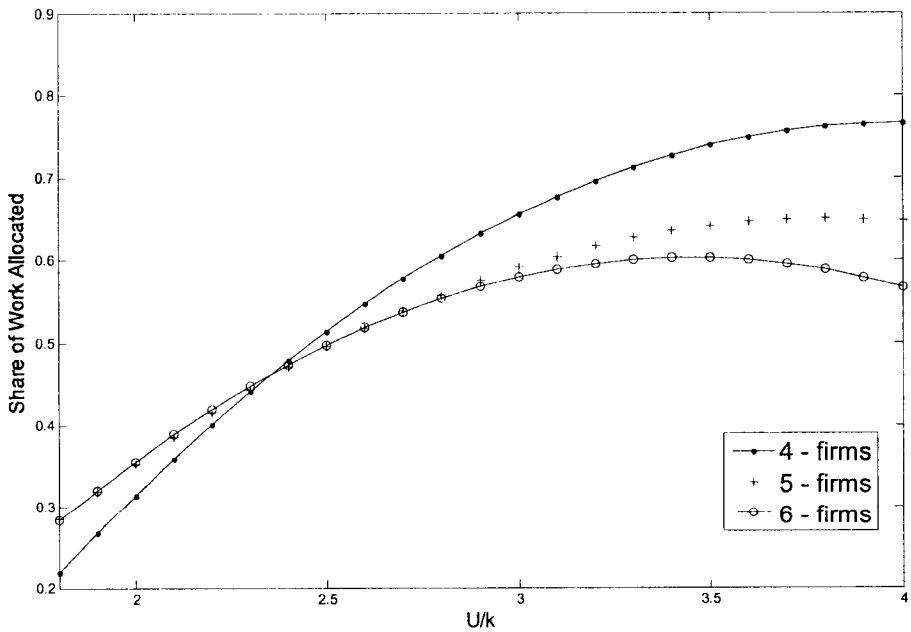


Figure 3.16: Share of Work Allocated (%) to Domestic Production (In-house and Onshorer) in the Quality Neutral Process Regime for different levels of market concentration.



3.8 Managerial Insights and Future Work

Given that firms have several sourcing options or production regimes, how should they allocate their work between the various options under different process regimes? The first research question probes the issue of the impact of customer valuation on the share of work allocated across the different production regimes. Regardless of the type of process regime, we find that when customer valuation is low a greater share of work is allocated between the Automated Utility and the Offshorer; whereas, as customer valuation starts to increase firms move away from the lower quality production regimes to the higher quality options of the Onshorer and In-house development. The only exception is in the Context Sensitive Process Regime where even the Onshorer offers a low level of quality and so beyond a particular customer valuation the share allocated to the Onshorer also starts to decline fast.

The share of production retained In-house under the Judgment Intensive Process Regime is lower than under the Context Sensitive Process Regime (see Figure 3.17). The reason for the above is that in the Context Sensitive Regime being close to the market is highly valued and outsourcing of tasks deeply diminishes the quality and in turn, the profits of the firms. While in the Judgment Intensive Regime, the Onshorer and Offshorer also offer high quality at lower costs and so retention of activities In-house is not as desirable. The constant trend, however, is that as the valuation ratio increases so does the share of production retained In-house.

Figure 3.17: Share of Work Allocated (%) to In-house Production in the Context Sensitive and Judgment Intensive Process Regimes.

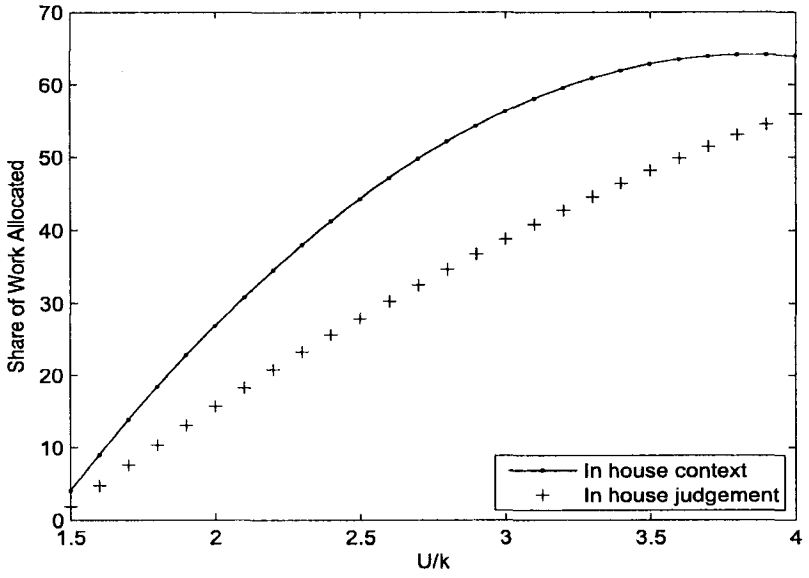
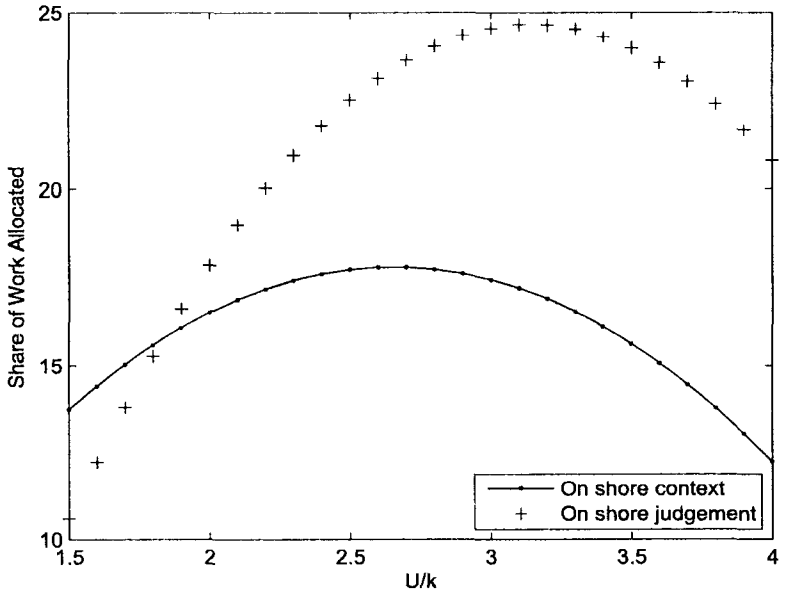
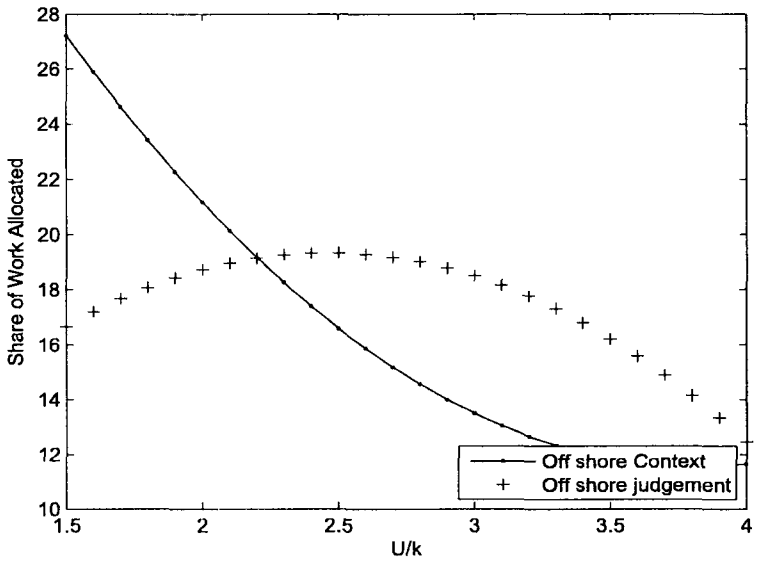


Figure 3.18: Share of Work Allocated (%) to the Onshorer in the Context Sensitive and Judgment Intensive Process Regimes.



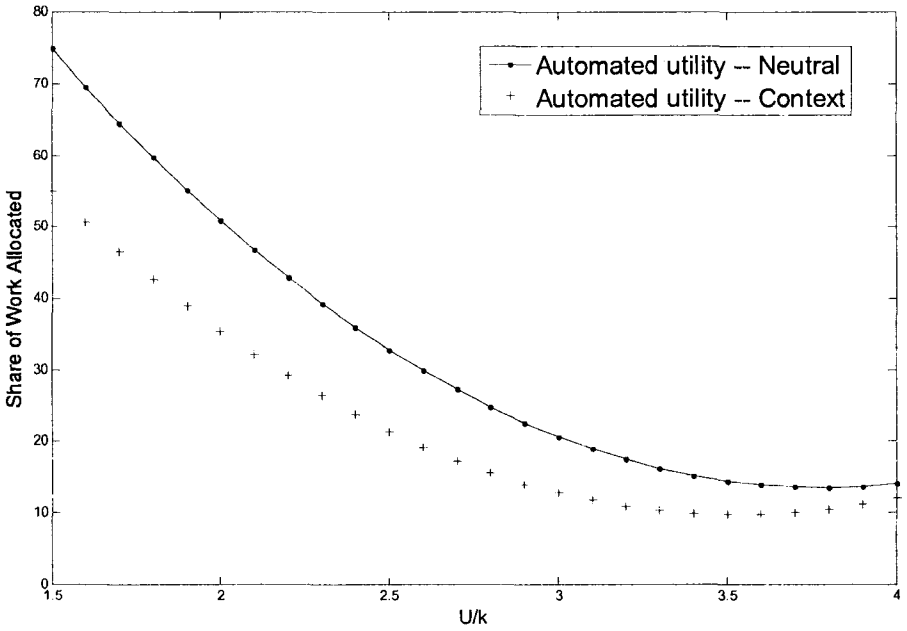
Allocated share of work to the Onshorer is higher in the Judgment Intensive Process Regime than in the Context Sensitive Regime as illustrated in Figure 3.18. In the Judgment Intensive Regime human judgment is valued and so the Onshorer is able to provide higher service of quality than in the Context Sensitive Regime; hence, a greater share of work is allocated to the Onshorer. Additionally, the trend in share allocated to the Onshorer is constant across the three regimes where initially, as the valuation ratio increases the share allocated to the Onshorer increases but beyond a point either starts to decline or level off. The trend is a result of two interacting forces. As the valuation of quality by customers rises, there is a move by firms towards higher quality production but at a lower cost, thus increasing the share to the Onshorer. However, a second force comes into play as the valuation rises even further where the advantage of In-house production with its higher quality capability becomes more attractive. Thus the share of In-house production also rises and the share allocated to the Onshorer decreases or levels off. Similar to the case of the Onshorer, we observe in Figure 3.19 that the share allocated to the Offshorer is also higher in the Judgment Intensive Process Regime than in the Context Sensitive Process Regime due to human judgment being valued in the former regime and the ability of the Offshorer to provide higher quality of service.

Figure 3.19: Share of Work Allocated (%) to the Onshorer Under the Context Sensitive and Judgment Intensive Process Regimes.



A declining trend is observed in the share allocated to the Automated Utility in all process regimes as the customer valuation ratio rises. The Automated Utility provides the highest quality of service in the Quality Neutral Process Regime as compared to the other two process regimes. Consequently, we are interested in analyzing the effect of the Automated Utility's ability of providing higher quality of service on the share of work allocated to the Automated Utility by the competing firms. Therefore, in Figure 3.20 we compare the share of work allocated to the Automated Utility in the Quality Neutral and Context Sensitive Process Regimes. We observe that the share of work allocated in the Context Sensitive Regime where it is extremely important for firms to be close to the market is consistently lower than the share in the Quality Neutral Regime.

Figure 3.20: Share of Work Allocated (%) to the Automated Utility Under the Quality Neutral and Context Sensitive Process Regimes.



To summarize, we observe that in the Context Sensitive and Judgment Intensive Process Regimes when customer valuation is low firms tend to allocate a greater share to the Automated Utility and the Offshorer, but as customer valuation increases firms shift their allocation to domestic production. Firms that wish to retain their work In-house should do so when the valuation for services is high. Another question of interest is what types of services should firms that are considering offshoring work focus on? Firms should consider offshoring work when valuation for services in general is low. Furthermore, in the Context Sensitive Process Regime where both onshoring and offshoring result in dramatic declines in quality, since offshoring is a cheaper option, firms should consider offshoring for low to medium values of the valuation ratio.

