Firm Organization and Market Structure: Centralization vs. Decentralization

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Abstract

The profitability of a firm is jointly determined by the market structure and the firm’s organizational structure. To explore the relationship between these two structures, a real-time information processing model in a dynamic duopoly environment is developed, which allows us to examine the effects of the product market competition and the cost of delay. It is found that Decentralization tends to outperform centralization when product market competition is intense due to the cost of delay associated with centralization. This result is supported by several empirical papers, such as Acemoglu et al. (2006) and Meagher and Wait (2006).

Keywords: Organizational Structure; Decentralization; Market Structure; Product Market Competition; Real-time Information Processing

1 Introduction

The performance of a firm is jointly determined by the external environment – ‘market structure’ and internal environment – ‘organizational structure’.

‘Market structure’ consists of the factors in a market which affect the payoffs of firm decision making. Product market competition is argued to be one of the most important factors in market structure, and other factors include the distribution of consumer tastes, consumer sensitivity to firm operations, and so on.

‘Organizational structure’ determines the architecture of an organization: who collects information, with whom information is communicated, and how decisions are made, which affect the quality of decision making. The two organizational forms that we will discuss in this thesis are ‘Centralization’
and ‘Decentralization’. Under centralization, the decision making authority is vested in the headquarters; while under decentralization, the decision making is delegated to the local managers who have superior local information (Kruisinga 1954).

Understanding the relationship between organizational structure and market structure is important, because the external and internal environments work together to determine the profitability of the firm. Thus, there is not a single best organizational structure for a firm, instead, we are looking for a fit between the organizational structure and market structure.

This thesis attempts to address two questions. Does market structure have any impact on the performance of an organizational structure? If so, how does the market structure affect the firm’s optimal organizational structure?

Only a small and recent literature has studied the relationship between organizational structure and market structure.

Meagher (1996) pioneered the analysis which explores the relationship between organization structure and market structure as described by a real-time information processing model for the case of a dynamic monopoly.

Chang and Harrington (2003) enriches the market environment by introducing product market competition. They draw the conclusion that centralization tends to outperform decentralization when product market competition is intense. However, the opposite results have been found by several empirical papers, that product market competition favors decentralization (Acemoglu et al. 2006; Meagher and Wait 2006).

We argue that Chang and Harrington have ignored an important factor in organization, namely, that individuals have limited capacities in communicating, formulating and processing, which is well known as ‘bounded rationality’.

‘Bounded rationality’ was first suggested by Simon (1955). The concept of bounded rationality revises the traditional ‘rational choice theory’ to account for the fact that perfectly rational decisions are often not desirable in practice due to the finite computational resources available for making them.

It is suggested by Van Zandt (1999) that it is important to recognize boundedness of rationality of economic decision makers in studying economics of organization.

The economies of today’s industrialized nations are dominated by giant firms, each with hundreds or even thousands of employees. A single person cannot be in control of everything. Hence, instead of treating a firm as a unitary ‘entrepreneur’, bent on maximizing profit, we should consider a firm as an organization of economic agents of bounded rationality (Radner 1992).

To synthesise Chang and Harrington (2003) and Meagher (1996), this the-
sis develops a real-time information processing model in a dynamic duopoly environment, which allows us to consider the effects of the product market competition as well as the cost of delay. In this computational model of chain stores, consumers keep searching among stores for a better match, and store managers continually search for better practices. In addition, new data about the environment arrives from time to time in each chain, and decisions are correspondingly revised that are computed from the lagged information under centralization.

The major finding of this thesis is that the choice of organizational structure is affected by the market structure, and the relative performance of decentralization is superior when the product market competition is more intense. This finding is consistent with the results found by several recent empirical papers (Acemoglu et al. 2006; Meagher and Wait 2006), that firms are more likely to decentralize in a more competitive product market.

The organization of the paper is following. Section 2 presents the computational model used. Section 3 presents the simulation design. Section 4 discusses the results. Section 5 presents the sensitivity analysis. Finally, Section 6 concludes and discuss the limitations as well as the future research.

2 Computational Model

The major weakness of the model of Chang and Harrington (2003) is that it does not consider the bounded rationality on the part of organization. They assume that information processing is effortless and occurs on the spot.

However, Simon (1955) introduced the concept of ‘bounded rationality’, which indicates that boundedly rational agents experience limits in communicating and processing information. Van Zandt (1999) also suggests that recognizing the boundedness of rationality is important to study seriously the economics of organization.

To synthesise Chang and Harrington (2003), Meagher (1996) and Radner and Van Zandt (2001), a reduced form of real-time decentralized information processing dynamic computational model will be developed in the duopoly case.

Bounded rationality has been introduced to this model, in which the cost of delay is considered. Our approach is different from Radner (1993). Delay is modeled as the time taken to transmit information between the store managers and the corporate headquarters instead of computational delay. It is assumed that when information is acquired by or generated internally, each member of the firm who uses this information must invest some time to do so.
2.1 Market Setup

There are two chains \(a\) and \(b\) competing in \(M\) distinct geographic markets. Each chain is modeled as a corporate headquarters (HQ) and \(M\) stores. Each store serves one single market. For each store, there are two organizational structures available: ‘Centralization’ and ‘Decentralization’, which are denoted by ‘C’ and ‘D’ respectively.

The operations of each store are viewed as a bundle of practices/attributes over \(N\) dimensions, such as ease of access, selection and quality of products, style of trading, service offered, and so on (Lancaster 1966; Mintel International Group Limited 1995). Specifically, the operations of chain \(j\)’s store in market \(h\) in period \(t\) is fully described by an \(N\)-dimensional vector

\[
\mathbf{z}^{j,h}(t) = (z_1^{j,h}(t), z_2^{j,h}(t), ..., z_N^{j,h}(t)) \in \{1, 2, ..., R\}^N,
\]

where \(z_k^{j,h}(t)\) is the overall operations of the store, \(z_k^{j,h}(t)\) is the practice for the \(k\)th dimension of the store’s operations, and \(R\) is number of feasible practices for each the \(N\) dimensions. All the dimensions are independent of each other.

There is a constant number of consumers \(C\) in each market. Each consumer \(i\) is defined as a bundle of preferences over these \(N\) dimensions of the store’s operations, \(w^i = (w_1^i, w_2^i, ..., w_N^i) \in \{1, 2, ..., R\}^N\), which is drawn independently across markets. Each consumer’s actual type is a random draw from a distribution that is parameterized by her ‘primary type’ over \(N\) dimensions. If a consumer’s primary type is \(s\), then her actual type is a random draw from \(\{s - E, ..., s + E\}^N \subset \{1, 2, ..., R\}^N\), according to a uniform distribution where \(E\) is a parameter. Each consumer’s primary type is a one dimensional vector, which is drawn from a triangular density distribution over \(\{S_h - G, ..., S_h + G\} \subset \{1, 2, ..., R\}\), where \(S_h\) denotes the mean of the market \(h\), and \(G\) denotes intra-market heterogeneity, which measures how different the consumers’ tastes are within a market. The difference of the means between market \(h'\) and market \(h''\) is measured by \(\alpha = |S_{h'} - S_{h''}|\), where \(\alpha\) is inter-market heterogeneity.

2.2 Organizational Structure and Decision Making

Store managers continually search for better practices in each period through generation, evaluation and implementation of innovation ideas. This process is described in the following.

2.2.1 Generation of Innovation Ideas

Innovation is modeled as a random search carried out in a fixed space of ideas. In each period, each store generates one idea. An idea is created by
randomly selecting a value from \{1,...,R\} over a randomly selected dimension from \{1,...,N\}.

Consider an example with 5 dimensions and 100 feasible practices. Suppose that the current store practice is \(24,77,43,52,12\), and an adoption of an innovation involves changing the practice in the second dimension from 77 to 59. Then the new store practice becomes \(24,59,43,52,12\).

2.2.2 Evaluation and Implementation of Innovation Ideas

In Chang and Harrington (2003)’s model, there is no information processing delay. They assume that information processing is effortless and occurs on the spot.

However, Radner (1993) suggests that it takes time to process information. To quantify the cost of delay, we need a temporal decision problem in which current decisions are computed from lagged information (Van Zandt 2003).

Thus, a reduced form of the cost of delay approach is adopted in this model. It is assumed that it involves one period delay for the transmission of information between store managers and the HQ, such that, for each period, store managers send local information to the HQ, and then receive the aggregated information from the HQ. The processing of this information transmission takes one period in total.

Under decentralization, in each period, each store manager generates one innovation idea. In each period, any store’s set of innovation ideas come from two sources: (1) the idea generated by the store itself, and (2) the store manager receives, via the HQ, the ideas adopted by other stores under the same chain in the previous period. The store manager sequentially evaluates all of these ideas, and adopts the idea which raises the store’s profit the most, and then sends this profitable idea to the HQ. If none of the innovation ideas raise its profit, it discards all, and the practices of the store remain the same as the practices in the previous period.

Modeling the inter-store learning under decentralization is still possible, but due to the information transmission delay, in each period, each store can only observe the ideas adopted by other stores in the previous period. As emphasized by Chang and Harrington (2003), decentralization also involves an implicit cost. When the practices of each store drift away from each other in order to adapt the local market, it is less likely for the store to learn from the ideas adopted by other stores, which in turn, hampers the effective learning between stores.

Under centralization, each store manager generates one innovation idea in each period, and evaluates this idea. If the idea raises the store’s own profit,
store manager sends it to the HQ, otherwise discards it at the local level. At the end of each period, the local information about the current consumer base and store profit in each market are sent to the HQ as well. Note that, due to the information transmission delay, in each period, all the information available to the HQ is the innovation ideas and local information sent by store managers in the previous period. Based on the lagged information, the HQ evaluates all the ideas sequentially, and implements the idea which raises the chain’s overall profit the most throughout the chain. If none of them raises the chain’s overall profit, then the HQ discards all of them, and the practices of the chain remain the same.

It is also assumed that the HQ does not have detailed information of stores’ markets. Information about the current consumer base and the store profit in each market is aggregated at the HQ level, on which the evaluation of innovation ideas is based. Inter-store learning is relatively effective under centralization in the sense that it promotes the spillover of profitable ideas across all the stores under the chain.

In both the centralization and decentralization cases, the evaluation of innovation ideas is based on the current consumers $\gamma^{i,h}(t)$, who just consumed from the store.

Once the idea is decided, implementation of innovation ideas has to be done. Under decentralization, store managers have the authority to implement ideas, while, under centralization, this authority rests with HQ only, who does not have detailed information of store’s markets so that it either implements a practice throughout the chain or not at all. This implies that centralization imposes uniform practices across all the stores in the chain. Once an innovation idea is implemented, the store’s practice in the specified dimension is changed to the new value.

### 2.3 Consumer Search and Demand

#### 2.3.1 Consumer Search

Bounded rationality on the consumer part suggests that consumers cannot be thinking about which store to purchase from every hour, or even every week due to their ‘attention budget’. Instead, a consumer rethinks such decisions from time to time regularly or at some random intervals (Radner 2003).

In our model, consumer search proceeds as follows. A consumer enters each period with a ‘favourite store’ which she currently prefers. In each period, with probability $Q \in [0, 1]$, a consumer engages in search, which involves searching all the stores in the market, and then buying from the store which gives her highest utility. Her favourite store is then changed to
the store that she has just purchased from. With probability \(1 - Q\), she does not search and buys from her current favourite store.

Note that if \(Q = 0\), then each consumer has absolute loyalty to her favourite store, in such case, no consumer searches or switches stores in each period, and each chain acts as a monopolist. On the other hand, if \(Q = 1\), then all consumers search in each period, but it does not necessarily lead to zero loyalty, as they may search without switching stores.

### 2.3.2 Demand/Consumption

The distance between a consumer’s ideal store practices and store’s actual practices is called the ‘preference distance’, which is measured by a function of Euclidian distance, \(\sqrt{\sum_{k=1}^{N} (z_k - w_k)^2}\).

A consumer ranks stores according to this preference distance. A small distance indicates that the store’s actual practices stay close to the consumer’s preference, which implies that the consumer’s utility is high. On the other hand, a large distance implies that the store’s actual practices are far away from the consumer’s ideal practices, which leads to a low consumer utility. A consumer’s decision on which store to purchase from is based on the rank of preference distance. A consumer buys from the store with smallest preference distance.