Consequently, a significant outcome of our analysis is that offshoring is not resulting in a loss of jobs but the root cause of job loss is due to the shift in the share of production allocated to the Automated Utility. The global outsourcing estimates also corroborate our results. OECD (2005) has estimated the global market for outsourced IT and BPO services in 2001 to be $260 billion, of which only $32 billion was offshored whereas the remaining $227 billion was allocated to domestic production. In addition, although the global estimates for 2003 and 2004 of outsourced IT services are $285 and $322, respectively, only $40 to $45 billion of these is estimated to be offshored (Gartner 2004).

The valuation ratio also impacts the average quality of service offered in the market. As the valuation ratio increases the quality levels in both the profit and welfare maximizing solutions increase. However, the profit maximizing solution tends to over invest in quality for high values of the valuation ratio. In this essay, we demonstrate the significant impact that consumer valuation has on the boundaries of the firm. We also demonstrate that our results are generalizable by investigating the impact of market concentration, in other words increasing the number of competing firms, on the share of allocation across the various production regimes.

In this essay, we don't differentiate between front-end and back-end work. In other words, regardless of what work is allocated to the Automated Utility it has the same effect on overall quality of service offered by a firm. However, in reality the effect on overall quality will not be the same. The Automated Utility provides commoditized services. Since, front-end tasks require a lot of customization, allocating those tasks to the Automated Utility will dilute the overall quality of the firm much more than if back-end

services, which require comparatively less customization, are outsourced. Consequently, it would be valuable to investigate the impact on the boundaries of the firm as overall quality of service offered by firms changes depending on the type of work allocated to the different vendors. Another interesting extension of our work is to study a model where some of the firms are forced to follow a certain work allocation strategy and determine the influence on competitors' allocation strategies. An example where firms would be forced to follow a fixed work allocation strategy would be defense contracting firms that would be forced to retain all the work in-house due to security reasons.

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3.10 Appendix

Pseudo-Code for a Genetic Algorithm

Generate an initial population of strategies;

Evaluate fitness of individual strategies in the population;

Repeat

Retain a % of the strategies from the old population for the new population;

Repeat

Select parents from the old population;

Crossover (mate) parents to produce children (offspring);

Randomly choose to mutate bits in offspring;

Include offspring in the new population;

Until size of new population equals User Specified Population Size Constant;

Repeat

Randomly pick a strategy to use from the population;

Evaluate fitness of individual strategies in the new population;

Until a certain number of tournaments is played*;

Until a satisfactory solution has been found;

*Number of tournaments should be selected so that in expectation each strategy has a probability of being chosen least once.

Table 3.10: GA parameter values

Encoding of Bit String	Binary
Length of Chromosome	12
Population Size	30
Number of Tournaments	50
Strategy Selection Method – probabilistic	Fitness / $\sum$ Fitnesses
Reproduction Method	Steady-state approach
Percentage of Population Retained for next Generation	8%
Crossover Points	Single
Probability of Crossover	0.6
Probability of Mutation	0.06

4 Pipal Research: A Multi-Shore, Deep-Linked Research Provider

4.1 Introduction

When a manager thinks of offshoring, the first thought that comes to his mind is a call center worker somewhere in India or the Philippines with a "neutralized" accent offering tech support. Managers rarely think of a brain-on-tap offshore. Yet, that is what Manoj Jain, CEO of Pipal Research has created. It is perhaps a mischaracterization to term Pipal Research as an offshore firm. The Chicago-based company with offices in New Delhi, London, Toronto and New York has forged a model that is perhaps best termed "Multi-Shore" provider of research; making the geographic location irrelevant through *deep inter-company linkages* which is a part of what Pipal is all about.

Pipal Research - headquartered in Chicago - was founded in 2001 by ex-McKinsey consultants and researchers. Manoj Jain was an Associate Principal with McKinsey & Company when the idea of Pipal Research came to him. He was one of the consultants who was instrumental in setting up McKinsey's knowledge center in India. What began as an operation that produced PowerPoint templates soon morphed into a knowledge center that produced research and analysis for clients. Manoj had just been given a demo of the opportunity that lay dormant in countries like India and China. Countries like India and China have for decades been training large numbers of graduates in Mathematics and the Sciences. Additionally, India's Raj legacy meant that it was turning out millions of scientists and engineers who were taught in English and had

acquired the habit of articulating ideas in English and carrying out complex analytical work in groups that communicate in English. The top 10 percent or so of this workforce constituted an exceptionally well-trained set of professionals with a well marked flair for analytical work; in short, a first world workforce in a third world country. Manoj gathered about him a cast and crew that had seen McKinsey's operations go from back office to a knowledge center that supported the leading edge of consulting practice in US and Europe. Manoj and his friends launched Pipal Research – a firm that would offer 'Research on Tap' to corporations in North America and Europe. Several of the founders of Pipal Research are former consultants at McKinsey & Company. They in turn brought on board others with an experience in research and with prior experience in dealing with western corporations. Please refer to Table 4.4 in the Appendix for founders' background.

The pioneering efforts of GE Capital and McKinsey in employing offshore resources to support their growing businesses, in addition to improving their efficiency, was the precursor to the deployment of today's offshoring ventures. GE Capital, in 1996, found that it didn't have the resources to sustain the growth of its mortgage refinance business. Therefore, it experimented by setting up an office in New Delhi, India, to tap into the English-speaking highly qualified graduates at relatively low investment risk due to the lower set up costs in India. The success of this endeavor resulted in the then CEO, Jack Welch, ordering different GE divisions to use offshoring to streamline their operations and also, gave encouragement to other companies. In addition, costs of telecommunication rates started decreasing dramatically and hence, in 1999 McKinsey & Co. set up its knowledge center in New Delhi to support its US operations

(BusinessWeek 2006). Researchers at the center would support McKinsey Consultants worldwide by researching data, crunching numbers, performing analysis of trends, and sometimes creating entire PowerPoint presentations. A number of other MNCs opened captive centers in India as well, such as JP Morgan, Reuters, Fidelity, Morgan Stanley and Citigroup.

The success of offshore centers in providing high-quality efficient analyses motivated ambitious consultants to start their own businesses. One such company that was founded was Pipal Research, a market research services company delivering customized, high-quality, and cost-effective research. However, unlike the knowledge centers of GE Capital and McKinsey which provided services exclusively to their parent companies, Pipal Research was set up in order to provide similar services to different clients looking for third-party vendors services. Manoj's timing could not have been better. Even as he was busy formulating a model of offshoring that was at the high-end of the value chain, India itself was beginning to move up along the value chain as a provider of offshore services.

In this research essay, we conduct a fine-grained analysis of Pipal Research's Multi-Shore Research Model and address three important research issues:

- How does technology impact on the boundaries of the firm, on the allocation of share of production of services between on-shore and off-shore production regimes?
- How does information flow between buyers and providers of services across the boundaries of the firm impact on the buyer's decision to source services through spot market or contractual means?

- What effect does deep-linking between organizations have on the behavior of contractual clients and spot market (ad-hoc) buyers?

The essay is arranged as follows. In the next section we summarize relevant literature in this area. Section 4.3 discusses the move in services' outsourcing from commoditized to value-added services, while Section 4.4 describes the market for knowledge intensive research services. Section 4.5 outlines the services offered by Pipal Research and its' competitive advantage. We present our research hypotheses and analyze data collected in Section 4.6. Section 4.7 provides a summary along with managerial insights.

4.2 Literature Review

Seminal work addressing issues revolving around boundaries of the firm is accredited to Coase (1937). He argued that the size of the firm should be determined and not taken for granted. Further, he argued that the determining factor should be the relative cost associated with performing the activities in-house versus turning to the market for the same activities. In other words, the decision to make or buy is essentially a tradeoff between production and coordination costs. Williamson (1979) extended Coase's theory and introduced the theory of Transaction Cost Economics. He stated that frequency, uncertainty and asset specificity are key factors in determining whether the "market or hierarchy" will have lower transaction costs in different conditions.

The dramatic technological changes in the past couple of decades have rekindled the interest of researchers in understanding the boundaries of firms. Malone, Benjamin, and Yates (1987) hypothesized that since information technology (IT) reduces

coordination costs, IT would affect the optimal governance structure by pushing firms towards markets, thereby increasing outsourcing activities by firms. The effect of IT on the boundaries of the firm has also been studied from the combined perspective of transaction-costs and agency-costs by Gurbaxani and Whang (1991). However, no claim is made about whether there is an increase in the shift towards markets or hierarchies because IT not only reduces external coordination costs but also internal agency costs.

Kodak is believed to be the pioneer in embracing outsourcing which it did as early as 1989 when it outsourced a significant portion of its information services department to IBM (Appelgate and Montealegre 1991). Soon the perception among practitioners, academics and consultants came to be that information systems services are commodities. Additionally, the promised savings of 10 to 50 percent from large vendors such as IBM and EDS resulted in firms increasing the outsourcing of their IT functions (Lacity and Hirschheim, 1993). As a result researchers started to focus on understanding the contractual relationship. A game-theoretical model with incentive payments has been derived by Whang (1992) such that at equilibrium the vendor's incentive is perfectly aligned with that of in-house development. Banker and Kemerer (1992) also study the agency problem that exists in vendor-buyer outsourcing relationships. They prescribe metrics for evaluating the performance of vendors which aid in developing an incentive compatible contract; whereas, Chaudhury et al. (1995) propose a bidding mechanism wherein vendors are induced to submit competitive bids.

Many outsourcing deals, however, have started to fail despite the enormous benefits that can be attained from outsourcing. As a result, interest in research has shifted to understanding reasons for failure of contracts. However, instead of developing *ideal*

contracting relationships, researchers are conducting empirical analyses and interviewing executives to practically investigate factors contributing to failures as well as successes of outsourcing contracts. After extensive interviews with executives at firms with outsourcing contracts, Lacity et al. (1996) have developed a selective outsourcing framework to aid managers in determining which IT functions to outsource and which not to. The appropriate contracts depend on parameters such as degree of technology integration and technological maturity, contribution of activity to business operations or business positioning, etc. Aron and Singh (2005), similarly, prescribe a framework of *right sourcing* with appropriate governance structures based on the operational and structural risks of different IT activities. Aron and Liu (2005b) outline the factors that impact the operational risks of offshore outsourcing via empirical analysis. While Aron et al. (2005) investigate how monitoring impacts the problems of moral hazard and principal-agency in off-shore outsourcing contracts. They use offshore survey findings to corroborate their game-theoretic model. Their results demonstrate that vendors provide higher levels of quality for processes with lower inspection costs than they do for processes with higher inspection costs, since clients are less likely to inspect processes with high inspection costs. Consequently, Aron and Liu (2005a) develop a hybrid governance model under which the welfare level at equilibrium converges to the welfare maximizing solution. They corroborate the predictions of their model with empirical data. Profitability of offshore vendors is studied by Gopal et al. (2003). They analyze project level data from an Indian software vendor to investigate conditions under which the vendor opts for a fixed-price contract versus a time-and-materials contract. Variables

such as requirements uncertainty, project team size and resource shortage explain the type of contract chosen which in turn affects the vendor's profit.

We contribute to the literature on outsourcing by first analyzing the factors that contribute to the overall quality of output in multi-shore service production. Secondly, we investigate how inter-organizational information flow evolves over time and how the patterns and channels of information inter-change differ between Ad-hoc and contractual sourcing contexts. Finally, we analyze the factors that determine the buyer's choice of sourcing structure – via Ad-hoc purchases or through long term contracts which specify volume commitments.

4.3 From BPO to KPO: India moves up along the value chain

Services outsourcing initially began with outsourcing of IT functions, which was followed by outsourcing of complete business processes called Business Process Outsourcing (BPO). The processes are high-volume, labor-intensive and provide support functionality, such as payroll, accounting, and human resources. Apart from experiencing cost savings, firms pursuing outsourcing have been able to expend greater focus on their core competency. The maturity and success of BPO has paved a path for the next addition to the global outsourcing scene - Knowledge Process Outsourcing (KPO). KPO includes high-end knowledge work like R&D, analytics and data mining, business and market research, medical services, paralegal services, IP research, taxation support, and equity financial and insurance research, among others.