Once a consumer decides which store to purchase from, the number of units demanded by the consumer depends on the preference distance as well, which is specified as

\[
A - \sigma \sqrt{\sum_{k=1}^{N} (z_k - w_k)^2} \tag{1}
\]

This is decreasing in the preference distance, so that a consumer buys more if she is more satisfied by the store practices. \(A\) is specified as the minimum value to ensure the positive demand for each consumer, \(A = \sqrt{\sum_{k=1}^{N} (R/2 + G + E)^2} \), and \(\sigma\) measures the sensitivity of the consumer responding to store practices.

Defining \(\gamma^{j,h}(t)\) to be the set of consumers that are shopping at chain \(j\)’s store in market \(h\) in period \(t\), then this store’s profit in period \(t\) is specified as

\(\gamma^{j,h}(t)\) \( (R/2 + G + E) \) is the maximum distance between a consumer’s preference and store’s actual practice in each dimension.
\[
\pi^{j,h}(t) = \sum_{i \in \gamma^{j,h}(t)} \left[ A - \sqrt{\sum_{k=1}^{N} (z_k - w_k)^2} \right]^\sigma
\]

This is the sum of consumers’ demands as the price is set to one, and costs are normalized to zero. A chain’s profit is the sum of profits of all the stores under this chain.

For the purpose of comparison, all the profits are scaled to one, by dividing each store’s nominal profit \( \pi^{j,h}(t) \) by \( \sum_{i=1}^{C} A^\sigma \). \(^2\)

3 Simulation Design

3.1 Parameters

The simulation program is written in MatLab. Since there is no pre-developed software for this type of joint agent-market simulation, we had to write our own program.

Simulations were run with sets of parameters with different values, as shown in Table 1. For each set of parameter values, the computational experiment consists of \( X \) replications of the procedures over \( T \) periods described in the ‘Computational Model’ section.

Each replication involves a randomly drawn market set-up, generation of innovations, so each replication is independent of the rest. \(^3\)

There are three geographically distinct markets \( M = 3 \), which are defined

\(^2\sum_{i=1}^{C} (A - 0)^\sigma \) is the maximum demand/profit which a store can get, which assumes that all the consumers in the market buy from the store, and the preference distance is zero for each of them.

\(^3\)For each replication, the same initial practices and the same sequence of ideas for each store are used under both organizational forms, so that we are able to control for two sources of randomness.
Table 1: Table of Model Parameters:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Replications ($X$)</td>
<td>${1, 400}$</td>
</tr>
<tr>
<td>Number of Periods ($T$)</td>
<td>${100, 500, 1000}$</td>
</tr>
<tr>
<td>Number of Markets ($M$)</td>
<td>${2, 3}$</td>
</tr>
<tr>
<td>Number of Consumers ($C$)</td>
<td>${100, 800}$</td>
</tr>
<tr>
<td>Number of Dimensions ($N$)</td>
<td>${2, 5, 10}$</td>
</tr>
<tr>
<td>Fluctuation to Consumers’ Primary Types ($E$)</td>
<td>${0, 2}$</td>
</tr>
<tr>
<td>Feasible Practices for Each Dimension ($R$)</td>
<td>${100}$</td>
</tr>
<tr>
<td>Inter-market Heterogeneity ($\alpha$)</td>
<td>${0, 2, 4}$</td>
</tr>
<tr>
<td>Intra-market Heterogeneity ($G$)</td>
<td>${10, 25, 40}$</td>
</tr>
<tr>
<td>Consumer’s Sensitivity to Store Practices ($\sigma$)</td>
<td>${3, 9, 15}$</td>
</tr>
<tr>
<td>Consumer Search Probability ($Q$)</td>
<td>${0, 0.05, 0.5, 1}$</td>
</tr>
</tbody>
</table>

as $S^1, S^2, S^3 = \{\frac{R}{2} - \alpha, \frac{R}{2}, \frac{R}{2} + \alpha\}$. $S^1, S^2, S^3$ also denote the ‘consumer peak’ in market 1, market 2, and market 3 respectively and the consumer peak in market 2 lies between the consumer peak in market 1 and market 3.

There are three parameters to which we need to pay special attention.

Firstly, in this thesis, intensity of competition is measured by the consumer search probability $Q$ (Stahl 1996). When $Q$ is approaching zero, there is no competition in the market, as each consumer has absolute loyalty to her favourite store, in that case, each store acts as a monopolist (Axell 1997; Stahl 1996). On the other hand, when $Q$ is approaching one, each consumer searches in every single period, which results in a intense product market competition (Salop and Stiglitz 1977).

Secondly, the intra-market heterogeneity $G$ measures how different consumers are in a market. A small $G$ indicates that tastes of consumers in a market is relatively homogenous, while a large $G$ means the market is relatively spread out with heterogeneous consumer tastes. For example, when $C = 800$, $R = 100$, $E = 0$, the consumer densities over each dimension in all markets are shown in Fig. 1 when $G = \{10, 25, 40\}$. It is shown that, for each row, from the left to the right with increasing intra-market heterogeneity $G$, the consumers are more heterogenous represented by a more spread out consumer density; while for each column, from the top to the bottom, the

\footnote{Note that when there is no fluctuation to consumers’ primary types $E = 0$, the density of consumers over each dimension is the same, which is density of the consumers’ primary types.}
consumer peak moves to the right due to the *inter-market heterogeneity* $\alpha$.

Figure 1: Triangular density of consumers in the 3 market when $G = \{10, 25, 40\}$

NOTE: This figure shows the triangular consumer density for each dimension $N$ in different markets with different intra-market heterogeneity $G$, where fluctuation to the consumers’ primary types $E$ is zero. The first row of the figure shows the consumer density in market 1, the second row and third row show the consumer density in market 2 and market 3 respectively. For each market, from the left to the right, the consumer densities with different intra-market heterogeneity $G = \{10, 25, 40\}$ are shown.

Lastly, recall that $\sigma$ denotes the sensitivity of consumer’s demand responding to the store practices. With a larger value of $\sigma$, the consumer is more sensitive to the store practices, so that the same amount of increase in the preference distance would lead to a larger drop in the demand. On the other hand, a smaller value of $\sigma$ implies that the consumer is less sensitive to store practices.