Table 4.1: Comparative Opportunities in the KPO Market (2003-2010)[45]

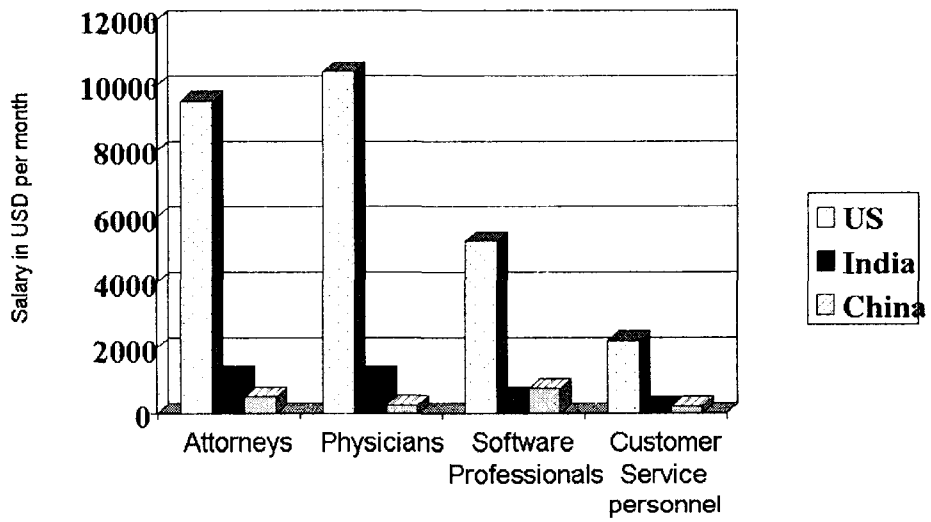
KPO Sectors	FY 003	FY 2010	CAGR
Equity, Financial, Insurance Research	0	0.4	N/A
Data Search, Integration and Management	0.3	5.0	50%
Research and Information Services in HR	0	0.2	-
Market Research and Competitive Intelligence	0 01	0.4	70%
Engineering and Design	0.4	2.0	29%
Animation and Simulation Services	0.1	1.4	46%
Paralegal Content and Services	0	0.3	N/A
Medical Content and Services	0	0.3	N/A
Remote Education and Publishing	0	2.0	N/A
Biotech and Pharmaceuticals (CRO, lead optimization, and manufacturing processes)	0 28	3.0	40%
Research and Development	0 2	2 0	39%
Total (USD Billion)	**1.29**	**17.0**	**46%**

The need to reduce costs even further and the shortage of skilled labor force resulted in the offshoring of business processes to lower cost global destinations. The benefits received from offshoring have encouraged firms to experiment with the offshoring of high-end knowledge and judgment services as well. While the cumulative annual growth rate of global low-end outsourcing services (BPO) is expected to be 26% by 2010, the global KPO market is expected to grow by 46% and reach USD 17 billion by 2010, as stated in a report by GlobalSourcingNow (2004) (see Table 4.1 for more details). Moreover, India is forecasted to be the provider of 71% of the $17 billion market. The major contenders for low-cost offshored services apart from India and China will be Israel, Russia, the Czech Republic and Ireland.

[45] *Source: Evalueserve Analysis*

KPO services fetch higher returns for service providers than BPO services but the returns come at the expense of greater challenges faced by KPO providers. The main tenet of KPO services is to provide value to clients. Consequently, KPO service providers are expected to maintain much higher levels of quality and provide domain-based expertise rather than just process expertise, which would require workers to possess advanced analytical and specialized skills[46]. The enormous demand for specialized and highly skilled workers has resulted in the tapping of offshore talent which also has the advantage of lower wages resulting in cost arbitrage. Figure 4.1 shows a comparison of wages in the US, India and China for a few select professions. In addition, since KPO services lie at the higher-end of the value chain, offshoring them results in greater cost savings than when BPO or IT services are offshored.

Figure 4.1: Advantages of Off-shore High-end services[47]



[46] Source: http://www.outsource2india.com/why_india/articles/KPO.asp.
[47] *Source: AsiaWeek. Year 2000 figures.*

Several of the large Wall Street firms have set up their own equity-research teams offshore for data analysis, development of financial models and in-depth research, not only for reducing costs but also for the expansion of their research coverage. However, not all firms have the resources to set up their own offshore research centers. As a result, many independent third-party vendors have started to provide similar services to fill the growing demand. OfficeTiger, located in India, is one of the largest diversified BPO providers that also specializes in KPO services such as equity research. Large biotech companies are offshoring their laboratories and pharmaceutical companies such as AstraZeneca and GlaxoSmithKline have set up offshore drug discovery centers for R&D activities. As a result, companies like Clinigene International, a clinical trials company in Bangalore, India, are emerging with the anticipation of benefiting from trends like the offshoring of R&D centers.

In the wake of tremendous opportunities that have emerged in KPO, Pipal Research has established itself as an innovative provider of customized research in the spot and contractual market for knowledge services.

4.4 The Market for Offshore Research: The State of Praxis

When the wave of IT outsourcing ebbed to allow the next wave of business process outsourcing to flow, traditional IT service providers started to move into BPO in order to diversify and maintain their profitability. In 2002, Infosys, a global IT services, solutions, and consulting firm headquartered in India, started its BPO subsidiary called

Progeon. On the other hand,.Wipro Technologies, an India-based global services provider, resorted to an acquisition for entering the BPO domain. Wipro acquired Spectramind in 2002 and integrated it with its existing IT outsourcing operations as Wipro BPO. A telecom company, Bharati Teletech, teamed up with a US based BPO company in a joint venture to set-up BPO operations in India. Lured now by the next wave of outsourcing namely, KPO, BPO service providers are beginning to provide KPO services to their already established client base. KPO service providers are either captive centers of global firms such as JP Morgan, HSBC, Reuters, Fidelity, Morgan Stanley and Citigroup, or third-party vendors.

A further categorization of knowledge services is whether the service vendor provides business or technical research. Some of the BPO providers provide knowledge services in specialized areas or services for specific products. OfficeTiger, a Chennai (India) based BPO provider offers financial services such as valuation services, and equity research. Thuriam, another BPO provider, has started to offer knowledge services in the area of legal services by providing detailed research reports in all areas of law and assistance in the preparation of legal briefs and facts. With the success of GE Capital's and McKinsey's knowledge centers, a market for outsourced research and analytics emerged. Gartner and Forrester are two of the world's leading providers of research and analysis about the IT industry. They collect data, conduct analysis and provide advice on how technology is going to impact their client. They also collect industry wide data and investigate trends in the market. IDC is yet another globally renowned provider of market intelligence and advisory services for the information technology, telecommunications and consumer technology markets. On the other hand, Nandini Institute, based in India,

provides global research and analysis in the specialized area of chemical and allied fields, while Pangea3.com offers research services for litigation support in addition to patent drafting and analytics services. Market research for the pharmaceutical industry is provided by MarketRx, headquartered in Bridgewater, NJ. The company provides research and analysis tools to help monitor sales force performance and marketing effectiveness. Apart from market research services, the company provides sales management optimization and product management services.

Unlike specialized technical research providers, broad-based knowledge providers offer market research and analytics services to clients in different industries. Market research includes revenue forecasts, competitor analysis, market trends, new product opportunities, etc. Some of the BPO companies are entering the non-industry specific market research domain as well. The BPO division of Tata Consultancy Services, based in India, has ventured into the arena of KPO services by tying up with a market research firm in order to provide analytics and research services along with their BPO services (Vidyalakshmi, 2005). WNS, another traditional BPO provider, not only offers specialized knowledge services in the areas of finance and legal research but also offers business and market research Table 4.1 shows that the market size for market and business research services alone was $10 million in 2003 and is expected to grow to $400 million by 2010. As a result of the enormous expected growth in the demand for such services, apart from the large players, several smaller firms have entered the industry of market research services as well. We shall go into greater detail on the competitive scene in the section on Competitors of Pipal Research.

4.5 Pipal Research – The Company

Market research activities used to be typically performed in-house with firms relying on customer feedback and information obtained from sales personnel. Due to the tight link between data analysis and the firm's future strategies, firms have been reluctant to outsource data analytic services. The competitive environment, more recently, has changed drastically pressing firms to use market research as a tool to develop competitive strategies. The lifecycles of products and services offered to customers are reducing, causing customers to switch loyalties often. Consequently, firms must constantly stay abreast of developments in the market but information overload makes the task formidable. As a result, firms are increasingly turning to third-parties for assistance in market research activities. In addition, since vendors of IT and BPO have mostly maintained client confidentiality, firms are more willing to outsource high-end value services like data analytics. By outsourcing data analytics, in-house teams can focus their efforts on strategy formulation without expending immense efforts on data collection and analysis.

Manoj and the other founders of Pipal Research noticed the growing demand from companies for unbiased high-quality research and hence, founded Pipal Research. The aim of Pipal Research is to become an extended arm of organizations, by providing organizations with market research and in-depth analysis of the client's competitive environment as well as by identifying opportunities for growth. The company also endeavors to become a globally renowned and trusted spot-market provider of customized research services.

Pipal Research provides research services and intelligence services. Under investment research the company provides bond pricing, and valuations and risk modeling services. Under the area of operations research, the company offers multi-variate problem-solving and data mining solutions like clustering and segmentation for customer demographic insights. In terms of intelligence services, the company provides innovation support research through intellectual property (IP) value analysis along with patent and trademark opportunity analysis. Strategic intelligence is also provided by M&A identification and due diligence, apart from scenario and marketing analysis.

4.5.1 Services Provided by the Company

Unlike BPO services where the requirements are specified by the client and the provider follows the specifications and fulfils the need, KPO demands astute judgment and advanced technical expertise from the service providers. BPO services are more commoditized whereas KPO services are highly customized and dependent on the needs of individual clients. KPO involves processes that are higher on the value chain such as fund management, risk and actuarial analysis, equity research, design animation and simulation services, and paralegal & market research. Pipal Research provides services that fall into the category of "research and analytics services" under KPO. Pipal provides in-depth research and analysis which may then be used by companies to study their competitive environment, formulate strategic plans, and devise investment decisions. The company is involved in spot market research services such as fact finding and quick research requests.

The company provides research and intelligent services to consultants, investment bankers, managers and analysts, and other corporate executives from the following wide range of industries: global banks, accounting firms, other investment and financial institutions, strategy and management consulting firms, leading publishers of information products, law firms, pharmaceutical companies, software & IT firms, retail and textile companies, consumer packaging firms, and manufacturers of industrial equipment & building materials.

Research Services

Research services provided by Pipal Research can be broadly categorized into three areas: (1) investment research, (2) quantitative analytics and operations research, and (3) corporate research and analytics.

Investment Research

Pipal Research provides investment banks, hedge funds, equity firms, and other financial institutions with modeling support, qualitative research, and reporting and risk management services. The company is responsible for collecting data and synthesizing information from relevant sources. Further modeling support is provided by building different types of financial projections such as the next season's earnings projections of a company, or 3 to 5 year forecasts of a company's income statement, balance sheet and cash flows based on historical data. Qualitative research is provided in the form of due diligence (validating a specific investment opportunity), analyzing the impact of an event on a stock or a portfolio of stocks, compiling company profiles, and investigating macro analyses at the domestic economy or global level. Other custom research requests include M&A valuations, and equity and fixed income research. Risk services include ensuring

that clients' operations meet regulations and their reports meet the requirements. In risk management services, Pipal Research analyzes and estimates risk for portfolios.

Quantitative Analytics and Operations Research

Pipal Research provides a wide range of quantitative and analytical services in different areas such as customer analysis, market scenario analysis, forensic accounting, operations support and financial analysis apart from the analytics involving investment research. Researchers at Pipal Research perform data processing activities such as data tabulation, cleaning and converting data as needed, developing new models and recalibrating existing models. The researchers also use multi-variate statistical techniques such as segmentation, clustering, regression trees, conjoint analysis and discrete choice models. The techniques are used to thoroughly investigate the client's current or target customer base based on demographics, psychographics and lifestyles. The highly qualified researchers who are PhDs, Statisticians, CPAs, are well versed in advanced models from econometrics, statistics, marketing science, and finance. Researchers study the client's customer, supplier and partner bases and generate a priority/ranking model for the client to refer to under unforeseen circumstances. They also assist clients in negotiations by conducting analyses of client's vendor and supply markets including prices and terms of contracts.

Corporate Research and Analytics

Under the category of corporate research, Pipal Research provides strategic planning support and competitive analytics to clients. The company monitors industry developments such as product and/or technology trends and innovations, identifies opportunities for new products or services or M&As, investigates successful marketing

strategies and discovers innovative channels for distribution. Competitive intelligence is conducted as well, by studying competitor moves, profiling competitive landscape scenarios, performing competitor financial reviews, conducting SWOT analyses, and comparing different product portfolios. Based on the quantitative models and analyses conducted, Pipal Research also assists clients in their negotiations. Further, the company conducts industry wide analysis, develops performance metrics and industry best practices/benchmarks, and keeps the clients abreast of any changes in government regulations.

Intelligent Services

Intelligent services provided by Pipal Research span innovation support research, knowledge management services and customized spot-market research service.

Innovation Support Research

Pipal Research offers its clients assistance in protecting patents/copyrights/trademarks, conducting intellectual property value analysis and discovering royalty opportunities. Further, the company thoroughly analyzes the innovation pipeline and identifies opportunities for the impact of innovations.

Knowledge Management Services

In the category of knowledge management services, the company sanitizes, indexes, and synthesizes knowledge created within the client organizations. In other words, Pipal Research provides corporate library services, management of documents and aids in the publishing of white papers.

Customized Spot-Market Research Services

Pipal Research also offers an innovative service – Pipal Answers – a customized spot-market service for client (firms or individuals) queries that require finding and synthesizing data and facts quickly. The service is provided 24/7 to business professionals from large organizations to small enterprises, to independent business owners and even to individuals in presentation ready formats and at affordable prices.

4.5.2 Client Service Models: From Supply Chain to Spot Market

Pipal Research offers four different service models to clients depending on the client's current needs, type of business, etc. Pipal Research could be deeply integrated into a client's firm through a long-term sourcing contract or could be used as a spot-market source for quick fact finding.

Transactional Relationship

The first model is on the basis of a client's needs due to a particular project. The services of the company are only employed for the duration of the project. Pricing for this service model is a fixed bid based on Pipal's estimate of total hours of research involved. This particular sourcing model is ideal for clients who require intensive research services for projects and the clients know the type of information and analysis they require at the beginning of the project. A client looking to offshore his IT services for instance, would find this service model useful because he could employ Pipal's researchers to conduct intelligent services to study offshoring trends, survey hot spots, forecast costs, etc.

Steady State Sourcing

Pipal Research can also be employed on a retainer basis by the client, with Pipal providing services for a fixed number of hours per month. Clients can use the hours at any time during the month and any unused hours are carried over to the next month, allowing clients to adjust to periods of intense and low research usage. This type of model is ideal for clients who have an ongoing requirement but uncertainty exists with respect to the magnitude of service needed every month. Pricing for this model is per month and fixed at contract negotiation. Paying a fixed low monthly price per month is amenable to customers because costs are predictable. This particular sourcing model is applicable for organizations that require some amount of research services and reporting of white papers on a regular basis, but their needs are not large enough to justify dedicating a team of researchers.

Dedicated Supplier

The third type of service model is on the basis of outsourcing, where the company dedicates a team of researchers to the client who has ongoing activities that require constant research and analysis. The pricing structure for the third model is highly dependent on the needs of the client; for instance, the speed with which information has to reported to the client, the extent of customization to client specific needs, the complexity of the research and analysis involved, the type of research that needs to be conducted – secondary sources or primary sources such as interviews, etc. A *Dedicated Supplier* model is ideal for medium-size consulting firms that require constant research and analytics since they have a steady stream of clients to provide consulting services

too, yet are not large enough like McKinsey & Co. or Bain & Co. to set up their own offshore research captive centers.

Spot Market Model

Finally, the fourth service model – Pipal Answers - is a spot model where clients can request facts and information or pose questions that require quick responses. Clients can be business professionals from large or small organizations or even individuals. The Spot Market Model is ideal for clients who require quick information or specific facts based on thorough in-depth research at cost-effective rates. Pipal Answers responds to client queries with cost and time estimates within 6 hours of receiving a request. In addition, unless the request requires complex analysis and modeling, most requests are fulfilled within 2 to 5 business days. Pricing for spot-market queries is a function of the time constraints and effort required to respond to the queries, where effort in turn is determined by the complexity of the research. Complexity is defined by the degree of difficulty of data availability and the skill requirements necessary to respond to the query. Pipal Answers has *3 types of service* and *pricing structures*: (1) any-time (ad-hoc) request – priced on complexity, (2) answer pack – obtains a volume discount of 10% over ad-hoc requests when a pack of 100 answer-days is bought, and (3) answer desk – obtains a 30% discount where an analyst is dedicated to a client and acts as an on-call service.

4.5.3 Competition

At present, Pipal Research is competing with the following types of providers: (1) Traditional BPO Providers venturing into market research services, (2) Research Services Providers offering research services targeted at niche markets – such as Insurance.

Investment Banking etc. and (3) other (usually, smaller) research services providers offering similar services but at lower quality levels[48].

As mentioned previously, some of the traditional BPO providers like Tata Consultancy Services and WNS Global Services are moving into KPO offering market research services. These traditional BPO providers can position themselves as a one-stop provider with the incentive of reducing coordination costs for the client. Pipal Research is acutely aware of this barrier. Therefore, Pipal Research addresses this challenge through a two-fold response. The firm absorbs a substantial proportion of the client's coordination costs by establishing deep-linked inter-organizational information channels that integrate information that flows through direct personal contact between human intermediaries, web, telephones, faxes and e-mail; and it also offers a highly customizable white-label service[49] through its proprietary, deep-linked interface. On the other hand, organizations are also beginning to move away from the single-sourced supplier model because of inflexibility and dangers of becoming entrenched with no innovation on the part of the vendor. By breaking up IT functions, clients can gain access to best-of-breed vendors and keep a close watch on the performance of their vendors. Although, coordination costs increase with multiple vendors, overall benefits under some conditions do outweigh the coordination costs. Lehman Brothers, for instance, has chosen to outsource some of its development and maintenance processes to two Indian offshore service vendors, Wipro and Tata Consultancy Services, while it has also set up a fully-owned offshore service in India (Aron and Singh, 2005).

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[48] Perhaps there are firms that aim to provide higher quality than Pipal Research. We did not come across any and are not in a position to comment on this.

[49] A white label service is a combination of back-end software with a template-based customizable front-end.

Apart from some of the previously mentioned providers of targeted market research services, such as Pangea3 for legal services and MarketRx for the pharmaceutical industry, the second category of competitors also comprises firms offering other horizontally differentiated market services. Brandimension, for instance, combines market intelligence services with brand protection services. Due to the internet being inundated with information on a daily basis, the company monitors information or commentary generated by customers, potential customers, competitors, journalists and industry professionals and updates its clients with relevant information to assist them in making strategic decisions. The company uses proprietary internet monitoring technology along with an innovative web-content analyzing methodology to capture relevant information on a daily basis and notify the clients about their products and organizations. The continuous monitoring service frees up time for the client's executives who can then use the time to focus on strategy development and implementation plans. The second service protects the clients from online crimes such as phishing, identity theft, counterfeit product sales, stolen credit card sales, and trademark abuses[50]. Power Decisions Group is another provider of market research services. However, their primary focus is on consumer research with the company using the research to assist clients with their marketing strategies, such as product positioning and branding research, and advertising research. They not only collate the data and conduct the analysis by evaluating and interpreting the data, but also provide consulting services such as advice on the market strategy to adopt and assistance in executing the suggested strategy. They employ qualitative research techniques such as focus groups, in-depth interviews, and photo-

[50] Source: http://www.brandimensions.com/brand-protection/default.asp?loc1=brand-protection&loc2=intro

ethnography (watching consumers' decision-making process) to discover the depths and range of buyer attitudes and beliefs. The company also conducts quantitative research such as on-line surveys, mail surveys and interviews to measure and/or forecast market size and segments.

While the above firms provide more horizontally differentiated services from Pipal Research, the following small players provide similar services in a market of vertically differentiated services.

Exevo is a market and business research services provider headquartered in New York. The company provides data collection and analysis services with a greater emphasis on the data synthesis process which includes survey programming, data collection, data entry, and data processing/conversion. Although, the company conducts analyses such as conjoint analysis, cluster analysis, discrete choice models, the analyses offered by Pipal Research span a wider range of techniques and tools including complex valuations of portfolios, risk measurement and bond pricing. Currently, Exevo has 24 clients while Pipal Research has close to 100 clients[51]. RocSearch is another global provider of research support and analysis services. The company offers business and financial research and analysis to clients across industry sectors. Their value proposition consists of low-cost, high-quality service and they guarantee a response to a spot-market research query with a quote within 48 hours. However, Pipal Research's response time is eight times faster with a response within 6 hours.

Copal Partners provides business intelligence, market research services, and financial research and analytics. It was founded by professionals with executive

[51] From a presentation made by the CEO at the Mack Center for Technological Innovation at The Wharton School of Business.

experience at top consulting firms such as McKinsey & Co. and top tier investment banks such as Goldman Sachs, JP Morgan, etc. The offshore research teams cater to clients from the following industries: banking and insurance, consumer goods, utilities, pharmaceuticals and biotech, media, real-estate, telecom and technology. They pride themselves in their low attrition rates of employees and in the integrity and quality of their work. Unlike Pipal Research that offers its clients 4 different service models to choose from which encompasses all types of client needs, Copal Partners only offers clients two service models – on-demand requests or outsourced responsibility for certain functions or products. As a result, clients with seasonal research requests will be forced to pay for service even when they are not being served. Another firm providing independent research and analytics for product and corporate development, investment decisions and R&D is SmartAnalyst Inc. Corporate clients are in the life sciences, consumer goods and services, and financial services industries. The firm provides research and analysis at cost effective rates by adopting a multi-shore model. Like Copal Partners, the service options offered by SmartAnalyst are not as flexible as those offered by Pipal Research. Clients can either opt for a dedicated team to cater to their research needs or subscribe to one or more of the research services offered by them. Although, one advantage is that through the company's affiliation with PSi Inc., a consulting firm, clients have access to market and strategy consulting services as well. On the other hand, since ICICI OneSource has a majority stake in Pipal Research, it gives Pipal Research an opening to cross-sell some of its services as well as gain access to I-OneSource's client relationships.

Two other close yet larger competitors of Pipal Research are EvalueServe and Guideline Inc. (formerly, Find/SVP). Evalueserve also provides offshore global research

services in the areas of business intelligence, market research, statistical analysis, investment research and intellectual property services to clients worldwide. The industry sectors where they offer services are financial, hi-tech and telecom, pharma and biotech, energy and chemical, and consumer products. The company has a presence in US, Europe and Asia. However, unlike at Pipal Research where 75% of the employees hold advanced degrees like PhDs, MBAs and CPAs, Evaluserve employees don't possess doctoral degrees and only 40% have MBAs. Please refer to Figure 4.8 in the Appendix for details on educational backgrounds and work experience of Pipal Research's employees. Guideline Inc. is also a large contender in the area of market research services offering business and market research, strategic and product development intelligence. The company caters to a similar industry mix as do EvalueServe and Pipal Research. Guideline Inc. does not boast a multi-shore model and hence, does not compete on cost but on quality of services provided.

It is thus quite apparent that Pipal Research does not stand alone as a provider of market research services. In fact, the market is very fragmented with not even the largest firms having dominant market shares (FindSVP Report 2004). The KPO sector of market research services is growing at a furious pace and is forecasted to have the largest cumulative annual growth rate of 70% in the KPO industry by 2010, according to a report by GlobalSourcingNow (2004) (see Table 4.1). Pipal Research competes on two dimensions – (1) as a multi-shore service provider which allows the company to provide cost-effective service and (2) by providing constant and easy communication through its web-platform for deep-linking with its clients. On the basis of its established dimensions Pipal Research is able to compete effectively with its competitors. Not all of Pipal

Research's competitors have a multi-shore service model. Guideline Inc. and Cadence Group have all of their operations and researchers based in the US. Whereas due to Pipal's multi-shore model with sales & marketing executives based in the US, close to clients, and their researchers based in India, the company is able to offer high-quality service at much lower costs. Although other competitors such as EvalueServe, Copal Partners, and SmartAnalyst Inc. all have a multi-shore model, none of them offers the deep-linking and communication services with clients like Pipal Research. Just like the brain acts as a central controller and relays messages to the different parts of the body through the nervous system, Pipal Research acts as the central repository of information and analysis and through its organizational API provides deep client support.

The dimension of deep-linking and communication with clients allows Pipal Research to enjoy high profit margins. Currently, Pipal Research's revenues are $5 million. Although, Pipal Research offers reduced cost services due to its multi-shore model, the company does not position itself as the cheapest provider. In fact in many instances, Pipal Research has been able to displace the cheapest provider due to its superior organizational API, especially in sectors such as finance, IT/Telecom and health care where skills and quality are of utmost importance. The company, for instance, has displaced a NY-based custom research firm that used to provide investment decision-making support to several private equity firms because not only was the competitor charging more than twice the price but was also providing much lower-level support.

Pipal Research has a three-fold objective; (1) the company wants to expand through high-margin services and not by offering low-margin, high-volume services (2) secondly, Pipal Research wants to retain customer traction by linking itself to customers

(3) and finally, the company wants to continue to diversify its offerings to customers in different industrial sectors.

4.5.4 Value Addition Provided by Pipal Research

The typical challenges faced by organizations, especially mid to small-size organizations, are that there is too much of information, even worse - the data is fragmented. Furthermore, the organization has limited resources and is under considerable pressure to execute against deadlines even as it must find a way to not only collect and analyze data but also to incorporate the analysis into an action plan. Since KPO services have a more immediate and direct impact than BPO services, firms need to have a higher level of control over the output of KPO service providers and be assured of greater provisions for confidentiality. Viewed against this backdrop we ask a question that Pipal research's founders faced when they formulated their strategy.