### 3.2 Initialization

In the first period, due to the empty consumer base, the evaluation of ideas based on an existing consumer base is impossible. Thus a decentralized store implements the innovation idea generated by itself without evaluation, while under centralization, HQ implements a randomly generated idea throughout the chain.
In the second period, a decentralized store follows the same pattern described in the ‘Computation Model’ section. Under centralization, the set up of the second period is different. Because it takes time to transfer information between store managers and the HQ, in the second period, no prompt decision can be made by the HQ. Thus, there is no implementation of a new idea in the second period for a centralized chain, and the practices stay the same as the practices in period 1.

On the other side of the market, it is assumed that each consumer searches in the first period, and buys from the store which gives her highest utility. This store becomes her favourite store in period 1. Thus, the first period consumer base and profit of each chain are determined by the random initialization of store practices.

3.3 Statistical Testing

For each replication, there are four scenarios which are simulated, denoted by $CC, CD, DC$ and $DD$. The first entry gives the organizational structure of Chain $a$, while Chain $b$’s organizational structure is given by the second entry. For example, $CC/DD$ describes the market where both chains are centralized/decentralized; $CD$ is where Chain $a$ is centralized while Chain $b$ is decentralized, and $DC$ is where Chain $a$ is decentralized while Chain $b$ is centralized.

Let $v^{t,n}_C(O)$ denote the profit of a centralized chain in period $t$ for replication $n$, given the other chain’s organizational structure $O$, and $O$ can be either centralization or decentralization. Similarly, $v^{t,n}_D(O)$ denote the profit of a decentralized chain instead.

We are also interested in the time series on $\frac{1}{X} \sum_{n=1}^{X} \left[ v^{t,n}_C(O) - v^{t,n}_D(O) \right]$, which describes how the average performance across all the replications differs between centralized and decentralized chains over the $T$ periods. Define $\delta^n(T;O) \equiv V^C_T(O;T) - V^D_T(O;T)$ and $\bar{\delta}(T;O) \equiv \frac{1}{X} \sum_{n=1}^{X} \delta^n(T;O)$ where $V^C_T(O;T) \equiv \sum_{t=1}^{T} 1_T v^{t,n}_C(O)$ and $V^D_T(O;T) \equiv \sum_{t=1}^{T} 1_T v^{t,n}_D(O)$.

This statistic is used to test whether $\delta(O;T) = 0$ or not, which is, in turn, used to determine whether one organizational structure form outperforms another. The test statistic is constructed as follows:

$$\hat{\delta}(O;T) = \left( \frac{1}{X} \sum_{n=1}^{X} (\delta^n(O;T))^2 - (\bar{\delta}(O;T))^2 \right)^{1/2}$$ (3)

where $\frac{1}{X} \sum_{n=1}^{X} (\delta^n(O;T))^2 - (\bar{\delta}(O;T))^2$ is the estimator of variance of $\delta^n(T;O)$, and $\sqrt{\frac{1}{X} \sum_{n=1}^{X} (\delta^n(O;T))^2 - (\bar{\delta}(O;T))^2} / \sqrt{X}$ is estimator of standard deviation of $\hat{\delta}(O;T)$.
For example, if \( \bar{\delta}(C; T) > 0 \) and \( \bar{\delta}(C; T)/\left(\sqrt{\frac{1}{X} \sum_{n=1}^{X} (\delta^n(C; T))^2 - (\bar{\delta}(C; T))^2}/\sqrt{X}\right) \)
is rejected at 5% level, centralization outperforms decentralization when the competing chain is centralized, and it is statistically significant.

3.4 The Profit Landscape

Search takes place over a rugged landscape defined over the space of store practices \( \{1, \ldots, R\} \). Store profit, corresponding to the store practices, forms a landscape over which the store manager can search for better practices through a hill-climbing rule (Carley and Lee 1998).

In case of a monopoly described by Chang and Harrington (2000), when the market environment is specified to be unchanging, each store manager searches over a fixed landscape. It is shown that in such case, the global optimum in the profit landscape is fixed at the location that most consumers prefer, or what we call the ‘consumer peak’ in the market.

However, in the case of duopoly, where product market competition takes place, the profit landscape becomes volatile. The shape of landscape and the location of the global optimum are not fixed, but jointly determined by the market structure and practices chosen by the competing chain.

Take market 2 as an example where the consumer peak is 50, we randomly generate the practices of Chain b’s store in market 2 over all the dimensions \( \{1, \ldots, N\} \) and practices of Chain a’s store in market 2 over the dimensions \( \{1, \ldots, N-1\} \). By fixing these practices, Fig. 2 plots the profit landscapes of Chain a’s store in the market 2 corresponding to the feasible practices of the Nth dimension of Chain a’s store in 4 different random cases.

It is shown that the shapes of these four profit landscapes are all different, as the shapes are jointly determined by the operations of both stores in the market.

In the case of duopoly competition, unlike monopoly, chains do not want to locate at the same point - the consumer peak, instead, they both want to locate slightly from each other in order to relax the competition by satisfying their own target consumers better. This is evidenced by each store’s actual location at the end of period \( T \) for each replication, which is shown in the Appendix B.

4 Results and Analysis

This section is organized as follows. Section 5.1 briefly describes the pattern of the results. Section 5.2 analyzes the relationship between organizational structure and the product market competition. Section 5.3 and 5.4 analyze the relationship between organizational structure and other factors in the market structure. Section 5.5 discusses the limitations of this paper as well as possible extensions for future research.
NOTE: Randomly generate the practices of Chain b’s store in market 2 over \{1, ..., N\} dimensions and practices of Chain a’s store over \{1, ..., N - 1\}. The Chain a’s profit in market 2 is plotted corresponding to all the feasible practices on the Nth dimension of Chain a’s store in market 2. Four different random cases are shown with one trial of replication.

4.1 Introduction

The experiments in this section assume, unless noted otherwise, \(M = 3\), \(\alpha = 4\), \(G = 25\), \(E = 2\), \(Q = 0.5\), \(\sigma = 3\), \(N = 5\), \(T = 1000\), \(X = 400\), while the other parameter values can be found in Section 4.1.