So why should organizations use the research services provided by Pipal Research? There are numerous reasons why a client firm would consider outsourcing and even offshoring these services. We examine each of these in turn below.

Capacity Utilization & Slack - Cost Frontier and Capacity Utilization: Firstly, by utilizing the services provided by a third-party vendor, organizations can ***transform their cost structure from a fixed cost to a variable cost*** with the organization only paying for service when it uses it. Pipal Research offers a variety of engagement models calibrated to different kinds of client needs. If a client needs only occasional research support, the client can opt for the spot-sourcing model and pay for the service based on the

complexity of the work involved. Whereas, a client that requires research services that are dependent on business cycles and the varying demand for its own products (or services) can opt for steady-state sourcing; whereby the client pays for a fixed volume of work that it can demand at any time during the month and can carry over unused processing capacity to the next month for a pre-determined fixed price. ***Thus, the cost of carrying fallow capacity and sufficient slack capacity to service fluctuating demand is transferred to Pipal Research by the client.*** When multiple clients[52] transfer demands that fluctuate seasonally it allows Pipal research to manage its capacity better through ***Demand Smoothing and minimization of wasteful Slack Capacity.*** The price although fixed is much lower than if the client were to maintain a research group in-house. Clearly, carrying slack capacity in-house and in the high wage regimes of North America and Europe is significantly more costly than carrying the same capacity in China or India. Thus, Pipal research enjoys a two-fold advantage: (i) First of all, it is able to smooth multiple (often correlated) seasonal demands from clients thereby creating a ***more predictable aggregate demand structure and better capacity utilization*** and (ii) by transferring costly slack capacity to an off-shore lower wage regime Pipal Research operates on a ***Lower Slack Cost Frontier*** than any of its clients.

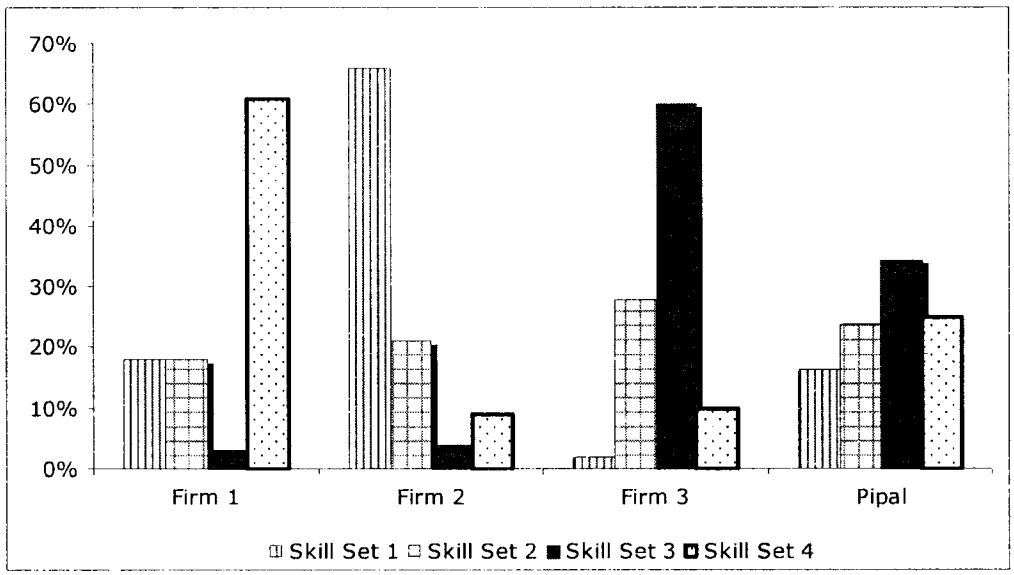
Economies of Scope, Specialization & Overheads Costs: Demand smoothing and load balancing enable Pipal Research to enjoy comparatively greater ***Economies of Scale.***

[52] An interesting issue that arises is when demand is correlated across clients. Clients in different industry verticals – such as health care, financial services and consumer goods rarely, if ever experience correlated demand. While clients in the same industry vertical compete in overlapping markets and experience correlated demand on occasion. In this case too it is easier to carry higher slack offshore in a lower wage regime than in the industrialized economies of North America and Europe.

There is another important benefit that accrues to Pipal Research due in part to its ability to aggregate demand; the firm can spread its fixed costs and invariant overheads over a larger base. Training in research methods[53] and domain-specific[54] research skills has significant cost implications for client firms. Therefore, by aggregating both different demand volumes and demand types, Pipal Research also gains from ***Economies of Scope***. Consider for example an investment banking firm that needs forecasting services based on analytical models of risk scenarios. The firm may experience a one-time need for researchers with specialized skill sets – such as yield analysis and cash flow forecasting - to work together with its researchers on risk-based scenarios. For this investment banking firm training a researcher to be able to service an infrequent (perhaps a one-time) demand is an expensive overhead that offers poor returns on capital deployed. However, Pipal Research can train researchers in esoteric skill-sets with the expectation of redeploying these researchers across a variety of clients. Figure 4.2 below provides an illustration of this idea. We compare the usage of four skill sets with the generic titles[55] Skill Set 1 through 4 respectively in three of Pipal's clients and contrast it with the weighted average utilization of these skill sets by Pipal.

[53] Such as Forecasting, Monte-Carlo Simulaitons, Linear and Non-Linear Optimmization.
[54] Such as Option Pricing and Cash-Flow Analysis.
[55] Client confidentiality constraints and stringent NDAs prevent us from revealing the actual names of the skill sets.

Figure 4.2: Usage of 4 generic skill sets - comparison of usage at Pipal Research with that of usage at three of its clients.



Therefore, by being able to aggregate a *variety of demand types*, Pipal generates a higher return on its investment in training – especially in ***Domain-Independent Research Skills*** – thus allowing the client to transfer the low-yield activities to Pipal research. This in turn allows Pipal Research to employ research agents with a wide variety of skills which would be prohibitively expensive for any single client. As a result, Pipal Research is able to garner ***Economies of Specialization*** that only the rare very large corporation could match. Furthermore, Pipal Research's Information Systems allows it to calibrate training programs to the client's needs. The deep-linking of inter-organizational information systems and coordination through their ASP platform allows experts – in the client firm and in Pipal Research - to exchange ideas and collect real-time feedback on research in progress. Pipal Research also provides its clients with access to highly

qualified graduates where 40% of their researchers hold PhDs and CPAs, and over 35% of them hold MBAs and MAs[56].

A second source of overhead costs is the information resources and research databases which serve as sources of secondary information and provide the data feeds into specific research projects. In order to collect data and information, the company not only resorts to primary sources of data such as personal interviews and survey information but also to secondary sources such as research databases. While these research databases are rich in information they are very expensive. Pipal Research has bought access to a larger number of databases such as Hoovers, Bloomberg, Factiva, LivEdgar, etc.[57] owing to its ability to distribute overhead costs over all of its clients. As we saw earlier these databases and information gained from these databases can be used for multiple projects and the investment in secondary information resources brings far greater yields to Pipal than it would to its clients.

Pipal Research also houses a greatly varied set of skills under a single roof, which is prohibitively expensive especially for small to medium-size organizations. The researchers and analysts represent experts from a wide spectrum of skills. The advantages of ***Economies of Specialization*** offered by Pipal Research are difficult and nearly impossible to replicate in-house. Pipal Research has specialists according to sectors and functions. The sector specialists are in the areas of IT/telecom, financial services, healthcare, pharmaceuticals, consumer packaged goods, utilities, and industrial and professional services; whereas the functional specialists are in the areas of equity/fixed income research, quantitative marketing analytics, and corporate intelligence. The

[56] The reader is referred to Figure 4.8 in the Appendix for details on employees' educational backgrounds.
[57] The reader is referred to Figure 4.10 in the Appendix for a list of databases.

company has easy access to experts from varied fields and is thus able to bring together a variety of specialists – such as operations research experts, financial modelers, economists and statisticians - to work on a project to sift through data, collate relevant information, build models and then perform advanced analytics. Deep specialization in industry domains and verticals enables Pipal Research to identify, understand, and synthesize fragmented data sources in the context of vertical industry trends and use its experts to validate assumptions. In order to ensure the validity of the data and analysis, the company's expert panelists perform a second round of validation of assumptions and analyses. The company provides rapid turnaround on research requirements due to its highly-refined search and analytics processes as well access to researchers around the clock who are located in different time zones. The experts present the results to clients along with insightful observations. Manoj Jain, CEO of Pipal Research, sums it up succinctly "the value of using Pipal Research's services is access to highly-integrated, high-quality, cost-effective, timely and unbiased data. In addition, client confidentiality is at the core of Pipal Research whose employees are professional, responsive, reliable, and ethical."

Pipal Research enjoys high-margins since it provides higher-quality differentiated service as compared to a majority of its competitors through its web-based research workflow which allows for deep-linking between itself and its clients. This observation leads us to an investigation of Pipal Research's Deep-Linked information flow model and how it impacts on Pipal Research's client relationship.

4.5.4.1 Deep-Linking – Pipal Research's Workflow and Knowledge Management Platform

One of the complications of remote delivery of high-end research services is that the clients and the analysts are separated and in the case of a multi-shore model, they are separated by thousands of miles. However, research services often require interaction between the client and the provider and in the early stages of some projects the client and provider may well need to work iteratively. Thus it is of utmost importance that the clients' managers and the provider's analysts and researchers be able to share information, ideas and research specifications in real-time; and be able to access their own historical interaction to establish the business context of some specialized research. Furthermore, clients will often have to be able to customize the output of Pipal Research's analysts so as to present as per specific organizational templates.

Pipal Research includes a web-based research workflow and knowledge management platform. The platform provides *information workflow tools* such as on-line request generation, research queue/quote management, and allows for on-going discussions. Clients may also attach a template file to better describe their research context, state any budget or time constraints, and request a preferred mode of communication (phone, fax, email, or the platform). In addition to the ease of requesting information, clients may also check the status of their requests through the online request-status facility. Content management services allow for *better and real-time communication* between clients and analysts. Content management offers clients the capabilities of storing, tagging and searching through work-in-progress and finished

documents with check-in and check-out functionalities. After the initial mode of communication, clients and researchers are constantly in contact through an interactive message board, a powerful feature of the platform which offers *deep customization.* Pipal also provides its clients with access to their internally generated knowledge management database which clients can use to conduct their own searches. Although Pipal does not bill clients for the elements of research that they access via queries, the relationship between Pipal and its clients becomes tighter with the client using more of Pipal's services. The customizable service, and its ease of use makes clients' relationships with Pipal sticky and acts as an invisible barrier to switching of providers by the client. Thus, it is a significant strategic tool used by Pipal to create switching costs for clients.

The platform maintains a skill database which eases staffing for projects by matching the skills desired for a client project with those of the employees while taking into account their availability. Projects and teams are managed online to which clients have full access and the team members share knowledge and brain-storm new ideas via the message board. Conference calls via VOIP and instant messaging between clients and researchers, who are available 24/7, also help in easing the complications associated with long-distance interactions and result in achieving high-quality solutions. Finally, web-based presentation tools also provide a graphical and online tool to demonstrate or graphically discuss issues or analyses. The newly scaled version of the platform which is due to release in September 2006 will enable 10,000 users per client organization to access the enterprise library services and knowledge management services outsourced to Pipal Research.

The company leverages its platform to deliver distinctive service, track requests and expenditures, drive productivity, and increase collaboration which enhances knowledge building and expertise. Pipal Research ranks at the top on the scale of connectivity services between clients and its researchers, and its proprietary deep-linking platform eliminates the problems with remote delivery.

4.6 Research Hypotheses and Analysis

It is intuitively clear that the ease of use of the platform created by Pipal, the customizable service that deep-linking enables, as well as the benefits of interactive and iterative research should result in customers committing to more regular usage and be willing to migrate more of their research to Pipal. We examine based on data if this indeed is the case.

4.6.1 Benefits of Deep-linking to Pipal Research

Figure 4.9 in the Appendix outlines the research process followed by experts at Pipal Research. First, the client's needs are studied by the researchers, then, based on the complexity of the needs, the client and the researchers may go through several rounds of communication in order to completely understand the requirements. After client needs are understood, facts are collected, analyzed and synthesized. As mentioned in the previous section, before the report is submitted to the client it goes through a second round review process where managers and/or executives check the validity of any assumptions and models. The information and results are prepared and communicated to the client in the

format requested by the client. The level of customization could be so high that clients could request the study/report to be in presentation ready format for the client to use in a presentation without any changes. Finally, the executives in the company follow-up with the clients on their satisfaction level in terms of quality of information provided, whether the information met the requirements of the client and whether the time-line of the filled request was satisfactory.