On the basis of average chain profit, Table 2 presents the profit matrix which determines the equilibrium organizational structure given the values of parameter specified above. The results were generated as follows. For each replication, the profits of Chain a and Chain b under the four scenarios – CC, CD, DC and DD, were calculated. After replicating 400 times, the profits in each period were averaged across replications. This gave us a time series for average chain profits under all of these four scenarios. The profits were then averaged across T periods and they were used as entries in a 2x2 payoff matrix for the game in which chains simultaneously select organizational structures.

As shown in Table 2, given the average profits of Chain a and Chain b under the four scenarios, it is clear that DD is the equilibrium organizational structure, where both chains choose to decentralize. This profit matrix provides an example for constructing the equilibrium organizational form, and the equilibrium tables shown later all follow this procedure.

Fig. 3 and 4 plot a time series for the difference of chain profits between a
Table 2: Profit Matrix for Organizational Structure

<table>
<thead>
<tr>
<th>Chain a / b</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>(0.3975, 0.3994)</td>
<td>(0.3515, 0.4490)</td>
</tr>
<tr>
<td>D</td>
<td>(0.4506, 0.3499)</td>
<td>(0.4005, 0.4011)</td>
</tr>
</tbody>
</table>

Note: There are two strategies for each Chain- C and D, where C denotes centralization, while D denotes decentralization. Given \( \alpha = 4 \), \( Q = 0.5 \), \( G = 25 \) and \( \sigma = 3 \), the first figure in each bracket denotes the average profit of Chain a across 400 replications and 1000 periods given the organizational structure chosen by each chain; while the second figure denotes the average profit of Chain b.

centralized and a decentralized organization, given that the competing chain is centralized and decentralized, respectively, \( (1/X) \sum_{n=1}^{X} [v_{C}^{t,n}(O) - v_{D}^{t,n}(O)] \). It is shown that the pattern of these two figures are similar, and they both look fairly systematic. Both of the curves lie below zero, which indicates that centralization is strictly dominated by decentralization in any period in this specific case. This result is highly consistent with the equilibrium organizational structure that we just found, DD.

These two curves initially dip at the early periods, because stores’ initial practices are highly suboptimal so that a store can probably effectively learn on its own as most new innovation ideas generated are effective in improving on existing practices. Hence, in this stage, the inter-store learning achieved by centralization is not that important.

Decentralization is increasingly performing better until the curves start to rise in the second stage. In this stage, as stores get out of having highly suboptimal practices, finding profitable ideas becomes more difficult. As a result, inter-store learning starts becoming important, which allows stores to choose from a larger set of innovation ideas. Thus, centralization performs relatively better in this stage, because inter-store learning, which is effectively achieved by centralization, promotes the spillover of profitable ideas across the chain.

After period 150, the curves start to flatten out, which means centralization is not as favorable as in the second stage. At this point of time, stores begin to hit the limit of centralization because the uniformity of practices imposed by
centralization prevents stores from approaching their own global optimum. The advantage of ‘local adaptability’ under decentralization starts to appear critical at this point, which allows stores to tailor their practices to the local market in order to achieve their global optimum.

4.2 The Relationship between a Firm’s Optimal Organizational Structure and the Product Market Competition

PROPERTY 1. The relative performance of decentralization is superior when the product market competition is intense, where competition is measured by the consumer search probability $Q$.

Table 3 reports the equilibrium organizational structures with different values of consumer search probability $Q$ and inter-market heterogeneity $\alpha$, over short run ($T = 100$), median run ($T = 500$) and long run ($T = 1000$). The construction of this equilibrium table has been described in Section 5.1. An equilibrium is statistically significant if the difference in payoffs between the equilibrium structure for a chain and the alternative structure, given the other firm’s equilibrium organizational structure, is rejected at 5% level. The number in each bracket presents the difference of profits between centralized chain and decentralized chain, given that the competing chain is decentralized.\(^5\)

\(^5\)As shown in Table 2, decentralization is the dominant strategy for both chains, so we only focus on the profit differentials when the competing chain is decentralized.
Table 3: Organizational Structure Equilibrium, Consumer Search Probability \( Q \) and Inter-market Heterogeneity \( \alpha \)

<table>
<thead>
<tr>
<th>( T ) / ( \alpha )</th>
<th>( \alpha = 0 )</th>
<th>( \alpha = 2 )</th>
<th>( \alpha = 4 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( Q = 0 )</td>
<td>DD ((-0.0065))</td>
<td>DD* ((-0.0073))</td>
<td>DD* ((-0.0111))</td>
</tr>
<tr>
<td>( Q = 0.05 )</td>
<td>DD* ((-0.0756))</td>
<td>DD* ((-0.0888))</td>
<td>DD* ((-0.0941))</td>
</tr>
<tr>
<td>( Q = 0.5 )</td>
<td>DD* ((-0.1066))</td>
<td>DD* ((-0.1134))</td>
<td>DD* ((-0.1277))</td>
</tr>
<tr>
<td>( Q = 1 )</td>
<td>DD* ((-0.1200))</td>
<td>DD* ((-0.1348))</td>
<td>DD* ((-0.1520))</td>
</tr>
<tr>
<td>500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( Q = 0 )</td>
<td>DD ((-0.0056))</td>
<td>DD* ((-0.0066))</td>
<td>DD* ((-0.0093))</td>
</tr>
<tr>
<td>( Q = 0.05 )</td>
<td>DD* ((-0.0355))</td>
<td>DD* ((-0.0495))</td>
<td>DD* ((-0.0505))</td>
</tr>
<tr>
<td>( Q = 0.5 )</td>
<td>DD* ((-0.0574))</td>
<td>DD* ((-0.0673))</td>
<td>DD* ((-0.0701))</td>
</tr>
<tr>
<td>( Q = 1 )</td>
<td>DD* ((-0.0692))</td>
<td>DD* ((-0.0788))</td>
<td>DD* ((-0.0825))</td>
</tr>
<tr>
<td>1000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( Q = 0 )</td>
<td>DD ((-0.0045))</td>
<td>DD* ((-0.0061))</td>
<td>DD* ((-0.0074))</td>
</tr>
<tr>
<td>( Q = 0.05 )</td>
<td>DD* ((-0.0267))</td>
<td>DD* ((-0.0360))</td>
<td>DD* ((-0.0396))</td>
</tr>
<tr>
<td>( Q = 0.5 )</td>
<td>DD* ((-0.0412))</td>
<td>DD* ((-0.0521))</td>
<td>DD* ((-0.0537))</td>
</tr>
<tr>
<td>( Q = 1 )</td>
<td>DD* ((-0.0518))</td>
<td>DD* ((-0.0598))</td>
<td>DD* ((-0.0642))</td>
</tr>
</tbody>
</table>

NOTE: With different values of consumer search probability \( Q \) and inter-market heterogeneity \( \alpha \), the equilibria were derived over short run \( T = 100 \), median run \( T = 500 \), and long run \( T = 1000 \). DD describes the situation where both chains are decentralized. Those configurations marked with an asterisk are statistically significant at the 5% level. The figure in each bracket shows the difference of profits between a centralized chain and a decentralized chain when the competing chain is decentralized.
As shown in Table 3, although the equilibria in all the specifications are $DDs^6$, where both chains decentralize, the profit differentials shown in the brackets illustrate a clear pattern. For each column, from the top to the bottom for each value of time $T$, the differential profits decrease in the consumer search probability $Q$, which demonstrates that decentralization performs increasingly better in a more competitive environment in terms of the increasing consumer search probability given the inter-market heterogeneity $\alpha$ fixed. For each row, from the left to the right, the differential profits decrease in the inter-market heterogeneity $\alpha$, which illustrates that the relative performance of decentralization increases when the markets are more heterogeneous, as decentralization allows each store to tailor its practices to its own unique market.

It should not be too surprising to see that, with all sets of parameters, decentralization outperforms centralization. In the case of single chain, decentralization almost always outperforms centralization (Chang and Harrington 2000), and competition makes the performance of decentralization even superior. Thus, when product market competition is introduced, decentralization should be more preferred by each chain.

Figure 5: Differential Profit when $Q = 0.05, 0.5, 1$, where the competing chain is decentralized.

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$^6$Decentralization significantly outperforms centralization in all the specifications, except that when $Q = 0$ and $\alpha = 0$, centralization is insignificantly dominated by decentralization over short run, median run and long run.

$^7$As shown in Table 3, the equilibria for all specifications are $DD$, where both chains are decentralized. Thus, we only focus on the profit differential path when the competing
It is clear that when the consumer search probability $Q$ increases, the profit differential curve shifts downwards, which illustrates that the relative performance of decentralization tends to be superior when the product market competition becomes more intense.

After introducing the ‘cost of delay’, the competitive advantage of decentralization becomes apparent. According to the cost of delay, it takes time for the transmission of information between store managers and the HQ. Under centralization, the HQ evaluates the innovation ideas based on the information about the chain’s overall consumer base in the previous period. When the consumer search probability is high, a store’s consumer base is changing quickly from time to time, so that the group of consumers who are consuming from the store in the current period can be extremely different from the group of consumers who purchased from this store in previous period. This leads to the information about the store’s consumer base, on which the evaluation of innovation ideas is based, becoming obsolete very quickly. This obsolesce of the information is costly because the implementation of the practices under centralization based on the previous consumer information may not be able to satisfy the current consumers effectively.

A second force is also at work. Competition favors decentralization because it makes the inter-market learning under decentralization more likely. When the consumer search probability is high, movement from the initial point of practices to the global optimum is more likely. Because, when the consumer search probability $Q$ approaches zero, the consumer base for each store is likely to be localized, which can be extremely different from each other depending on the initial conditions. In order to satisfy the current consumers, the location of each store can possibly be far away from each other, which prevents inter-market learning between stores under decentralization. On the other hand, higher consumer search probability $Q$ allows consumers to search more actively and frequently, in order to satisfy the changing consumer base, stores are likely to move from the localized point towards the global optimum more quickly. Although the global optimum in each market is different from each other according to the inter-market heterogeneity $\alpha$, the movement from the localized point towards the global optimum still reduces the difference of the target consumers of each store, which effectively increases the inter-market learning.

By introducing the cost of delay of transferring information between store managers and the HQ, our model gives us a result which is consistent with the empirical finding (Acemoglu 2006; Meagher and Wait 2006), that decentralization is more likely when the product market is more competitive.

It is widely accepted that centralization is associated with a cost of delay (Aoki 1986) and competition motivates prompt decision making (Aghion and Tirole 1997; Meagher, Orbay and Van Zandt, 2001). In our learning model, consumers search and change their favourite stores over time, the better a store or a chain un-chain is decentralized. The results are similar when the competing chain is centralized, which are included in Appendix C.
derstands its own current consumers, the more likely it can effectively satisfy and retain these consumers. Under centralization, intense competition, in terms of high consumer search probability, makes the information about the current consumers becoming obsolete quickly, as the group of consumers on which the evaluation based is different from the group of consumers who actually consume from the chain. Consequently, the practices adopted by a centralized chain may mismatch the targeted consumer base which the chain is supposed to pursue. Hence, the relative performance of decentralization is superior when the product market competition is intense. This is not only because decentralization utilizes the local adaptability, but also because it takes advantage of more fresh information about its consumers, which allows it to make more prompt and accurate decisions in order to satisfy its consumers more effectively.

4.3 The Relationship between a Firm’s Optimal Organizational Structure and Consumer Tastes in the Market

PROPERTY 2. Decentralization performs relatively better when consumer tastes are more homogenous in the market, which is captured by a relatively small intra-market heterogeneity $G$.

Recall that $G$ captures the intra-market heterogeneity, which measure how different the consumers are in a market. Larger $G$ indicates that the tastes of consumers in the market are more heterogenous, while smaller $G$ indicates that consumer tastes are more homogenous.

Table 4 reports the equilibrium organizational structures with different values of intra-market heterogeneity $G$ when the intra-market heterogeneity $\alpha = 4$ and the consumer search probability $Q = 0.5$. It is shown that, decentralization is still the dominant strategy for both chains under all the specifications. However, the difference of profits between a centralized chain and a decentralized chain when the competing chain is decentralized, as shown in each bracket, increases in $G$, which indicates that centralization tends to perform relatively better in the market with heterogenous consumer tastes.

A similar message is sent by Fig. 6, which is a plot of the difference of profits between centralization and decentralization when the competing chain is decentralized. It is shown that the profit differential curve shifts down when the intra-market heterogeneity $G$ becomes smaller, which demonstrates that the relative performance of decentralization is superior when the consumers in the market are more homogenous in their tastes.