Pipal Research has a high degree of customer retention in spite of its high profit margins. In its spot-sourcing market – Pipal Answers, for example, the company receives on an average 8 research queries per day of which 6 requests are from previous clients. Furthermore, one-third of the new requests get converted into steady-state sourcing for the clients within 2 months and another one-third of the requests get converted into transactional relationships (project basis). Word of mouth results in 2-3 interested parties calling per week to inquire about Pipal's services and models. Based on customer feedback received, apparently at least one-fourth of the requests received are for Pipal Research's quality level and deep-linking capabilities. This leads us to our first hypothesis which is:

Hypothesis 1: Customer satisfaction is higher for Pipal Research than for competitors providing similar services.

4.6.1.1 Comparison of Customer Satisfaction

In Figure 4.3 below, we compare Pipal Research with two firms that do not have a deep linked inter-organizational information system. We selected three kinds of services that all three firms provide and compared the C-Sat scores across all three firms. Note

that while Pipal generally scores higher on the Customer Satisfaction than the two other firms, what is equally noteworthy is the trendline – while Pipal's C-Sat score increases over time, the other two do not show any significant improvement over time.

Having observed higher customer-satisfaction feedback received by Pipal Research, as compared to its competitors who provide similar services but without the deep-linked platform, we hypothesize the reason for Pipal's higher customer feedback to be due to its workflow and knowledge management platform.

Hypothesis 2: Customer (client) satisfaction is higher for Pipal Research because of its flexible and deep-linked platform.

4.6.1.2 Factors Impacting Customer Satisfaction

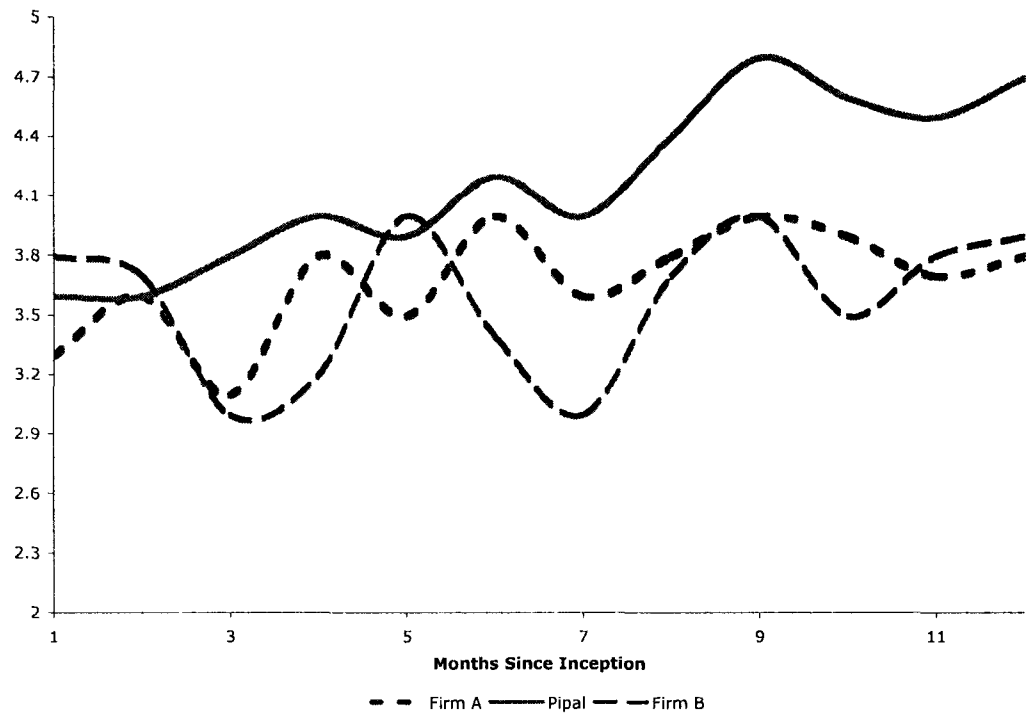
Econometric Model

Customer satisfaction (CS) is modeled as a linear combination of quality of output (Q), timeliness (T), and ease of platform (E), all of which are significant factors that vendors of market research services boast. We write the econometric model as follows[58]:

$$CS_i = \beta_1 + \beta_2 Q_i + \beta_3 T_i + \beta_4 E_i + \varepsilon_i$$

[58] Where the subscript i, refers to the i^{th} project.

Figure 4.3: Comparison of Customer-Satisfaction Scores of Pipal Research with two firms that don't provide deep-linked inter-organizational information systems.



We collected data from Pipal Research for 60 projects starting from February of 2005 to March of 2006. Our analysis shows that in general there is robust empirical support for our hypothesis that the major driver of high customer satisfaction scores enjoyed by Pipal Research is due to its platform which provides clients with greater control and customization. Table 4.2 below shows the results of the regression analysis. We find that greater C-Sat scores are strongly correlated with ease of platform usage, where a unit increase in the platform usage metric results in a 58.1% increase in the C-Sat score.

Table 4.2: Regression Analysis - Model of Customer Satisfaction

Variable	*Coefficient*	*Standard Error*	*p-value*
Intercept	-0.207	0.129	0.113
Quality	0.214	0.016	< 0.001
Timeliness	0.240	0.018	< 0.001
Ease of Platform	0.581	0.019	< 0.001
$R^2 = 95.6\%$			

4.6.2 Client Analysis

4.6.2.1 Movement Away from Context Sensitive Modes of Communication

Pipal Research provides savings of 30% over in-house teams and 40-50% compared to some competitors. Additionally, the deep-linking platform assists clients in their migration from costly in-person and telephone based information dissemination modes to email and other less costly channels. Initially customers perceive their processes to be idiosyncratic and highly context dependent. However, with time the tightly linked platform makes the knowledge less viscous and more easily transferable. Hence, customers begin to move away from expensive channels to electronic ones. See Figure 4.4, Figure 4.5 and Figure 4.6 which plot the average number of contacts per project – where a contact is defined as a direct exchange of information between an employee of the client and one or more employees of the provider. Such an exchange could take place via direct, in-person communication, over the phones, e-mail or through static media such as faxes and paper-based communication. We studied the pattern of communication over time (collected the average per project twice each month) and

contrasted the behavior of Retainer Clients with Ad-hoc spot market sourcers. In order to make sure that we were working on data that was comparable we controlled for project size and collected data only from near identical projects. The data spans over 100 projects over a period of 12 months[59]. Since each Retainer Client generates considerably more business than Ad-hoc Clients, we balanced the data by selecting equal number of projects from both kinds of clients. In Figure 4.4, Figure 4.5 and Figure 4.6Figure 4.6 below, the Y –axis represents the average number of interactions per project and the X-Axis is the temporal scale. Figure 4.4, Figure 4.5 and Figure 4.6 contrast the usage of email, telephone and in-person channels (respectively) by Retainer and Ad-hoc Clients. As illustrated in the figures it can be seen that for Retainer Clients, over time, the usage of costly ***Synchronous Channels*** (that are human coordination-intensive) such as in-person interviews and telephone-based communication ***decreases*** while that of ***Asynchronous Channels*** such as emails ***increases*** and then stabilizes. In contrast, for Ad-hoc Clients this is not case. There is no perceptible decrease in the usage of Synchronous Channels and neither is there a perceptible increase in the usage of Asynchronous Channels. The data illustrates that unlike in the case for retainer clients the use of costly channels of communication does not decay with time for Ad-hoc clients. Moreover, the usage of email is far less than that of the telephone. A common finding is that Pipal Research in general needs to communicate less with its Retainer Clients than with Ad-hoc clients in all modes (after controlling for project size and type). Further, although the use of in-person interviews starts off roughly the same for both types of clients, as the relationship

[59] 24 time stamps over 12 months.

with Retainer Clients becomes deeply-linked the use of in-person interviews starts to decline very rapidly.

4.6.2.2 Adoption of a Multi-shore Outsourcing Model by Clients

Based on the replacement of costly communication channels by asynchronous cheaper channels, we hypothesize that it would result in Retainer clients moving towards greater offshoring of their research services.

Hypothesis 3: Deep inter-organizational linking results in Retainer Clients moving more towards offshoring of services.

When the research context of clients is context sensitive, clients prefer to retain a large portion of their outsourcing work on-shore. However, with the passage of time, as the relationship between Retainer Clients and Pipal Research becomes deeply rooted, Retainer Clients move away from on-shore towards offshore outsourcing. Since the needs of the clients are well understood by Pipal, the shift of research production offshore results in the same levels of quality being offered to the clients but at lower costs. Figure 4.7Figure 4.7(a) and Figure 4.7Figure 4.7(b) depict the share of production allocated on-shore and offshore by Pipal for its Retainer and Ad-hoc clients as a function of the outsourcing relationship.

Figure 4.4: Compares the average number of Email contacts per project of Ad-hoc (spot-market) Clients with Retainer Clients as a function of time.

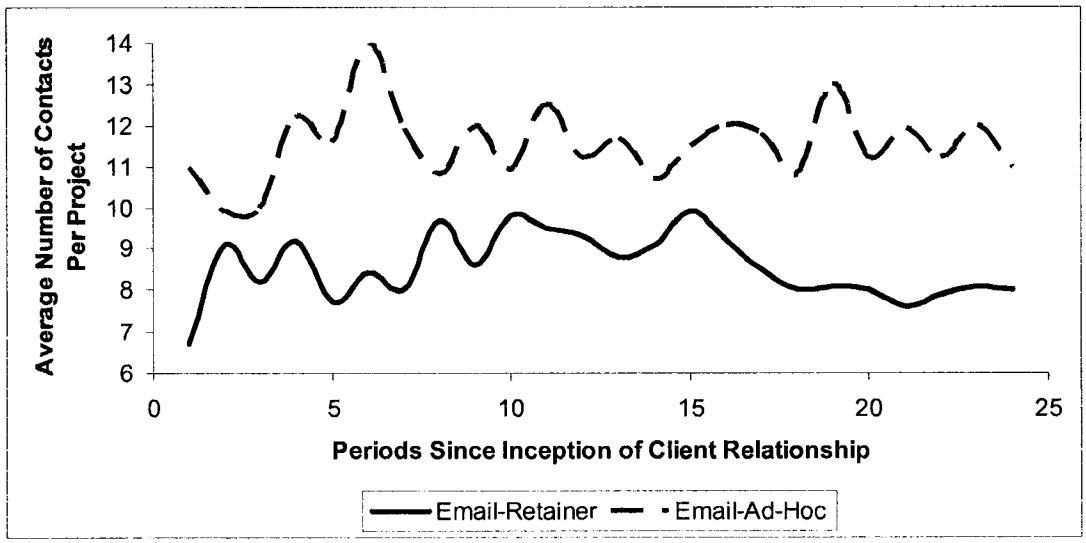


Figure 4.5: Compares the average number of Telephone contacts per project of Ad-hoc (spot-market) Clients with Retainer Clients as a function of time.

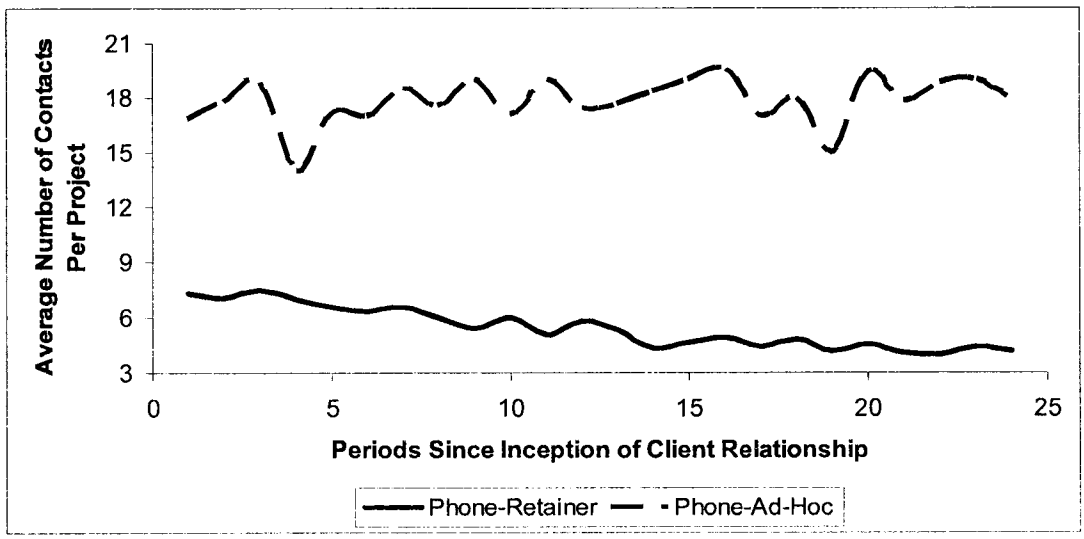


Figure 4.6: Compares the average number of In-person contacts per project of Ad-hoc (spot-market) Clients with Retainer Clients as a function of time.

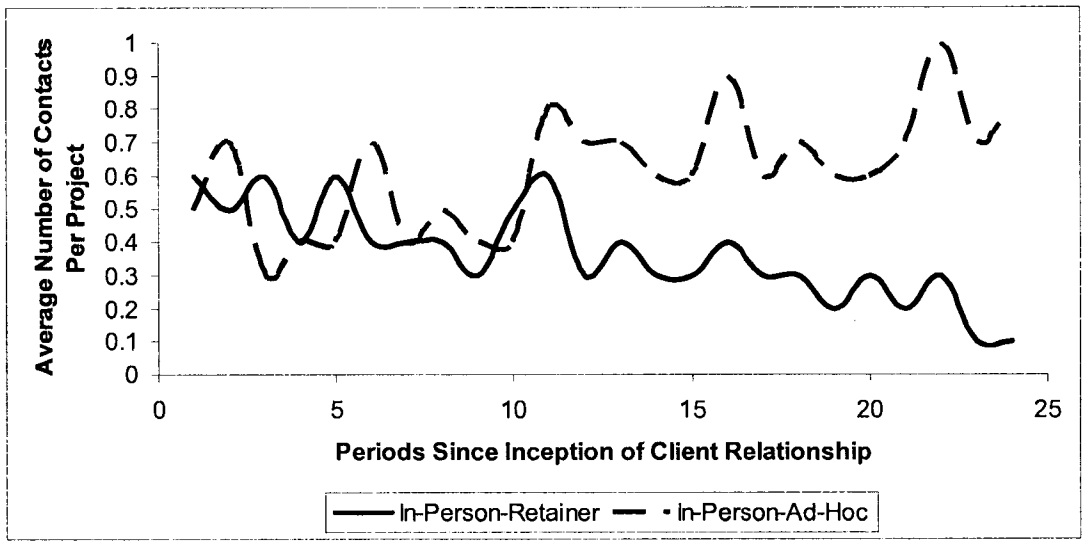
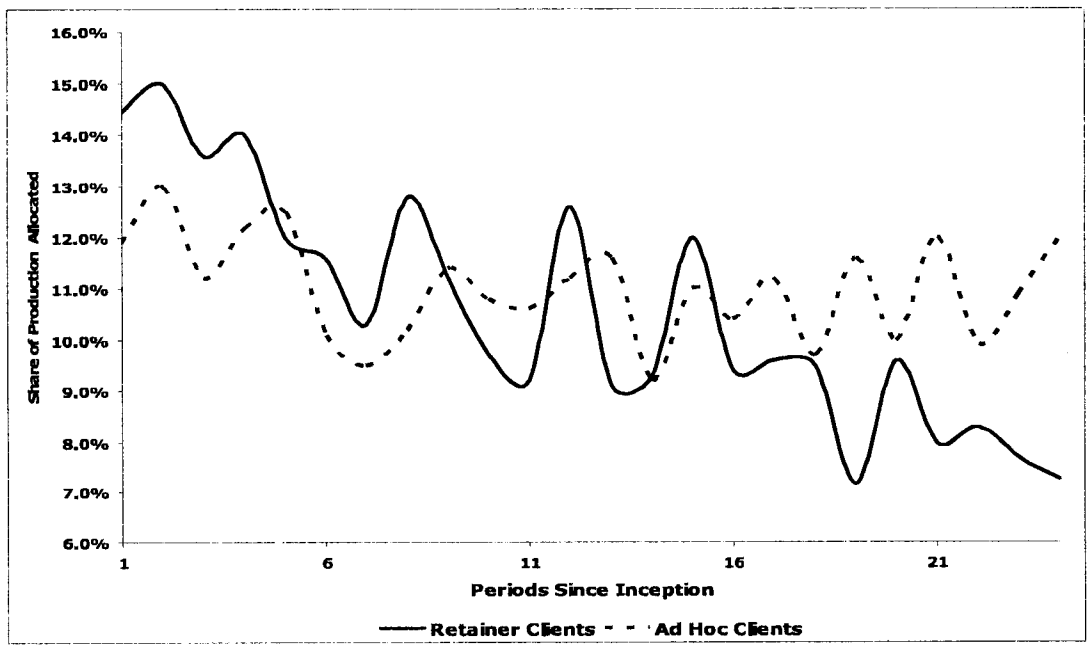
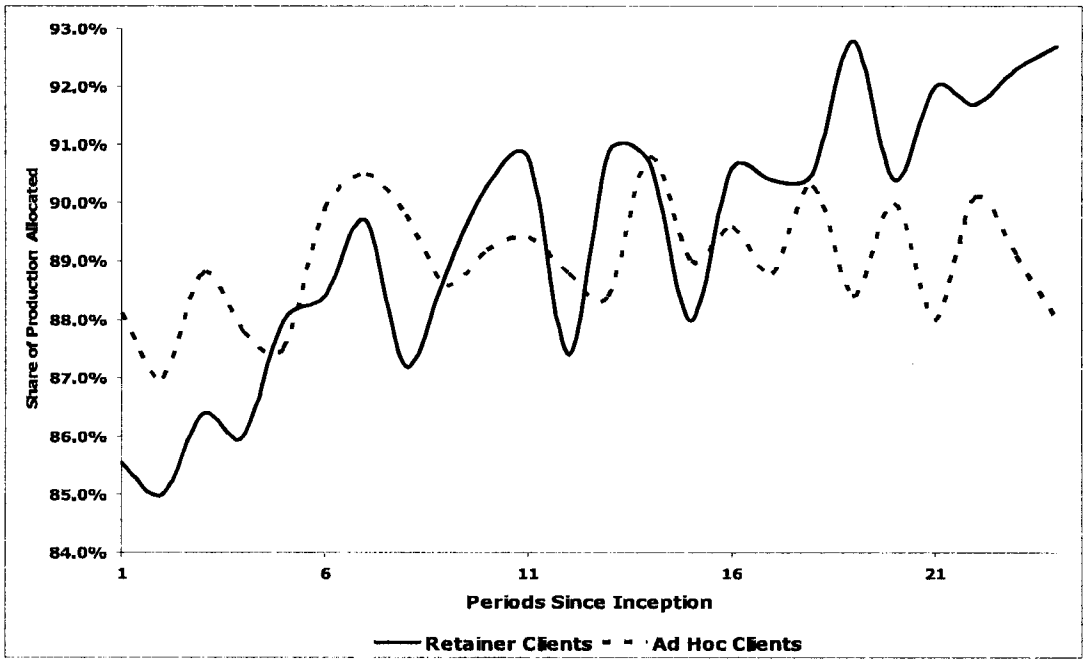


Figure 4.7: Comparing the share of production allocated on-shore and off-shore for Ad-hoc and Retainer Clients as a function of time: (a) On-shore, (b) Offshore

(a) On-shore



(b) Off-shore



4.6.2.3 Factors Leading to the Adoption of a Multi-shore Outsourcing Model by Clients

Based on the data we analyzed and the interviews with executives at Pipal Research, we find that Pipal has a high customer retention rate as well as a high conversion rate of spot sourcers (Ad-hoc clients) to contractual (Retainer) clients. Of the new spot-market research services requests that Pipal receives, one-third of them get converted into steady-state sourcing for the clients within 2 months and another one-third of the requests get converted into transactional relationships (project basis). Consequently, we are interested in determining the factors that influence the decision-making of clients and in their decision to convert to a contractual relationship. The customer feedback model presented earlier strongly indicates the reason for Pipal's high

customer satisfaction scores to be the deep inter-organizational platform. Therefore, we hypothesize that:

Hypothesis 4: The greater the deep inter-organizational linkage between the client and the provider, the greater the probability of an Ad-hoc Client converting to a Retainer relationship.

The data for examining the influence of client conversion was collected from Pipal Research. Based on the data and on the interviews with executives at other service providers based in India and Singapore that planned to transition processes offshore, we identified a set of factors that influenced the buyer's decision to switch from an Ad-hoc, spot sourcing relationship to a retainer relationship based on long term contracts. We use the following variables to investigate the significant factors in determining the conversion of customers (clients) from ad-hoc to retainer (contractual): timeliness of vendor (T), satisfaction with the quality of service provided by vendor (Q), quality of vendor's Information System platform (E), average high intensity of interactions[60] (I), number of projects requested by customer that take a day to complete (D1), number of projects requested by customer that take 1-3 days to complete (D2), and number of projects requested by customer that take 3-7 days to complete (D3). We write the logit regression model as follows[61], where the dependent variable is binary and a value of 1 indicates that the Ad-hoc client will convert to a Retainer client:

[60] Average number of interactions per project for the Ad-hoc client via Synchronous Channels.
[61] Where the subscript i, refers to the i^{th} customer.

$$C_i^{'} = \beta_1 + \beta_2 T_i + \beta_3 Q_i + \beta_4 E_i + \beta_5 I_i + \beta_6 D1_i + \beta_7 D2_i + \beta_8 D3_i + \varepsilon_i$$

$$C_i^{'} = \log_e \left[\frac{p}{1-p} \right]$$

$$p = \frac{\exp(\beta_1 + \beta_2 T_i + \beta_3 Q_i + \beta_4 E_i + \beta_5 I_i + \beta_6 D1_i + \beta_7 D2_i + \beta_8 D3_i + \varepsilon_i)}{1 + \exp(\beta_1 + \beta_2 T_i + \beta_3 Q_i + \beta_4 E_i + \beta_5 I_i + \beta_6 D1_i + \beta_7 D2_i + \beta_8 D3_i + \varepsilon_i)}$$

The logit regression results further corroborate the finding that deep-linking provided by vendors is of significant importance to customers in the value-added outsourcing service industry. The coefficient of *Ease of Platform* is positive and has a value of 35.612, indicating that a one unit change in the variable results in 35.612 units of change in the log of the odds of conversion. The variable D1 defined as the number of projects with duration of 1 day outsourced to Pipal during the relationship has the largest coefficient. It is clear that as the Ad-hoc client starts sourcing more and more frequently – especially in the case of well structured, short duration projects, it is more likely that the said client will transition to a contractual model of sourcing and reap the benefits of volume discounts that Pipal offers for retainer clients. A similar explanation holds for the positive co-efficients associated with the other two projects also. What is intriguing is the small *negative* co-efficient associated with the *Timeliness* factor. Surely, as the client's satisfaction increases with Pipal's timely delivery of output, the client must become more - not less – inclined to convert to a retainer client? This is true except for the fact it ignores a self selection bias. There are some Ad-hoc clients that have large in-house operations and resort to sourcing from Pipal only when they face deadlines that they cannot handle with in-house resources. Thus, for these clients the single most important attribute of Pipal is that it will help them to meet deadlines. In other words, they go to

Pipal only for its timely service. Such clients self select – they will source almost always on a spot basis from Pipal, almost always for Pipal's ability to deliver on time. *Thus, for these clients, the more they value Pipal's timely delivery, the more they use it as a spot market fall back mechanism.* Table 4.3 below shows the results of the logit regression analysis.

Table 4.3: Logit Regression Analysis - Model of Customer Conversion

Variable	*Coefficient*	*Standard Error*	*p-value*
Intercept	-384.641	11.122	0.000
Timeliness	-9.7	0.776	0.000
Quality of Output	19.156	1.714	0.000
Ease of Platform	35.612	1.981	0.000
Average High Intensity Interactions	13.607	0.545	0.000
Projects of 1 day duration	43.118	1.156	0.000
Projects of 1-3 days duration	11.527	1.377	0.000
Projects of 3-7 days duration	19.991	1.253	0.000

4.7 Managerial Insights and Conclusions

This study is motivated by our desire to contribute to the empirical research on understanding failures and successes of outsourcing relationships. Although, this is a

preliminary study we believe it is a first step in analyzing contractual relationships at the higher-end of the value chain.

Our results show the importance of deep-linking between vendors and customers in value-added services through their impact on customer satisfaction levels. The principal barrier to offshoring interaction and information intensive services is the coordination and communication costs. In a market characterized by a high degree of competition, the threat of opportunistic behavior is considerably reduced. Pipal has recognized this barrier and created a platform that greatly reduces the cost of communication and coordination.