Following the same pattern as discussed in the subsection 5.1, Fig. 7 plots the three different profit landscapes in market 2 when $G = \{10, 25, 40\}$ respectively given the practice of Chain a’s store in market 2 over the Nth dimension changing from $\{1, \ldots, R\}$. It is shown that when the intra-market heterogeneity $G$ is small,
### Table 4: Organizational Structure Equilibrium and Intra-market Heterogeneity $G$

<table>
<thead>
<tr>
<th>Intra-market heterogeneity $G$</th>
<th>Equilibrium</th>
</tr>
</thead>
<tbody>
<tr>
<td>$G = 10$</td>
<td>DD* ($-0.1456$)</td>
</tr>
<tr>
<td>$G = 25$</td>
<td>DD* ($-0.0524$)</td>
</tr>
<tr>
<td>$G = 40$</td>
<td>DD* ($-0.0186$)</td>
</tr>
</tbody>
</table>

**NOTE:** The equilibrium was derived by calculating the average profits across 400 replications and 1000 periods, where the inter-market heterogeneity $\alpha = 4$ and the consumer search probability $Q = 0.5$.

Figure 6: Differential Profit when $G = 10, 25, 40$, where the competing chain is decentralized.
such as $G = 10$, the profit landscape appears to be relatively steep; when $G$ increases to 40, the profit landscape becomes much flatter. This suggests that when the market is more homogenous, a slight deviation from the global optimum will lead to a large drop in the profit. Thus, the local information possessed by store managers appears especially important when consumer tastes are more homogenous in the market, which allows each store to adapt the global optimum in its own market.

In Fig. 7, attention should also be paid to the global optimum of the profit landscape shown in the datatip in each sub-figure. When the consumer tastes in the market are homogenous with a small $G$, in order to achieve the global optimum, the store tends to locate more close to the middle of the market, which is known as the consumer peak.

It is concluded by Anderson et al. (1994), the store that has the larger consumer base tends to have lower consumer satisfaction. Chang and Harrington (2003) also show that decentralization tends to have higher consumer satisfaction but a smaller loyal consumer base. However, we argue that when consumer tastes are relatively homogenous in a market, decentralization does not only satisfy consumers better but also tends to have a larger consumer base. This is because, when the consumers are relatively homogenous in a market, a practice which satisfies the consumer types who are most prevalent in the market will also tend to satisfy many other consumers in the market. Thus, decentralized store utilizes its superior local information to satisfy its current consumers, and, in turn, to satisfy most of the consumers in the market effectively.
4.4 The Relationship between a Firm’s Optimal Organizational Structure and the Consumer’s Sensitivity to Store Practices.

PROPERTY 3. The relative performance of decentralization is superior when consumers are not too sensitive to store practices, which is captured by a relatively small $\sigma$.

Table 5: Organizational Structure Equilibrium and Consumer Sensitivity to Store Practices $\sigma$

<table>
<thead>
<tr>
<th>Consumer Sensitivity $\sigma$</th>
<th>Equilibrium</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma = 3$</td>
<td>DD* ($-0.0522$)</td>
</tr>
<tr>
<td>$\sigma = 9$</td>
<td>DD* ($-0.0384$)</td>
</tr>
<tr>
<td>$\sigma = 15$</td>
<td>DD* ($-0.0268$)</td>
</tr>
</tbody>
</table>

NOTE: The equilibrium was derived by calculating the average profits across 400 replications and 1000 periods, where inter-market heterogeneity $\alpha = 4$.

As shown in Table 5, given the different value of consumer sensitivity to store practices $\sigma = \{3, 9, 15\}$, decentralization is always the dominant strategy for each chain no matter whether the competing chain is centralized or decentralized. The number in each bracket shows the difference of profits between centralization and decentralization, given that the competing chain is decentralized. It is shown that even though all the profit differentials are negative, they increase in $\sigma$. This illustrates that relative performance of centralization is superior when consumers are more sensitive to the store practices.

Fig. 8 plots the difference of profits between centralization and decentralization when the competing chain is decentralized. The curve shifts up when $\sigma$ becomes larger, which demonstrate that when consumers are more sensitive to store practices, centralization performs relatively better.

To some degree, Fig. 9 provides an explanation to Property 3. Following the same pattern as discussed in subsection 5.1, Figure 5.9 plots the profit landscape
Figure 8: Differential Profit when $\sigma = 3, 9, 15$, when the competing chain is decentralized.

Figure 9: The Profit Landscape all the 3 Markets when Consumer’s Sensitivity $\sigma = 3, 9, 15$. 
of Chain a in each market with different values of consumer sensitivity $\sigma$ corresponding to the practice on the $N$th dimension of the each store under Chain a. For each column, from the top to the bottom, the sub-figures show the profit landscapes in market 1, market 2 and market 3 respectively, given the consumer’s sensitivity; while for each row, from the left to the right, the sub-figures show the profit landscapes when the consumer’s sensitivity to store practices $\sigma$ increases from 3, 9 to 15. The datatip in each figure points out the global optimum of the profit, given the practice of the $N$th dimension for each store under Chain a. Given the inter-market heterogeneity $\alpha = 4$, it is shown that when $\sigma$ is relatively small, each store under the same chain tends to locate differently from the others in order to adapt its own local market. For example, as shown, when $\sigma = 3$, the optimal practice on the $N$th dimension for the stores in market 1, 2 and 3 are 44, 46 and 47 respectively, which implies that when $\sigma$ is relatively small, uniformity of practices imposed by centralization is not favorable as it prevents the store in each market from achieving its own unique global optimum. On the other hand, when $\sigma$ is relatively large, the optimum position in each market corresponding to the global optimum is shown to be overlapping. When $\sigma = 15$, it is shown that the optimum practice for each stores under Chain a is 44, which gives the highest profit to the store in each market under Chain a. Therefore, centralization performs better when consumers are sensitive to store practices because the uniformity of practices imposed by centralization tends to promotes the spillover of profitable ideas across the chain without suffering from the loss of ‘local adaptability’ in such case.

However, the underlying reason that centralization is favored when consumers are more sensitive to store practices cannot be well explained here. Thus, it still remains for future research on this point.