Role of Contract Type: Our research shows that as clients start interacting with Pipal more and more, they are less prone to use costly Synchronous Channels of communication and instead use Asynchronous Channels such as e-mail. It is also clear that over time clients that have a contractual sourcing relationship with Pipal are able to transmit information about their business context to offshore providers and are more likely to be able to transition their process production to the lower wage regime. The research that clients need is often context-sensitive and the research analysts need to have a clear understanding of the client's business context to be able deliver certain kinds of research. Our research clearly shows that Contractual Clients are more likely to migrate a greater share of their production offshore than Ad-hoc clients. Thus, contractual clients are more likely to invest in imparting an understanding of their business context to Pipal than Ad-hoc clients.

We also investigate the factors that contribute to Ad-hoc (spot-market) clients moving to a multi-shore model by becoming Retainer clients and our analysis shows that

deep-linking is a major contributor. The quality of Pipal's inter-organizational information system is an important factor in the client's decision to move from spot market sourcing to contractual sourcing. This is a second aspect in which technology contributes to the allocation of processes to offshore and onshore production regimes. Technology – i.e. deep-linked information systems – helps convert Ad-hoc clients to Retainer Clients which in turn results in a greater share of production being migrated to offshore facilities.

Some limitations of this research have to do with the data. Given the extreme political sensitivity associated with offshore production, we could not get data about several potentially interesting clients and projects. We were also limited to examining only subsets of projects and clients since the historical data on many of the earlier interactions were missing. It is possible that the effect size of some of the phenomena that we describe was either amplified or diminished because of the limitations of data selection.

In terms of future work, it would be useful to compare and contrast Pipal Research with a few of its close competitors, those with multi-shore models and those with only domestic models, in terms of their service models, customer satisfaction levels and factors that contribute to the profitability of the vendors.

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4.9 Appendix

Table 4.4: Pipal's Management Team - Founder's Background

	Role	Education	Prior Experience
Manoj Jain	CEO	MBA, US	McKinsey, Associate Principal
Sanjeev Arora	Vice President, Products and Operations	MBA, US	Agility, CEO McKinsey, Business Builder AirClic, Founder and VP
Purva Sule	Director, Client Services	MBA, India	ICICI, Structured Finance McKinsey, Associate
Chris Murphy	Director, Research	MBA, US	McKinsey, Research Office Head
Gopal Krishna	Head of Indian Operations	MBA, US	McKinsey, Engagement Manager FlatIron, Chief Research Officer
Jason Anderson	Director, Financial Services	CFA, US	Portfolio Manager, Ritchie Capital Telecom Analyst, Kingdon Capital
Santosh Kurup	Director, European Operations	MA, UK	Professor of Economics – St. Stephens Emerging markets banker – JP Morgan

Figure 4.8: Educational Background of Researchers/Analysts

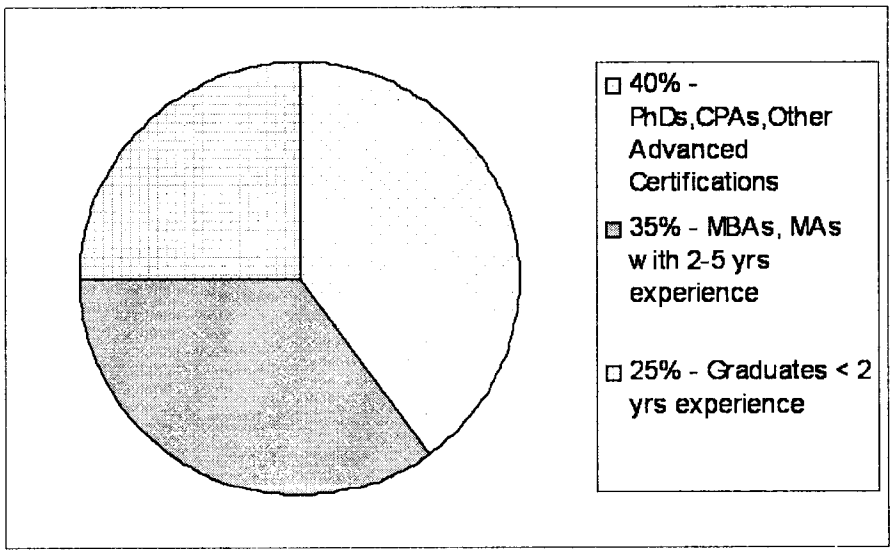

Figure 4.9: Research Process at Pipal Research

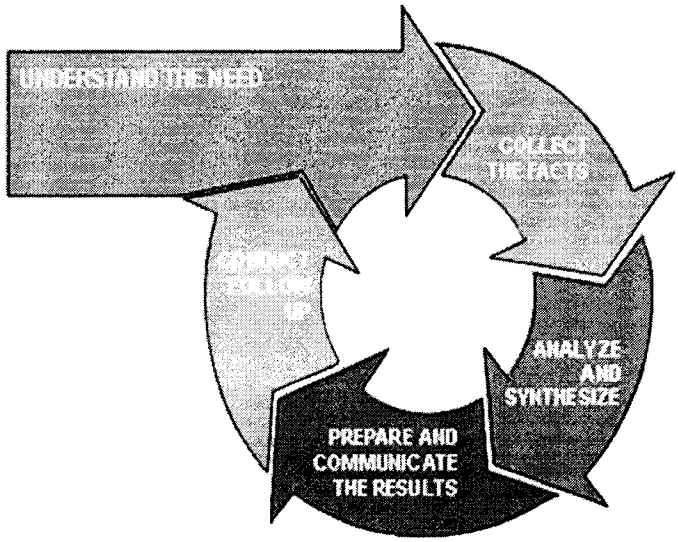

Figure 4.10: Research Databases

Examples of databases

- Alacra
- Bloomberg
- Compustat
- Dialog
- Dow Jones Interactive
- Dun & Bradstreet
- EIU
- Factiva
- Global Access
- Hoovers
- Harris Infosource
- Ingenta
- IntellectExchange
- Lexis-Nexis
- LivEdgar
- Multex
- Profound
- Research Bank
- S&P
- Thomson Securities Data

5 Conclusions

In this thesis we contribute to the literature on outsourcing by analyzing the impact of information technology on the boundaries of the firm and in particular, on the allocation of production capacities. The first essay complements previous work in the area of B2B markets while addressing the question of under what conditions is it viable for a firm to create a sustainable private exchange. The second essay investigates how firms in an oligopoly model of competition of vertically differentiated services allocate work across different production regimes. And finally in the third paper, we analyze data pertaining to a multi-shore vendor in order to empirically understand the factors that contribute to the outsourcing decisions of firms.

In the first essay, we examine the impact of a business-to-business market on the boundaries of a manufacturing firm and the firm's scale of operations. We provide insights on how a large producer can use a private electronic market (PEM) as a strategic tool to remove the 'cost pooling' mechanism which exists in a disaggregate procurement regime. Additionally, the creation of a PEM forces an increase in the procurement costs faced by the large producer's competitors which in turn affects the optimal production allocations of all producers. We also analyze the effects of a PEM on firms' profits, consumer surplus and social welfare, under different models of competition. Our analysis demonstrates that under Cournot competition, the large producer enjoys greater profits with the creation of a PEM than without. The opposite result holds true for the consortium of smaller producers who are strictly worse off after the creation of a PEM. Consumers, on the other hand, are worst off under the tacit collusion model of

competition and best off when producers compete without the creation of a PEM. The creation of a private exchange by a large producer has significant welfare implications as well, with welfare increasing as the production efficiency of inputs to production declines.

A significant contribution of this paper is our illustration of the increasing benefits to a large producer of creating a PEM as the cost of inputs of production increases. Further, the benefits to the large producer increase as the production constraint of the consortium increases. The advantages for a large producer in creating a PEM also increase as the demand curve becomes more inelastic. From a policy standpoint, when upstream suppliers are highly efficient, mechanisms should be enforced so that a large producer is dissuaded from creating a PEM of fragmented suppliers to hamper competition and in turn, dramatically decrease overall welfare.

In the second essay, we investigate the boundaries of firms by analyzing how production of services is allocated between different wage regimes and production structures -- In-house, On-shore, Offshore and Automated Utility. Our analysis also focuses on how production allocation is driven by vertical competition in markets. Therefore, unlike most papers in the area of information systems outsourcing that ignore the effect of competition on outsourcing decisions, we explicitly model competition in an oligopoly in the domain of services characterized by vertical differentiation. Based on survey findings, we create a quality hierarchy of production of the four different production regimes. We investigate how firms allocate production to these different regimes taking into consideration their relative cost and quality trade-offs for three kinds of market services, Neutral Quality, Context Sensitive and Judgment Intensive. Due to

the complexity of the model formulation, the model is analytically intractable and we use simulation to characterize the allocation of production capacity in equilibrium.

We analyze the impact of consumer valuation of quality on the share of production allocated to different production regimes. Our results demonstrate that for all three service regimes, as consumer valuation increases the share of production retained in-house increases while the share of production sourced to an automated utility decreases. Further, the share of in-house production is greatest in the Context Sensitive regime where it is extremely important for processing agents to be close to the end consumer market. The overall shares of work allocated to off-shore and on-shore production are greater in the Judgment Intensive Regime than in the Context Sensitive Regime due to human judgment being valued more in the former where the cost to quality tradeoff of production is very low; hence, off-shore and on-shore production serve as viable substitutes to the high quality of service provided by in-house production. However, for low customer valuation ratios the share allocated to off-shore production is greater than the share allocated to on-shore production in all service regimes, but as customer valuation increases, the share allocated to off-shore production starts to decrease while the share allocated to on-shore production tends to increase.

We also compare the average quality of service provided by firms under the welfare maximizing solution to that under the profit maximizing solution for the three types of services. Our results demonstrate an over-investment in quality by firms under the profit maximizing solution for high values of customer valuation, in all the regimes. Additionally, we investigate the effect of increased market concentration or increased competition on the allocation of production. The results corroborate the inverse

relationship between the share allocated to in-house production and the automated utility and the greater share allocated to on-shore production than offshore for high customer valuation ratios. Our results also illustrate that for high customer valuation ratios the share of work allocated to domestic production (in-house and on-shore) decreases as market concentration increases. An important finding in this essay is that the root cause of job loss is due to the shift in share of production allocated to automation or automated utilities and not due to the offshoring of services. Furthermore, the production of skilled services should be retained domestically.

In this thesis, we also empirically analyze the impact of information technology on the allocation of production capacity. In the third essay, we focus on Pipal Research, a service provider of high-end knowledge services, which has a multi-shore service model – it provides both on-shore (US based) and offshore services. The company provides service on a contractual basis (per project or fixed hours per month) and spot-sourcing as well where price is based on the complexity of service requested. By collecting in-depth project level data on the service provider we are able to investigate different aspects of the provider's contractual relationship. Although the market for "business and market research services" is expected to have a CAGR[61] of 70% by 2010 and become a $400 million business (GlobalSourcingNow 2004), the competitive environment is fraught with numerous competitors. Pipal Research is well aware of the competitive environment and chooses to differentiate itself from competitors through its deep customization and inter-organizational linkage offerings.

[61] Cumulative Annual Growth Rate

Since the company boasts of high growth prospects and a steady stream of customers despite its high profit margins, we first examine Pipal's customer satisfaction scores. We compare the customer satisfaction feedback scores received by Pipal Research to that of other providers offering similar market research services. Our analysis illustrates a higher level of customer satisfaction among Pipal's clients. We then build an econometric model to investigate the major contributors to the higher customer satisfaction scores received by Pipal and find the deep-linked platform to be the primary factor. Next, we examine two aspects of how information technology and the deep inter-organizational linkage affect a client's allocation of production capacities between on-shore and offshore sites. Our investigation of the evolution of inter-organizational information flow illustrates that as contractual clients start interacting with Pipal more and more, they are less prone to use costly synchronous channels of communication (in-person interviews, phone, etc) and instead use asynchronous channels such as e-mail. However, no such trends are observed for clients who choose spot-market sourcing. In addition, as the needs of retainer clients become less context sensitive, they tend to offshore a greater share of their production capacity. We also determine that the deep-customizable platform is a significant feature in converting ad-hoc clients to retainer clients. Finally, another interesting observation is that the *timeliness* factor of Pipal Research has a negative influence on the conversion of ad-hoc clients. We believe the cause to be the self-selection bias, where certain clients use the services of Pipal only for its ability to provide timely service, which the clients are unable to meet with in-house operations alone.

By studying the important issues discussed above, this thesis makes a significant contribution to extant literature by providing a better understanding of the impact of firm

competition in the presence of outsourcing options and can serve as a guide to firms' investment decisions in outsourcing.

5.1 References

[1] GlobalSourcingNow 2004: "The Next Big Opportunity – Moving up the Value Chain – From BPO to KPO," Business Research.