5 Sensitivity Analysis

We will conduct a sensitivity analysis in this section. As shown in the last section, ‘decentralization’ is the dominant strategy for each chain across all the specifications. Thus, we only present a time series for the difference of profits between a centralized and a decentralized chain for each case when the competing chain is decentralized.

Firstly, we change the number of markets $M$ in which the chains are competing with each other. In the case of 2 markets with inter-market heterogeneity $\alpha = 4$, Fig. 10, 11 and 12 plot the differences of profits between centralization and decentralization when the competing chain is decentralized with the consumer search probability $Q$, the intra-market heterogeneity $G$ and the consumer sensitivity to.

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8Form the unreported figures, it is also clear that the differential profit curve when the competing chain is centralized is quite similar to the curve when the competing chain is decentralized in each case.
store practices $\sigma$ varied respectively. It is shown that the change in the number of markets does not change our results.

Figure 10: Differential Profit and Consumer Search Probability $Q$ when the Number of Markets $M = 2$

![Graph of Differential Profit and Consumer Search Probability](image1)

Figure 11: Differential Profit and Intra-market Heterogeneity $G$ when the Number of Markets $M = 2$

![Graph of Differential Profit and Intra-market Heterogeneity](image2)

Figure 12: Differential Profit and Consumer Sensitivity to Store Practices $\sigma$ when the Number of Markets $M = 2$

![Graph of Differential Profit and Consumer Sensitivity to Store Practices](image3)

Second, we show that our results are robust to the number of consumers $C$ in each market. By changing the number of consumers in each market $C$ from 800 to 100, the profit differentials are plotted in Figure 13, 14 and 15 for the three properties.

Lastly, Figure 16, 17 and 18 plot the differential profits when the number of dimensions $N$ is changed from 5 to 2. It is found that the change in the number of dimensions of store practices does not change our results.

Therefore, it is found that our properties are not sensitive to small changes in our parameter values.
Figure 13: Differential Profit and Consumer Search Probability $Q$ when the Number of Consumers $C = 100$

Figure 14: Differential Profit and Intra-market Heterogeneity $G$ when the Number of Consumers $C = 100$

Figure 15: Differential Profit and Consumer Sensitivity to Store Practices $\sigma$ when the Number of Consumers $C = 100$
Figure 16: Differential Profit and Consumer Search Probability $Q$ when the Number of Dimensions $N = 2$

Figure 17: Differential Profit and Intra-market Heterogeneity $G$ when the Number of Dimensions $N = 2$

Figure 18: Differential Profit and Consumer Sensitivity to Store Practices $\sigma$ when the Number of Dimensions $N = 2$
6 Conclusion

The thesis examined the relationship between a firm’s optimal organization structure and the market structure.

By incorporating bounded rationality, a reduced form of a dynamic real-time decentralized information processing model has been developed in the duopoly case. This model allows us to consider the cost of delay (Meagher 1996) as well as product market competition (Chang and Harrington 2003).

It is found that the relative performance of decentralization tends to be superior when the product market competition is more intense. This is because more intense competition, which is measured by a relatively high consumer search probability, causes information about the consumers to become obsolete quickly, which in turn, limits a firm’s ability to satisfy its current consumers.

Fisher et al (1994) argue that the superior performance of firms like Wal-Mart, The Gap, The Limited and Benetton is largely due to their ability to manage demand uncertainty using ‘accurate response’ strategy. This implies that using more recent information and reacting to the changing consumer base more promptly serves as a competitive advantage for a firm. The need for timely decision making favors decentralization because it reduces the lag between the receipt of information and decision making.

Although this positive relationship between decentralization and product market competition has been briefly discussed in some organization textbooks (for example, Brickley, Smith and Zimmerman (2004)), no theoretical work to date supports this argument. Conversely, Chang and Harrington (2003) shows a contradictory result with their theatrical model, that product market competition favors centralization.

Since intuitively, the positive relationship between decentralization and product market competition holds, our finding is important, which provides theoretical evidence to reinforce this argument. Moreover, this result is also consistent with findings in several recent empirical papers, such as Acemoglu et al. (2006) and Meagher and Wait (2006).

Secondly, we find that decentralization performs relatively better in a market where consumer tastes are more homogenous. Based on superior local information, by tailoring its practices to the consumer types who are most prevalent in the market, decentralization can satisfy many other consumers if the consumer tastes in the market are similar.

Finally, we also find that the relative performance of decentralization is superior when the consumers are not too sensitive to store practices because a high consumer sensitivity makes the optimal practices of the store in each market overlapping. However, the future research on this point can be further expanded.

There are also two major limitations regarding the model and the simulation methodology respectively.

First, we find that, decentralization is the dominant strategy over all the spec-
ifications. However, in the real world, the performance of decentralization may not be as desirable as shown in our results. That is because one of the major drawbacks of decentralization – ‘loss of control’ – is not included in this model (Aghion and Tirole 1997). By introducing the loss of control, the relative performance of centralization is expected to increase, and centralization may become the dominant strategy when the markets are sufficiently homogenous and the product market competition is not too intense.9

Second, it has been customary to be sceptical of results that are produced by simulation. We agree that closed-form results may be more persuasive in the sense that they are independent of the particular values of parameters in the model. However, numerical methods provide a countervailing advantage, which allows us to explore new lines of theory which are beyond the scope of the traditional scientific methods. In our model, the complexity of finding the optimal organizational structure when multi-dimensional competition and consumer search take place in the market is too great to make closed-form solutions tractable. Alternatively, our numerical simulation makes it possible to explore the properties of the model that would otherwise be inaccessible to analysis.

In addition, there are several directions that future work can take, such as taking the price competition into account, making the consumer search probability endogenous 10, and introducing the market research (Peter and Olson, 2005).

In conclusion, the relationship between organizational structure and market structure is an important and interesting topic, because these two structures jointly determine the performance of a firm. However, very little research has been done to explore this relationship. This thesis develops a theoretical computational model to establish the link between the theory, empirical evidence and economic intuition.

References


9Although the loss of control may increases the relative performance of centralization, it does not invalidate our properties, as we considered the derivative of the difference of performance between centralization and decentralization instead of the level of the difference.

10For example, consumers only search if the utility that she receives from her favourite store falls below a certain level (Radner, 2003).


